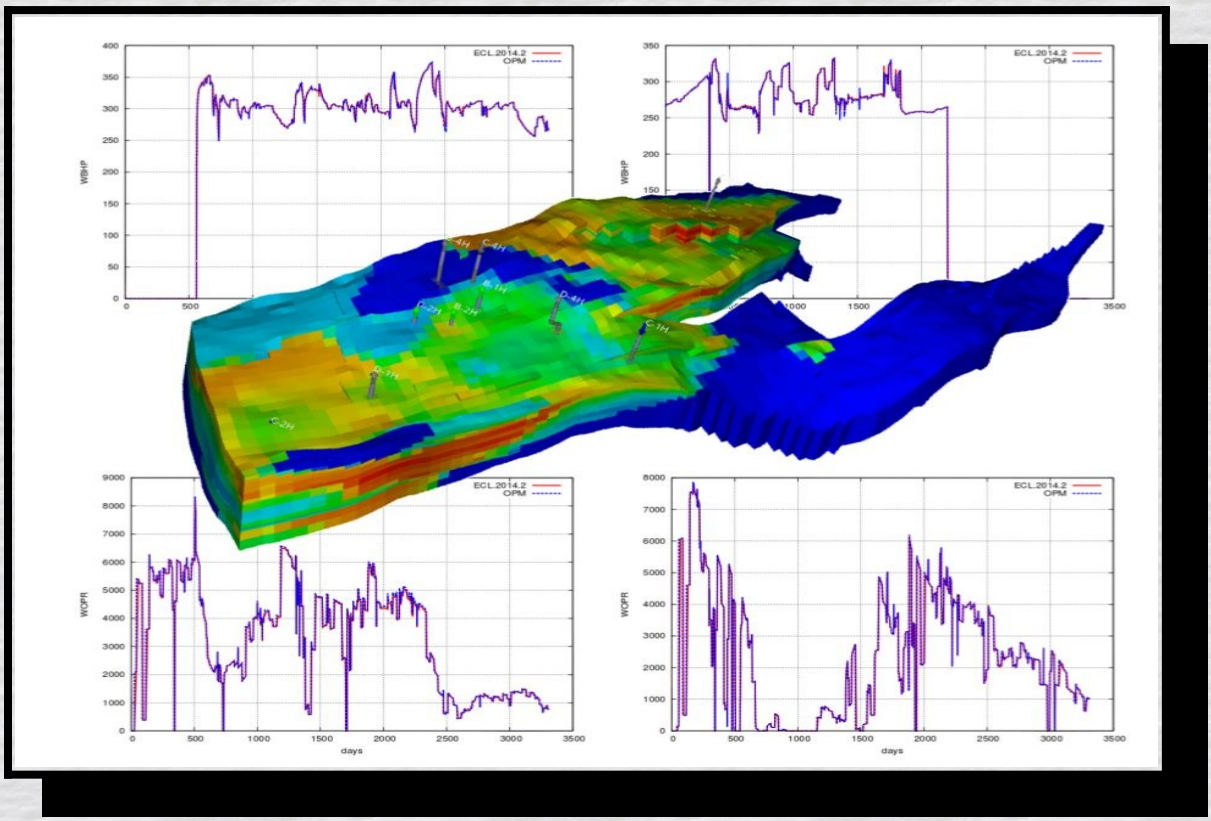
OPEN POROUS MEDIA

OPM Flow Reference Manual



OPM FLOW VERSION: 2020-04

MANUAL REVISION: Rev-1

OPEN POROUS MEDIA
OPM Flow Reference Manual
(2020-04)

Document Control	
Company	**Equinor ASA**
Confidentiality, copyright and reproduction	This document is Copyright 2020 by the OPEN POROUS MEDIA team. **Documentation Contributors:** Jostein Alvestad, David Baxendale, Kai Bao, Markus Blatt, Joakim Hove, Andreas Lauser, Cintia Goncalves Machado, Arne Morten Kvarving, Atgeirr Rasmussen, Alf Birger Rustad, Tor Harald Sandve, Bård Skaflestad, Torbjørn Skille One may distribute or modify the document under the terms of the Creative Commons Attribution-ShareALike 4.0 International License, version 4.0 or later (http://creativecommons.org/licenses/by/4.0/). All trademarks within this guide belong to their legitimate owners.
Document Type	OPEN POROUS MEDIA
Document Title	OPM Flow Reference Manual (2020-04)
Document Version	Rev-1
Document Ref.	2020-04-RPT
Author and Editor	OPM-OP AS Heyerdahlsvei 12b, 0777 Oslo, Norway
	David Baxendale
	david.baxendale@opm-op.com
Document Name	D:\Projects\Equinor\Miscellaneous\M70 Technical Reports and Notes\ OPM_Flow_Documentation_2020-04_Rev-1.odt

OPEN POROUS MEDIA
OPM Flow Reference Manual
(2020-04)

Document Control			
Document Revision	Date	Version and Revision	Status
	July 9, 2020	2020-04 Rev-1	Final
	June 25, 2020	2020-04 Rev-B	Developer's Review Draft for Appendix D
	May 20, 2020	2020-04 Rev-0	Final
	May 8, 2020	2020-04 Rev-A	Developer's Review Draft
	December 5, 2019	2019-10 Rev-0	Final
	November 6, 2019	2019-10 Rev-0	Final Draft
	June 20, 2019	2019-04 Rev-0	Final
	December 31, 2018	2018-10 Rev-2	Fix Broken Links etc.
	November 6, 2018	2018-10 Rev-1	Final (DRSDTR & DRVDTR)
	November 5, 2018	2018-10 Rev-0	Final
	October 4, 2017	2017-04 Rev-0	Final

Table of Contents

CHAPTER 1: INTRODUCTION....37

1.1 Overview....38

CHAPTER 2: INSTALLING AND RUNNING FLOW....41

2.1 Installing OPM Flow....42
2.1.1 Ubuntu Linux 16.04 (64-bit version only) and Higher....42
2.1.2 Red Hat Enterprise or CentOS (version 6 or 7)....43
2.1.3 Using a Docker container....43
2.1.4 Installing from source....43

2.2 Running OPM Flow 2020-04 From The Command Line....44

2.3 Running OPM Flow Using OPMRUN....62
2.3.1 OPMRUN Configuration....70
2.3.2 OPMRUN Tools – Compress Jobs....71
2.3.3 OPMRUN Tools - Keyword Generator....72

CHAPTER 3: KEYWORD DOCUMENTATION STRUCTURE....83

3.1 Introduction....84

3.2 Keyword Definitions....84

3.3 Multi-Section Keywords....84

3.4 Keyword Formats....85
3.4.1 Keyword Format Type – Comment....85
3.4.2 Keyword Format Type – Activation....85
3.4.3 Keyword Format Type - Vector (Row Vector)....86
3.4.4 Keyword Format Type – Vector (Columnar Vector)....88
3.4.5 Keyword Format Type – Array....89

3.5 Input File Structure....90

CHAPTER 4: GLOBAL SECTION KEYWORDS....91

4.1 Introduction....92

4.2 Keyword Definitions....92
4.2.1 COLUMNS – Define Input File Column Margins....93
4.2.2 DEBUG – Define the Debug Data to be Printed to File....94
4.2.3 ECHO – Activate Echoing of User Input Files to the Print File....95
4.2.4 END – Define the End of the Input File....96
4.2.5 ENDINC – Define the End of an Include File....97
4.2.6 ENDSKIP – DeActivate Skipping of Keywords and Input Data....98
4.2.7 EXTRAPMS – Activate Extrapolation Warning Messages....99
4.2.8 FORMFEED – Defined the Print File Form-Feed Character....100
4.2.9 INCLUDE – Load Another Data File at the Current Position....101
4.2.10 MESSAGE – Output User Message....102
4.2.11 MESSAGES – Define Message Print Limits and Stop Limits....103
4.2.12 NOECHO – Deactivate Echoing of User Input Files to the Print File....105
4.2.13 NOWARN – Deactivate Warning Messages....106
4.2.14 SKIP – Activate Skipping of All Keywords and Input Date....107
4.2.15 SKIP100 – Activate Skipping of “Black-Oil” Keywords and Input Date....108
4.2.16 SKIP300 – Activate Skipping of “Compositional” Keywords and Input Date....109
4.2.17 WARN – Activate Warning Messages....110

CHAPTER 5: RUNSPEC SECTION....111

5.1 Introduction....112

5.2 Keyword Definitions....112
5.2.1 ACTDIMS – ACTION Keyword Dimensions....113
5.2.2 ACTPARAM – Define Action Facility Target and Tolerance Parameters....114
5.2.3 AITS – Activate Intelligent Time Stepping....115
5.2.4 AITSOFF – Deactivate Intelligent Time Stepping....116
5.2.5 ALKALINE – Activate the Alkaline Phase and Model....117
5.2.6 API – Activate API Tracking....118
5.2.7 AQUDIMS – Define Aquifer Dimensions....119
5.2.8 AUTOREF - Define Auto Refinement Options....120
5.2.9 BIGMODEL – Activate Big Model Option (Retired)....121
5.2.10 BLACKOIL – Activate Black Oil Phases....122
5.2.11 BPARA – Activate Block Parallel License....123
5.2.12 BPIDIMS – Define the Dimensions of the Interpolated Block Quantities....124
5.2.13 BRINE – Activate Brine Tracking Option....125
5.2.14 CART – Activate Cartesian Geometry....127
5.2.15 CBMOPTS – Define Coal Bed Methane Options....128
5.2.16 COAL – Activate the Coal Phase (CBM Model)....129
5.2.17 CPR – Activate Constrained Pressure Residual (“CPR”) Linear Solver....130
5.2.18 DIFFUSE – Activate Molecular Diffusion Option....131
5.2.19 DIMENS – Define the Dimension of the Model....132
5.2.20 DISGAS – Activate the Dissolved Gas Phase in the Model....133
5.2.21 DISPDIMS – Define the Maximum Number of Dispersion Tables....134
5.2.22 DUALPERM – Activate Dual Permeability Model....135
5.2.23 DUALPORO – Activate Dual Porosity Model....136
5.2.24 DYNRDIMS – Define Dynamic Region Dimensions....137
5.2.25 ECLMC – Activate Multi-Component Brine Model....138
5.2.26 ENDSCALE – Activate Relative Permeability End-Point Scaling Option....139
5.2.27 EQLDIMS – Define the Equilibration Data Dimensions....141
5.2.28 EQLOPTS – Activate the Equilibration Options....142
5.2.29 FAULTDIM – Define the Number of Fault Segments....143
5.2.30 FIELD – Activate the Oil Field System of Units for the Model....144
5.2.31 FMTHMD – Activate The Format History Match Gradient File Option....145
5.2.32 FMTIN – Activate The Format Input File Option....146
5.2.33 FMTOUT – Activate The Format Output File Option....148
5.2.34 FOAM – Activate the Foam Phase and Model....150
5.2.35 FRICTION – Activate Wellbore Friction Option....151
5.2.36 FULLIMP – Activate Fully Implicit Solution Option....152
5.2.37 GAS – Activate the Gas Phase in the Model....153
5.2.38 GASFIELD – Define Gas Field Operations Options....154
5.2.39 GDIMS – Activate Instantaneous Gradient Option and Define Dimensions....155
5.2.40 GIMODEL – Activate Gi Pseudo Compositional Option....156
5.2.41 GRAVDR – Activate Gravity Drainage and Imbibition for Dual Porosity Model....157
5.2.42 GRAVDRB - Activate Vertical Discretized Gravity Drainage and Imbibition for Dual Porosity Model....158
5.2.43 GRAVDRM - Activate Alternative Gravity Drainage and Imbibition for Dual Porosity Model....159
5.2.44 GRIDOPTS - Grid Processing Options....160
5.2.45 HMDIMS – Define History Match Gradient Parameter Dimensions....162
5.2.46 HYST – Activate the Hysteresis Option (Retired)....163
5.2.47 IMPES – Activate Implicit Pressure Explicit Saturation Solution Option....164
5.2.48 IMPLICIT – Activate Fully Implicit Solution Option....165
5.2.49 INSPEC – Activate the INSPEC File Option....166
5.2.50 LAB - Activate the Laboratory System of Units for the Model....167
5.2.51 LICENSES – Define Required Licenses for Run....168
5.2.52 LIVEOIL – Activate the Live Oil Phase (Oil with Free and Dissolved Gas)....169
5.2.53 LGR – Define Local Grid Refinement Dimensions and Parameters....170
5.2.54 LGRCOPY – Activate Local Grid Refinement Inheritance....172
5.2.55 LOAD – Load a SAVE File for a Fast Restart....173
5.2.56 LOWSALT – Activate the Low Salt Brine Phase in the Brine Model....174
5.2.57 MEMORY – Define Allocated Memory (Retired)....175
5.2.58 MESSSRVC - Activate or Deactivate Database Message File Output....176
5.2.59 METRIC – Activate the Metric System of Units for the Model....177
5.2.60 MISCIBLE – Define Miscibility Todd-Longstaff Parameters....178

5.2.61 MONITOR – Activate Output of the Monitoring Data and File....179
5.2.62 MSGFILE – Active or Deactivate Message File Output....180
5.2.63 MULTIN – Activate the Non-Unified Multiple Input File Option....181
5.2.64 MULTOUT – Activate the Non-Unified Multiple Output File Option....183
5.2.65 MULTOUTS – Activate Non-Unified Multiple Summary Output File Option....185
5.2.66 MULTREAL – Activate Commercial Simulator's Multi-Realization License....186
5.2.67 NETWORK – Activate the Extended Network Option and Define Parameters....187
5.2.68 NINEPOIN – Activate the Nine-Point Discretization Option....188
5.2.69 NMATRIX – Activate the Discretized Matrix Dual Porosity Option....189
5.2.70 NNEWTF – Activate the Non-Newtonian Fluid Model....190
5.2.71 NOCASC – Activate Linear Solver Tracer Algorithm....191
5.2.72 NODPPM – Deactivate Fracture Porosity-Permeability Calculation....192
5.2.73 NOHYST - Deactivate the Hysteresis Option....193
5.2.74 NOINSPEC – Deactivate Output of the INIT Index File....194
5.2.75 NOMONITO – Deactivate Output of the Monitoring Data and File....195
5.2.76 NONNC – Deactivate Non-Neighbor Connections....196
5.2.77 NORSSPEC – Deactivate Output of the RESTART Index File....197
5.2.78 NOSIM – Activate the No Simulation Mode for Data File Checking....198
5.2.79 NRSOUT – Defined Maximum Number of RESTART Elements....199
5.2.80 NSTACK – Define the Stack Length for the Iterative Linear Solver....200
5.2.81 NUMRES – Define the Number of Reservoir Grids....201
5.2.82 NUPCOL – Define the Number of Newtonian Iterations Used to Update Well Targets....202
5.2.83 OIL – Activate the Oil Phase in the Model....203
5.2.84 OPTIONS – Activate Various Program Options....204
5.2.85 PARALLEL – Define Parallel Run Configuration....205
5.2.86 PARTTRAC – Activate and Define Partitioned Tracer Option....206
5.2.87 PATHS – Define Filename Directory Path Aliases....207
5.2.88 PEDIMS – Define Petro-Elastic Model Regions and Table Dimensions....208
5.2.89 PETOPTS – Define Petrel and Generic Simulation File Options....209
5.2.90 PIMTDIMS – Define Well Productivity Scaling Table Dimensions....210
5.2.91 POLYMER – Activate the Polymer Phase in the Model....211
5.2.92 PRECSALT – Activate the OPM Flow Salt Precipitation Model....212
5.2.93 PSTEADY – Activate Pseudo Steady State Flow Calculation Option....213
5.2.94 RADIAL – Radial Grid Activation Option....214
5.2.95 REGDIMS – Define the Maximum Number of Regions for a Region Array....215
5.2.96 RIVRDIMS – Define the River Dimensions and Associated Data....217
5.2.97 ROCKCOMP – Activate Rock Compaction....218
5.2.98 RPTCPL – Activate Couple Simulation Reporting....220
5.2.99 RPTHMD - Define Well History Match Gradient Reporting Options....221
5.2.100 RPTRUNSP – Activate RUNSPEC Reporting....222
5.2.101 RSSPEC – Activate Output of the RESTART Index File....223
5.2.102 RUNSPEC - Define the Start of the RUNSPEC Section of Keywords....224
5.2.103 SAMG – Activate Algebraic Multi-Grid Linear Solver....225
5.2.104 SATOPTS – Activate Relative Permeability Assignment Options....226
5.2.105 SAVE – Activate Output of a SAVE File for Fast Restarts....230
5.2.106 SCDPDIMS – Define Scale Deposition and Damage Table Dimensions....231
5.2.107 SMRYDIMS – Define Maximum Number of Summary Vectors to be Written....232
5.2.108 SOLVDIMS – Define PEBI Grid Nested Factorization Solver Dimensions....233
5.2.109 SOLVENT – Activate the SOLVENT Phase in the Model....234
5.2.110 START – Simulation Start Date....235
5.2.111 SURFACT – Activate the Surfactant Phase in the Model....236
5.2.112 SURFACTW – Activate the Surfactant Phase with Wettability Changes in the Model....237
5.2.113 TABDIMS – Define the Number of Tables and the Table Dimensions....238
5.2.114 TEMP – Activate the Temperature Modeling Option....241
5.2.115 THERMAL– Activate the Thermal Modeling Option....242
5.2.116 TITLE – Define the Title for the Input Deck....244
5.2.117 TRPLPORO – Activate the Triple Porosity Model Option....245
5.2.118 TRACERS – Activate Tracer Options and Set Tracer Array Dimensions....246
5.2.119 UDADIMS – Define the Dimensions of the User Defined Arguments....248
5.2.120 UDQDIMS – Define the Dimensions of the User Defined UDQ Feature....249
5.2.121 UDQPARAM – Define Parameters for the User Defined Quantity Feature....251
5.2.122 UDTDIMS – Define the Dimensions of the User Defined Tables....253
5.2.123 UNCODHMD – Activate History Match Gradient Unencoded Output....254

5.2.124 UNIFIN – Activate The Unified Input File Option....255
5.2.125 UNIFOUT – Activate The Unified Output File Option....257
5.2.126 UNIFOUTS – Activate The Unified Output Summary File Option....259
5.2.127 UNIFSAVE – Activate The Unified Output Save File Option....260
5.2.128 VAPOIL – Activate the Vaporize Oil in Wet Gas Phase in the Model....261
5.2.129 VAPWAT – Activate Vaporize Water in the Dry and Wet Gas Phases....262
5.2.130 VE – Activate Vertical Equilibrium Model (Global)....263
5.2.131 VFPIDIMS – Injection Vertical Flow Performance Table Dimensions....264
5.2.132 VFPPDIMS – Production Vertical Flow Performance Table Dimensions....265
5.2.133 VISAGE - Activate External Reservoir Geo-Mechanics VISAGE Option....266
5.2.134 VISCD – Activate Dual Porosity Viscous Displacement Option....267
5.2.135 WATER – Activate the Water Phase in the Model....268
5.2.136 WELLDIMS – Define the Wells and Group Dimensions....269
5.2.137 WPOTCALC – Well Potential Calculation Options....271
5.2.138 WSEGDIMS – Define Multi-Segment Well Dimensions....272

CHAPTER 6: GRID SECTION....273

6.1 Introduction....274

6.2 Data Requirements....275
6.2.1 Cartesian Regular Grid....275
6.2.2 Radial Grid....276
6.2.3 Irregular Corner-Point Grids....277
6.2.4 Rock Properties....280

6.3 Keyword Definitions....282
6.3.1 ACTNUM – Set the Status of a Grid Block To Active or Inactive....283
6.3.2 ADD – Add a Constant to a Specified Array....284
6.3.3 ADDREG – Add a Constant to an Array based on a Region Number....286
6.3.4 ADDZCORN – Add a Constant to the ZCORN Depth Array....288
6.3.5 AMALGAM – Define LGR Amalgamations....289
6.3.6 AQUANCON – Define Analytical Connections to the Grid....290
6.3.7 AQUCON – Define Numerical Aquifer Connections to the Grid....292
6.3.8 AQUCT – Define Carter-Tracy Analytical Aquifers....293
6.3.9 AQUNNC – Define Numerical Aquifer Non-Neighbor Connections....297
6.3.10 AQUNUM – Define Numerical Aquifer Properties....298
6.3.11 AUTOCOAR - Define Auto Refinement Grid Coarsen Area....299
6.3.12 BOUNDARY – Define a Boundary Box for Printing....300
6.3.13 BOX - Define a Range of Grid Blocks to Enter Property Data....301
6.3.14 BTOBALFA – Dual Porosity Matrix to Fracture Multiplier (All Cells)....303
6.3.15 BTOBALFV – Dual Porosity Matrix to Fracture Multiplier (Individual Cells)....304
6.3.16 CARFIN – Define a Cartesian Local Grid Refinement....305
6.3.17 COALNUM – Define the Coal Region Numbers....307
6.3.18 COARSEN – Define Grid Coarsening Cells....308
6.3.19 COLLAPSE – Define Compressed Vertical Equilibrium Cells....309
6.3.20 COORD – Define a Set of Coordinates Lines for a Reservoir Grid....310
6.3.21 COORDSYS – Define Coordinate Grid Options....312
6.3.22 COPY – Copy Array Data to Another Array....313
6.3.23 COPYBOX – Copy Array Data Defined by a Box....315
6.3.24 COPYREG – Copy an Array to Another Array based on a Region Number....318
6.3.25 CRITPERM – Define Minimum Permeability for Vertical Equilibrium Grid Cell Compression....320
6.3.26 DIFFMR – Define Grid Block Radial Direction Diffusivity Multipliers....321
6.3.27 DIFFMR- – Define Grid Block Negative Radial Direction Diffusivity Multipliers....322
6.3.28 DIFFMTHT – Define Grid Block Theta Direction Diffusivity Multipliers....323
6.3.29 DIFFMTH- – Define Grid Block Negative Theta Direction Diffusivity Multipliers....324
6.3.30 DIFFMX – Define Grid Block X-Direction Diffusivity Multipliers....325
6.3.31 DIFFMX- – Define Grid Block Negative X-Direction Diffusivity Multipliers....326
6.3.32 DIFFMY – Define Grid Block Y-Direction Diffusivity Multipliers....327
6.3.33 DIFFMY- – Define Grid Block Negative Y-Direction Diffusivity Multipliers....328
6.3.34 DIFFMZ – Define Grid Block Z-Direction Diffusivity Multipliers....329
6.3.35 DIFFMZ- – Define Grid Block Negative Z-Direction Diffusivity Multipliers....330
6.3.36 DOMAINS – Define the Parallel Domain Properties....331

6.3.37 DPGRID – Activate The Matrix Cell to Fracture Cell Option....332
6.3.38 DPNUM – Define Dual and Single Porosity Grid Block Array....333
6.3.39 DR - Define the Size of Grid Blocks in the R Direction for All Cells....334
6.3.40 DRV - Define the Size of Grid Blocks in the R Direction via a Vector....335
6.3.41 DTHETA - Define the Size of Grid Blocks in the THETA Direction for All Cells....336
6.3.42 DTHETAV - Sets the Size of Grid Blocks in THETA Direction via a Vector....337
6.3.43 DUMPFLUX – Activate Writing Out of a Flux File....338
6.3.44 DX - Define the Size of Grid Blocks in the X Direction for All Cells....339
6.3.45 DXV - Define the Size of Grid Blocks in the X Direction via a Vector....340
6.3.46 DY - Define the Size of Grid Blocks in the Y Direction for All Cells....341
6.3.47 DYV - Define the Size of Grid Blocks in the Y Direction via a Vector....342
6.3.48 DZ - Define the Size of Grid Blocks in the Z Direction for All Cells....343
6.3.49 DZMATRIX - Matrix Block Height for Gravity Drainage Model For All Cells....344
6.3.50 DZMTRX - Matrix Block Height for Gravity Drainage Model for the Grid....345
6.3.51 DZMTRXV - Matrix Block Height for Gravity Drainage Model For All Cells....346
6.3.52 DZNET – Define Grid Block Net Thickness for All Cells....347
6.3.53 DZV - Define the Size of Grid Blocks in the Z Direction via a Vector....348
6.3.54 ENDBOX – Define the End of the BOX Defined Grid....349
6.3.55 ENDFIN – End the Definition of a Local Grid Refinement....350
6.3.56 EQLZCORN - Modify the Depth of the Corner-Point Depth Array....351
6.3.57 EQUALREG – Sets an Array to a Constant by Region Number....352
6.3.58 EQUALS – Sets a Specified Array to a Constant....354
6.3.59 EXTFIN - Define an External Unstructured Local Grid Refinement....357
6.3.60 EXTHOST - Define Host Cells for External LGRs....358
6.3.61 EXTREPGL - Define Host Cells for External Unstructured LGRs....359
6.3.62 FAULTS – Define Faults in the Grid Geometry....360
6.3.63 FILEUNIT – Activate Unit Consistency Checking....362
6.3.64 FLUXNUM – Define the Flux Regions....363
6.3.65 FLUXREG – Define Active Flux Regions....364
6.3.66 FLUXTYPE – Defines the Flux Boundary Type....365
6.3.67 GDFILE – Load a Grid File....366
6.3.68 GDORIENT - Define Grid Orientation Parameters....367
6.3.69 GETDATA – Load and Assign Data Array from INIT or RESTART Files....368
6.3.70 GRID - Define the Start of the GRID Section of Keywords....369
6.3.71 GRIDFILE – Set the Grid File Output Options....370
6.3.72 GRIDUNIT – Define the Grid Units....371
6.3.73 HALFTRAN – Activate Half Block Transmissibility Calculations....372
6.3.74 HEATCR – Define Reservoir Rock Heat Capacity for All Cells....373
6.3.75 HEATCRT – Define Reservoir Rock Heat Capacity Temperature Dependence for All Cells. 374
6.3.76 HMFAULTS – History Match Fault Gradient Parameters....375
6.3.77 HMAQUNUM - History Match Numerical Aquifer Gradient Parameters....376
6.3.78 HMMLAQUN – History Match Numerical Aquifer Gradient Multipliers....377
6.3.79 HMMLT – History Match Grid Permeability Gradient Cumulative Multipliers....378
6.3.80 HMMMREGT - History Match Region Transmissibility Gradient Cumulative Multipliers...379
6.3.81 HMMULRGT – History Match Region Transmissibility Parameters....380
6.3.82 HMMULTFT – History Match Fault Transmissibility Gradient Cumulative Multipliers....381
6.3.83 HMMULTSG – History Match Dual porosity Sigma Gradient Cumulative Multipliers....382
6.3.84 HRFIN - Define the Ratio of LGR Grid Blocks in the R-Direction....383
6.3.85 HXFIN - Define the Ratio of LGR Grid Blocks in the X-Direction....384
6.3.86 HYFIN - Define the Ratio of LGR Grid Blocks in the Y-Direction....385
6.3.87 HZFIN - Define the Ratio of LGR Grid Blocks in the Z-Direction....386
6.3.88 IHOST – Assign LGRs to Parallel Process Number....387
6.3.89 IMPORT – Import Grid File Data at the Current Position....388
6.3.90 INIT – Activate the INIT File Option....389
6.3.91 INRAD – Define the Inner Radius of a Radial Grid....390
6.3.92 IONROCK – Define the Ion Exchange Capacity for All the Cells....391
6.3.93 ISOLNUM – Define the Independent Reservoir Regions....392
6.3.94 JFUNC - Activate the Leverett J-function Option....393
6.3.95 JFUNCR - Activate the Leverett J-function Saturation Table Option....396
6.3.96 LGRCOPY – Activate Local Grid Refinement Inheritance....399
6.3.97 LINKPERM - Assign Cell Permeabilities to Cell Faces....400
6.3.98 LTOSIGMA - Dual Porosity Viscous Displacement Sigma Parameters....401
6.3.99 LX - Dual Porosity Viscous Displacement X Direction Matrix Size for All Cells....402

6.3.100 LXFIN – Define Logarithmic LGR Grid Block Spacing in the X-Direction....403
6.3.101 LY - Dual Porosity Viscous Displacement Y Direction Matrix Size for All Cells....404
6.3.102 LYFIN – Define Logarithmic LGR Grid Block Spacing in the Y-Direction....405
6.3.103 LZ - Dual Porosity Viscous Displacement Z Direction Matrix Size for All Cells....406
6.3.104 LZFIN – Define Logarithmic LGR Grid Block Spacing in the Z-Direction....407
6.3.105 MAPAXES- Define the Map Origin Input Data....408
6.3.106 MAPUNITS – Define the Map Axes Units....409
6.3.107 MAXVALUE – Sets a Maximum Value for an Array Element....410
6.3.108 MINNNCT – Set a Minimum Non-Neighbor Connection Transmissibility....412
6.3.109 MINPORV – Set a Minimum Grid Block Pore Volume Threshold for All Cells....413
6.3.110 MINPV – Set a Minimum Grid Block Pore Volume Threshold for All Cells....414
6.3.111 MINPVV – Set a Minimum Grid Block Pore Volume Threshold for Individual Cells....415
6.3.112 MINVALUE – Set a Minimum Value for an Array Element....416
6.3.113 MPFANUM – Define Multi-Point Flux Discretization Regions....418
6.3.114 MPFNNC – Define Multi-Point Flux Non-Neighbor Connections....419
6.3.115 MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant....420
6.3.116 MULTIPLY – Multiply a Specified Array by a Constant....421
6.3.117 MULTIREG – Multiply an Array by a Constant based on a Region Number....423
6.3.118 MULTNUM – Define the Multiple Transmissibility Regions....425
6.3.119 MULTPV – Multiply Cell Pore Volumes by a Constant....426
6.3.120 MULTR - Multiply Cell Transmissibility in the +R Direction....427
6.3.121 MULTR- - Multiply Cell Transmissibility in the -R Direction....428
6.3.122 MULTREGD – Multiply Diffusivities Between Regions....429
6.3.123 MULTREGH – Multiply Thermal Conductivities Between Regions....431
6.3.124 MULTREGP – Multiply Pore Volumes Based On Region Number....433
6.3.125 MULTREGT – Multiply Transmissibilities Between Regions....434
6.3.126 MULTTHT - Multiply Cell Transmissibility in the +Theta Direction....436
6.3.127 MULTTHT- - Multiply Cell Transmissibility in the -Theta Direction....437
6.3.128 MULTX - Multiply Cell Transmissibility in the +X Direction....438
6.3.129 MULTX- - Multiply Cell Transmissibility in the -X Direction....439
6.3.130 MULTY - Multiply Cell Transmissibility in the +Y Direction....440
6.3.131 MULTY- - Multiply Cell Transmissibility in the -Y Direction....441
6.3.132 MULTZ - Multiply Cell Transmissibility in the +Z Direction....442
6.3.133 MULTZ- - Multiply Cell Transmissibility in the -Z Direction....443
6.3.134 NEWTRAN – Activate Irregular Corner-Point Grid Transmissibilities....444
6.3.135 NINENUM – Define the Nine-Point Discretization Region....445
6.3.136 NMATOPTS – Define the Discretized Matrix Dual Porosity Parameters....446
6.3.137 NNC – Define Non-Neighbor Connections Between Cells Manually....447
6.3.138 NODPPM – Deactivate Fracture Porosity-Permeability Calculation....450
6.3.139 NOGGF – Deactivate Output of Grid Geometry File....451
6.3.140 NTG – Define the Net-to-Gross Ratio for All the Cells....452
6.3.141 NXFIN – Define the Number of LGR Grid Blocks in the X-Direction....453
6.3.142 NYFIN – Define the Number of LGR Grid Blocks in the Y-Direction....454
6.3.143 NZFIN – Define the Number of LGR Grid Blocks in the Z-Direction....455
6.3.144 OLDTRAN – Activate Cartesian Regular Grid Transmissibilities....456
6.3.145 OLDTRANR – Activate Radial Regular Grid Transmissibilities....457
6.3.146 OPERATE – Define Mathematical Operations on Arrays....458
6.3.147 OPERATER – Define Mathematical Operations on Arrays by Region....461
6.3.148 OPERNUM – Define Regions for Mathematical Operations on Arrays....462
6.3.149 OUTRAD - Define the Outer Radius of a Radial Grid....463
6.3.150 PARAOPTS – Define Parallel Run Options....465
6.3.151 PEBI – Activate and Defined PEBI Grid Options....466
6.3.152 PERMAVE – Define Average Transmissibility Coefficients....467
6.3.153 PERMJFUN – Define Leverett J-Function Permeability for All Cells....468
6.3.154 PERMR – Define the Permeability for Each Cell in the R Direction....469
6.3.155 PERMTHT – Define the Permeability for Each Cell in the THETA Direction....470
6.3.156 PERMX - Define the Permeability in the X Direction for All the Cells....471
6.3.157 PERMY - Define the Permeability in the Y Direction for All the Cells....472
6.3.158 PERMZ - Define the Permeability in the Z Direction for All the Cells....473
6.3.159 PETGRID – Load a Generic Simulation Grid File....474
6.3.160 PINCH – Define Pinch-Out Layer Options....475
6.3.161 PINCHNUM – Define Pinch-Out Regions for the PINCHREG Keyword....477
6.3.162 PINCHOUT - Define Pinch-Out Layers Option (Fixed)....478

6.3.163 PINCHREG - Define Pinch-Out Region Options....479
6.3.164 PINCHXY – Define Pinch-Out Areal Options....481
6.3.165 PORO - Define the Porosity Values for All the Cells....482
6.3.166 PYEND – End the Definition of a PYINPUT Section....483
6.3.167 PYINPUT – Define the Start of a PYINPUT Section....485
6.3.168 QMOBIL Activate or Deactivate LGR End-Point Mobility Correction....487
6.3.169 RADFIN – Define a Radial Local Grid Refinement with One Column....488
6.3.170 RADFIN4 – Define a Radial Local Grid Refinement with Four Columns....489
6.3.171 REFINE – Start the Definition of a Local Grid Refinement....490
6.3.172 RESVNUM – Define Reservoir Coordinate Data Set....491
6.3.173 ROCKFRAC - Define the Rock Volume to Bulk Volume Fraction for All the Cells....493
6.3.174 RPTGRID – Define GRID Section Reporting....494
6.3.175 RPTGRIDL – Define GRID Section Reporting for LGRs....496
6.3.176 RPTINIT – Define Output to the INIT File....498
6.3.177 RPTISOL – Activate Isolated Reservoir Number Reporting....499
6.3.178 SIGMA – Dual Porosity Matrix to Fracture Sigma (All Cells)....500
6.3.179 SIGMAGD – Dual Porosity Matrix to Fracture Sigma for Gravity Drainage (All Cells)....501
6.3.180 SIGMAGDV – Dual Porosity Matrix to Fracture Sigma Gravity Drainage (Individual Cells) 502
6.3.181 SIGMAV – Dual Porosity Matrix to Fracture Sigma (Individual Cells)....503
6.3.182 SMULTX - Multiply Cell Transmissibility in the +X Direction (Auto-Refinement)....504
6.3.183 SMULTY - Multiply Cell Transmissibility in the +Y Direction (Auto-Refinement)....505
6.3.184 SMULTZ - Multiply Cell Transmissibility in the +Z Direction (Auto-Refinement)....506
6.3.185 SOLVDIRS – Define Linear Solver Principal Directions....507
6.3.186 SOLVNUM – Define PEBI Grid Correspondence to Solver Order....508
6.3.187 SPECGRID- Define the Dimensions of a Corner-Point Grid....509
6.3.188 SWATINIT – Define the Initial Water Saturation Array for Capillary Pressure Scaling....510
6.3.189 THCGAS – Define Gas Phase Thermal Conductivity for All Cells....511
6.3.190 THCOIL – Define Oil Phase Thermal Conductivity for All Cells....512
6.3.191 THCONR – Define Rock and Fluid Thermal Conductivity for All Cells....513
6.3.192 THCONSF – Define Gas Saturation Dependent Thermal Conductivity Scaling Factor for All Cells....514
6.3.193 THCROCK – Define Reservoir Rock Thermal Conductivity for All Cells....516
6.3.194 THCWATER – Define Water Phase Thermal Conductivity for All Cells....517
6.3.195 THPRESFT - Define Fault Threshold Pressures....518
6.3.196 TOPS - Define the Depth at the Center of the Top Face for Each Cell....520
6.3.197 TRANGL – Define Non-Neighbor Connections Between Global and LGR Cells Manually. .522
6.3.198 USEFLUX – Activate Flux Boundary Model and Define Flux File....524
6.3.199 USENOFLO – Activate Flux Boundary Model Without a Flux File....525
6.3.200 VEDEBUG – Vertical Equilibrium Debug Data Output....526
6.3.201 VEFIN – Activate Vertical Equilibrium Model (LGR)....527
6.3.202 ZCORN – Define the Depth of Each Corner-Point of a Grid Block....528

CHAPTER 7: EDIT SECTION....529

7.1 Introduction....530

7.2 Data Requirements....530

7.3 Keyword Definitions....532
7.3.1 ADD – Add a Constant to a Specified Array....532
7.3.2 ADDREG – Add a Constant to an Array based on a Region Number....532
7.3.3 BOUNDARY – Define a Boundary Box for Printing....532
7.3.4 BOX - Define a Range of Grid Blocks to Enter Property Data....532
7.3.5 COPY – Copy Array Data to Another Array....532
7.3.6 COPYREG – Copy an Array to Another Array based on a Region Number....532
7.3.7 DEPTH - Edits the Depth at the Center of Each Cell....533
7.3.8 DIFFR – Define Grid Block Radial Direction Diffusivity Values....534
7.3.9 DIFFTHT – Define Grid Block Theta Direction Diffusivity Values....535
7.3.10 DIFFX – Define Grid Block X-Direction Diffusivity Values....536
7.3.11 DIFFY – Define Grid Block Y-Direction Diffusivity Values....537
7.3.12 DIFFZ – Define Grid Block Z-Direction Diffusivity Values....538
7.3.13 EDIT - Define the Start of the EDIT Section of Keywords....539
7.3.14 EDITNNC – Scale Non-Neighbor Connections Between Cells Manually....540

7.3.15 EDITNNCR – Reset Non-Neighbor Connections Between Cells Manually....543
7.3.16 ENDBOX – Define the End of the BOX Defined Grid....546
7.3.17 ENDFIN – End the Definition of a Local Grid Refinement....546
7.3.18 EQUALREG – Sets an Array to a Constant by Region Number....546
7.3.19 EQUALS – Sets a Specified Array to a Constant....546
7.3.20 FILEUNIT – Activate Unit Consistency Verification....546
7.3.21 GETDATA – Load and Assign Data Array from INIT or RESTART File....546
7.3.22 HMMULT – History Match Grid Transmissibility & Pore Volume Gradient Cumulative Multipliers....547
7.3.23 IMPORT – Import Grid File Data at the Current Position....548
7.3.24 LGRCOPY – Activate Local Grid Refinement Inheritance....548
7.3.25 MAXVALUE – Sets a Maximum Value for an Array Element....548
7.3.26 MINVALUE – Set a Minimum Value for an Array Element....548
7.3.27 MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant....548
7.3.28 MULTIPLY – Multiply a Specified Array by a Constant....548
7.3.29 MULTIREG – Multiply an Array by a Constant based on a Region Number....549
7.3.30 MULTPV – Multiply Cell Pore Volumes by a Constant....549
7.3.31 MULTR - Multiply Cell Transmissibility in the +R Direction....549
7.3.32 MULTR- - Multiply Cell Transmissibility in the -R Direction....549
7.3.33 MULTREGD – Multiply Diffusivities Between Regions....549
7.3.34 MULTREGH – Multiply Thermal Conductivities Between Regions....549
7.3.35 MULTREGP– Multiply Pore Volumes Based On Region Number....550
7.3.36 MULTREGT– Multiply Transmissibilities Between Regions....550
7.3.37 MULTTHT - Multiply Cell Transmissibility in the +Theta Direction....550
7.3.38 MULTTHT- - Multiply Cell Transmissibility in the -Theta Direction....550
7.3.39 MULTX - Multiply Cell Transmissibility in the +X Direction....550
7.3.40 MULTX- - Multiply Cell Transmissibility in the -X Direction....550
7.3.41 MULTY - Multiply Cell Transmissibility in the +Y Direction....551
7.3.42 MULTY- - Multiply Cell Transmissibility in the -Y Direction....551
7.3.43 MULTZ - Multiply Cell Transmissibility in the +Z Direction....551
7.3.44 MULTZ- - Multiply Cell Transmissibility in the -Z Direction....551
7.3.45 OPERATE – Define Mathematical Operations on Arrays....551
7.3.46 OPERATER – Define Mathematical Operations on Arrays by Region....551
7.3.47 PORV - Define the Pore Volumes for All the Cells....552
7.3.48 PYEND – End the Definition of a PYINPUT Section....553
7.3.49 PYINPUT – Define the Start of a PYINPUT Section....553
7.3.50 REFINE – Start the Definition of a Local Grid Refinement....553
7.3.51 TRANR - Define the Transmissibility in the +R Direction for All the Cells....554
7.3.52 TRANTHT - Define the Transmissibility in the +Theta Direction for All the Cells....555
7.3.53 TRANX - Define the Transmissibility in the X Direction for All the Cells....556
7.3.54 TRANY - Define the Transmissibility in the Y Direction for All the Cells....557
7.3.55 TRANZ - Define the Transmissibility in the Z Direction for All the Cells....558

CHAPTER 8: PROPS SECTION....559

8.1 Introduction....560

8.2 Data Requirements....560
8.2.1 Fluid Property Tables....560
8.2.2 Saturation Tables (Relative Permeability and Capillary Pressure Tables)....564

8.3 Keyword Definitions....568
8.3.1 ADD – Add a Constant to a Specified Array....568
8.3.2 ADDREG – Add a Constant to an Array based on a Region Number....568
8.3.3 ADSALNOD – Salt Concentration Based on SATNUM Array....569
8.3.4 ADSORP – Define Generalized Langmuir Adsorption Function....571
8.3.5 ALKADS – Define Alkaline Adsorption Functions....572
8.3.6 ALKROCK – Define Rock Alkaline Properties....573
8.3.7 ALPOLADS – Polymer Adsorption versus Alkaline Concentration Multipliers....574
8.3.8 ALSURFAD – Surfactant Adsorption versus Alkaline Concentration Multipliers....575
8.3.9 ALSURFST – Water-Oil Surface Tension versus Alkaline Concentration Multipliers....576
8.3.10 APIGROUP – Define API Tracking Number of Grouped Oil PVT Tables....577
8.3.11 AQUCT – Define Carter-Tracy Analytical Aquifers....578
8.3.12 AQUTAB – Define Carter-Tracy Aquifer Influence Functions....579

8.3.13 BDENSITY – Define the Surface Brine Density for the Fluid....586
8.3.14 BGGI - Define Gi Gas Formation Volume Factor Pressure Tables....588
8.3.15 BOGI - Define Gi Oil Formation Volume Factor Pressure Tables....589
8.3.16 BOX - Define a Range of Grid Blocks to Enter Property Data....590
8.3.17 COALADS – Define Gas and Solvent Relative Adsorption Tables....591
8.3.18 COALPP – Define Gas and Solvent Partial Pressure Adsorption Tables....592
8.3.19 COPY – Copy Array Data to Another Array....593
8.3.20 COPYBOX – Copy Array Data Defined by a Box....593
8.3.21 COPYREG – Copy an Array to Another Array based on a Region Number....593
8.3.22 DENSITY – Define the Surface Oil, Water Gas Densities for the Fluids....594
8.3.23 DEPTHTAB – River Time and Depth Tables....596
8.3.24 DIAGDISP – Activate Alternate Form of Tracer Dispersion....597
8.3.25 DIFFC – Define PVT Region Molecular Diffusion Tables....598
8.3.26 DIFFCOAL – Define Coal Bed Methane Gas Diffusion Data....599
8.3.27 DIFFDP – Activate Dual Porosity Molecular Diffusion for Matrix-Fracture Flow Only....600
8.3.28 DIFFMMF – Define Diffusivity Multipliers for Matrix-Fractures....601
8.3.29 DISPERSE– Define Dispersion Tables....602
8.3.30 DPKRMOD – Modify Matrix Oil Relative Permeability Data....603
8.3.31 DSPDEINT – Activate Brine Tracer Dispersion Interpolation by Water Density....604
8.3.32 EHYSTR – Define Hysteresis Model and Parameters....605
8.3.33 EHYSTRR – Define Hysteresis Model and Parameters via SATNUM....608
8.3.34 ENDBOX – Define the End of the BOX Defined Grid....609
8.3.35 ENDFIN – End the Definition of a Local Grid Refinement....609
8.3.36 ENKRVD – Define Relative Permeability End-Points versus Depth Functions....610
8.3.37 ENPCVD – Define Maximum Capillary Pressure versus Depth Functions....611
8.3.38 ENPTVD – Define Relative Permeability Saturation End-Points versus Depth....612
8.3.39 ENSPCVD – Define Capillary Pressure End-Points versus Depth....613
8.3.40 EPSDBGS - Write End-Point Debug Data to the DEBUG File (Multiple)....614
8.3.41 EPSDEBUG - Write End-Point Debug Data to the DEBUG File (Individual)....615
8.3.42 EQUALREG – Sets an Array to a Constant by Region Number....616
8.3.43 EQUALS – Sets a Specified Array to a Constant....616
8.3.44 ESSNODE – Define Salt Concentration Data for Water-Oil Surface Tension....617
8.3.45 FHERCHBL – Define Herschel-Bulkley Data versus Polymer Concentration....618
8.3.46 FILEUNIT – Activate Unit Consistency Verification....619
8.3.47 FILLEPS – Activate Saturation End-Point Export to the INIT File....620
8.3.48 FOAMADS - Define Foam Rock Adsorption Tables....621
8.3.49 FOAMDCYO – Define Foam Decay versus Oil Saturation Tables....623
8.3.50 FOAMDCYW – Define Foam Decay versus Water Saturation Tables....624
8.3.51 FOAMFCN – Define Foam Gas Mobility Reduction versus Capillary Number....625
8.3.52 FOAMFRM – Define Foam Gas Mobility Reduction versus Reference Mobility....626
8.3.53 FOAMFSC – Define Foam Gas Mobility versus Surfactant Concentration Functions....627
8.3.54 FOAMFSO – Define Foam Gas Mobility Reduction versus Oil Saturation....630
8.3.55 FOAMFST – Define Foam Gas-Water Surface Tension versus Surfactant Concentration....631
8.3.56 FOAMFSW – Define Foam Gas Mobility Reduction versus Water Saturation....632
8.3.57 FOAMMOB - Define Foam Gas Mobility versus Foam Concentration Tables....633
8.3.58 FOAMMOBP – Define Foam Mobility Reduction versus Oil Pressure....635
8.3.59 FOAMMOBS – Define Foam Mobility Reduction versus Shear....636
8.3.60 FOAMOPTS - Define Foam Model Options....637
8.3.61 FOAMROCK - Define Foam Rock Properties....638
8.3.62 GASDENT – Define Gas Density Temperature Coefficients....640
8.3.63 GASVISCT – Define Gas Viscosity versus Temperature Functions....641
8.3.64 GETDATA – Load and Assign Data Array from INIT or RESTART File....642
8.3.65 GIALL – Define Gi Values and PVT Properties versus Pressure....643
8.3.66 GINODE – Define Gi Node Values....644
8.3.67 GRAVCONS – Re-Define Gravity Constant....645
8.3.68 GRAVITY– Define the Surface Oil, Water Gas Gravities for the Fluids....646
8.3.69 HA – History Match End-Point Gradient Additive Modifier....648
8.3.70 HDISP – Define Tracer Mechanical Dispersivity Parameters....650
8.3.71 HM – History Match End-Point Gradient Multiplicative Modifier....651
8.3.72 HMMROCK – History Match Rock Compressibility Gradient Cumulative Multipliers....653
8.3.73 HMMROCKT – History Match Rock Compaction Gradient Cumulative Multipliers....654
8.3.74 HMPROPS – History Match End-Point Section Start....655
8.3.75 HMROCK – History Match Rock Compressibility Gradient Parameters....656

8.3.76 HMROCKT – History Match Rock Compaction Gradient Parameters....657
8.3.77 HMRREF – History Match Rock Table Reference Pressure Values....658
8.3.78 HWKRO – End-Point Scaling of Grid Cell Kro(Swl) (High Salinity and Water Wet)....659
8.3.79 HWKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (High Salinity and Water Wet)....660
8.3.80 HWKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (High Salinity and Water Wet)....661
8.3.81 HWKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (High Salinity and Water Wet)....662
8.3.82 HWKRWR – End-Point Scaling of Grid Cell KRWR(Sw=1.0) (High Salinity and Water Wet) 663
8.3.83 HWPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (High Salinity and Water Wet).... 664
8.3.84 HWSOGCR – End-Point Scaling Grid Cell SOGCR (High Salinity and Water Wet)....665
8.3.85 HWSOWCR – End-Point Scaling Grid Cell SOWCR (High Salinity and Water Wet)....666
8.3.86 HWSWCR – End-Point Scaling Grid Cell SWCR (High Salinity and Water Wet)....667
8.3.87 HWSWL – End-Point Scaling Grid Cell SWL (High Salinity and Water Wet)....668
8.3.88 HWSWLPC – End-Point Scaling Grid Cell SWLPC (High Salinity and Water Wet)....669
8.3.89 HWSWU – End-Point Scaling Grid Cell SWU (High Salinity and Water Wet)....670
8.3.90 HYDRHEAD – Define Hydraulic Head Output Reference Data....671
8.3.91 HYMOBGDR – Activate Carlson and Killough Alternative Drainage Hysteresis Option....672
8.3.92 HYSTCHCK - Activate Hysteresis Inhibition and Drainage End-Point Validation....673
8.3.93 IKRG – End-Point Scaling of Grid Cell Krg(Sgu) (Imbibition)....674
8.3.94 IKRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Imbibition)....676
8.3.95 IKRO – End-Point Scaling of Grid Cell Kro(Swl) (Imbibition)....678
8.3.96 IKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Imbibition)....680
8.3.97 IKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Imbibition)....682
8.3.98 IKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Imbibition)....684
8.3.99 IKRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Imbibition)....686
8.3.100 IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions....688
8.3.101 IMPCVD – Imbibition Maximum Capillary Pressure versus Depth Functions....689
8.3.102 IMPORT – Import Grid File Data at the Current Position....690
8.3.103 IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth....691
8.3.104 IMSPCVD – Imbibition Capillary Pressure Connate Saturations versus Depth....692
8.3.105 INTPC – Activate Dual Porosity Integrated Capillary Pressure Option....693
8.3.106 IONXROCK - Define Ion Exchange Constant by Saturation Table Regions....694
8.3.107 IONXSURF - Define Surfactant Ion Exchange Constant by Saturation Table Regions....695
8.3.108 IPCG – End-Point Scaling of Grid Cell Gas Capillary Pressure (Imbibition)....696
8.3.109 IPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Imbibition)....697
8.3.110 ISGCR – End-Point Scaling of Grid Cell Critical Gas Saturation (Imbibition)....698
8.3.111 ISGL – End-Point Scaling of Grid Cell Connate Gas Saturation (Imbibition)....699
8.3.112 ISGLPC – End-Point Scaling of Grid Cell Capillary Pressure Connate Gas Saturation (Imbibition).... 700
8.3.113 ISGU – End-Point Scaling of Grid Cell Maximum Gas Saturation (Imbibition)....702
8.3.114 ISOGCR – End-Point Scaling of Grid Cell Critical Oil Saturation to Gas (Imbibition)....703
8.3.115 ISOWCR – End-Point Scaling of Grid Cell Critical Oil Saturation to Water (Imbib.)....704
8.3.116 ISWCR – End-Point Scaling of Grid Cell Critical Water Saturation (Imbibition)....705
8.3.117 ISWL – End-Point Scaling of Grid Cell Connate Water Saturation (Imbibition)....706
8.3.118 ISWLPC – End-Point Scaling Grid Cell Capillary Pressure Connate Water Saturations (Imbibition).... 707
8.3.119 ISWU – End-Point Scaling of Grid Cell Maximum Water Saturation (Imbibition)....709
8.3.120 KRG – End-Point Scaling of Grid Cell Krg(Sgu) (Drainage)....710
8.3.121 KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)....713
8.3.122 KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)....715
8.3.123 KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)....718
8.3.124 KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)....720
8.3.125 KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)....722
8.3.126 KRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Drainage)....724
8.3.127 LANGMPL – Define Langmuir Pressure Grid Cell Multiplier....726
8.3.128 LANGMUIR – Langmuir Adsorption Isotherm Tables....727
8.3.129 LANGSOLV – Langmuir Adsorption Isotherm Solvent Tables....728
8.3.130 LCUNIT – Define Linear Combination Rate and Volume Units....729
8.3.131 LKRO – End-Point Scaling of Grid Cell Kro(Swl) (Low Salinity and Oil Wet)....730
8.3.132 LKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Low Salinity and Oil Wet)....731
8.3.133 LKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Low Salinity and Oil Wet)....732
8.3.134 LKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Low Salinity and Oil Wet)....733
8.3.135 LKRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Low Salinity and Oil Wet)....734

8.3.136 LPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Low Salinity and Oil Wet) 735
8.3.137 LSALTFNC - Define Low Salt Weighting Factors versus Salt Concentration Functions.....736
8.3.138 LSOGCR – End-Point Scaling Grid Cell SOGCR (Low Salinity and Oil Wet).....737
8.3.139 LSOWCR – End-Point Scaling Grid Cell SOWCR (Low Salinity and Oil Wet).....738
8.3.140 LSWCR – End-Point Scaling Grid Cell SWCR (Low Salinity and Oil Wet).....739
8.3.141 LSWL – End-Point Scaling Grid Cell SWL (Low Salinity and Oil Wet).....740
8.3.142 LSWLPC – End-Point Scaling Grid Cell SWLPC (Low Salinity and Oil Wet).....741
8.3.143 LSWU – End-Point Scaling Grid Cell SWU (Low Salinity and Oil Wet).....742
8.3.144 LWKRO – End-Point Scaling of Grid Cell Kro(Swl) (Low Salinity and Water Wet).....743
8.3.145 LWKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Low Salinity and Water Wet).....744
8.3.146 LWKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Low Salinity and Water Wet).....745
8.3.147 LWKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Low Salinity and Water Wet).....746
8.3.148 LWKRWR – End-Point Scaling of Grid Cell KRWR(Sw=1.0) (Low Salinity and Water Wet) 747
8.3.149 LWPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Low Salinity and Water Wet)..... 748
8.3.150 LWSOGCR – End-Point Scaling Grid Cell SOGCR (Low Salinity and Water Wet).....749
8.3.151 LWSOWCR – End-Point Scaling Grid Cell SOWCR (Low Salinity and Water Wet).....750
8.3.152 LWSWCR – End-Point Scaling Grid Cell SWCR (Low Salinity and Water Wet).....751
8.3.153 LWSWL – End-Point Scaling Grid Cell SWL (Low Salinity and Water Wet).....752
8.3.154 LWSWLPC – End-Point Scaling Grid Cell SWLPC (Low Salinity and Water Wet).....753
8.3.155 LWSWU – End-Point Scaling Grid Cell SWU (Low Salinity and Water Wet).....754
8.3.156 MASSFLOW – Define River Mass Flow versus Time Tables.....755
8.3.157 MAXVALUE – Sets a Maximum Value for an Array Element.....756
8.3.158 MINVALUE – Set a Minimum Value for an Array Element.....756
8.3.159 MISC – Define Solvent Miscibility-Immiscibility Transform Functions.....757
8.3.160 MLANG – Define Langmuir Maximum Gas Concentration for All Grid Cells.....759
8.3.161 MLANGSLV – Define Langmuir Maximum Solvent Concentration for All Grid Cells.....760
8.3.162 MSFN – Miscible Normalized Relative Permeability Tables.....761
8.3.163 MULTIPLY – Multiply a Specified Array by a Constant.....762
8.3.164 MULTIREG – Multiply an Array by a Constant based on a Region Number.....762
8.3.165 NOWARNEP – Deactivate End-Point Scaling Warning Messages.....763
8.3.166 OILDENT – Define Oil Density Temperature Coefficients.....764
8.3.167 OILVISCT – Define Oil Viscosity versus Temperature Functions.....766
8.3.168 OPERATE – Define Mathematical Operations on Arrays.....768
8.3.169 OPERATER – Define Mathematical Operations on Arrays by Region.....768
8.3.170 OVERBURD – Define Rock Overburden Pressure versus Depth Tables.....769
8.3.171 PCG – End-Point Scaling of Grid Cell Maximum Gas Capillary Pressure (Drainage).....771
8.3.172 PCG32D – Gas-Oil Capillary Pressure versus Oil and Water Saturation Tables.....772
8.3.173 PCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Drainage).....773
8.3.174 PCW32D – Water-Oil Capillary Pressure versus Oil and Gas Saturation Tables.....774
8.3.175 PECOEFS – Define Petro-Elastic Model Coefficients.....775
8.3.176 PEGTAB – Petro-Elastic Pressure Shear Modulus Table.....776
8.3.177 PEKTAB – Petro-Elastic Pressure Bulk Modulus Table.....777
8.3.178 PERMFACT– Permeability Multiplication Factor as a Function of Porosity Change.....778
8.3.179 PLMIXPAR – Define the Polymer Todd-Longstaff Mixing Parameters.....780
8.3.180 PLYADS - Define Polymer Rock Adsorption Tables.....781
8.3.181 PLYADSS - Define Polymer Rock Adsorption with Salt Dependence Tables.....783
8.3.182 PLYATEMP – Define Polymer Adsorption Table Temperature.....785
8.3.183 PLYCAMAX - Define Polymer-Rock Maximum Adsorption by Cell.....787
8.3.184 PLYDHFLF - Define Polymer Thermal Degradation Half-Life Tables.....788
8.3.185 PLYESAL – Define Polymer Effective Salinity Coefficient.....789
8.3.186 PLYKRRF – Define Polymer Rock Permeability Reduction by Cell.....790
8.3.187 PLYMAX - Define Polymer-Salt Viscosity Mixing Concentrations.....791
8.3.188 PLYRMDEN - Define Polymer Model In Situ Rock Density.....792
8.3.189 PLYROCK - Define Polymer-Rock Properties.....793
8.3.190 PLYSHEAR – Activate and Define Polymer Shearing Parameters.....795
8.3.191 PLYSHLOG - Activate and Define the Polymer Shearing Logarithmic Parameters.....796
8.3.192 PLYTRRF – Define Polymer Rock Permeability Reduction versus Temperature.....799
8.3.193 PLYTRRFA – Define Polymer Rock Permeability Reduction versus Temperature Option...800
8.3.194 PLYVISC – Define Polymer Viscosity Scaling Factors.....801
8.3.195 PLYVISCS – Define Polymer-Salt Viscosity Scaling Factors.....803
8.3.196 PLYVISCT – Define Polymer-Temperature Viscosity Scaling Factors.....804

8.3.197 PLYVSCST – Define Polymer-Salt-Temperature Viscosity Scaling Factors....805
8.3.198 PMAX – Maximum and Minimum Pressure for Total Compressibility Check....806
8.3.199 PMISC – Define Miscibility versus Pressure Tables....807
8.3.200 PPCWMAX – Define SWATINIT Calculated Capillary Pressure Constraints....808
8.3.201 PROPS - Define the Start of the PROPS Section of Keywords....810
8.3.202 PVCDO - Oil PVT Properties for Dead Oil (Constant Compressibility)....811
8.3.203 PVCO - Oil PVT Properties for Live Oil....813
8.3.204 PVDG - Gas PVT Properties for Dry Gas....815
8.3.205 PVDO – Oil PVT Properties for Dead Oil....817
8.3.206 PVDS - Solvent PVT Properties for the Solvent Model....819
8.3.207 PVTG - Gas PVT Properties for Wet Gas with Vaporized Oil....821
8.3.208 PVTGW - Gas PVT Properties for Dry Gas with Vaporized Water....823
8.3.209 PVTGWO - Gas PVT Properties for Wet Gas with Vaporized Water and Oil....826
8.3.210 PVTO - Oil PVT Properties for Live Oil....829
8.3.211 PVTW - Define Water Fluid Properties for Various Regions....832
8.3.212 PVTWSALT - Define Brine Water Fluid Properties for Various Regions....834
8.3.213 PVZG - Gas PVT Properties for Dry Gas (Z-Factor)....837
8.3.214 PYEND – End the Definition of a PYINPUT Section....840
8.3.215 PYINPUT – Define the Start of a PYINPUT Section....840
8.3.216 QHRATING – Define River Mass Flow versus Depth Tables....841
8.3.217 REFINE – Start the Definition of a Local Grid Refinement....842
8.3.218 RIVRXSEC – Define River Cross-Section versus Depth Parameters....843
8.3.219 RKTRMDIR - Activate ROCKTAB Keyword Directional Transmissibility Multipliers....844
8.3.220 ROCK - Define the Rock Compressibility for Various Regions....845
8.3.221 ROCK2D – Pore Volume Compaction versus Pressure and Sw Tables....847
8.3.222 ROCK2DTR – Transmissibility Compaction versus Pressure and Sw Tables....849
8.3.223 ROCKOPTS – Define Rock Compaction and Compressibility Options....851
8.3.224 ROCKPAMA – Define Coal Palmer-Mansorri Rock Model Parameters....853
8.3.225 ROCKTAB – Rock Compaction Tables....854
8.3.226 ROCKTABH – Rock Compaction Hysteresis Tables....857
8.3.227 ROCKTABW – Rock Compaction Tables (Water Induced)....860
8.3.228 ROCKTHSG – Rock Compaction Hysteresis Tables (Dual Porosity)....861
8.3.229 ROCKTSIG – Rock Compaction Tables (Dual Porosity)....862
8.3.230 ROCKWNODE – Water Saturation Values for Compaction Pressure-Sw Tables....863
8.3.231 RPTPROPS – Define PROPS Section Reporting....865
8.3.232 RSCONST – Define Constant GOR (Rs) for All Dead Oil PVT Fluids....866
8.3.233 RSCONSTT – Define Constant GOR (Rs) for Each Dead Oil PVT Fluid....867
8.3.234 RSGI – Define Gas-Oil Ratio versus Pressure and Gi Tables....868
8.3.235 RTEMP - Define the Initial Reservoir Temperature for the Model....869
8.3.236 RTEMPA - Define the Initial Reservoir Temperature for the Model....870
8.3.237 RVCONST – Define Constant CGR (Rv) for All Dry Gas PVT Fluids....871
8.3.238 RVCONSTT – Define Constant CGR (Rv) for Each Dry Gas PVT Fluid....872
8.3.239 RVGI – Define Condensate-Gas Ratio versus Pressure and Gi Tables....873
8.3.240 RWGSALT – Water Vaporization versus Pressure and Salt Concentration....874
8.3.241 SALTNODE – Salt Concentration Based PVTNUM Array....876
8.3.242 SALTSOL – Define the Salt Solubility Limit for All Cells....877
8.3.243 SCALECRS – Define End-Point Scaling Option....878
8.3.244 SCALELIM – End-Point Scaling versus Depth Maximum Water Saturation....880
8.3.245 SDENSITY – Define the Miscible or Solvent Surface Gas Density....881
8.3.246 SGCR – End-Point Scaling Grid Cell Critical Gas Saturations....882
8.3.247 SGCWMIS – Miscible Critical Gas versus Water Saturation Functions....883
8.3.248 SGF32D – Gas Saturation Tables versus Oil and Water Saturations....884
8.3.249 SGFN – Gas Saturation Tables (Format Type 2)....885
8.3.250 SGL – End-Point Scaling Grid Cell Connate Gas Saturations....886
8.3.251 SGLPC – End-Point Scaling Grid Cell Capillary Pressure Connate Gas Saturations....887
8.3.252 SGOF – Gas-Oil Saturation Tables versus Gas (Format Type 1)....889
8.3.253 SGU – End-Point Scaling Grid Cell Gas Saturation....891
8.3.254 SGWFN – Gas-Water Saturation Tables (Format Type 2)....892
8.3.255 SHRATE - Activate and Define the Polymer Shearing Logarithmic Parameters....894
8.3.256 SKRO – End-Point Scaling of Grid Cell Kro(Swl) (Surfactant)....895
8.3.257 SKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Surfactant)....896
8.3.258 SKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Surfactant)....897
8.3.259 SKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Surfactant)....898

8.3.260 SKRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Surfactant)....899
8.3.261 SLGOF – Gas-Oil Saturation Tables versus Gas (Format Type 1)....900
8.3.262 SOCRS – End-Point Scaling Grid Cell Miscible Critical Oil Saturation with Respect to Water 902
8.3.263 SOF2 – Oil Saturation Tables with Respect to Gas or Water (Format Type 2)....903
8.3.264 SOF3 – Oil Saturation Tables with Respect to Gas and Water (Format Type 2)....905
8.3.265 SOF32D – Oil Saturation Tables with Respect to Water and Gas (Three Phase)....907
8.3.266 SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas....908
8.3.267 SOMGAS – STONE1 Model Minimum Oil Saturation versus Gas Saturation....909
8.3.268 SOMWAT – STONE1 Model Minimum Oil Saturation versus Water Saturation....910
8.3.269 SORWMIS – Miscible Residual Oil versus Water Saturation Functions....911
8.3.270 SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water....912
8.3.271 SPECHEAT – Define the Specific Heat of Oil, Water and Gas....913
8.3.272 SPECROCK – Define the Specific Heat of the Reservoir Rock....915
8.3.273 SSFN – Solvent and Gas Relative Permeability Tables....917
8.3.274 SSGCR – End-Point Scaling Grid Cell Surfactant Critical Gas Saturations....919
8.3.275 SSGL – End-Point Scaling Grid Cell Surfactant Connate Gas Saturations....920
8.3.276 SSOGCR – End-Point Scaling Grid Cell Surfactant Critical Oil Saturation with Respect to Gas....921
8.3.277 SSOWCR – End-Point Scaling Grid Cell Surfactant Critical Oil Saturation with Respect to Water....922
8.3.278 SSWCR – End-Point Scaling Grid Cell Critical Water Saturation....923
8.3.279 SSWL – End-Point Scaling Grid Cell Surfactant Connate Water Saturation....924
8.3.280 SSWU – End-Point Scaling Grid Cell Surfactant Maximum Water Saturation....925
8.3.281 STOG Define Capillary Pressure Oil-Gas Surface Tension versus Pressure....926
8.3.282 STONE – Activate Stone's Second Three Phase Oil Relative Permeability Model (Alias for STONE2)....927
8.3.283 STONE1 – Activate Stone's First Three Phase Oil Relative Permeability Model....928
8.3.284 STONE1EX – Define Stone's First Three Phase Oil Relative Permeability Parameter....929
8.3.285 STONE2 – Activate Stone's Second Three Phase Oil Relative Permeability Model....930
8.3.286 STOW Define Capillary Pressure Oil-Water Surface Tension versus Pressure....931
8.3.287 STWG Define Capillary Pressure Water-Gas Surface Tension versus Pressure....932
8.3.288 SURFADDW – Defined Surfactant Adsorbed Concentration versus Wettability Fraction...933
8.3.289 SURFADS - Define Surfactant Rock Adsorption Tables....934
8.3.290 SURFCAPD – Capillary Number versus Miscibility Tables....936
8.3.291 SURFESAL – Define Surfactant Effective Salinity Coefficient....937
8.3.292 SURFROCK - Define Surfactant-Rock Properties....938
8.3.293 SURFST - Surfactant Water-Oil Surface Tension versus Surfactant Concentration....939
8.3.294 SURFSTES - Surfactant Water-Oil Surface Tension versus Surfactant and Salt Concentrations....940
8.3.295 SURFVISC – Surfactant Solution Viscosity versus Concentration....941
8.3.296 SWCR – End-Point Scaling Grid Cell Critical Water Saturation....943
8.3.297 SWF32D – Water Saturation Tables with Respect to Oil and Gas (Three Phase)....944
8.3.298 SWFN – Water Saturation Tables (Format Type 2)....945
8.3.299 SWL – End-Point Scaling Grid Cell Connate Water Saturation....947
8.3.300 SWLPC – End-Point Scaling Grid Cell Capillary Pressure Connate Water Saturations....948
8.3.301 SWOF – Water-Oil Saturation Tables (Format Type 1)....950
8.3.302 SWU – End-Point Scaling Grid Cell Maximum Water Saturation....952
8.3.303 TEMPNODE - Temperature Table for Polymer Solution Viscosity....953
8.3.304 TEMPTVD – Activate Temperature Flux Limited Transport Option....954
8.3.305 TLMIXPAR – Define the Miscible Todd-Longstaff Mixing Parameters....955
8.3.306 TOLCRIT – Define The Critical Saturation Tolerance....956
8.3.307 TPAMEPS – Volumetric Strain versus Coal Gas Concentration Tables....957
8.3.308 TPAMEPSS - Volumetric Strain versus Coal Solvent Concentration Tables....958
8.3.309 TRACER – Define Passive Tracer Variables....959
8.3.310 TRACERKM – Multi-Partitioned Tracer Option K(P) Tables....961
8.3.311 TRACERKP – Standard Partitioned Tracer Option K(P) Tables....962
8.3.312 TRACITVD – Activate and Define Tracer Implicit Flux Limited Transport Option....963
8.3.313 TRACTVD – Activate Tracer Explicit Flux Limited Transport Option....964
8.3.314 TRADS – Environmental Tracer Adsorption Tables....965
8.3.315 TRDCY – Environmental Tracer Decay Tables....966
8.3.316 TRDIF – Tracer Diffusion Tables....967
8.3.317 TRDIS – Tracer Dispersion Table Number Allocation....968

8.3.318 TRNHD – Activate Dispersion Non-Homogeneous Diffusion Option....969
8.3.319 TRROCK – Environmental Tracer-Rock Property Data....970
8.3.320 TZONE – End-Point Scaling Transition Zone Options....971
8.3.321 VDFLOW – Velocity Dependent Flow Coefficient for Grid Block Flow (Grid)....973
8.3.322 VDFLOWR – Velocity Dependent Flow Coefficient for Grid Block Flow (Region)....974
8.3.323 VEFRAC – Vertical Equilibrium Relative Permeability Fraction (Grid)....975
8.3.324 VEFRACP – Vertical Equilibrium Capillary Pressure Fraction (Grid)....976
8.3.325 VEFRACPV – Vertical Equilibrium Capillary Pressure Fraction (Cell)....977
8.3.326 VEFRACV – Vertical Equilibrium Relative Permeability Fraction (Cell)....978
8.3.327 VISCREF - Define Viscosity-Temperature Reference Conditions....979
8.3.328 WAGHYSTR – Define Water-Alternating-Gas Hysteresis Parameters....980
8.3.329 WATDENT – Define Water Density Temperature Coefficients....981
8.3.330 WATVISCT – Define Water Viscosity versus Temperature Functions....982

CHAPTER 9: REGIONS SECTION....983

9.1 Introduction....984

9.2 Data Requirements....984

9.3 Keyword Definitions....986
9.3.1 ADD – Add a Constant to a Specified Array....986
9.3.2 ADDREG – Add a Constant to an Array based on a Region Number....986
9.3.3 BOUNDARY – Define a Boundary Box for Printing....986
9.3.4 BOX - Define a Range of Grid Blocks to Enter Property Data....986
9.3.5 COPY – Copy Array Data to Another Array....986
9.3.6 COPYBOX – Copy Array Data Defined by a Box....986
9.3.7 COPYREG – Copy an Array to Another Array based on a Region Number....987
9.3.8 ENDBOX – Define the End of the BOX Defined Grid....987
9.3.9 ENDFIN – End the Definition of a Local Grid Refinement....987
9.3.10 ENDNUM – Define the End-Point Scaling Depth Region Numbers....988
9.3.11 EQLNUM – Define the Equilibration Region Numbers....989
9.3.12 EQUALREG – Sets an Array to a Constant by Region Number....990
9.3.13 EQUALS – Sets a Specified Array to a Constant....990
9.3.14 FILEUNIT – Activate Unit Consistency Verification....990
9.3.15 FIP – Define the Fluid In-Place Names and Region and Numbers....991
9.3.16 FIPNUM – Define the Fluid In-Place Region Numbers....992
9.3.17 FIPOWG – Activate Oil, Gas, and Water FIP Zone Reporting....994
9.3.18 GETDATA – Load and Assign Data Array from INIT or RESTART File....995
9.3.19 HBNUM – Define Herschel-Bulkley Region Numbers....996
9.3.20 HM – History Match Region Gradient Parameters....997
9.3.21 HMPROPS – History Match End-Point Section Start....999
9.3.22 HWSNUM – Define the Saturation Table Region Numbers (High Salinity and Water Wet) 1000
9.3.23 IMBNUM – Define the Imbibition Saturation Table Region Numbers....1001
9.3.24 IMBNUMMF – Define the Imbibition Saturation Table Region Numbers (Matrix-Fracture) 1002
9.3.25 IMPORT – Import Grid File Data at the Current Position....1003
9.3.26 KRNUM – Define the Directional Saturation Table Region Numbers....1004
9.3.27 KRNUMMF – Define the Saturation Table Region Numbers (Matrix-Fracture)....1005
9.3.28 LSLTWNUM – Define the Low Salt Water Wet Saturation Table Region Numbers....1006
9.3.29 LSNUM – Define the Low Salt Oil Wet Saturation Table Region Numbers....1007
9.3.30 LWSLTNUM – Define the Low Salt Oil Wet Saturation Table Region Numbers....1008
9.3.31 LWSNUM – Define the Low Salt Water Wet Saturation Table Region Numbers....1009
9.3.32 MISNUM – Define the Miscibility Region Numbers....1010
9.3.33 MULTIPLY – Multiply a Specified Array by a Constant....1011
9.3.34 MULTIREG – Multiply an Array by a Constant based on a Region Number....1011
9.3.35 OPERATE – Define Mathematical Operations on Arrays....1011
9.3.36 OPERNUM – Define Regions for Mathematical Operations on Arrays....1011
9.3.37 OPERATER – Define Mathematical Operations on Arrays by Region....1011
9.3.38 PENUM – Define the Petro-Elastic Region Numbers....1012
9.3.39 PLMIXNUM – Define the Polymer Region Numbers....1013
9.3.40 PVTNUM – Define the PVT Regions....1014
9.3.41 PYEND – End the Definition of a PYINPUT Section....1016

9.3.42 PYINPUT – Define the Start of a PYINPUT Section....1016
9.3.43 REFINE – Start the Definition of a Local Grid Refinement....1016
9.3.44 REGIONS - Define the Start of the REGIONS Section of Keywords....1017
9.3.45 RESIDNUM – Define Vertical Equilibrium Residual Flow Region Numbers....1018
9.3.46 ROCKNUM – Define Rock Compaction Table Region Numbers....1019
9.3.47 RPTREGS – Define REGIONS Section Reporting....1020
9.3.48 SATNUM – Define the Saturation Table Region Numbers....1021
9.3.49 SURFNUM – Define the Surfactant Miscible Saturation Table Region Numbers....1022
9.3.50 SURFWNUM – Define the Saturation Table Region Numbers (High Salinity and Water Wet) 1023
9.3.51 TNUM – Define Passive Tracer Concentration Regions....1024
9.3.52 TRKPF – Define Partitioned Tracer Regions....1026
9.3.53 WH2NUM – Define WAG Hysteresis Saturation Table Region Numbers (Two Phase)....1028
9.3.54 WH3NUM – Define WAG Hysteresis Saturation Table Region Numbers (Three Phase)....1029

CHAPTER 10: SOLUTION SECTION....1031

10.1 Introduction....1032

10.2 Data Requirements....1032

10.3 Keyword Definitions....1033
10.3.1 ADD – Add a Constant to a Specified Array....1033
10.3.2 ADDREG – Add a Constant to an Array based on a Region Number....1033
10.3.3 APIVD - Equilibration Oil API Gravity versus Depth Tables....1034
10.3.4 AQANCONL – Define Analytical Connections to a LGR Grid....1035
10.3.5 AQANNC – Define Analytic Aquifer Non-Neighbor Connections....1037
10.3.6 AQANTRC - Define Analytic Aquifer Initial Tracer Concentrations....1038
10.3.7 AQUALIST – Define An Analytic Aquifer Name to Aquifer Numbers....1039
10.3.8 AQUANCON – Define Analytical Connections to the Grid....1040
10.3.9 AQUCHGAS – Define Constant Pressure Gas Analytical Aquifer Properties....1041
10.3.10 AQUCHWAT – Define Constant Pressure Water Analytical Aquifer Properties....1042
10.3.11 AQUCON – Define Numerical Aquifer Connections to the Grid....1043
10.3.12 AQUCT – Define Carter-Tracy Analytical Aquifers....1043
10.3.13 AQUFET – Define Fetkovich Analytical Aquifer and Connections....1044
10.3.14 AQUFETP – Define Fetkovich Analytical Aquifers....1047
10.3.15 AQUFLUX - Define Constant Flux Analytical Aquifer....1050
10.3.16 BOUNDARY – Define a Boundary Box for Printing....1051
10.3.17 BOX - Define a Range of Grid Blocks to Enter Property Data....1051
10.3.18 COPY – Copy Array Data to Another Array....1051
10.3.19 COPYREG – Copy an Array to Another Array based on a Region Number....1051
10.3.20 DATUM – Define the Datum Depth for the Model....1052
10.3.21 DATUMR – Define Datum Depths for the FIPNUM Regions....1053
10.3.22 DATUMRX – Define Datum Depths for the FIP Allocated Regions....1054
10.3.23 DYNAMICR – Start of Dynamic Region Parameter Definition....1055
10.3.24 ENDBOX – Define the End of the BOX Defined Grid....1056
10.3.25 ENDDYN– End of Dynamic Region Parameter Definition....1057
10.3.26 ENDFIN – End the Definition of a Local Grid Refinement....1058
10.3.27 EQUALREG – Sets an Array to a Constant by Region Number....1058
10.3.28 EQUALS – Sets a Specified Array to a Constant....1058
10.3.29 EQUIL – Define the Equilibration Initialization Data....1059
10.3.30 FILEUNIT – Activate Unit Consistency Verification....1062
10.3.31 GASCONC – Define the Initial Equilibration Coal Gas Concentration for All Grid Blocks1063
10.3.32 GASSATC – Define the Initial Equilibration Saturated Coal Gas Concentration for All Grid Blocks....1064
10.3.33 GCVD – Define Equilibration Coal Gas Concentration versus Depth Tables....1065
10.3.34 GETDATA – Load and Assign Data Array from INIT or RESTART File....1067
10.3.35 GETGLOB – Activate Loading of Global Grid Restart Data Option....1068
10.3.36 GI - Define the Initial Equilibration Gi Values for All Grid Blocks....1069
10.3.37 HMAQUCT – History Match Carter-Tracy Aquifer Gradient Parameters....1070
10.3.38 HMAQUFET – History Match Fetkovich Aquifer Gradient Parameters....1071
10.3.39 HMMLCTAQ – History Match Carter-Tracy Aquifer Gradient Multipliers....1072
10.3.40 HMMLFTAQ – History Match Fetkovich Aquifer Gradient Multipliers....1073
10.3.41 HMMLTWCN – History Match Well Connection and Skin Multipliers....1074

10.3.42 HMWELCON – History Match Well Connection and Skin Parameters....1075
10.3.43 IMPORT – Import Grid File Data at the Current Position....1076
10.3.44 MULTIPLY – Multiply a Specified Array by a Constant....1076
10.3.45 MULTIREG – Multiply an Array by a Constant based on a Region Number....1076
10.3.46 OILAPI – Define the Initial Equilibration Oil API for All Grid Blocks....1077
10.3.47 OPERATE – Define Mathematical Operations on Arrays....1078
10.3.48 OPERATER – Define Mathematical Operations on Arrays by Region....1078
10.3.49 OUTSOL – Define Data to be Written to the RESTART File (Retired)....1079
10.3.50 NOHMD – Deactivate History Match Gradient Derivative Calculations....1080
10.3.51 NOHMO – Deactivate History Match Gradient Derivative Calculations (Alias)....1081
10.3.52 PBUB – Define the Initial Equilibration Bubble-Point Pressure for All Grid Blocks....1082
10.3.53 PBVD – Equilibration Bubble-Point versus Depth Tables....1083
10.3.54 PDEW – Define the Initial Equilibration Dew-Point Pressure for All Grid Blocks....1084
10.3.55 PDVD – Define Equilibration Dew-Point versus Depth Tables....1085
10.3.56 PRESSURE – Define the Initial Equilibration Pressures for All Grid Blocks....1086
10.3.57 PRVD – Define the Initial Equilibration Pressures versus Depth....1087
10.3.58 PYEND – End the Definition of a PYINPUT Section....1089
10.3.59 PYINPUT – Define the Start of a PYINPUT Section....1089
10.3.60 RAINFALL – Constant Flux Aquifer Rainfall Flux by Month....1090
10.3.61 RBEDCONT – Define River Grid Block Contact Area versus Depth....1091
10.3.62 REFINE – Start the Definition of a Local Grid Refinement....1092
10.3.63 RESTART – Restart Run From an Existing Restart File....1093
10.3.64 RIVERSYS - Define River System (Branch Structure and Boundary Conditions)....1095
10.3.65 RPTRST – Define Data to be Written to the RESTART File....1096
10.3.66 RPTSOL – Define SOLUTION Section Reporting....1099
10.3.67 RS – Define the Initial Equilibration GOR (Rs) for All Grid Blocks....1100
10.3.68 RSVD – Equilibration Dissolved Gas-Oil Ratio (Rs) versus Depth Tables....1101
10.3.69 RTEMP - Define the Initial Reservoir Temperature for the Model....1102
10.3.70 RTEMPA - Define the Initial Reservoir Temperature for the Model....1102
10.3.71 RTEMPVD - Define the Initial Reservoir Temperature versus Depth Tables....1103
10.3.72 RV – Define the Initial Equilibration CGR (Rv) for All Grid Blocks....1105
10.3.73 RVVD – Equilibration Vaporized Oil-Gas Ratio (Rv) versus Depth Tables....1106
10.3.74 SALT – Define the Initial Equilibration Salt Concentration for All Grid Blocks....1107
10.3.75 SALTREST – Define the Restart Salt Concentration for All Grid Blocks....1108
10.3.76 SALTPVD – Equilibration Salt Precipitated Concentration versus Depth Tables....1109
10.3.77 SALTVD – Equilibration Salt Concentration versus Depth Tables....1111
10.3.78 SCVD – Define Equilibration Coal Solvent Concentration versus Depth Tables....1114
10.3.79 SFOAM – Define the Initial Equilibration Foam Concentration for All Grid Blocks....1116
10.3.80 SGAS – Define the Initial Equilibration Gas Saturation for All Grid Blocks....1117
10.3.81 SOIL – Define the Initial Equilibration Oil Saturation for All Grid Blocks....1118
10.3.82 SPOLY – Define the Initial Equilibration Polymer Concentration for All Grid Blocks....1119
10.3.83 SOLUTION - Define the Start of the SOLUTION Section of Keywords....1120
10.3.84 SOLVCONC – Define the Initial Coal Solvent Concentration for All Grid Blocks....1121
10.3.85 SOLVFRAC – Define the Initial Gas Solvent Fraction for All Grid Blocks....1122
10.3.86 SSOL – Define the Initial Equilibration Solvent Saturation for All Grid Blocks....1123
10.3.87 SURF – Define the Initial Equilibration Polymer Concentration for All Grid Blocks....1124
10.3.88 SWAT – Define the Initial Equilibration Water Saturation for All Grid Blocks....1125
10.3.89 TBLK – Define Tracer Initial Grid Block Concentrations....1126
10.3.90 TEMPI – Define the Initial Temperature Values for All Cells....1128
10.3.91 TEMPVD - Define the Initial Reservoir Temperature versus Depth Tables....1129
10.3.92 THPRES - Define Equilibration Region Threshold Pressures....1131
10.3.93 TVDP – Define the Initial Equilibration Tracer Saturation versus Depth Functions....1133
10.3.94 VAPPARS – Oil Vaporization Parameters....1134
10.3.95 VISDATES – Define External Reservoir Geo-Mechanics VISAGE Stress Dates....1136
10.3.96 VISOPTS – Define External Reservoir Geo-Mechanics VISAGE Options....1137

CHAPTER 11: SUMMARY SECTION....1139

11.1 Introduction....1140

11.2 Data Requirements....1143
11.2.1 Summary Variable Mnemonic Syntax....1143
11.2.2 Summary Variable Format....1145
11.2.3 Aquifer Summary Variables....1148

11.2.4 Field, Group, Well, Well Connection and Completion Summary Variables....1149
11.2.5 Field, Group and Well Control Mode Summary Variables....1156
11.2.6 Field, Region and Block Summary Variables....1158
11.2.7 Field and Region Summary Recovery Variables....1163
11.2.8 Option Specific Summary Variables – Alkaline Model....1165
11.2.9 Option Specific Summary Variables – API and Tracer Tracking....1166
11.2.10 Option Specific Summary Variables – Asphaltene Model....1168
11.2.11 Option Specific Summary Variables – Brine Model....1169
11.2.12 Option Specific Summary Variables – Coal Bed Methane Model....1171
11.2.13 Option Specific Summary Variables – Conductive Faults Model....1171
11.2.14 Option Specific Summary Variables – Environmental Tracers....1171
11.2.15 Option Specific Summary Variables – Foam Model Tracers....1172
11.2.16 Option Specific Summary Variables – Gas Field Operations Model....1173
11.2.17 Option Specific Summary Variables – Gas Lift Optimization Model....1173
11.2.18 Option Specific Summary Variables – Gas Calorific Value Reporting....1173
11.2.19 Option Specific Summary Variables – Gi Psuedo-Compositional Model....1173
11.2.20 Option Specific Summary Variables – LGR and Coarsening....1173
11.2.21 Option Specific Summary Variables – Multi-Segment Wells....1174
11.2.22 Option Specific Summary Variables – Network Model....1177
11.2.23 Option Specific Summary Variables – OPM Flow Simulation Performance....1178
11.2.24 Option Specific Summary Variables – Polymer Model....1182
11.2.25 Option Specific Summary Variables – Pseudo Steady State....1185
11.2.26 Option Specific Summary Variables – Reservoir Coupling....1185
11.2.27 Option Specific Summary Variables – Solvent Model....1186
11.2.28 Option Specific Summary Variables – Surfactant Model....1187
11.2.29 Option Specific Summary Variables – Thermal Model....1188
11.2.30 Option Specific Summary Variables – User Define Quantities....1189
11.2.31 Option Specific Summary Variables – Wellbore Friction model....1191

11.3 Keyword Definitions....1192
11.3.1 ALL – Export Standard Summary Variable Vectors to File....1193
11.3.2 DATE - Activate the DATE Option for the SUMMARY File....1196
11.3.3 EXCEL - Activate the EXCEL Option for the SUMMARY File....1197
11.3.4 FMWSET - Export Well Status Vectors for the Field to File....1198
11.3.5 GMWSET - Export Well Status Vectors by Group to File....1200
11.3.6 NMESSAGE – Export Cumulative Message Summary Variables to File....1202
11.3.7 MONITOR – Activate Output of the Monitoring Data and File....1203
11.3.8 NARROW – Activate Run Summary Narrow Column Output Option....1204
11.3.9 NEWTON – Activate Newton Iteration SUMMARY Output....1205
11.3.10 NOMONITO – Deactivate Output of the Monitoring Data and File....1206
11.3.11 OFM – Activate OFM File Output of the SUMMARY Data....1207
11.3.12 PERFORMA – Export Standard Simulator Performance Summary Variables to File....1208
11.3.13 PYEND – End the Definition of a PYINPUT Section....1210
11.3.14 PYINPUT – Define the Start of a PYINPUT Section....1210
11.3.15 RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File....1211
11.3.16 RPTONLYO - Deactivate the Report Time Steps Only Option for the SUMMARY File....1212
11.3.17 RPTSMRY - Activate or Deactivate Summary List Report....1213
11.3.18 RUNSUM – Activate RSM File Output of the SUMMARY Data....1214
11.3.19 SEPARATE – Activate the Separate RSM File Output Option....1215
11.3.20 SUMMARY - Define the Start of the SUMMARY Section of Keywords....1216
11.3.21 SUMTHIN – Define SUMMARY Data Reporting Time Steps....1217

CHAPTER 12: SCHEDULE SECTION....1219

12.1 Introduction....1220

12.2 Data Requirements....1221
12.2.1 History Matching Runs....1229
12.2.2 Prediction Runs....1231
12.2.3 Well Productivity....1236

12.3 Keyword Definitions....1239
12.3.1 ACTION – Define Action Conditions and Command Processing (Field)....1240
12.3.2 ACTIONG – Define Action Conditions and Command Processing (Groups)....1241

12.3.3 ACTIONR – Define Action Conditions and Command Processing (Regions)....1242
12.3.4 ACTIONS – Define Action Conditions and Command Processing (Well Segments)....1243
12.3.5 ACTIONW – Define Action Conditions and Command Processing (Wells)....1244
12.3.6 ACTIONX – Define Action Conditions and Command Processing....1245
12.3.7 AITS – Activate Intelligent Time Stepping....1253
12.3.8 AITSOFF – Deactivate Intelligent Time Stepping....1253
12.3.9 APILIM – Define API Tracking Grid Block Limits....1254
12.3.10 AQUCHGAS – Define Constant Pressure Gas Analytical Aquifer Properties....1255
12.3.11 AQUCHWAT – Define Constant Pressure Water Analytical Aquifer Properties....1255
12.3.12 AQUCWFAC – Modify Constant Pressure Water Analytical Aquifer Properties....1256
12.3.13 AQUFETP – Define Fetkovich Analytical Aquifers....1257
12.3.14 AQUFLUX - Define Constant Flux Analytical Aquifer....1257
12.3.15 BOUNDARY – Define a Boundary Box for Printing....1257
12.3.16 BOX - Define a Range of Grid Blocks to Enter Property Data....1257
12.3.17 BRANPROP – Define Network Branch Properties for Extended Network Option....1258
12.3.18 CALTRAC – Define a Gas Calorfic Value Tracer....1259
12.3.19 CECON – Define Well Connections Economic Limit Criteria....1260
12.3.20 CECONT – Define Well Connections Tracer Economic Limit Criteria....1261
12.3.21 COMPDAT – Define Well Connections to the Grid....1262
12.3.22 COMPDATL – Define Well Connections to a LGR Grid....1266
12.3.23 COMPDATM – Define Well Connections to an Amalgamated LGR Grid....1270
12.3.24 COMPIMB – Assign Imbibition Saturation Tables to Well Connections....1271
12.3.25 COMPINJK – Assign Injection well Relative Permeability Values....1273
12.3.26 COMPLMPL – Assign Well LGR Connections to Completions....1274
12.3.27 COMPLUMP – Assign Well Connections to Completions....1277
12.3.28 COMPOFF – Deactivate Network Automatic Compressors....1279
12.3.29 COMPORD - Define Well Connection Ordering....1280
12.3.30 COMPRIV – Define Grid Cell Connections to a River....1282
12.3.31 COMPRP – Re-Scale Fluid Saturations of Well Connections....1283
12.3.32 COMPRPL – Re-Scale Fluid Saturations of Well LGR Connections....1284
12.3.33 COMPSEGL – Define Well Connections for Multi-Segment Wells in a LGR....1285
12.3.34 COMPSEGS – Define Well Connections for Multi-Segment Wells....1288
12.3.35 COMPVE – Re-Define Well Connection Depths....1291
12.3.36 COMPVEL – Re-Define Well LGR Connection Depths....1292
12.3.37 CPIFACT – Define Well Connection Transmissibility Multipliers....1293
12.3.38 CPIFACTL – Define Well Connection Transmissibility Multipliers in a LGR....1294
12.3.39 CSKIN – Re-Define Well Connection Skin Factors....1295
12.3.40 DATES – Advance Simulation by Reporting Date....1296
12.3.41 DCQDEFN – Define Gas DCQ Units as Rate or Energy....1299
12.3.42 DELAYACT - Define Delayed Action Keywords....1300
12.3.43 DIFFMMF – Define Diffusivity Multipliers for Matrix-Fractures....1301
12.3.44 DIMPES – Define IMPES Dynamic Solution Parameters....1302
12.3.45 DIMPLICT – Activate Fully Implicit Dynamic Solution Formulation....1303
12.3.46 DRILPRI – Define Prioritized Drilling Queue Priority Parameters....1304
12.3.47 DRSDT – Solution Gas (Rs) Maximum Rate of Increase Parameters....1305
12.3.48 DRSDTR – Solution Gas (Rs) Maximum Rate of Increase Parameters by Region....1307
12.3.49 DRVDT – Solution Oil (Rv) Maximum Rate of Increase Parameters....1309
12.3.50 DRVDTR – Solution Oil (Rv) Maximum Rate of Increase Parameters by Region....1310
12.3.51 DUMPCUPL – Activate Output to the Reservoir Coupling File....1312
12.3.52 DYNAMICR – Define Dynamic Region Parameters....1313
12.3.53 ENDACTIO – End the Definition of ACTION Commands....1314
12.3.54 ENDBOX – Define the End of the BOX Defined Grid....1315
12.3.55 ENDDYN– End of Dynamic Region Parameter Definition....1315
12.3.56 ENDFIN – End the Definition of a Local Grid Refinement....1315
12.3.57 EPSDBGS – Write End-Point Debug Data to the DEBUG File (Multiple)....1315
12.3.58 EPSDEBUG - Write End-Point Debug Data to the DEBUG File (Individual)....1315
12.3.59 EXCAVATE - Set the Status of a Grid Block To Active or Excavate....1316
12.3.60 EXIT – Exit Simulation from within an Action Section....1317
12.3.61 FBHPDEF – Define Well Default BHP Target and Constraints....1319
12.3.62 FILEUNIT – Activate Unit Consistency Verification....1320
12.3.63 GASBEGIN – Define Start of Annual Scheduling Section....1321
12.3.64 GASEND – Define End of Annual Scheduling Section....1322
12.3.65 GASFCOMP – Define Automatic Gas Compressors....1323

12.3.66 GASFDECR – Define Field Gas Sales Contract Monthly Reduction....1324
12.3.67 GASFDELC – Define Gas Deliverability Calculation....1325
12.3.68 GASFTARG – Define Field Gas Sales Contract Monthly Target....1326
12.3.69 GASMONTH – Define Start of Annual Scheduling Event....1327
12.3.70 GASPERIO – Advance Simulation by Gas Contract Period....1328
12.3.71 GASYEAR – Advance Simulation by Gas Contract Year....1329
12.3.72 GCALECON – Group Economic Criteria for Production Calorific Groups....1330
12.3.73 GCONCAL – Group Production Calorific Targets....1332
12.3.74 GCONENG – Group Production Energy Targets....1334
12.3.75 GCONINJE – Group Injection Targets and Constraints....1335
12.3.76 GCONPRI – Group Production Priority Targets and Constraints....1338
12.3.77 GCONPROD – Group Production Targets and Constraints....1341
12.3.78 GCONSALE – Define Group Sales Gas Production Targets and Constraints....1345
12.3.79 GCONSUMP – Define Group Gas Consumption and Gas Import Targets....1346
12.3.80 GCONTOL – Define Group Constraint Tolerance....1347
12.3.81 GCUTBACK – Define Group Cutback Limits and Parameters....1348
12.3.82 GCUTBACT – Define Group Tracer Cutback Limits and Parameters....1349
12.3.83 GDCQ – Define Group Multiple Daily Contract Quantities....1350
12.3.84 GDCQECON – Group Economic Criteria for DCQ Production Groups....1351
12.3.85 GDRILPOT – Define Group Potential Rates for Automatic Drilling....1352
12.3.86 GECON – Group Economic Criteria for Production Groups....1353
12.3.87 GECONT – Group Tracer Economic Criteria for Production Groups....1356
12.3.88 GEFAC – Define Group Efficiency....1359
12.3.89 GLIFTLIM – Group Artificial Lift Constraints....1360
12.3.90 GLIFTOPT – Define Group Gas Optimization Limits....1362
12.3.91 GNETDP – Group Network Pressure and Rate Controls....1363
12.3.92 GNETINJE – Define Group Injection Network Configuration....1364
12.3.93 GNETPUMP – Standard Network Automatic Compressor and Pumps....1365
12.3.94 GPMAINT – Define Group Pressure Maintenance Targets and Controls....1366
12.3.95 GRADGRUP – Define Group History Match Gradient File Output....1367
12.3.96 GRADRESV – Define Solution Derivative History Match Gradient Output....1368
12.3.97 GRADRFT – Define RFT Derivative History Match Gradient Output....1369
12.3.98 GRADWELL – Define Well History Match Gradient File Output....1370
12.3.99 GRDREACH – Define River and Grid Block Connections....1371
12.3.100 GRUPMAST – Define Master and Slave Groups....1372
12.3.101 GRUPNET – Define Group Standard Network Parameters....1373
12.3.102 GRUPRIG – Group Drilling and Workover Rig Specifications....1377
12.3.103 GRUPSLAV – Define Slave Groups in Slave Reservoirs....1378
12.3.104 GRUPTARG – Modify Group Targets and Constraints Values....1379
12.3.105 GRUPTREE – Define Group Tree Hierarchy....1381
12.3.106 GSATINJE – Define Group Satellite Injection Rates....1383
12.3.107 GSATPROD – Define Group Satellite Production Rates....1384
12.3.108 GSEPCOND – Assign Group Separators....1385
12.3.109 GSSCPTST – Perform Sustainable Capacity Test....1386
12.3.110 GSWINGF – Define Group Multiple Gas Contract Parameters....1387
12.3.111 GTADD – Add a Constant to a Group Target or Constraint....1388
12.3.112 GTMULT – Multiply Group Target or Constraint by a Constant....1389
12.3.113 GUIDECAL – Scale Guide Rates Based on Gas Calorific Value....1390
12.3.114 GUIDERAT – Define Group Guide Rate Formula....1391
12.3.115 GUPFREQ – Instantaneous Gradient Option Update Frequency....1392
12.3.116 GWRTWCV – Instantaneous Gradient Option Well Variables....1393
12.3.117 HMWPIMLT – History Match Well Productivity Index Parameters....1394
12.3.118 LGRFREE – Activate Local Grid Refinement Independent Time Steps....1395
12.3.119 LGRLOCK – Deactivate Local Grid Refinement Independent Time Steps....1396
12.3.120 LGROFF – Deactivate a Local Grid Refinement....1397
12.3.121 LGRON – Activate a Local Grid Refinement....1398
12.3.122 LIFTOPT – Activate Gas Lift Optimization....1399
12.3.123 LINCOM – Define Linear Combination Coefficients....1400
12.3.124 MATCORR – Activate the Material Balance Correction Option....1401
12.3.125 MESSOPTS – Reset Severity Level for Forced Time Steps....1402
12.3.126 MULSGGD – Multiply Matrix-Fracture Coupling for Oil-Gas Gravity Drainage for All Cells 1403
12.3.127 MULSGGDV – Multiply Matrix-Fracture Coupling for Oil-Gas Gravity Drainage for

Individual Cells....1404
12.3.128 MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant....1405
12.3.129 MULTPV – Multiply Cell Pore Volumes by a Constant....1405
12.3.130 MULTR - Multiply Cell Transmissibility in the +R Direction....1405
12.3.131 MULTR- - Multiply Cell Transmissibility in the -R Direction....1405
12.3.132 MULTSIG – Multiply Matrix-Fracture Coupling for All Cells....1406
12.3.133 MULTSIGV – Multiply Matrix-Fracture Coupling for Individual Cells....1407
12.3.134 MULTTHT - Multiply Cell Transmissibility in the +Theta Direction....1408
12.3.135 MULTTHT- - Multiply Cell Transmissibility in the -Theta Direction....1408
12.3.136 MULTX - Multiply Cell Transmissibility in the +X Direction....1408
12.3.137 MULTX- - Multiply Cell Transmissibility in the -X Direction....1408
12.3.138 MULTY - Multiply Cell Transmissibility in the +Y Direction....1408
12.3.139 MULTY- - Multiply Cell Transmissibility in the -Y Direction....1408
12.3.140 MULTZ - Multiply Cell Transmissibility in the +Z Direction....1409
12.3.141 MULTZ- - Multiply Cell Transmissibility in the -Z Direction....1409
12.3.142 NCONSUMP - Node Gas Consumption (Extended Network)....1410
12.3.143 NEFAC - Node Efficiency Factors (Extended Network)....1411
12.3.144 NETBALAN – Network Balancing Parameters....1412
12.3.145 NETCOMPA – Define Automatic Compressors (Extended Network)....1413
12.3.146 NEXT – Maximum Next Time Step Size (Alias for NEXTSTEP)....1414
12.3.147 NEXTSTEP – Maximum Next Time Step Size....1415
12.3.148 NEXTSTPL – Maximum Next Time Step Size (LGR)....1418
12.3.149 NODEPROP – Define Network Node Properties for Extended Network....1419
12.3.150 NOHMD – Deactivate History Match Gradient Derivative Calculations....1420
12.3.151 NOHMO – Deactivate History Match Gradient Derivative Calculations (Alias)....1420
12.3.152 NOSIM – Activate the No Simulation Mode for Data File Checking....1420
12.3.153 NUPCOL – Define the Number of Newtonian Iterations Used to Update Well Targets..1420
12.3.154 NWATREM – Node Water Removal (Extended Network)....1421
12.3.155 OUTSOL – Define Data to be Written to the RESTART File (Retired)....1422
12.3.156 PICOND – Define the Generalized Pseudo Pressure Parameters....1423
12.3.157 PIMULTAB – Define Well Productivity Index versus Water Cut Tables....1424
12.3.158 PLYADS - Define Polymer Rock Adsorption Tables....1426
12.3.159 PLYDHFLF - Define Polymer Thermal Degradation Half-Life Tables....1426
12.3.160 PLYMAX - Define Polymer-Salt Viscosity Mixing Concentrations....1426
12.3.161 PLYROCKM - Modify Polymer-Rock Properties....1427
12.3.162 PLYSHEAR – Activate and Define Polymer Shearing Parameters....1428
12.3.163 PLYSHLOG - Activate and Define the Polymer Shearing Logarithmic Parameters....1428
12.3.164 PLYVISC – Define Polymer Viscosity Scaling Fact....1428
12.3.165 PLYVISCS – Define Polymer-Salt Viscosity Scaling Factors....1428
12.3.166 PLYVISCT – Define Polymer-Temperature Viscosity Scaling Factors....1428
12.3.167 PLYVSCST – Define Polymer-Salt-Temperature Viscosity Scaling Factors....1429
12.3.168 PRIORITY – Activate and Define Well Prioritization Coefficients....1430
12.3.169 PRORDER – Define a Group Production Rules Sequence....1432
12.3.170 PYACTION – Define Python Based Action Conditions and Command Processing....1433
12.3.171 PYEND – End the Definition of a PYINPUT Section....1438
12.3.172 PYINPUT – Define the Start of a PYINPUT Section....1438
12.3.173 QDRILL – Define Sequential Drilling Queue Wells....1439
12.3.174 RAINFALL – Constant Flux Aquifer Rainfall Flux by Month....1440
12.3.175 RCMASTS – Reservoir Coupling Group Minimum Time Step for Flow Restriction....1441
12.3.176 REACHES – Define River Reaches Structure....1442
12.3.177 READDATA – Read Schedule Data Based on Current Time Step....1443
12.3.178 REFINE – Start the Definition of a Local Grid Refinement....1444
12.3.179 RIVDEBUG – Define the Debug Data to be Printed to File (Rivers)....1445
12.3.180 RIVERSYS - Define River System (Branch Structure and Boundary Conditions)....1446
12.3.181 RIVRPROP – Modify River Reaches Properties....1447
12.3.182 RIVSALT – Define River Upstream Flow Salt Concentrations....1448
12.3.183 RIVTRACE – Define River Upstream Flow Tracer Concentrations....1449
12.3.184 RPTHMG - Define Well History Match Gradient Reporting (Groups)....1450
12.3.185 RPTHMW - Define Well History Match Gradient Reporting (Wells)....1451
12.3.186 RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File....1452
12.3.187 RPTONLYO - Deactivate the Report Time Steps Only Option for the SUMMARY File...1452
12.3.188 RPTRST – Define Data to be Written to the RESTART File....1452
12.3.189 RPTSCHED – Define SCHEDULE Section Reporting....1453

12.3.190 SAVE – Activate Output of a SAVE File for Fast Restarts....1460
12.3.191 SCDATAB – Well Connection PI Multipliers versus Scale Deposit....1461
12.3.192 SCDETAB – Well Connection Karst Aquifer Properties for Scale Deposit....1462
12.3.193 SCDPTAB – Well Connection Scale Deposition Tables....1463
12.3.194 SCDPTRAC – Allocate Sea Water Tracer for Scale Deposition....1464
12.3.195 SCHEDULE - Define the Start of the SCHEDULE Section of Keywords....1465
12.3.196 SEPVALS – Define Separator Oil Formation Volume Factor and GOR....1466
12.3.197 SHRATE - Activate and Define the Polymer Shearing Logarithmic Parameters....1467
12.3.198 SIMULATE - Activate the Simulation Mode....1468
12.3.199 SKIPREST – Activate Skipping of Restart Schedule Data....1469
12.3.200 SLAVES – Define Slave Reservoir Simulation Parameters....1470
12.3.201 SUMTHIN – Define SUMMARY DATA Reporting Time Steps....1471
12.3.202 SURFVISC – Surfactant Solution Viscosity versus Concentration....1471
12.3.203 SWINGFAC – Define Field Gas Contract Parameters....1472
12.3.204 TIGHTEN – Tighten and Relax Numerical Controls....1473
12.3.205 TIGHTENP – Tighten and Relax Numerical Controls Individually....1474
12.3.206 TIME – Advance Simulation by Cumulative Reporting Time....1475
12.3.207 TSTEP – Advance Simulation by Reporting Time....1477
12.3.208 TUNING - Numerical Tuning Control....1479
12.3.209 TUNINGDP – Numerical Tuning Control for High Throughput Cases....1484
12.3.210 TUNINGH – Numerical Tuning Control for History Match Gradient Calculations....1485
12.3.211 TUNINGL - Numerical Tuning Control for All LGRs....1486
12.3.212 TUNINGS - Numerical Tuning Control for Individual LGRs....1490
12.3.213 UDQ - Declare User Define Quantities (“UDQ”)....1495
12.3.214 UDT - Declare User Define Tables (“UDT”)....1499
12.3.215 USECUPL – Load a Reservoir Coupling File....1500
12.3.216 VAPPARS – Oil Vaporization Parameters....1501
12.3.217 VFPCHK – Define Production Vertical Flow Performance BHP Check....1502
12.3.218 VFPINJ – Define Injection Vertical Flow Performance Tables....1504
12.3.219 VFPPROD – Define Production Vertical Flow Performance Tables....1507
12.3.220 VFPTABL – Define Production Vertical Flow Performance ALQ Interpolation....1513
12.3.221 WAITBAL – Wait On Network Balance Before Allowing Further Actions....1514
12.3.222 WALKALIN – Define Water Injection Alkaline Concentration....1515
12.3.223 WALQCALC – Define Well VFP Surface ALQ Phase Density....1516
12.3.224 WAPI – Define Oil Well Injection API Gravity....1517
12.3.225 WBHGLR – Define Well Bottom-Hole GLR Constraint....1518
12.3.226 WBOREVOL – Define Effective Wellbore Storage Volume....1519
12.3.227 WCALCVAL – Define Gas Well Calorific Value....1520
12.3.228 WCONHIST – Define Well Historical Production Rates and Pressures....1521
12.3.229 WCONINJ – Well Injection Targets and Constraints....1525
12.3.230 WCONINJE – Well Injection Targets and Constraints....1526
12.3.231 WCONINJH – Well Historical Observed Injection Rates and Pressures....1529
12.3.232 WCONINJP – Define Well Injection Targets and Constraints for Pattern Flood Wells....1532
12.3.233 WCONPROD – Define Well Production Targets and Constraints....1533
12.3.234 WCUTBACK – Define Well Cutback Limits and Parameters....1537
12.3.235 WCUTBACT – Define Well Tracer Cutback Limits and Parameters....1538
12.3.236 WCYCLE – Define Automatic Well Opening and Closing Cycling Parameters....1539
12.3.237 WDFAC – Define Gas Flow Dependent Skin Factor....1540
12.3.238 WDFACCOR – Gas Flow Dependent Skin Factor (Correlation)....1541
12.3.239 WDRILPRI – Add Wells to the Drilling Priority Drilling Queue....1542
12.3.240 WDRILRES – Activate Prevention of Multi-Completions in the Same Cell for Queued Wells 1543
12.3.241 WDRILTIM – Define Drilling Parameters for Automatic Drilling of New Wells....1544
12.3.242 WECON – Well Economic Criteria for Production Wells....1545
12.3.243 WECONINJ – Well Economic Criteria for Injection Wells....1549
12.3.244 WECONT – Well Economic Tracer Criteria for Production Wells....1551
12.3.245 WEFAC – Define Well Efficiency....1554
12.3.246 WELCNTL – Modify Well Control and Targets....1555
12.3.247 WELDEBUG – Define the Well Debug Data to be Printed to File....1557
12.3.248 WELDRAW – Define Maximum Draw Down for Production Wells....1558
12.3.249 WELEVNT – Define Well WPWEM Summary Mnemonic Output Value....1559
12.3.250 WELMOVEL – Move Global Well Into an LGR....1560
12.3.251 WELOPEN – Define Well and Well Connections Flowing Status....1561

12.3.252 WELOPENL – Define Well and Well Connections Flowing Status (LGR)....1564
12.3.253 WELPI – Define Well Productivity and Injectivity Indices....1566
12.3.254 WELPRI – Assign Well Priority....1567
12.3.255 WELSEGS – Define Multi-Segment Wells and Their Segment Structure....1568
12.3.256 WELSOMIN – Define Well Connection Minimum Oil Saturation for Opening....1576
12.3.257 WELSPECL – Define Well Specifications for Local Grid Refinements....1577
12.3.258 WELSPECS – Define Well Specifications....1581
12.3.259 WELTARG – Modify Well Target and Constraint Values....1585
12.3.260 WFOAM - Define Well Foam Injection Concentrations....1587
12.3.261 WFRICSEG – Convert Friction Well to Multi-Segment Well....1588
12.3.262 WFRICSGL – Convert Friction Well to Multi-Segment Well (LGR)....1589
12.3.263 WFRICTN – Define Well as a Friction Well....1590
12.3.264 WFRICTNL – Define Well as a Friction Well (LGR)....1591
12.3.265 WGASPROD – Define Sale Gas Well Production Targets....1592
12.3.266 WGORPEN – Define Well GOR Penalty Parameters....1593
12.3.267 WGRUPCON – Define Well Guide Rates for Group Control....1594
12.3.268 WHEDREFD – Define Well Hydraulic Head Reference Depth....1596
12.3.269 WHISTCTL - Define Well Historical Target Phase....1597
12.3.270 WHTEMP – Define Well Tubing Head Temperature Parameters....1599
12.3.271 WINJMULT – Define Well Pressure Dependent Injectivity Multipliers....1600
12.3.272 WINJTEMP – Define Injection Fluid Thermal Properties....1601
12.3.273 WLIFT – Define Well Re-Tubing, THP and Lift Switching Workover Operations....1603
12.3.274 WLIFTOPT – Define Well Gas Lift Optimization Parameters....1604
12.3.275 WLIMTOL – Define Well Constraint Tolerance....1605
12.3.276 WLIST – Define Well Lists (Static)....1606
12.3.277 WLISTARG – Modify Well List Target and Constraint Values (Static)....1608
12.3.278 WLISTNAM – Define Well Lists (WLISTARG)....1610
12.3.279 WNETCTRL – Define Well Control for Network Control Option....1612
12.3.280 WNETDP – Define Well THP to Network Pressure Drop....1613
12.3.281 WORKLIM – Define Well Workover Time....1614
12.3.282 WORKTHP – Define Well Workover Options for THP Killed Wells....1615
12.3.283 WPAVE – Well Block Average Pressure Calculation Parameters for All Wells....1616
12.3.284 WPAVEDEP – Define Well Reference Depth for Pressure Calculations....1618
12.3.285 WPIMULT – Define Well Connection Multipliers....1620
12.3.286 WPIMULTL – Define Well Connection Multipliers (LGR)....1622
12.3.287 WPITAB - Assign Well Productivity Index versus Water Cut Tables....1624
12.3.288 WPLUG – Define Well Plug Back Length....1625
12.3.289 WPOLYMER - Define Water Injection Well Polymer and Salt Concentrations....1626
12.3.290 WPOLYRED – Define Well Polymer-Water Viscosity Reduction Factor....1628
12.3.291 WREGROUP – Automatic Re-Assignment of Wells to Groups....1629
12.3.292 WRFT – Activate Well RFT Reporting to the RFT File....1630
12.3.293 WRFTPLT – Activate Well RFT and PLT Reporting to the RFT File....1632
12.3.294 WSALT - Define Water Injection Well Salt Concentrations....1634
12.3.295 WSCCLEAN – Well Deposited Scale Adjustment....1636
12.3.296 WSCCLENL – Well Deposited Scale Adjustment (LGR)....1637
12.3.297 WSCTAB – Assign Well Scale Deposition and Scale Damage Tables....1638
12.3.298 WSEGAICD – Define Multi-Segment Well Autonomous ICD Connections....1639
12.3.299 WSEGDFIN – Define Multi-Segment Well Drift Flux Slip Model Input Data....1640
12.3.300 WSEGDFMD – Define Multi-Segment Well Drift Flux Slip Model....1641
12.3.301 WSEGDFPA – Define Multi-Segment Well Drift Flux Slip Model Parameters....1642
12.3.302 WSEGEXSS – Define Multi-Segment Well Import-Export Segment Volumes....1643
12.3.303 WSEGFLIM - Define Multi-Segment Well Artificial Choke Connections....1644
12.3.304 WSEGFMOD – Define Multi-Segment Well Model....1645
12.3.305 WSEGINIT - Define Multi-Segment Well Initial Conditions....1646
12.3.306 WSEGITER – Define Multi-Segment Wells Iteration Parameters....1647
12.3.307 WSEGLABY - Define Multi-Segment Well Labyrinth ICD Connections....1648
12.3.308 WSEGLINK - Define Multi-Segment Well Looped Flow Paths....1649
12.3.309 WSEGMULT – Define Multi-Segment Well Frictional Pressure Loss Multipliers....1650
12.3.310 WSEGPROP – Modify Multi-Segment Wells and Their Segment Structure....1651
12.3.311 WSEGPULL – Define a Multi-Segment Well Down-Hole Separator Pump....1653
12.3.312 WSEGSEP – Define a Multi-Segment Well Down-Hole Separator....1654
12.3.313 WSEGSICD – Define Multi-Segment Well Spiral ICD Connections....1655
12.3.314 WSEGSOLV Define Multi-Segment Well Iterative Linear Solver Parameters....1661

12.3.315 WSEGTABL – Assign Multi-Segment Well VLP Tables to Segments....1662
12.3.316 WSEGVALV – Define Multi-Segment Well Sub-Critical Valve....1663
12.3.317 WSOLVENT - Define Gas Injection Well Solvent Fraction....1667
12.3.318 WSURFACT - Define Water Injection Well Surfactant Concentration....1668
12.3.319 WTADD – Add a Constant to a Well Target or Constraint....1669
12.3.320 WTEMP – Define An Injection Well's Fluid Temperature....1670
12.3.321 WTEMPQ – Output Well Names and Well Lists to the Print File....1671
12.3.322 WTEST – Well Testing Criteria for Re-Opening Closed Wells....1672
12.3.323 WTHPMAX – Define a Well's Maximum Flowing THP for Shut-In....1674
12.3.324 WTMULT – Multiple a Well Target or Constraint by a Constant....1675
12.3.325 WTRACER – Define An Injection Well's Tracer Concentration....1676
12.3.326 WVFPDP – Modify Well BHP Obtained from VFP Tables....1678
12.3.327 WVFPEXP – Define Well VFP Interpolation Options....1680
12.3.328 WWPAVE – Well Block Average Pressure Calculation Parameters for Individual Wells..1681
12.3.329 ZIPP2OFF – Deactivate Automatic Time Step Control....1682
12.3.330 ZIPPY2 – Activate Automatic Time Step Control....1683

APPENDIX A: KEYWORD INDEX - ALPHABETIC LISTING....1685

A....1686
B....1688
C....1689
D....1691
E....1694
F....1696
G....1698
H....1701
I....1705
J....1710
K....1711
L....1713
M....1715
N....1717
O....1719
P....1720
Q....1724
R....1725
S....1728
T....1734
U....1736
V....1737
W....1738
X....1742
Y....1743

Z....1744

APPENDIX B: OPM FLOW RELEASE HISTORY....1745

B.1 Release 2020-04....1746

B.2 Release 2019-10....1749

B.3 Release 2019-04....1753

B.4 Release 2018-10....1755

B.5 Release 2018-04....1756

B.6 Release 2017-10 Update 1....1758

B.7 Release 2017-10....1758

B.8 Release 2017-04....1758

APPENDIX C: RUNNING PREVIOUS RELEASES OF OPM FLOW....1761

C.1 Running OPM Flow 2019-10....1762

C.2 Running OPM Flow 2019-04....1774

C.3 Running OPM Flow 2018-10....1786

C.4 Running OPM Flow 2018-04....1797

APPENDIX D: OPM FLOW OUTPUT FILE FORMATS....1803

D.1 Overview....1804
D.1.1 File Types....1804
D.1.2 File Naming Conventions....1808
D.1.3 Unformatted File Format Considerations....1810
D.1.4 File Output Format....1811

D.2 EGRID - Model Structural Data for Irregular Corner-Point Grids File....1815
D.2.1 EGRID Header Keywords....1817
D.2.2 EGRID Global Irregular Corner Point Grid Keywords....1820
D.2.3 EGRID LGR Irregular Corner Point Grid Keywords....1824
D.2.4 EGRID Non-Neighbor Connections for Irregular Corner Point Grid Keywords....1827

D.3 EGRID - Model Structural Data for Unstructured Grids File....1830

D.4 EGRID - Model Structural Data for Mixed Grids File....1830

D.5 GRID - Model Structural Data File....1830

D.6 INIT – Model Initialization and Static Data File....1831
D.6.1 INIT Index File....1831
D.6.2 INIT Data File Specification....1832
D.6.3 INIT Data – Static Data Header Keywords....1835
D.6.4 INIT Data – Static Grid Array Data Keywords....1839
D.6.5 INIT Data - LGR Static Data Header Keywords....1842
D.6.6 INIT Data - LGR Grid Array Data Keywords....1845
D.6.7 INIT Data – Static Tabular Data Header Keyword....1847
D.6.8 INIT Data – Static Tabular and Constant Data Array Keywords....1850

D.7 RESTART Files – Solution Data....1852
D.7.1 RESTART Index Files....1852
D.7.2 RESTART Data File Specification....1853
D.7.3 RESTART Data - Header Keywords....1855
D.7.4 RESTART Data – Group, Well and Connection Data Keywords....1866
D.7.5 RESTART Data – Aquifer Data Keywords....1884
D.7.6 RESTART Data – Hidden Keyword....1888

D.7.7 RESTART Data - Solution Data keyword....1889
D.7.8 RESTART Data - LGR Grid Header Keywords....1897
D.7.9 RESTART Data - LGR Solution Data Keywords....1899

D.8 RFT Files – Pressure, Saturation and Production Log Data....1902
D.8.1 RFT Data File Specification....1902
D.8.2 RFT Data File – Time and Date keywords....1903
D.8.3 RFT Data File – Well and Connection Data Keyword....1904
D.8.4 RFT Data File – RFT Solution Data Keyword....1906
D.8.5 RFT Data File – Solution PLT Data Keywords....1908
D.8.6 RFT Data File – Solution Multi-Segment Well Keywords....1908
D.8.7 RFT Data File – Solution River Keywords....1908

D.9 SUMMARY Files – Time Based Vector Data....1909
D.9.1 SUMMARY Index File keywords....1909
D.9.2 SUMMARY Data File Keywords....1914

D.10 SAVE Files - Initialization and Solution Data....1916

Index of Tables

Table 2.1: OPM Flow 2019-04 Command Line Options....59
Table 3.1: Example Keyword Table Section....84
Table 3.2: ADD Keyword Table Section....84
Table 3.3: PORO Keyword Description....89
Table 3.4: OPM Flow Input Deck Sections....90
Table 4.1: EXTRAPMS Keyword Description....99
Table 4.2: FORMFEED Keyword Description....100
Table 4.3: INCLUDE Keyword Description....101
Table 4.4: MESSAGES Keyword Description....104
Table 5.1: ACTDIMS Keyword Description....113
Table 5.2: ACTPARAM Keyword Description....114
Table 5.3: AQUDIMS Keyword Description....119
Table 5.4: BRINE Keyword Description....125
Table 5.5: DIMENS Keyword Description....132
Table 5.6: ENDSCALE Keyword Description....140
Table 5.7: EQLDIMS Keyword Description....141
Table 5.8: EQLOPTS Keyword Description....142
Table 5.9: FAULTDIM Keyword Description....143
Table 5.10: FMTIN Keyword Description....147
Table 5.11: FMOUT Keyword Description....149
Table 5.12: FRICTION Keyword Description....151
Table 5.13: GRAVDRM Keyword Description....159
Table 5.14: GRIDOPTS Keyword Description....160
Table 5.15: LGR Keyword Description....170
Table 5.16: MISCIBLE Keyword Description....178
Table 5.17: MSGFILE Keyword Description....180
Table 5.18: MULTIN Keyword Description....182
Table 5.19: MULTOUT Keyword Description....184
Table 5.20: Network Keyword Description....187
Table 5.21: NMATRIX Keyword Description....189
Table 5.22: NNEWTF Keyword Description....190
Table 5.23: NRSOUT Keyword Description....199
Table 5.24: NSTACK Keyword Description....200
Table 5.25: NUMRES Keyword Description....201
Table 5.26: NUPCOL Keyword Description....202
Table 5.27: OPTIONS Keyword Description....204
Table 5.28: PARALLEL Keyword Description....205
Table 5.29: PATHS Keyword Description....207
Table 5.30: PIMTDIMS Keyword Description....210
Table 5.31: REGDIMS Keyword Description....215
Table 5.32: ROCKCOMP Keyword Description....219
Table 5.33: SATOPTS Keyword Description....228
Table 5.34: SATOPTS Relative Permeability Function Allocation Keywords....228
Table 5.35: SCDPDIMS Keyword Description....231
Table 5.36: SMRYDIMS Keyword Description....232
Table 5.37: START Keyword Description....235
Table 5.38: TABDIMS Keyword Description....239
Table 5.39: Reservoir Temperature Keywords....241
Table 5.40: OPM Flow's THERMAL Option Associated Keywords....243
Table 5.41: TITLE Keyword Description....244
Table 5.42: TRPLPORO Keyword Description....245
Table 5.43: TRACERS Keyword Description....246
Table 5.44: UDADIMS Keyword Description....248
Table 5.45: UDQDIMS Keyword Description....249
Table 5.46: UDQPARAM Keyword Description....251
Table 5.47: UDTDIMS Keyword Description....253
Table 5.48: UNIFIN Keyword Description....256
Table 5.49: UNIFOUT Keyword Description....258
Table 5.50: VFPIDIMS Keyword Description....264
Table 5.51: VFPPDIMS Keyword Description....265
Table 5.52: WELLDIMS Keyword Description....270

Table 5.53: WESEGDIMS Keyword Description....272
Table 6.1: Key Static Grid Properties....280
Table 6.2: ACTNUM Keyword Description....283
Table 6.3: ADD Keyword Description....284
Table 6.4: ADD Keyword Applicable Arrays by Section....285
Table 6.5: ADDREG Keyword Description....286
Table 6.6: ADDREG Keyword Applicable Arrays by Section....287
Table 6.7: AQUANCON Keyword Description....291
Table 6.8: AQUCT Keyword Description....294
Table 6.9: BOX Keyword Description....301
Table 6.10: CARFIN Keyword Description....306
Table 6.11: COALNUM Keyword Description....307
Table 6.12: COORD Keyword Description....310
Table 6.13: COPY Keyword Description....313
Table 6.14: COPY Keyword Applicable Arrays by Section....314
Table 6.15: COPYBOX Keyword Description....316
Table 6.16: COPYBOX Keyword Applicable Arrays by Section....316
Table 6.17: COPYREG Keyword Description....318
Table 6.18: COPYREG Keyword Applicable Arrays by Section....319
Table 6.19: DR Keyword Description....334
Table 6.20: DRV Keyword Description....335
Table 6.21: DTHETA Keyword Description....336
Table 6.22: DTHETA Keyword Description....337
Table 6.23: DX Keyword Description....339
Table 6.24: DXV Keyword Description....340
Table 6.25: DY Keyword Description....341
Table 6.26: DYV Keyword Description....342
Table 6.27: DZ Keyword Description....343
Table 6.28: DZNET Keyword Description....347
Table 6.29: DZV Keyword Description....348
Table 6.30: EQUALREG Keyword Description....352
Table 6.31: EQUALREG Keyword Applicable Arrays by Section....353
Table 6.32: EQUALS Keyword Description....354
Table 6.33: EQUALS Keyword Applicable Arrays by Section....355
Table 6.34: FAULTS Keyword Description....360
Table 6.35: FILEUNIT Keyword Description....362
Table 6.36: FLUXNUM Keyword Description....363
Table 6.37: GDFILE Keyword Description....366
Table 6.38: GRIDFILE Keyword Description....370
Table 6.39: GRIDUNIT Keyword Description....371
Table 6.40: HEATCR Keyword Description....373
Table 6.41: HEATCRT Keyword Description....374
Table 6.42: HMMLT Keyword List....378
Table 6.43: HRFIN Keyword Description....383
Table 6.44: HXFIN Keyword Description....384
Table 6.45: HYFIN Keyword Description....385
Table 6.46: HZFIN Keyword Description....386
Table 6.47: INRAD Keyword Description....390
Table 6.48: ISOLNUM Keyword Description....392
Table 6.49: JFUNC Keyword Description....394
Table 6.50: JFUNCR Keyword Description....397
Table 6.51: LX Keyword Description....402
Table 6.52: LY Keyword Description....404
Table 6.53: LZ Keyword Description....406
Table 6.54: MAPAXES Keyword Description....408
Table 6.55: MAPUNITS Keyword Description....409
Table 6.56: MAXVALUE Keyword Description....410
Table 6.57: MAXVALUE Keyword Applicable Arrays by Section....411
Table 6.58: MINPORV Keyword Description....413
Table 6.59: MINPV Keyword Description....414
Table 6.60: MINPVV Keyword Description....415
Table 6.61: MINVALUE Keyword Description....416
Table 6.62: MINVALUE Keyword Applicable Arrays by Section....417

Table 6.63: MULTFLT Keyword Description....420
Table 6.64: MULTIPLY Keyword Description....421
Table 6.65: MULTIPLY Keyword Applicable Arrays by Section....422
Table 6.66: MULTIREG Keyword Description....423
Table 6.67: MULTIREG Keyword Applicable Arrays by Section....424
Table 6.68: MULTNUM Keyword Description....425
Table 6.69: MULTPV Keyword Description....426
Table 6.70: MULTR Keyword Description....427
Table 6.71: MULTR- Keyword Description....428
Table 6.72: MULTREGD Keyword Description....429
Table 6.73: MULTREGH Keyword Description....431
Table 6.74: MULTREGP Keyword Description....433
Table 6.75: MULTREGT Keyword Description....434
Table 6.76: MULTTHT Keyword Description....436
Table 6.77: MULTTHT- Keyword Description....437
Table 6.78: MULTX Keyword Description....438
Table 6.79: MULTX- Keyword Description....439
Table 6.80: MULTY Keyword Description....440
Table 6.81: MULTY- Keyword Description....441
Table 6.82: MULTZ Keyword Description....442
Table 6.83: MULTZ- Keyword Description....443
Table 6.84: NINENUM Keyword Description....445
Table 6.85: NNC Keyword Description....448
Table 6.86: NTG Keyword Description....452
Table 6.87: NXFIN Keyword Description....453
Table 6.88: NYFIN Keyword Description....454
Table 6.89: NZFIN Keyword Description....455
Table 6.90: OPERATE Keyword Description....459
Table 6.91: OPERATE Keyword Applicable Arrays by Section....459
Table 6.92: OUTRAD Keyword Description....463
Table 6.93: OUTRAD Radial Grid Example....464
Table 6.94: PEBI Keyword Description....466
Table 6.95: PERMJFUN Keyword Description....468
Table 6.96: PERMX Keyword Description....471
Table 6.97: PERMY Keyword Description....472
Table 6.98: PERMZ Keyword Description....473
Table 6.99: PINCH Keyword Description....476
Table 6.100: PINCHNUM Keyword Description....477
Table 6.101: PINCHREG Keyword Description....480
Table 6.102: PINCHXY Keyword Description....481
Table 6.103: PORO Keyword Description....482
Table 6.104: PYINPUT Keyword Description....485
Table 6.105: RESVNUM Keyword Description....491
Table 6.106: NTG Keyword Description....493
Table 6.107: RPTGRID Keyword Description....494
Table 6.108: RPTGRIDL Keyword Description....496
Table 6.109: SMULTX Keyword Description....504
Table 6.110: SMULTY Keyword Description....505
Table 6.111: SMULTX Keyword Description....506
Table 6.112: SPECGRID Keyword Description....509
Table 6.113: SWATINIT Keyword Description....510
Table 6.114: THCGAS Keyword Description....511
Table 6.115: THCOIL Keyword Description....512
Table 6.116: THCONR Keyword Description....513
Table 6.117: THCROCK Keyword Description....514
Table 6.118: THCROCK Keyword Description....516
Table 6.119: THCWATER Keyword Description....517
Table 6.120: THPRESFT Keyword Description....518
Table 6.121: TOPS Keyword Description....520
Table 6.122: TRANGL Keyword Description....522
Table 6.123: ZCORN Keyword Description....528
Table 7.1: EDIT Section Arrays Available for Modification....530
Table 7.2: Depth Keyword Description....533

Table 7.3: EDITNNC Keyword Description....541
Table 7.4: EDITNNCR Keyword Description....544
Table 7.5: HMMULT Keyword List....547
Table 7.6: PORV Keyword Description....552
Table 7.7: TRANR Keyword Description....554
Table 7.8: TRANR Keyword Description....555
Table 7.9: TRANX Keyword Description....556
Table 7.10: TRANY Keyword Description....557
Table 7.11: TRANZ Keyword Description....558
Table 8.1: Fluid Property Keywords versus Oil, Gas and Water Fluid Type....561
Table 8.2: Fluid Property Keywords versus Foam, Polymer and Solvent Fluid Types....562
Table 8.3: Oil-Water Relative Permeability End-Point Data Definitions....565
Table 8.4: Gas-Oil Relative Permeability End-Point Data Definitions....566
Table 8.5: Saturation Table Formats and Phases....566
Table 8.6: ADSALNOD Keyword Description....569
Table 8.7: AQUTAB Keyword Description....579
Table 8.8: Carter-Tracy Aquifer Influence Functions (R_D =1.5, 2.0, 2.5 and 3.0)....580
Table 8.9: Carter-Tracy Aquifer Influence Functions (R_D =3.5, 4.0, 4.5 and 5.0)....581
Table 8.10: Carter-Tracy Aquifer Influence Functions (R_D =6.0, 7.0, 8.0 and 9.0)....582
Table 8.11: Carter-Tracy Aquifer Influence Functions (R_D =10 and Finite Linear)....583
Table 8.12: Carter-Tracy Infinite Radial Aquifer Influence Function (Default)....584
Table 8.13: BDENSITY Keyword Description....586
Table 8.14: DENSITY Keyword Description....594
Table 8.15: EHYSTR Keyword Description....607
Table 8.16: EHYSTRR Keyword Description....608
Table 8.17: FOAMADS Keyword Description....621
Table 8.18: FOAMFSC Keyword Description....628
Table 8.19: FOAMMOB Keyword Description....633
Table 8.20: FOAMOPTS Keyword Description....637
Table 8.21: FOAMROCK Keyword Description....638
Table 8.22: GASDENT Keyword Description....640
Table 8.23: GASVISCT Keyword Description....641
Table 8.24: GRAVCONS Keyword Description....645
Table 8.25: GRAVITY Keyword Description....646
Table 8.26: HA Keyword List....648
Table 8.27: HM Keyword List....651
Table 8.28: IKRG Keyword Description....674
Table 8.29: Critical Displacement Relationships....675
Table 8.30: IKRGR Keyword Description....676
Table 8.31: Critical Displacement Relationships....676
Table 8.32: IKRO Keyword Description....678
Table 8.33: Critical Displacement Relationships....679
Table 8.34: IKRORG Keyword Description....680
Table 8.35: Critical Displacement Relationships....680
Table 8.36: IKRORW Keyword Description....682
Table 8.37: Critical Displacement Relationships....682
Table 8.38: IKRW Keyword Description....684
Table 8.39: Critical Displacement Relationships....685
Table 8.40: IKRWR Keyword Description....686
Table 8.41: Critical Displacement Relationships....686
Table 8.42: IPCG Keyword Description....696
Table 8.43: IPCW Keyword Description....697
Table 8.44: ISGCR Keyword Description....698
Table 8.45: ISGL Keyword Description....699
Table 8.46: ISGLPC Keyword Description....700
Table 8.47: ISGU Keyword Description....702
Table 8.48: ISOGCR Keyword Description....703
Table 8.49: ISOWCR Keyword Description....704
Table 8.50: ISWCR Keyword Description....705
Table 8.51: ISWL Keyword Description....706
Table 8.52: ISWLPC Keyword Description....707
Table 8.53: ISWU Keyword Description....709
Table 8.54: KRG Keyword Description....710

Table 8.55: Critical Displacement Relationships....711
Table 8.56: KRGR Keyword Description....713
Table 8.57: Critical Displacement Relationships....713
Table 8.58: KRO Keyword Description....715
Table 8.59: Critical Displacement Relationships....716
Table 8.60: KRORG Keyword Description....718
Table 8.61: Critical Displacement Relationships....718
Table 8.62: KRORW Keyword Description....720
Table 8.63: Critical Displacement Relationships....720
Table 8.64: KRW Keyword Description....722
Table 8.65: Critical Displacement Relationships....723
Table 8.66: KRWR Keyword Description....724
Table 8.67: Critical Displacement Relationships....724
Table 8.68: MISC Keyword Description....757
Table 8.69: MSFN Keyword Description....761
Table 8.70: OILDENT Keyword Description....764
Table 8.71: OILVISCT Keyword Description....766
Table 8.72: OVERBURD Keyword Description....769
Table 8.73: PCG Keyword Description....771
Table 8.74: PCW Keyword Description....773
Table 8.75: PERMFACT Keyword Description....778
Table 8.76: PLMIXPAR Keyword Description....780
Table 8.77: PLYADS Keyword Description....781
Table 8.78: PLYADSS Keyword Description....783
Table 8.79: PLYATEMP Keyword Description....785
Table 8.80: PLYDHFLF Keyword Description....788
Table 8.81: PLYDMAX Keyword Description....791
Table 8.82: PLYROCK Keyword Description....793
Table 8.83: PLYSHEAR Keyword Description....795
Table 8.84: PLYSHLOG Keyword Description....797
Table 8.85: PLYVISC Keyword Description....801
Table 8.86: PMISC Keyword Description....807
Table 8.87: PPCWMAX Keyword Description....808
Table 8.88: PVCDO Keyword Description....811
Table 8.89: PVCO Keyword Description....814
Table 8.90: PVDG Keyword Description....815
Table 8.91: PVDO Keyword Description....817
Table 8.92: PVDS Keyword Description....819
Table 8.93: PVTG Keyword Description....822
Table 8.94: PVTGW Keyword Description....824
Table 8.95: PVTGW Keyword Description....827
Table 8.96: PVTO Keyword Description....830
Table 8.97: PVTW Keyword Description....832
Table 8.98: PVTWSALT Keyword Description....835
Table 8.99: PVZG Keyword Description....837
Table 8.100: ROCK Keyword Description....845
Table 8.101: ROCK2D Keyword Description....847
Table 8.102: ROCK2DTR Keyword Description....849
Table 8.103: ROCKOPTS Keyword Description....851
Table 8.104: ROCKTAB Keyword Description....855
Table 8.105: ROCKTABH Keyword Description....858
Table 8.106: ROCKWNOD Keyword Description....863
Table 8.107: RPTPROPS Keyword Description....865
Table 8.108: RSCONST Keyword Description....866
Table 8.109: RSCONSTT Keyword Description....867
Table 8.110: RTEMP Keyword Description....869
Table 8.111: RTEMPA Keyword Description....870
Table 8.112: RVCONST Keyword Description....871
Table 8.113: RVCONSTT Keyword Description....872
Table 8.114: RWGSALT Keyword Description....874
Table 8.115: SALTNODE Keyword Description....876
Table 8.116: SALTSOL Keyword Description....877
Table 8.117: SCALECRS Keyword Description....878

Table 8.118: End-Point Arrays Used in the End-Point Scaling Options....878
Table 8.119: SDENSITY Keyword Description....881
Table 8.120: SGCR Keyword Description....882
Table 8.121: SGCWMIS Keyword Description....883
Table 8.122: SGFN Keyword Description....885
Table 8.123: SGL Keyword Description....886
Table 8.124: SGLPC Keyword Description....887
Table 8.125: SGOF Keyword Description....889
Table 8.126: SGU Keyword Description....891
Table 8.127: SGWFN Keyword Description....892
Table 8.128: SKRO Keyword Description....895
Table 8.129: SKRORG Keyword Description....896
Table 8.130: SKRORW Keyword Description....897
Table 8.131: SKRW Keyword Description....898
Table 8.132: SKRWR Keyword Description....899
Table 8.133: SLGOF Keyword Description....900
Table 8.134: SOGCR Keyword Description....902
Table 8.135: SOF2 Keyword Description....903
Table 8.136: SOF3 Keyword Description....905
Table 8.137: SOGCR Keyword Description....908
Table 8.138: SORWMIS Keyword Description....911
Table 8.139: SOWCR Keyword Description....912
Table 8.140: SPECHEAT Keyword Description....913
Table 8.141: SPECROCK Keyword Description....915
Table 8.142: SSFN Keyword Description....917
Table 8.143: SSGCR Keyword Description....919
Table 8.144: SSGL Keyword Description....920
Table 8.145: SSOGCR Keyword Description....921
Table 8.146: SSOWCR Keyword Description....922
Table 8.147: SSWCR Keyword Description....923
Table 8.148: SSWL Keyword Description....924
Table 8.149: SSWU Keyword Description....925
Table 8.150: STONE1EX Keyword Description....929
Table 8.151: SURFADS Keyword Description....934
Table 8.152: SURFROCK Keyword Description....938
Table 8.153: SURFVISC Keyword Description....941
Table 8.154: SWCR Keyword Description....943
Table 8.155: SWFN Keyword Description....945
Table 8.156: SWL Keyword Description....947
Table 8.157: SWLPC Keyword Description....948
Table 8.158: SWOF Keyword Description....950
Table 8.159: SWU Keyword Description....952
Table 8.160: TLMIXPAR Keyword Description....955
Table 8.161: TOLCRIT Keyword Description....956
Table 8.162: TRACER Keyword Description....959
Table 8.163: TZONE Keyword Description....971
Table 8.164: VISCREF Keyword Description....979
Table 8.165: WATDENT Keyword Description....981
Table 8.166: WATVISCT Keyword Description....982
Table 9.1: REGION Section Allocation Array Summary....984
Table 9.2: ENDNUM Keyword Description....988
Table 9.3: EQLNUM Keyword Description....989
Table 9.4: FIP Keyword Description....991
Table 9.5: FIPNUM Keyword Description....992
Table 9.6: HM Region Grid Gradient Parameter Keyword List....997
Table 9.7: HM Region End-Point Gradient Parameter Keyword List....998
Table 9.8: HWSNUM Keyword Description....1000
Table 9.9: IMBNUM Keyword Description....1001
Table 9.10: KRNUM Keyword Description....1004
Table 9.11: LSLTWNUM Keyword Description....1006
Table 9.12: LSNUM Keyword Description....1007
Table 9.13: LWSLTNUM Keyword Description....1008
Table 9.14: LWSNUM Keyword Description....1009

Table 9.15: MISNUM Keyword Description....1010
Table 9.16: PLMIXNUM Keyword Description....1013
Table 9.17: PVTNUM Keyword Description....1014
Table 9.18: RESIDNUM Keyword Description....1018
Table 9.19: ROCKNUM Keyword Description....1019
Table 9.20: RPTREGS Keyword Description....1020
Table 9.21: SATNUM Keyword Description....1021
Table 9.22: SURFNUM Keyword Description....1022
Table 9.23: SURFWNUM Keyword Description....1023
Table 9.24: TNUM Keyword Name Format....1024
Table 9.25: TNUM Keyword Data Description....1024
Table 9.26: TRKPF Keyword Name Format....1026
Table 9.27: TRKPF Keyword Data Description....1026
Table 9.28: WH2NUM Keyword Description....1028
Table 9.29: WH3NUM Keyword Description....1029
Table 10.1: APIVD Keyword Description....1034
Table 10.2: AQANCONL Keyword Description....1036
Table 10.3: AQUFET Keyword Description....1045
Table 10.4: AQUFETP Keyword Description....1048
Table 10.5: DATUM Keyword Description....1052
Table 10.6: DATUMR Keyword Description....1053
Table 10.7: DATUMR Keyword Description....1054
Table 10.8: EQUIL Keyword Description....1061
Table 10.9: GASCONC Keyword Description....1063
Table 10.10: GASSATC Keyword Description....1064
Table 10.11: GCVD Keyword Description....1065
Table 10.12: PRESSURE Keyword Description....1077
Table 10.13: PBUB Keyword Description....1082
Table 10.14: PBVD Keyword Description....1083
Table 10.15: PDEW Keyword Description....1084
Table 10.16: PDVD Keyword Description....1085
Table 10.17: PRESSURE Keyword Description....1086
Table 10.18: PRVD Keyword Description....1087
Table 10.19: RESTART Keyword Description....1093
Table 10.20: RPTRST Keyword Description....1097
Table 10.21: Data Sets Automatically Written to the RESTART File....1098
Table 10.22: RPTSOL Keyword Description....1099
Table 10.23: RS Keyword Description....1100
Table 10.24: RSVD Keyword Description....1101
Table 10.25: RTEMPVD Keyword Description....1103
Table 10.26: RV Keyword Description....1105
Table 10.27: RVVD Keyword Description....1106
Table 10.28: SALT Keyword Description....1107
Table 10.29: SALTREST Keyword Description....1108
Table 10.30: SALTPVD Keyword Description....1109
Table 10.31: SALTVD Keyword Description....1111
Table 10.32: SCVD Keyword Description....1114
Table 10.33: SFOAM Keyword Description....1116
Table 10.34: SGAS Keyword Description....1117
Table 10.35: SOIL Keyword Description....1118
Table 10.36: SPOLY Keyword Description....1119
Table 10.37: SOLVCONC Keyword Description....1121
Table 10.38: SOLVFRAC Keyword Description....1122
Table 10.39: SSOL Keyword Description....1123
Table 10.40: SURF Keyword Description....1124
Table 10.41: SWAT Keyword Description....1125
Table 10.42: TBLK Keyword Description....1126
Table 10.43: TEMPI Keyword Description....1128
Table 10.44: TEMPVD Keyword Description....1129
Table 10.45: THPRES Keyword Description....1131
Table 10.46: VAPPARS Keyword Description....1134
Table 11.1: OPM Flow Summary Output File Summary....1140
Table 11.2: RUNSPEC Input and Output File Format Keywords....1141

Table 11.3: OPM Flow File Naming Conventions....1142
Table 11.4: Summary Variable Mnemonic Syntax....1143
Table 11.5: Summary Variable Mnemonics Examples....1144
Table 11.6: Summary Variable Mnemonics Examples Not Following the General Syntax....1144
Table 11.7: Summary Variable Format....1147
Table 11.8: Aquifer Summary Variables....1148
Table 11.9: Field, Group, Well, Well Connection and Completion Summary Variables....1155
Table 11.10: Field and Group Control Mode Reporting....1156
Table 11.11: Well Control Mode Reporting....1157
Table 11.12: Block, Field and Region Summary Variables....1162
Table 11.13: Field and Region Summary Recovery Variables....1163
Table 11.14: API and Tracer Tracking Summary Variables....1166
Table 11.15: Brine and Multi-Component Brine Model Summary Variables....1170
Table 11.16: Foam Model Tracers Summary Variables....1172
Table 11.17: Multi-Segment Wells Summary Variables....1176
Table 11.18: OPM Flow Simulator Performance Summary Variables....1181
Table 11.19: Polymer Model Summary Variables....1184
Table 11.20: Solvent Model Summary Variables....1186
Table 11.21: Thermal Model Summary Variables....1188
Table 11.22: User Define Quantities Summary Variables....1189
Table 11.23: Standard Production, Injection, and Pressure Summary Variables....1194
Table 11.24: Standard Aquifer Summary Variables....1194
Table 11.25: FMWSET - Standard Field and Group Well Status Summary Variables....1199
Table 11.26: GMWSET - Standard Field and Group Well Status Summary Variables....1201
Table 11.27: Simulator Performance Summary Variables (Cumulative Messages)....1202
Table 11.28: Simulator Performance Summary Variables (Numerical Performance)....1209
Table 11.29: RPTSMRY Keyword Description....1213
Table 11.30: SUMTHIN Keyword Description....1217
Table 12.1: Major Well Specification Keywords....1223
Table 12.2: Major Group Specification Keywords....1223
Table 12.3: Schedule Advancement, Control and Reporting Keywords....1224
Table 12.4: ACTIONX Keyword Description....1247
Table 12.5: ACTIONX Variable Definitions....1250
Table 12.6: COMPDAT Keyword Description....1264
Table 12.7: COMPDATL Keyword Description....1268
Table 12.8: COMPIMB Keyword Description....1272
Table 12.9: COMPLUPL Keyword Description....1275
Table 12.10: COMPLUMP Keyword Description....1278
Table 12.11: COMPORD Keyword Description....1280
Table 12.12: COMPSEGL Keyword Description....1286
Table 12.13: COMPSEGS Keyword Description....1289
Table 12.14: DATES Keyword Description....1296
Table 12.15: DRSDT Keyword Description....1305
Table 12.16: DRSDTR Keyword Description....1307
Table 12.17: DRVDT Keyword Description....1309
Table 12.18: DRVDTR Keyword Description....1310
Table 12.19: EXIT Keyword Description....1317
Table 12.20: GCALECON Keyword Description....1330
Table 12.21: GCONCAL Keyword Description....1332
Table 12.22: GCONENG Keyword Description....1334
Table 12.23: GCONINJE Keyword Description....1337
Table 12.24: GCONPRI Keyword Description....1339
Table 12.25: GCONPROD Keyword Description....1343
Table 12.26: GDCQECON Keyword Description....1351
Table 12.27: GECON Keyword Description....1354
Table 12.28: GECONT Keyword Description....1357
Table 12.29: GEFAC Keyword Description....1359
Table 12.30: GCONENG Keyword Description....1360
Table 12.31: GRUPNET Keyword Description....1375
Table 12.32: GRUPTARG Keyword Description....1380
Table 12.33: GRUPTREE Keyword Description....1381
Table 12.34: LGRFREE Keyword Description....1395
Table 12.35: LGRLOCK Keyword Description....1396

Table 12.36: LGROFF Keyword Description....1397
Table 12.37: LGRON Keyword Description....1398
Table 12.38: NEXT Keyword Description....1414
Table 12.39: NEXTSTEP Keyword Description....1415
Table 12.40: NEXTSTPL Keyword Description....1418
Table 12.41: PIMULTAB Keyword Description....1424
Table 12.42: PRIORITY Keyword Description....1431
Table 12.43: PYACTION Keyword Description....1434
Table 12.44: PYACTION Module Script Definition....1435
Table 12.45: RPTSCHED Keyword Description....1454
Table 12.46: SCDPTRAC Keyword Description....1464
Table 12.47: TIME Keyword Description....1475
Table 12.48: TSTEP Keyword Description....1477
Table 12.49: TUNING Keyword Description....1482
Table 12.50: TUNINGDP Keyword Description....1484
Table 12.51: TUNINGH Keyword Description....1485
Table 12.52: TUNINGL Keyword Description....1489
Table 12.53: TUNINGS Keyword Description....1493
Table 12.54: UDQ Keyword Description....1496
Table 12.55: VFPCHK Keyword Description....1502
Table 12.56: VFPINJ Keyword Description....1505
Table 12.57: VFPPROD Keyword Description....1510
Table 12.58: VFPTABL Keyword Description....1513
Table 12.59: WCONHIST Keyword Description....1523
Table 12.60: WCONINJE Keyword Description....1528
Table 12.61: WCONINJH Keyword Description....1530
Table 12.62: WCONPROD Keyword Description....1535
Table 12.63: WECON Keyword Description....1547
Table 12.64: WECONINJ Keyword Description....1549
Table 12.65: WECONT Keyword Description....1552
Table 12.66: WEFAC Keyword Description....1554
Table 12.67: WELCNTL Keyword Description....1556
Table 12.68: WELOPEN Keyword Description....1561
Table 12.69: WELOPENL Keyword Description....1565
Table 12.70: WELSEGS Keyword Description....1572
Table 12.71: WELSPECL Keyword Description....1580
Table 12.72: WELSPECS Keyword Description....1583
Table 12.73: WELTARG Keyword Description....1586
Table 12.74: WFOAM Keyword Description....1587
Table 12.75: WGRUPCON Keyword Description....1595
Table 12.76: WHEDREFD Keyword Description....1596
Table 12.77: WHISTCTL Keyword Description....1597
Table 12.78: WHTEMP Keyword Description....1599
Table 12.79: WINJTEMP Keyword Description....1601
Table 12.80: WLIST Keyword Description....1606
Table 12.81: WLISTARG Keyword Description....1609
Table 12.82: WLISTNAM Keyword Description....1610
Table 12.83: WPAVE Keyword Description....1617
Table 12.84: WPAVDEP Keyword Description....1618
Table 12.85: WPIMULT Keyword Description....1620
Table 12.86: WPIMULT Keyword Description....1622
Table 12.87: WPITAB Keyword Description....1624
Table 12.88: WPOLYMER Keyword Description....1626
Table 12.89: WRFT Keyword Description....1630
Table 12.90: WRFTPLT Keyword Description....1632
Table 12.91: WSALT Keyword Description....1634
Table 12.92: WSEGPROP Keyword Description....1652
Table 12.93: WSEGSICD Keyword Description....1657
Table 12.94: WSEGVALV Keyword Description....1665
Table 12.95: WELVALV Conversion Factor Constants and Units....1665
Table 12.96: WSOLVENT Keyword Description....1667
Table 12.97: WSURFACT Keyword Description....1668
Table 12.98: WTEMP Keyword Description....1670

Table 12.99: WTEST Keyword Description....1673
Table 12.100: WTRACER Keyword Description....1676
Table 12.101: WVFPDP Keyword Description....1678
Table B.1: New Keywords for the 2020-04 Release....1747
Table B.2: New Keywords for the 2019-10 Release....1751
Table B.3: New Keywords for the 2019-04 Release....1754
Table B.4: New Keywords for the 2018-10 Release....1755
Table B.5: New Keywords for the 2018-04 Release....1757
Table C.1: OPM Flow 2019-10 Command Line Options....1773
Table C.2: OPM Flow 2019-04 Command Line Options....1785
Table C.3: OPM Flow 2018-10 Command Line Options....1796
Table C.4: OPM Flow 2018-04 Command Line Options....1801
Table D.1: OPM Flow Output File Types Summary....1807
Table D.2: RUNSPEC Input and Output File Format Keywords....1808
Table D.3: OPM Flow File Naming Conventions....1810
Table D.4: Big-Endian and Little-Endian Representation....1810
Table D.5: Output File Keyword Format....1811
Table D.6: INTEHEAD Keyword - IWEL Example....1813
Table D.7: EGRID - Model Structural Data for Irregular Corner-Point Grids....1816
Table D.8: EGRID Header Keywords....1818
Table D.9: EGRID Global Irregular Corner Point Grid Keywords....1822
Table D.10: EGRID LGR Irregular Corner Point Grid Keywords....1825
Table D.11: EGRID NNC Keywords for Irregular Corner Point Grids....1828
Table D.12: INIT Data File Structure....1834
Table D.13: INIT Data – Static Data Header Keywords....1838
Table D.14: INIT Data – Static Grid Array Data Keywords....1841
Table D.15: INIT Data - LGR Static Data Header Keywords....1843
Table D.16: INIT Data - LGR Grid Array Data Keywords....1845
Table D.17: INIT Data – Static Tabular Data Header Keyword....1849
Table D.18: INIT Data – Static Tabular and Constant Data Array Keywords....1850
Table D.19: RESTART Data File Structure....1854
Table D.20: RESTART Data - Header Keywords....1864
Table D.21: RESTART Data – Group, Well and Connection Keywords (Groups)....1869
Table D.22: RESTART Data – Group, Well and Connection Keywords (Multi-Segment Wells)....1872
Table D.23: RESTART Data – Group, Well and Connection Keywords (Wells)....1877
Table D.24: RESTART Data – Group, Well and Connection Keywords (Connections)....1880
Table D.25: RESTART Data – Group, Well and Connection Keywords (Tracers)....1881
Table D.26: RESTART Data – Group, Well and Connection Keywords (Network)....1882
Table D.27: RESTART Data – Analytical Aquifer Data Keywords....1886
Table D.28: RESTART Data – Numerical Aquifer Data Keywords....1886
Table D.29: RESTART Data – Hidden Keyword....1888
Table D.30: RESTART Data - Solution Data keyword....1889
Table D.31: RESTART Data – Solution Data Keyword for Tracer Concentration Name....1890
Table D.32: RESTART Data - Solution Data Keywords....1895
Table D.33: RESTART Data - LGR Grid Header Keywords....1898
Table D.34: RESTART Data – LGR Solution Data Keywords....1899
Table D.35: RFT Data File Format....1903
Table D.36: RFT Data File – Time and Date Keywords....1903
Table D.37: RFT Data File – Well and Connection Data Keyword....1905
Table D.38: RFT Data File – RFT Solution Data Keywords....1906
Table D.39: SUMMARY Index File Keywords (Global)....1911
Table D.40: SUMMARY Index File Keywords (LGR)....1912
Table D.41: SUMMARY Index File Keywords (Commercial Simulator)....1912
Table D.42: SUMMARY Data File Keywords....1914
Table D.43: SUMMARY Data File Keywords (LGR)....1915

Index of Figures

Figure 2.1: OPMRUN: Initial Display....62
Figure 2.2: OPMRUN: Display Elements....63
Figure 2.3: OPMRUN: Add Job Dialog Box....63
Figure 2.4: OPMRUN: Load Job Queue Dialog Box and Queue Display....64
Figure 2.5: OPMRUN: Edit Job Parameter File....65
Figure 2.6: OPMRUN: Select Run Option Dialog Box....65
Figure 2.7: OPMRUN: Running Jobs....66
Figure 2.8: OPMRUN: Session Log File....66
Figure 2.9: OPMRUN: Configuration Options....70
Figure 2.10: OPMRUN: Configuration Options - Project Directories....70
Figure 2.11: OPMRUN Tools: Compress Jobs....71
Figure 2.12: OPMRUN Tools: Keyword Generator - Menu Location....72
Figure 2.13: OPMRUN Tools: Keyword Generator - Dialog Window....73
Figure 2.14: OPMRUN Tools: Keyword Generator - Keyword Filter Example....74
Figure 2.15: OPMRUN Tools: Keyword Generator - INCLUDE Keyword Example....75
Figure 2.16: OPMRUN Tools: Keyword Generator - RUNSPEC Keyword Example....76
Figure 2.17: OPMRUN Tools: Keyword Generator - SUMMARY Keyword Example....77
Figure 2.18: OPMRUN Tools: Keyword Generator - SCHEDULE Keyword Example....78
Figure 2.19: OPMRUN Tools: Keyword Generator – DATA Option Example....79
Figure 2.20: OPMRUN Tools: Keyword Generator – MODEL Option Example....80
Figure 2.21: OPMRUN Tools: Keyword Generator - Saving the Keywords....81
Figure 2.22: OPMRUN Tools: Keyword Generator - Edit a Template and Template Help....82
Figure 6.1: Numerical Model Dimensions....274
Figure 6.2: SPE Simulation Case #01 Cartesian Regular Grid....275
Figure 6.3: Norne Field Grid Skeleton....277
Figure 6.4: Norne Field Corner-Point Geometry Example....278
Figure 6.5: Norne Grid Ternary Solution Display....279
Figure 7.1: Volve Full Field Model PORV Array....531
Figure 7.2: Volve Full Field Model TRANX Array....531
Figure 8.1: Volve Field Live Oil PVT Data....562
Figure 8.2: Volve Field Gas Dry PVT Data....563
Figure 8.3: Example Oil-Water Relative Permeability Curves....564
Figure 8.4: Example Gas-Oil Relative Permeability Curves....565
Figure 9.1: Volve Full Field Model SATNUM Array....985
Figure 9.2: Volve Full Field Model EQUIL Array....985
Figure 12.1: Calibration of Well Productivity Index....1232
Figure 12.2: Well Calibration Example....1233
Figure 12.3: Norne Group Tree Hierarchy Example....1382
Figure 12.4: RPTSCHED: FIP (Balance) Report....1455
Figure 12.5: RPTSCHED: WELLS - Production Sub-Report....1455
Figure 12.6: RPTSCHED: WELLS - Injection Sub-Report....1456
Figure 12.7: RPTSCHED: WELLS - Cumulative Production and Injection Sub-Report....1456
Figure 12.8: RPTSCHED: WELLSPECS - Production Well Control Sub-Report....1457
Figure 12.9: PTSCHED: WELLSPECS - Well Connection Data Sub-Report....1457
Figure 12.10: RPTSCHED: WELLSPECS - Multi Segment Well Structure Sub-Report....1458
Figure 12.11: RPTSCHED: WELLSPECS - Multi Segment Well Connection Sub-Report....1458
Figure 12.12: Multi-Segment Well OP01 Completion 3D View....1575
Figure B.1: Module Structure for 2019-10 Release....1752
Figure B.2: Module Structure for 2018-04 Release....1756
Figure D.1: IWEL Property Keyword Example....1813
Figure D.2: ICON Property Keyword Example....1813

CHAPTER 1: INTRODUCTION

1.1 OVERVIEW

OPM Flow is a fully-implicit, black-oil simulator capable of running industry-standard simulation models. The simulator is implemented using automatic differentiation to enable rapid development of new fluid models. The program is in active development with new features added in each bi-annual release. Currently the program has the following functionality:

Model Formulation:

- Back-oil with dissolved gas and vaporized oil.
- Rock-dependent capillary and relative-permeability curves.
- End-point scaling and hysteresis.
- Oil vaporization controls (VAPPARS).
- Rock compaction.

EOR Options:

- The Polymer Model in OPM Flow is based on a black-oil polymer formulation, which is developed by extending the black-oil model with a polymer component. The effects of the polymer mixing are simulated based on the Todd-Longstaff mixing model, and adsorption, dead pore space, and permeability reduction effects are also considered. A logarithmic shear thinning/thickening model has also been incorporated since the 2015-10 Release (see *Flow-polymer*). Note that Polymer model has now been incorporated into the main OPM Flow simulator and is no longer a separate simulator.
- The Solvent Model in OPM Flow extra component is again based on extending the black-oil oil formulation with a fourth component the simulator by adding a solvent component to the gas phase (see *Flow-solvent*). Note that Solvent model has now been incorporated into the main OPM Flow simulator and is no longer a separate simulator.
- An experimental foam module has been added to OPM Flow 2019-10 release. With this it is possible to simulate certain types of surfactant injection. Such injection stimulates formation of foam to change mobility ratios, and give better reservoir sweep. The implemented foam model treats surfactant transported in the gas phase, and reduces the mobility of that phase depending on the surfactant concentration. In addition to mobility reduction, adsorption to the reservoir rock is included in the model.

Description of Geology:

- Rectilinear and fully-unstructured grid.
- Corner-point grids from the commercial simulator input, including fault and region multipliers, minimum pore volume, pinch outs, etc.

Well and Group Controls:

- Bottom-hole pressure and surface/reservoir rate.
- Group controls.
- Shut/stop/open individual completions.
- History-matching wells.
- Well lists.
- Action conditions and command processing.

Input and Output:

- General reader/parser for Eclipse input decks.
- XML-based or simple text-format input of additional parameters.
- Flexible output of summary and restart files in Eclipse format.
- Logging to terminal and print file.

Simulation Technology:

- Fully-implicit in time.
- Two-point flux approximation in space with upstream-mobility weighting.
- Flexible assembly through the use of automatic differentiation.
- Block-structured linear solver with ILU0 pre-conditioner.
- Adaptive step-size controls.

CHAPTER 2: INSTALLING AND RUNNING FLOW

2.1 INSTALLING OPM FLOW

OPM Flow can be installed and used in a variety of ways. Perhaps the simplest way is to use the operating system's package manager to install the OPM modules as binary packages, including OPM Flow and other OPM programs. That way all prerequisite libraries will automatically be installed on the system. This is supported on Ubuntu Linux version 16.04 and Red Hat Enterprise (or CentOS) version 6 or 7.

OPM Flow can also be used via a Docker container. This allows OPM Flow to run on any system that supports Docker, including Microsoft Windows, without installing prerequisite libraries or affecting any other software on your system.

Finally, OPM Flow can be installed by compiling from source on Linux or macOS systems.

2.1.1 UBUNTU LINUX 16.04 (64-BIT VERSION ONLY) AND HIGHER

The easiest way to install the Ubuntu packages is to first add the OPM personal package archive (ppa). In order to do that we need to install the apt-add-repository command.

```
sudo apt-get update

sudo apt-get install software-properties-common
```

Then we add the repository, and run update again:

```
sudo apt-add-repository ppa:opm/ppa

sudo apt-get update
```

At this point, all the OPM modules should be available to install. To see a list of (for example) the opm-simulators packages:

```
apt-cache search opm-simulators
```

Then, to install the opm-simulators programs (including Flow) and their dependencies,

```
sudo apt-get install mpi-default-bin

sudo apt-get install libopm-simulators-bin
```

Notes

1) The mpi install above is required for the mpi libraries which the OPM executables are linked to, even those that are not intended to be run with mpirun. The reason the OPM packages do not depend on that package is that by Debian policy the user should be allowed to choose which MPI implementation to use (above we picked the default set by Ubuntu).

2) If an old versions of prerequisite libraries have already been installed (for example from installing a previous release of OPM) it may be necessary to upgrade them via the following commands:

```
sudo apt-get update

sudo apt-get upgrade
```

3) Some users have experienced trouble with OPM Flow simply aborting with no error message. In some cases that can be related to locale issues. Check by running the "locale" command. OPM Flow requires the "C" or an English locale to run correctly. One way to fix this can be to put the following in your ".bash_profile" (note the initial period or full stop in the filename), and open a new terminal (command) window:

```
LANG="en_US.UTF-8"

export LANG

LC_ALL="en_US.UTF-8"

export LC_ALL
```

2.1.2 Red Hat Enterprise or CentOS (version 6 or 7)

First add the OPM package repository:

```
sudo yum-config-manager --add-repo \
http://www.opm-project.org/package/opm.repo
```

The OPM software is split in several packages. To list all available OPM packages one can use:

```
sudo yum search opm-
```

For example you can install the opm-simulators binary package to get access to the OPM Flow reservoir simulator:

```
sudo yum install opm-simulators-bin
```

Development packages are available using the -devel suffix. For example, to install the opm-upscaling development package use:

```
sudo yum install opm-upscaling-devel
```

2.1.3 Using a Docker container

See the tutorial on the OPM website *Running Flow in Docker.*

2.1.4 Installing from source

See instructions on the OPM website *Building from Source*.

2.2 RUNNING OPM FLOW 2020-04 FROM THE COMMAND LINE

This section describes how to run the OPM Flow simulator and the various command line options associated with this release, the command line syntax for running OPM Flow is:

```
flow [OPTIONS] CASENAME
```

and typing the following command from your terminal:

```
flow CASENAME
```

will start the simulator and run the case specified by CASENAME.DATA. Alternatively, you can type the path to the binary and the *.DATA file, as per the example below:

```
path_to_binary/flow path_to_data/CASENAME
```

The simulator can also be run using command line parameters for example to run the previous CASENAME one could use:

```
flow --ecl-deck-file-name=path_to_data/CASENAME
```

Note that there must be no spaces around the equals sign.

By default output files are generated in the same folder as the *.DATA file. To override this one can use the *–ecl-output-dir* command line parameter, for instance:

```
flow --ecl-output-dir=foo CASENAME
```

will send the output files to the foo directory. Alternatively one can use a parameter file to define the input deck and the various parameters via:

```
flow –-parameter-file=path_to_data/CASENAME.param
```

If one wishes to use the same parameter file for various cases one can use the same parameter file followed by the DATA file, for example:

```
flow –-parameter-file=path_to_data/CASENAME.param CASENAME.DATA
```

If OPM Flow is installed with parallel capabilities:

```
mpirun -np 4 flow --parameter-file=path_to_data/CASENAME.param
```

will start OPM Flow on four nodes etc.

A list of command line options for this release is outlined in Table 2.1 and past releases are documented in section *APPENDIX C: RUNNING PREVIOUS RELEASES OF OPM FLOW*.

Note

On Red Hat based distributions, including centOS distributions, one needs to install the openmpi version of the simulator, opm-simulators-openmpi-bin, via:

sudo yum install opm-simulators-openmpi-bin

and then set the MPI version to use. The way this is done is by first making the module command available, by running the following command:

. /usr/share/Modules/init/bash

Then query for the installed modules with:

module avail

And lastly, you tell the system it to use openmpi with:

module add mpi/openmpi-x86_64

On Ubuntu based distributions, there is no need for this as openmpi is installed and mpirun just works.

Additional tutorials for running OPM Flow is available on OPM website in the *Tutorials* section.

OPM Flow release 2018-10 and beyond have switched to the eWoms/ebos[1] command line interface. Previously the simulator used only OPM Flow specific command line parameters which were internally translated to the equivalent eWoms/ebos command line parameters. The pre 2018-10 set of command line parameters are now depreciated but are still documented in section *APPENDIX C: RUNNING PREVIOUS RELEASES OF OPM FLOW* for backward compatibility with previous releases of the simulator. For the 2020-04 release a combination of OPM Flow and eWoms/ebos command line parameters are available as tabulated in Table 2.1 on this and subsequent pages. It is anticipated that future releases of OPM Flow will fully migrate to the eWoms/ebos command line parameter set.

OPM Flow accepts command line options to control various aspects of the simulator's run time behavior, as described in the table below. To give a command line option use "key=value" syntax, with no spaces around the equals sign. It is also possible to put multiple options together in a parameter file. To do so, put one option on each line of the file with ".param" as the extension and pass that filename as a command line parameter to OPM Flow using:

```
flow --parameter-file=CASENAME.PARAM
```

to instruct OPM Flow to read the parameter file.

A complete list of command line options and their function is given in the table below.

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
	General eWoms/ebos Command Line Parameters		
1	-h or --help	A character string that causes OPM Flow to print a help message that gives a brief description of the available command line parameters.	N/A

[1] *eWorms is a C++ software framework concerned with fully-implicit numerical models for flow and transport in porous media. It it is developed as an integral part of the Open Porous Media (OPM) initiative.*

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
2	--continue-on-convergence-error	A Boolean value set to true or false that that instructs the simulator to continue (true) with a non-converged solution instead of giving up (false) if it encounter a time step size smaller than the minimum time step size.	false
3	--cpr-ell-solvetype	A positive integer that defines the solver type of the elliptic pressure solver: 0) 0: bicgstab, 1) 1: cg, 2) 2: only amg preconditioner)	0
4	--cpr-max-ell-iter	A positive integer that sets the maximum number of Iterations for the elliptic pressure part of the Constrained Pressure Residual ("CPR") solver.	20
5	--cpr-reuse-setup	A positive integer that defines if the CPR solver should re-use the Amg setup.	0
6	--cpr-solver-verbose	A defined positive integer value that defines the output from CPR solver: 1) 0: no output 2) 1: output summary of inner linear solver 3) 2: output extensive information about inner linear solve, including setup information	0
7	--cpr-use-drs	A Boolean value set to true or false that switches on (true) or off (false) the use of dynamic row sum weights in the CPR solver.	false
8	--dbph-max-rel	A real positive value that sets maximum relative change of the bottom-hole pressure in a single iteration	1.0
9	--dp-max-rel	A real positive double precision value that sets the maximum allowed relative change of pressure per iteration.	0.3
10	--ds-max	A real positive double precision value that sets the maximum allowed change in saturation per iteration.	0.2
11	--dwell-fraction-max	A real positive double precision value that sets the maximum allowed change in well's volume fraction per iteration.	0.2
12	--ecl-deck-file-name	A character string that defines the name of the OPM Flow input file which contains the simulator's ECLIPSE formatted input deck to be simulated.	""

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
13	--ecl-enable-drift-compensation	A Boolean value set to true or false that enables (true) or disables (false) partial compensation of systematic mass losses via the source term of the next time step.	false
14	--ecl-output-double-precision	A Boolean value set to true or false that switches on (true) or off (false) double precision in restart files. Useful for 'perfect' restarts.	false
15	--ecl-output-interval	An integer value defining the number of report steps that ought to be skipped between two writes of restart files results.	-1
16	--ecl-strict-parsing	A Boolean value set to true or false that switches on (true) or off (false) strict parsing mode for parsing - all errors are collected before the application exists. Useful for debugging initial runs.	false
17	--edge-weights-method	A defined positive integer value that defines the edge-weighing strategy: 1) 0: for uniform, 2) 1: for trans, 0r 3) 2" for log(trans).	1
18	--enable-adaptive-time-stepping	A Boolean value set to true or false that turns on (true) or off (false) adaptive time stepping. If set to false the report time steps provided by the input deck are used.	true
19	--enable-async-ecl-output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to restart and summary files in the commercial simulators format.	true
20	--enable-async-vtk-output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to the VTK output files.	true
21	--enable-dry-run	A Boolean value set to true or false that specifies if the simulation should actually run, (true) or just check the input deck (false). This option is equivalent to activating the NOSIM keyword in the RUNSPEC section of the input deck (see section *5.2.78 NOSIM – Activate the No Simulation Mode for Data File Checking*).	true
22	--enable-ecl-output	A Boolean value set to true or false that specifies if the binary output files (restart, summary files, etc.) should be written in the commercial simulator's format (true), or OPM Flow's format (false).	true

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
23	--enable-logging-fallout-warning	A Boolean value set to true or false that sets the developer option to see whether logging was on non-root processors (true). If set to true output will be appended to the *.DBG or *.PRT files.	false
24	--enable-opm-rst-file	A Boolean value set to true or false to write OPM specific data sets to the commercial simulators restart file to enable restart of an OPM Flow runs (true), or not to write the data (false).	true
25	--enable-storage-cache	A Boolean value set to true or false that turns on (true) or off (false) storing previous storage terms and avoid re-calculating them.	true
26	--enable-terminal-output	A Boolean value set to true or false that turns on (true) or off (false) high-level information about the simulation's progress to the terminal	true
27	--enable-tracer-mode	A Boolean value set to true or false that turns on (true) or off (false) transport tracer calculations for when tracers have been declared in the input deck. **Experimental - use with caution.**	false
28	--enable-tuning	A Boolean value set to true or false that instructs OPM Flow to read the time stepping parameters from the *TUNING - Numerical Tuning Control* keyword in the input deck, if set to true. Note that only the first record of the TUNING keyword is processed.	false
29	--enable-vtk-output	A Boolean value set to true or false that turns on (true) or off (false) a global switch for writing VTK files.	false
30	--enable-well-operability-check	A Boolean value set to true or false that enables (true) checking of a well's operating status, or disables (false) the checking.	true
31	--enable-write-all-solutions	A Boolean value set to true or false that turns on (true) or off (false) the writing of all solutions to disk instead of only the ones for the report steps.	false
	OPM Flow Specific Command Line Parameters		
32	--flow-linear-solver-verbosity	A positive integer value that defines the output from linear solver: 1) 0: no extra output 2) 1: output per solution iteration 3) >1: output per iteration	0

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
33	--flow-newton-max-iterations	A positive integer that defines the maximum number of Newton iterations per time step used by the simulator.	20
34	--flow-newton-min-iterations	A real positive value that sets the minimum number of Newton iterations per time step used by the simulator.	1
	General eWoms/ebos Command Line Parameters		
35	--force-disable-fluid-in-place-output	A Boolean value set to true or false that instructs OPM Flow to not to print the Fluid In-Place report after each report time step (true) or not (false).	false
36	--full-time-step-initially	A Boolean value set to true or false that instructs OPM Flow to always attempt to finish a report step using a single time step (true) or not (false).	false
37	--ignore-keywords	A character string that defines a list of keywords which should be ignored by OPM Flow. The keyword string should be enclosed in quotes and each keyword separated by a colon, that is ':' .	“”
38	--ilu-fillin-level	A positive integer value that sets the fill in level for the ILU pre-conditioner.	0
39	--ilu-redblack	A Boolean value set to true or false that instructs OPM Flow to use red-black partitioning for the ILU pre-conditioner. (true) or not (false).	false
40	--ilu-relaxation	A real positive double precision value that sets the relaxation factor of the linear solver's ILU pre-conditioner	0.9
41	--ilu-reorder-spheres	A Boolean value set to true or false specifies OPM Flow to reorder the entries of the matrix in the red-black ILU pre-conditioner in spheres starting at an edge (true) or not (false) If false the original ordering is preserved in each color. Otherwise try to ensure D4 ordering (in a 2D structured grid, the diagonal elements are consecutive).	false
42	--initial-time-step-in-days	A real double precision value that sets the size of initial time step in days.	1.0

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
43	--linear-solver-configuration	A defined quoted character string that sets the configuration of the solver, valid values are: 1) ilu0 (default), 2) cpr_quasiimpes, 3) cpr_trueimpes, or 4) a file specified by the LinearSolverConfigurationJsonFile parameter. The default is "ilu0".	ilu0
44	--linear-solver-configuration-json-file	A character string enclosed in quotes that defines the filename of a JSON configuration file for the flexible linear solver system.	none
45	--linear-solver-ignore-convergence-failure	A Boolean value set to true or false that if set to true convergences failures in the linear solver are ignored. This option should be used with care, as the results may be unreliable.	false
46	--linear-solver-max-iter	A positive integer value that defines the maximum number of linear iterations.	200
47	--linear-solver-reduction	A real positive double precision value that sets the tolerance for the linear solver. The linear solver convergences when the residual is reduced sufficiently.	0.01
48	--linear-solver-require-full-sparsity-pattern	A Boolean value set to true or false that if set to true the simulator will produce the full sparsity pattern for the linear solver.	false
49	--linear-solver-restart	A positive integer value that sets the number of iterations after which GMRES is restarted.	40
50	--matrix-add-well-contributions	A Boolean value set to true or false that if set to true explicitly specifies the influences of wells between cells in the Jacobian and pre-conditioner matrices.	false
51	--max-inner-iter-ms-wells	A positive integer value that defines the maximum number of inner iterations for multi-segment wells.	100
52	--max-pressure-change-ms-wells	A real positive value that defines the maximum relative pressure change for a single iteration of the multi-segment well model.	1.0×10^6
53	--max-residual-allowed	A real positive value that sets the absolute maximum tolerance for residuals without cutting the time step size.	1.0×10^7

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
54	--max-single-precision-days	A real positive value that set the maximum time step size where single precision floating point arithmetic can be used solving for the linear systems of equations.	20.0
55	--max-strict-iter	A positive integer that sets the maximum number of Newton iterations before relaxed tolerances are used for the CNV convergence criterion.	8
56	--max-welleq-iter	A positive integer that defines the maximum number of iterations to determine the solution to the well equations.	30
57	--milu-variant	A defined character string that specifies which variant of the modified-ILU preconditioner ought to be used. Possible variants are: 1) ILU (default, plain ILU), 2) MILU_1 (lump diagonal with dropped row entries), 3) MILU_2 (lump diagonal with the sum of the absolute values of the dropped row entries), 4) MILU_3 (if diagonal is positive add sum of dropped row entries. Otherwise subtract them), 5) MILU_4 (if diagonal is positive add sum of dropped row entries. Otherwise do nothing. The default is ILU	ILU
58	--min-time-step-before-shutting-problematic-wells-in-days	A real positive value that sets the minimum time step size in days for which problematic wells are not shut. Time steps below this value will result in problematic wells being shut-in by the simulator.	0.25
59	--newton-max-relax	A real positive value that sets the maximum relaxation factor of a Newton iteration used by the simulator.	0.5
60	--newton-relaxation-type	A character string that defines the type of relaxation used in Newton's method, default is dampen.	dampen
61	--output-dir	A character string that defines the directory to which OPM Flow is to write the commercial simulator compatible output files (restart, summary files etc.). The default value results in the files be written to the same directory as the input file.	“”
62	--output-interval	A positive integer that specifies the number of report steps between two consecutive writes of restart data.	1

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
63	--output-mode	A character string that defines the output to the *.PRT and *.DEBUG files: 1) none: No output to the files. 2) log or false: Output logging information only. 3) all or true: Output everything. For example to just output logging information use: `--output-mode=log or --output-mode=false`	all
64	--owner-cells-first	A Boolean value set to true or false that determines if the cells owned by a rank should be ordered before ghost/overlapping the cells (true), or not (false).	true
65	--parameter-file	A character string that defines the name of a parameter file which contains the simulator's set of run-time parameters, as listed in this table.	""
66	--pri-var-oscilation-threshold	A real positive vale that defines the threshold value for the primary variable switching conditions after its meaning has switched to hinder oscillations.	1×10^{-5}
67	--print-parameters	A positive integer value that request that the run time parameters be printed at the start of the run: 1) 0: No output to the files. 2) 1: Output *.DBG file 3) 2: Output to *.DBG and *.PRT files (default)	2
68	--print-properties	A positive integer value that request that the compile time parameters be printed at the start of the run: 1) 0: No output to the files. 2) 1: Output *.DBG file 3) 2: Output to *.DBG and *.PRT files (default)	2
69	--scale-linear-system	A Boolean value set to true or false that switches on (true) or off (false) the scaling of linear system of equations according to the equation scale and primary variable types.	false
70	--sched-restart	A Boolean value that determines for a restart run if the case should initialize wells and groups from the historical SCHEDULE section (true), or from the well and group data on the restart file (false). Note that the commercial simulator always uses data from the restart file (false).	true

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
71	--solve-welleq-initially	A Boolean value set to true or false that switches on (true) or off (false) the solving of the well equations as a pre-processing step. Note that the well equations are always added to the full system and solved until converged.	true
72	--solver-growth-factor	A real positive value that specifies the allowed value a time step can be increased by, subject to the maximum allowable time step size set by the *--flow-solver-max-time-step-in-days* parameter. For example, if the current time step has converged at 10 days and *--flow-solver-growth-factor* is set to the default value, then the next time step will be 2.0 * 10 days, that is at 20 days.	2.0
73	--solver-max-growth	A real positive value that specifies the maximum allowed value a time step can be increased by after a report time step. subject to the maximum allowable time step size set by the *--flow-solver-max-time-step-in-days* parameter.	3.0
74	--solver-max-restarts	A positive integer that defines the number of allowed consecutive restarts (or time step chops) before the simulation is terminated.	10
75	--solver-max-time-step-in-days	A real positive double precision value that specifies the maximum allowed time step size in days.	365
76	--solver-min-time-step	A real positive double precision value that specifies the minimum size of a time step in seconds. If a step cannot converge without getting cut below this step size the simulator will stop.	0.0
77	--solver-restart-factor	A real positive double precision value that sets the time step chop factor of the time step after a convergence failure. For example, if the current non-convergent time step is 30 days and *--flow-solver-restart-factor* is set to the default value, then the time step will be repeated using 0.33 * 30 days as the time step, that is 9.9 days.	0.33
78	--solver-verbosity	A positive integer that specifies the "chattiness" of the non-linear solver.	1

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
79	--system-strategy	A character string that defines the strategy for reformulating and scaling linear system of equations and is set to one of the following: 1) none: No scaling - should not be used with the CPR solver. 2) original: Use weights that are equivalent to no scaling - should not be used with the CPR solver. 3) simple: Form pressure equation as simple sum of conservation equations. 4) quasiimpes: Form pressure equation based on diagonal block. 5) trueimpes: Form pressure equation based on linearization of the accumulation term.	none
80	--threads-per-process	A positive integer value that stipulates the maximum number of threads to be instantiated per process ('-1' means 'automatic').	-1
81	--time-step-after-event-in-days	A real double precision value that sets maximum allowed time step after an event; for example, when a well is open or closed etc. The default value of -1 means that events to do effect the time stepping.	-1
82	--time-step-control	A character string that defines the time stepping control algorithm and is set to one of the following: 1) pid: PID controller based adaptive time step control as suggested by Turek and Kuzmin[2]. 2) pid+iteration: Use PID and linear iteration numbers to guide the time step. 3) pid+newtoniteration: Use PID and non-linear iterations numbers to guide the time step. 4) Hardcoded: Use time steps supplied by user via the time-step-control-filename parameter.	pid
83	--time-step-control-decay-rate	A real positive value that specifies the decay rate a time step can be decreased by after the number of target iterations has been exceeded	0.75

[2] *Algebraic Flux Correction III. Incompressible Flow Problems. Uni Dortmund, Turek and Kuzmin, January, 2006 (DOI: 10.1007/3-540-27206-2_8)*

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
84	--time-step-control-file-name	A character string enclosed in quotes that specifies a filename where time steps are specified. The default is the character string timesteps For instance time steps can be generated by the ecl_summary application in libecl as per the following UNIX command line: `path_to_libecl_applications/ecl_summary DECK TIME > filename` Where: DECK is the name of the data deck you want to get the time steps from, TIME tells the application to return the timing for the run, and "filename" is the name of the file the times are piped to.	timesteps
85	--time-step-control-growth-rate	A real positive value that specifies the growth rate of the time step size of the number of target iterations is undercut.	1.25
86	--time-step-control-target-iterations	A positive integer that defines the number of linear iterations which the time step control scheme should aim for (if applicable).	30
87	--time-step-control-target-newton-iterations	A positive integer that specifies the number of Newtonian iterations which the time step control scheme should aim for (if applicable).	8
88	--time-step-control-tolerance	A real double precision value that sets the tolerance for PID (only used with the pid and pid+ options defined by the *–time-step-control* option).	0.1
89	--time-step-verbosity	A positive integer that specifies the "chattiness" during the time integration.	1
90	--tolerance-cnv	A real positive double precision value that specifies the maximum non-linear tolerance error. This is the local convergence tolerance (maximum of local saturation errors).	0.01
91	--tolerance-cnv-relaxed	A real positive value that defines the relaxed local convergence tolerance that applies for iterations after the iterations with the strict tolerance.	1.0×10^{9}
92	--tolerance-mb	A real positive double precision value that sets the maximum mass balance error, that is the tolerated mass balance error relative to total mass present.	1.0×10^{6}
93	--tolerance-pressure-ms-wells	A real positive double precision value that specifies the tolerance for the pressure equations for multi-segment wells.	1000

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
94	--tolerance-well-control	A real positive double precision value that sets the maximum tolerance for the well control equations.	1.0×10^{-7}
95	--tolerance-wells	A real positive double precision value that defines the maximum non-linear error for the well equations.	0.0001
96	-update-equations-scaling	A Boolean value set to true or false that switches on (true) or off (false) the updating of the scaling factors for mass balance equations during the simulation.	false
97	--use-amg	A Boolean value set to true or false that if set to true OPM Flow will use AMG as the linear solver's pre-conditioner	false
98	--use-cpr	A Boolean value set to true or false that when set to true OPM Flow will use CPR as the linear solver's pre-conditioner	false
99	--use-gmres	A Boolean value set to true or false that when set to true OPM Flow will use Generalized Minimal Residual ("GMRES") solver instead of Biconjugate Gradient Stabilized ("BiCGSTAB") as the linear solver within the Newton iterations.	false
100	--use-gpu	A Boolean value that when set to true will result in OPM Flow using the Graphics Processing Unit ("GPU") cusparseSolver as the linear solver.	false
101	--use-inner-iterations-ms-wells	A Boolean value set to true or false that when set to true the simulator will use nested iterations for multi-segment wells.	true
102	--use-multisegment-well	A Boolean value set to true or false that when set to true the simulator will use the well model for multi-segment wells instead of the one for single-segment wells.	false
103	--use-update-stabilization	A Boolean value set to true or false that switches on (true) or off (false) the stabilized Newton option. This option may improve convergence for some cases.	true
	VTK Graphics Command Line Parameters[3]		
104	--vtk-write-average-molar-masses	A Boolean value set to true or false that turns on (true) or off (false) the output of the average phase mass in the VTK output files.	false

[3] *Virtualization ToolKit ("VTK") files used to visualize the 3D results from the model using ParaView, an open-source, multi-platform general purpose data analysis and visualization application (https://www.paraview.org/overview/). For the commercial simulator's compatible output files OPM's ResInsight 3D visualization package can be used instead and is specifically tailored for OPM Flow and the commercial simulator.*

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
105	--vtk-write-densities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase densities to the VTK output files	true
106	--vtk-write-dof-index	A Boolean value set to true or false that turns on (true) or off (false) the output of the tracer concentrations to the VTK output files.	false
107	--vtk-write-ecl-tracer-concentration	A Boolean value set to true or false that turns on (true) or off (false) the output of the index of the degrees of freedom to the VTK output files.	false
108	--vtk-write-extrusion-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the of the extrusion factor of the degrees of freedom to the VTK output files.	false
109	--vtk-write-filter-velocities	A Boolean value set to true or false that turns on (true) or off (false) the output of the filter velocities of the phases in the VTK output files.	false
110	--vtk-write-fugacities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component fugacities to the VTK output files.	false
111	--vtk-write-fugacity-coeffs	A Boolean value set to true or false that turns on (true) or off (false) the output of the component fugacity coefficients to the VTK output files.	false
112	--vtk-write-gas-dissolution-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas dissolution factor (Rs) of the observed oil to the VTK output files.	false
113	--vtk-write-gas-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas formation volume factor (Bg) to the VTK output files.	false
114	--vtk-write-gas-saturation-pressure	A Boolean value set to true or false that turns on (true) or off (false) the output of the saturation pressure of gas (Pg,sat) to the VTK output files'	false
115	--vtk-write-intrinsic-permeabilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the intrinsic permeability to the VTK output files.	false
116	--vtk-write-mass-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the mass fractions to the VTK output files.	false
117	--vtk-write-mobilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase mobilities to the VTK output files.	false

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
118	--vtk-write-molarities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component molarities to the VTK output files.	false
119	--vtk-write-mole-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the mole fractions to the VTK output files.	true
120	--vtk-write-oil-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil formation volume factor (Bo) to the VTK output files.	false
121	--vtk-write-oil-saturation-pressure	A Boolean value set to true or false that turns on (true) or off (false) the output of the saturation pressure of oil (Po,sat) to the VTK output files.	false
122	--vtk-write-oil-vaporization-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil vaporization factor (Rv) of the observed gas to the VTK output files.	false
123	--vtk-write-porosity	A Boolean value set to true or false that turns on (true) or off (false) the output of the porosity array to the VTK output files.	true
124	--vtk-write-potential-gradients	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase pressure potential gradients to the VTK output files.	false
125	--vtk-write-pressures	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase pressures to the VTK output files.	true
126	--vtk-write-primary-vars	A Boolean value set to true or false that turns on (true) or off (false) the output of the primary variables to the VTK output files.	false
127	--vtk-write-primary-vars-meaning	A Boolean value set to true or false that turns on (true) or off (false) the output of the how the primary variables should be interpreted to the VTK output files.	false
128	--vtk-write-process-rank	A Boolean value set to true or false that turns on (true) or off (false) the output of the MPI process rank to the VTK output files.	false
129	--vtk-write-relative-permeabilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase relative permeabilities to the VTK output files.	true
130	--vtk-write-saturated-gas-oil-vaporization-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil vaporization factor (Rv,sat) of oil saturated gas to the VTK output files.	false

OPM Flow 2020-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
131	--vtk-write-saturated-oil-gas-dissolution-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas dissolution factor (Rs,sat) of gas saturated oil to the VTK output files.	false
132	--vtk-write-saturation-ratios	A Boolean value set to true or false that turns on (true) or off (false) the output of the ratio of the actually and maximum dissolved component of the mixture to the VTK output files	false
133	--vtk-write-saturations	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase saturations to the VTK output files.	true
134	--vtk-write-temperature	A Boolean value set to true or false that turns on (true) or off (false) the output of the temperature array to the VTK output files.	true
135	--vtk-write-total-mass-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the total mass fractions to the VTK output files.	false
136	--vtk-write-total-mole-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the total mole fractions to the VTK output files.	false
137	--vtk-write-viscosities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component phase viscosities to the VTK output files.	false
138	--vtk-write-water-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil formation volume factor (Bo) to the VTK output files.	false

Notes:

1) Cells colored green in the No. column are new command line parameters for this release.
2) Items shaded in gray are considered to be developer options that should be used with caution as the values associated with these command line parameters are subject to change.
3) As per all UNIX and LINUX based system the input is case dependent.
4) If a parameter file is used to set one of the above parameters, the leading "--" should not be incorporated in the parameter file.

Table 2.1: OPM Flow 2019-04 Command Line Options

As per all UNIX and LINUX based system the input is case dependent. The command line parameters must either be entered as lower case or CamelCase, for example:

```
flow --enable-dry-run=false CASNAME.DATA
```

or:

```
flow --EnableDryRun=false CASNAME.DATA
```

If a parameter file is used to set one of the above parameters, the leading "--" should not be incorporated in the parameter file, for example on the command line use

```
flow --enable-dry-run=false CASNAME.DATA
```

but in the parameter file use:

```
ecl-deck-file-name=CASENAME.DATA
enable-dry-run=false
```

or:

```
EclDeckFileName=CASENAME.DATA
EnableDryRun=false
```

OPM Flow prints out the command line run time and compile time parameters in CamelCase in both the *.PRT and *.DBG files for reference, one can therefore use this as basis for creating additional run specific parameter files.

Note

It is worth considering having a parameter file for each run of the form CASENAME.param, in order to re-run a case and to use the same parameters for other cases.

Example

The following example is taken for the Norne project and the comments in the example (preceded with "/#") explain the parameter setting used in the file.

```
# ------------------------------------------------------------------------------
# INPUT AND OUTPUT OPTIONS
# ------------------------------------------------------------------------------
#
# Input File
#
ecl-deck-file-name=NORNE_ATW2013.DATA
#
# Output and Output Directory
#
output-dir='\$HOME\OPM\NORNE\'
#
# ------------------------------------------------------------------------------
# NEWTON SOLVER PARAMETER
# ------------------------------------------------------------------------------
#
# Define Numerical Tolerances
#
tolerance-cnv=1e-2
tolerance-mb=1e-5
tolerance-wells=1e-2
#
# Set Min Newtonian Solver iterations to 1 and Max to 15
#
flow-newton-min-iterations=1
flow-newton-max-iterations=15
#
# ------------------------------------------------------------------------------
```

Notice that the leading "--" have not be incorporated in the parameter file, as per the notes in Table 2.1.

In order to use the above parameter file called one would use the following format:

```
flow --parameter-file=CASENAME.PARAM
```

If the above parameter file was called NORNE_ATW2013.PARAM, then the command would be:

```
flow --parameter-file=NORNE_ATW2013.PARAM
```

or:

```
flow --ParameterFile=NORNE_ATW2013.PARAM
```

2.3 RUNNING OPM FLOW USING OPMRUN

This section describes how to run the OPM Flow simulator using the Graphical User Interface ("GUI") program called OPMRUN. The program is written in Python 3 and has been tested under Unbuntu-Mate 20.04 TLS. The software can be downloaded from the following link:

https://github.com/OPM/opm-utilities/tree/master/opmrun

The intent is to develop a graphical user interface to OPM Flow that has similar functionality to the commercial simulator's program, with the targeted audience being Reservoir Engineers in a production environment. Developers and experienced Linux users will already have compatible work flows. OPMRUN enables the editing and management of OPM Flow's run time parameters, setting up job queues to run a series of simulation jobs sequentially, as well as the management of the job queues. Figure 2.1 shows the initial display.

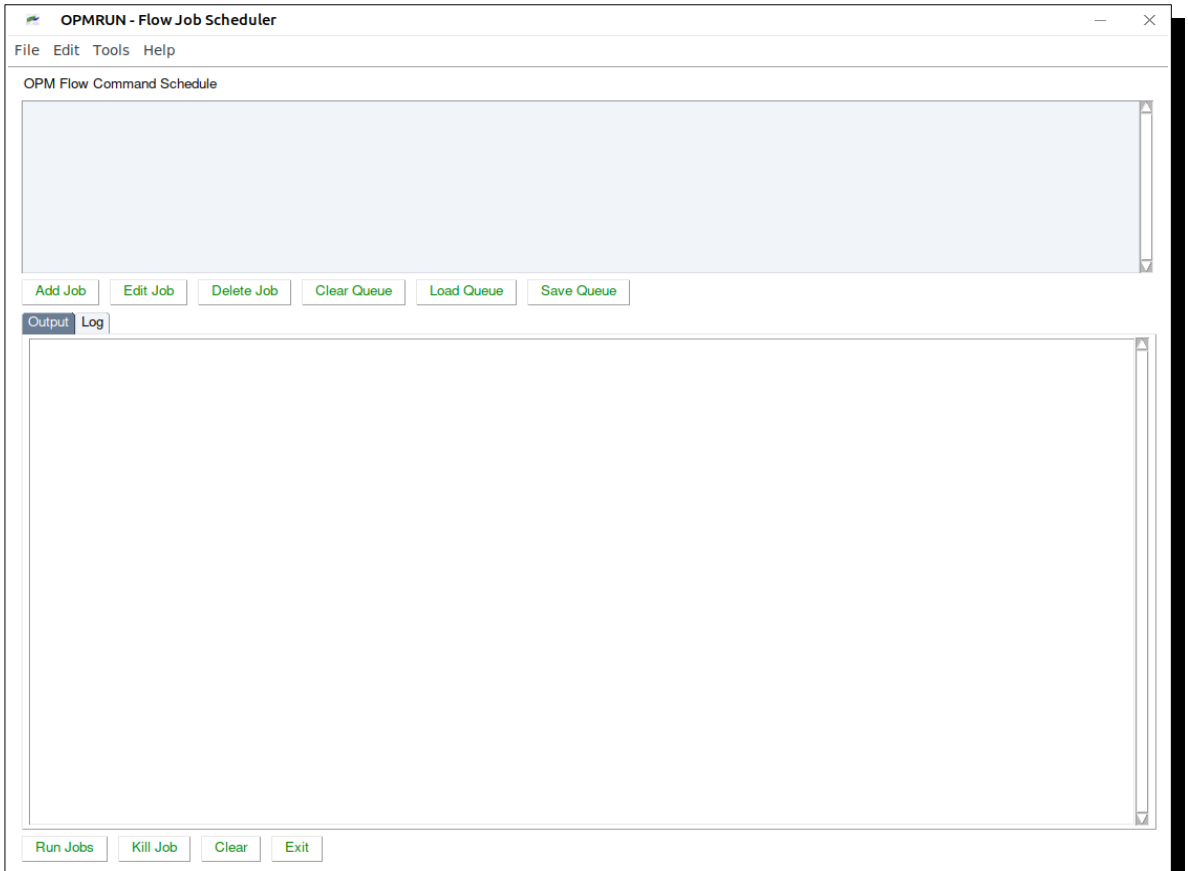


Figure 2.1: OPMRUN: Initial Display

Upon launch the program runs OPM Flow to get a list of command line parameters from the current version of OPM Flow. These default parameters can be edited for each case, or alternative default parameter sets can be loaded from an existing parameter file from another job, or a *.PRT file from a completed simulation.

As can be seen in Figure 2.2 the program has upper and lower display elements. The upper element shows a list of simulation jobs that are in the job queue and the lower element consists of two elements, one for the OPM Flow Output (the terminal output from OPM Flow) and a second element (OPM Run Log) that is a session log of the jobs run by OPMRUN. Clicking the OPM Flow Output and OPM Run Log tabs switches the display on the lowered element between two display types.

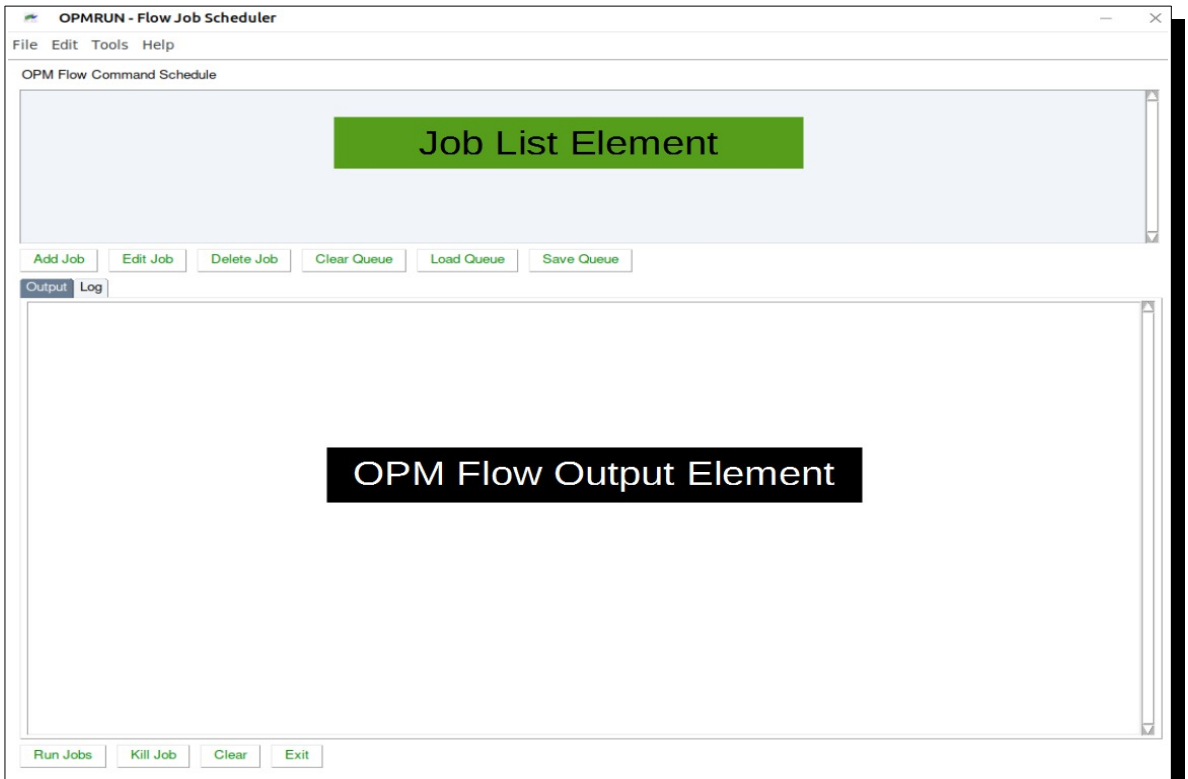


Figure 2.2: OPMRUN: Display Elements

To add jobs to the queue use the Add Job button or load an existing job queue using the Load Queue button. Jobs can be edited or deleted from the queue using the Edit Job and Delete Job buttons, and a series of jobs can be saved as a job queue by using the Save Queue button. The Clear Queue button deletes all jobs from the queue.

Pressing the Add Job button will display the following dialogue box:

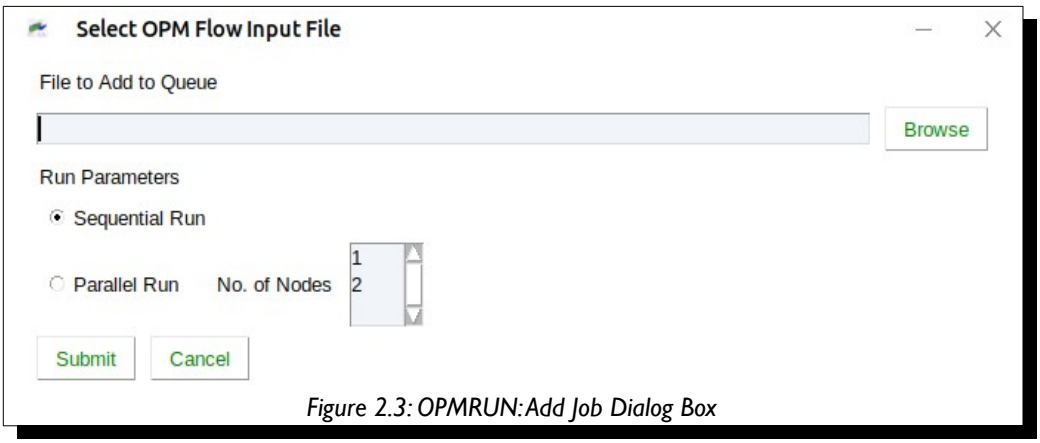


Figure 2.3: OPMRUN: Add Job Dialog Box

Use the Browse button to select the input file to add to the queue, then select the Run Parameters for this input file, then press the Submit button to add the input file to the job queue.

To load a previously saved job queue, press the Load Queue button this will display a dialog box allowing the user to select a queue file (*.que), after pressing the OK button the jobs will be displayed in the top element as illustrated in Figure 2.4.

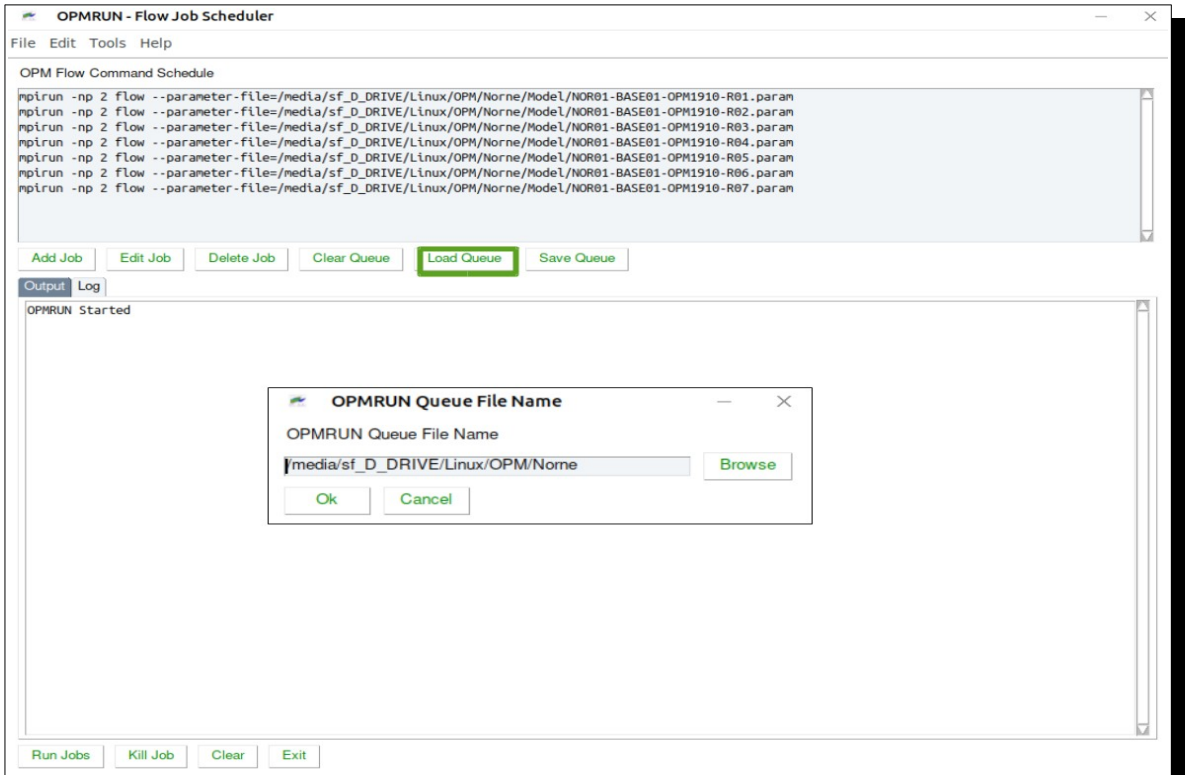


Figure 2.4: OPMRUN: Load Job Queue Dialog Box and Queue Display

Jobs in the queue can be edited by selecting the Edit Job button that will display two options: one to edit the input file using the defined editor and the second to edit the OPM Flow Parameter File. If the second option is selected OPMRUN will display a dialog box that shows a list of the OPM Flow command line parameters together with the parameter help information (Figure 2.5). Selecting a parameter from the list and selecting the Edit button will display the setting for the selected parameter (alternatively one can double click the required entry). One can then edit the parameter as required. Use the Save button to save the change and use the Exit but to save all the changes to the parameter file. The Cancel button will cancel all changes to the parameter file.

Alternatively one can use the:

1) Edit OPM Flow Parameter menu option to edit the parameter file for a job.

2) List OPM Flow Parameters menu option to list the commands in the parameter file for a job.

3) Set OPM Flow Default Parameters to set the default parameters for all subsequent jobs added to the queue. This option allows the user to load a default set of parameters from (1) OPM Flow, (2) an OPM Flow Parameter File, or (3) an OPM Flow print file (*.PRT).

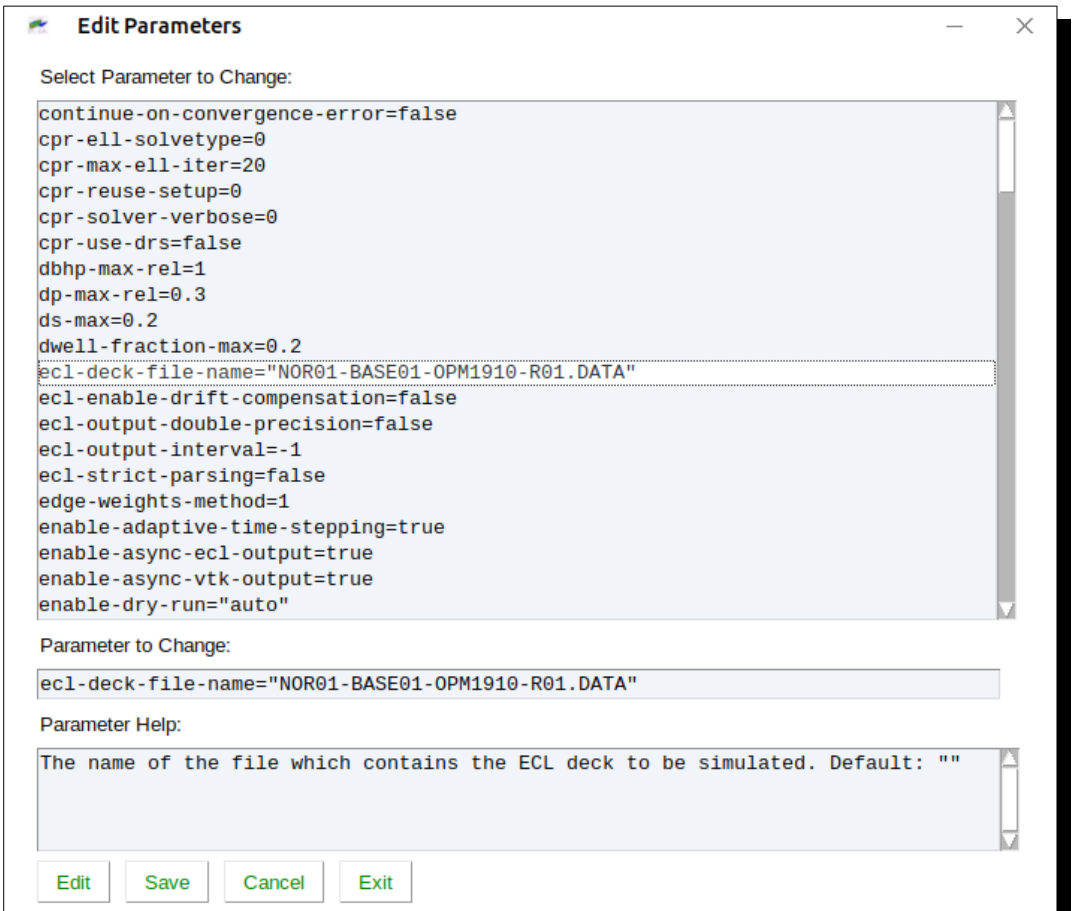


Figure 2.5: OPMRUN: Edit Job Parameter File

Selecting the Run Jobs button displays the Select Run Option dialog box shown in Figure 2.6.

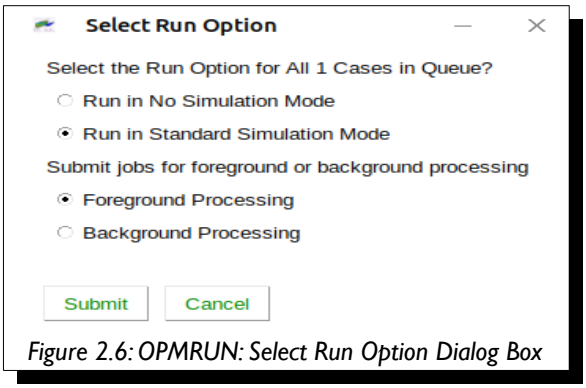


Figure 2.6: OPMRUN: Select Run Option Dialog Box

The Run in No Simulation Mode option is equivalent to setting the NOSIM option in the input deck for all jobs in the queue (see see section *5.2.78 NOSIM – Activate the No Simulation Mode for Data File Checking* and the –enable-dry-run command line parameter in Table 2.1 in section *2.2 Running OPM Flow 2019-04 From The Command Line*. This allows for checking all the jobs at once.

Selecting Run in Standard Simulation Mode will run all the jobs in the queue sequentially, with the OPM Flow terminal output directed to OPM Flow Output Element, as shown in Figure 2.7. The terminal output is also directed to a *.LOG file as well, similar to what the commercial simulator does.

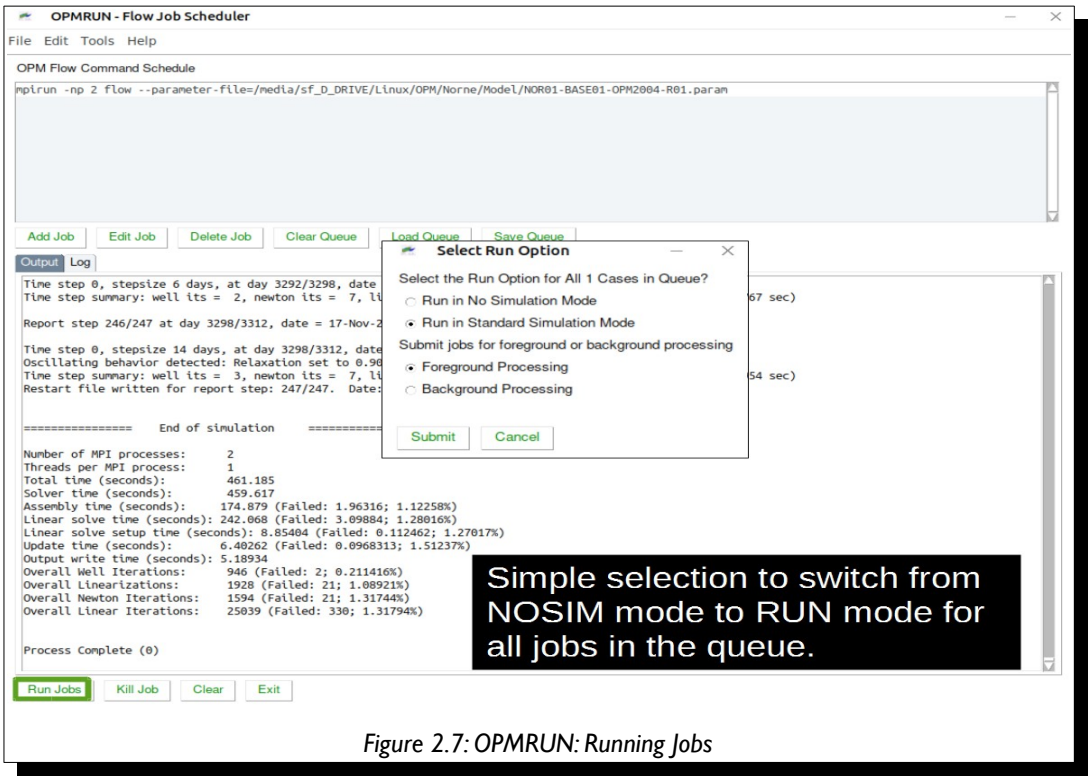


Figure 2.7: OPMRUN: Running Jobs

Clicking the OPM Run Log tab displays the OPMRUN's session log file that records the time and date of the major events that have occurred, including the start and end times of each run. Notice also how OPMRUN deletes all the existing output files for a given job, if they exists, before running OPM Flow.

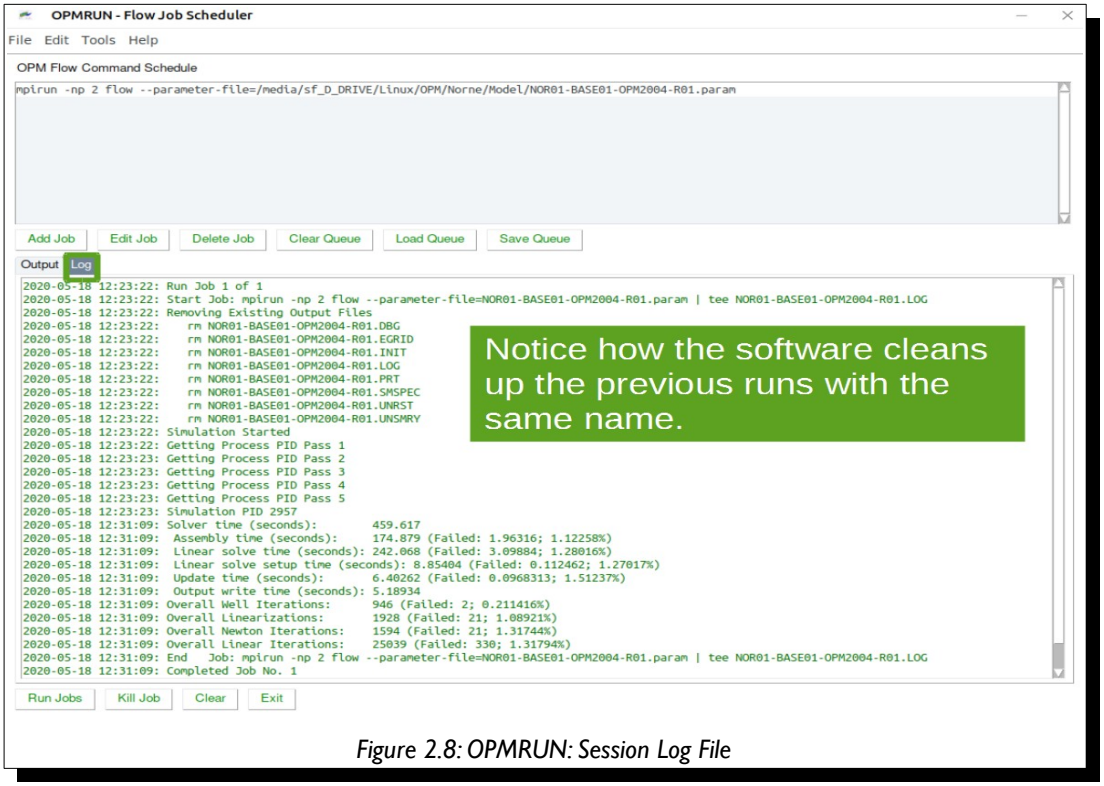


Figure 2.8: OPMRUN: Session Log File

Finally, an example *.param file generated by OPMRUN for the 2020-04 release is shown below and on the following pages for reference:

```
#
# OPMRUN Parameter File
#
# File Name   : "/media/Linux/OPM/Norne/Model/NOR01-RSM-ALL-OPM2004.param"
# Created By  : OPMUSER
# Date Created: 2020-04-24 12:57:38
#
continue-on-convergence-error=false
cpr-ell-solvetype=0
cpr-max-ell-iter=20
cpr-reuse-setup=0
cpr-solver-verbose=0
cpr-use-drs=false
dbhp-max-rel=1
dp-max-rel=0.3
ds-max=0.2
dwell-fraction-max=0.2
ecl-deck-file-name="NOR01-RSM-ALL-OPM2004.DATA"
ecl-enable-drift-compensation=false
ecl-output-double-precision=false
ecl-output-interval=-1
ecl-strict-parsing=false
edge-weights-method=1
enable-adaptive-time-stepping=true
enable-async-ecl-output=true
enable-async-vtk-output=true
enable-dry-run="auto"
enable-ecl-output=true
enable-logging-fallout-warning=false
enable-opm-rst-file=false
enable-storage-cache=true
enable-terminal-output=true
enable-tracer-model=false
enable-tuning=false
enable-vtk-output=false
enable-well-operability-check=true
enable-write-all-solutions=false
flow-linear-solver-verbosity=0
flow-newton-max-iterations=20
flow-newton-min-iterations=1
force-disable-fluid-in-place-output=false
full-time-step-initially=false
ignore-keywords=""
ilu-fillin-level=0
ilu-redblack=false
ilu-relaxation=0.9
ilu-reorder-spheres=false
initial-time-step-in-days=1
linear-solver-configuration="ilu0"
linear-solver-configuration-json-file="none"
linear-solver-ignore-convergence-failure=false
linear-solver-max-iter=200
linear-solver-reduction=0.01
linear-solver-require-full-sparsity-pattern=false
linear-solver-restart=40
matrix-add-well-contributions=false
max-inner-iter-ms-wells=100
max-pressure-change-ms-wells=1e+06
max-residual-allowed=1e+07
max-single-precision-days=20
max-strict-iter=8
max-welleq-iter=30
```

```
milu-variant="ILU"
min-time-step-before-shutting-problematic-wells-in-days=0.25
newton-max-relax=0.5
newton-relaxation-type="dampen"
output-dir=""
output-interval=1
output-mode="all"
owner-cells-first=true
parameter-file=""
pri-var-oscilation-threshold=1e-05
print-parameters=2
print-properties=2
scale-linear-system=false
sched-restart=true
solve-welleq-initially=true
solver-growth-factor=2
solver-max-growth=3
solver-max-restarts=10
solver-max-time-step-in-days=365
solver-min-time-step=0
solver-restart-factor=0.33
solver-verbosity=1
system-strategy="none"
threads-per-process=-1
time-step-after-event-in-days=-1
time-step-control="pid"
time-step-control-decay-rate=0.75
time-step-control-file-name="timesteps"
time-step-control-growth-rate=1.25
time-step-control-target-iterations=30
time-step-control-target-newton-iterations=8
time-step-control-tolerance=0.1
time-step-verbosity=1
tolerance-cnv=0.01
tolerance-cnv-relaxed=1e+09
tolerance-mb=1e-06
tolerance-pressure-ms-wells=1000
tolerance-well-control=1e-07
tolerance-wells=0.0001
update-equations-scaling=false
use-amg=false
use-cpr=false
use-gmres=false
use-gpu=false
use-inner-iterations-ms-wells=true
use-multisegment-well=true
use-update-stabilization=true
vtk-write-average-molar-masses=false
vtk-write-densities=true
vtk-write-dof-index=false
vtk-write-ecl-tracer-concentration=false
vtk-write-extrusion-factor=false
vtk-write-filter-velocities=false
vtk-write-fugacities=false
vtk-write-fugacity-coeffs=false
vtk-write-gas-dissolution-factor=false
vtk-write-gas-formation-volume-factor=false
vtk-write-gas-saturation-pressure=false
vtk-write-intrinsic-permeabilities=false
vtk-write-mass-fractions=false
vtk-write-mobilities=false
vtk-write-molarities=false
vtk-write-mole-fractions=true
vtk-write-oil-formation-volume-factor=false
vtk-write-oil-saturation-pressure=false
```

```
vtk-write-oil-vaporization-factor=false
vtk-write-porosity=true
vtk-write-potential-gradients=false
vtk-write-pressures=true
vtk-write-primary-vars=false
vtk-write-primary-vars-meaning=false
vtk-write-process-rank=false
vtk-write-relative-permeabilities=true
vtk-write-saturated-gas-oil-vaporization-factor=false
vtk-write-saturated-oil-gas-dissolution-factor=false
vtk-write-saturation-ratios=false
vtk-write-saturations=true
vtk-write-temperature=true
vtk-write-total-mass-fractions=false
vtk-write-total-mole-fractions=false
vtk-write-viscosities=false
vtk-write-water-formation-volume-factor=false
#
# End of Parameter File
```

In the above example, all the default parameters have be used.

2.3.1 OPMRUN CONFIGURATION

OPMRUN has several configuration options that can be set via the Edit/Options menu option as illustrated in Figure 2.9.

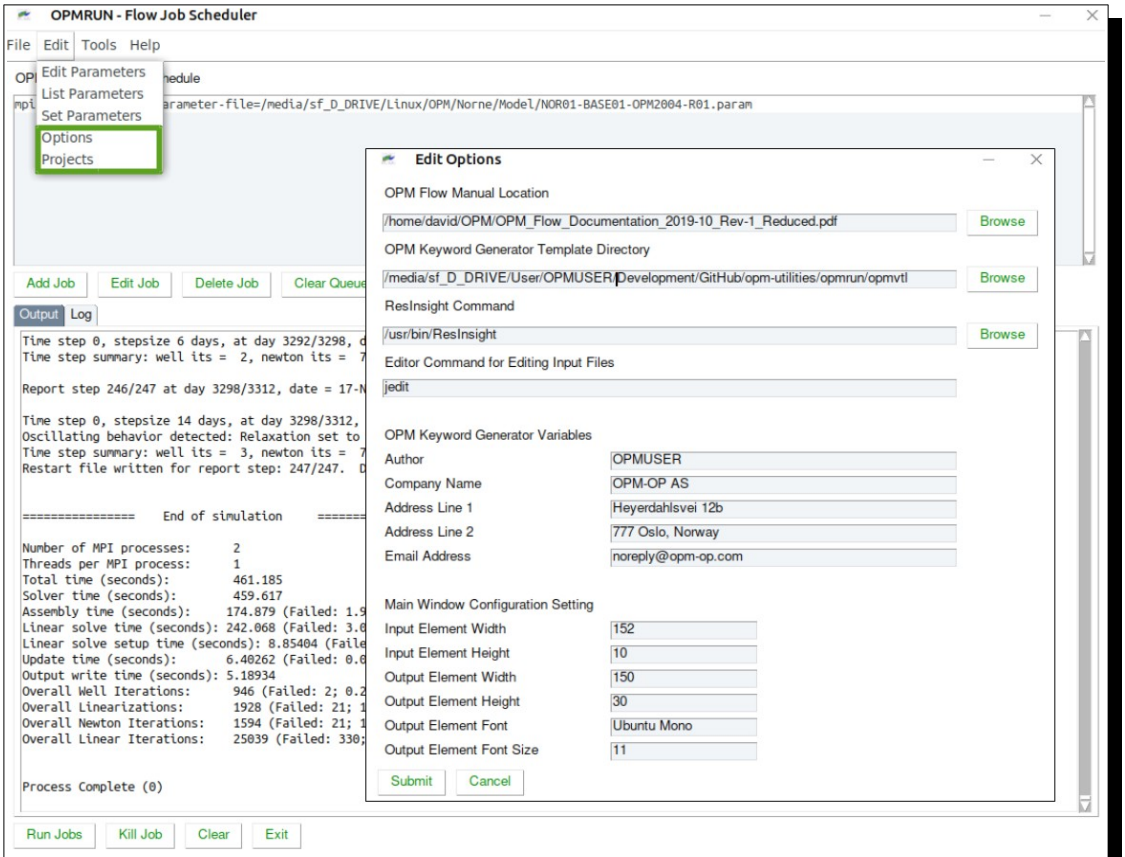


Figure 2.9: OPMRUN: Configuration Options

These include setting the location of the OPM Flow manual, the Keyword Generator Template Directory, the location of the ResInsight program, as well as the editor command to used to edit the input decks. The Keyword Generator Variables section sets the fields used in some templates used by the Keyword Generator application. Note if an "author property" field is not defined then the template variable will be output instead – this can easily be deleted in the application. The Main Window Configuration Setting parameters define OPMRUN's input and output panel's size, font and font size.

In addition to the aforementioned options, the Edit/Projects menu item enables the setting of project directories that allows the user to set a default directory for loading and saving files within OPMRUN and the auxiliary applications.

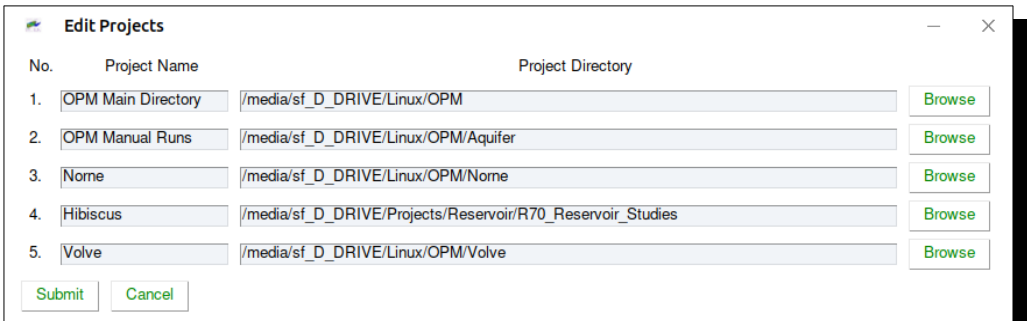


Figure 2.10: OPMRUN: Configuration Options - Project Directories

2.3.2 OPMRUN TOOLS – COMPRESS JOBS

Simulation input and output files can be extremely large, especially for large full field models. Running multiple cases in these circumstances can easily use up all available disk space, especially if multiple users are running multiple cases. OPMRUN therefore provides a facility to compress and uncompress a series of OPM Flow runs to save hard disk space, as shown in Figure 2.11.

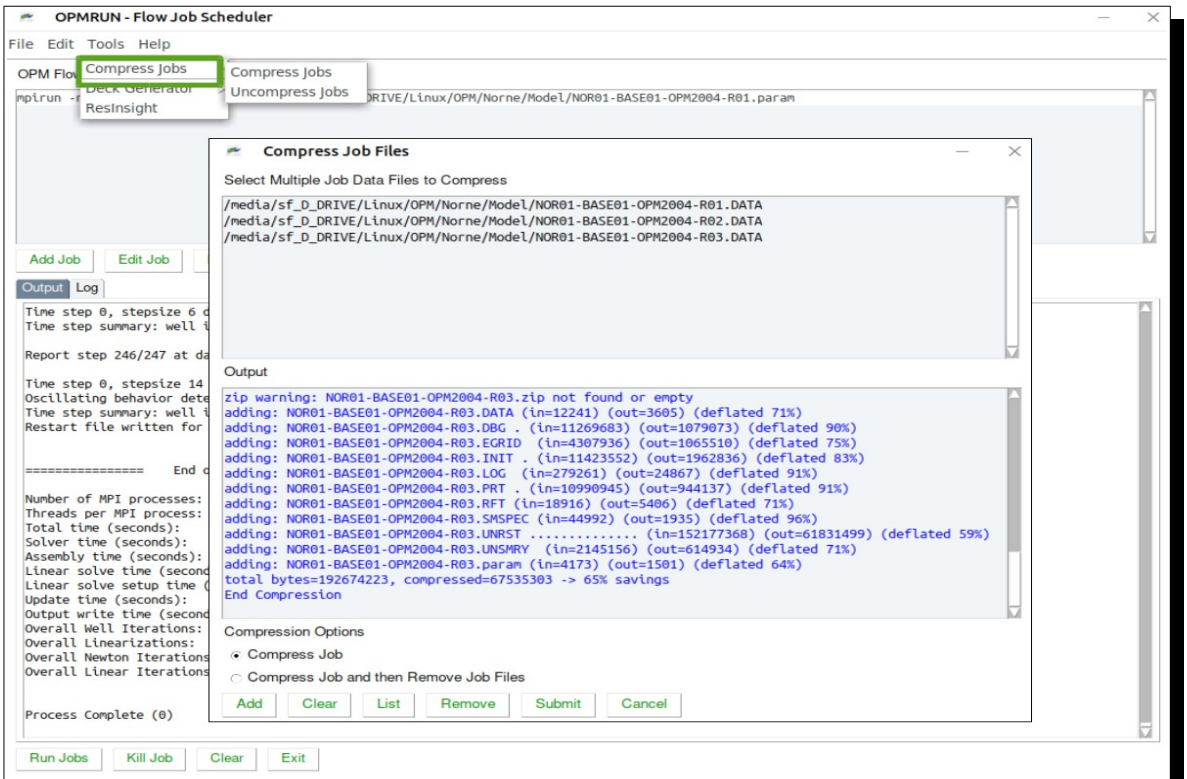


Figure 2.11: OPMRUN Tools: Compress Jobs

Hence, one can batch compress and uncompress a series of runs in one step.

2.3.3 OPMRUN TOOLS - KEYWORD GENERATOR

The OPMRUN Keyword generator is an application that generates OPM Flow keywords that can be cut and pasted into any editor or saved to a separate file to form the basis of a new input deck. One still has to edit the resulting keywords to match the data require, but the structure and comments are provided by the application. The Keyword Generator is located under the "Tools" menu "Deck Generator" option, as shown in Figure 2.12.

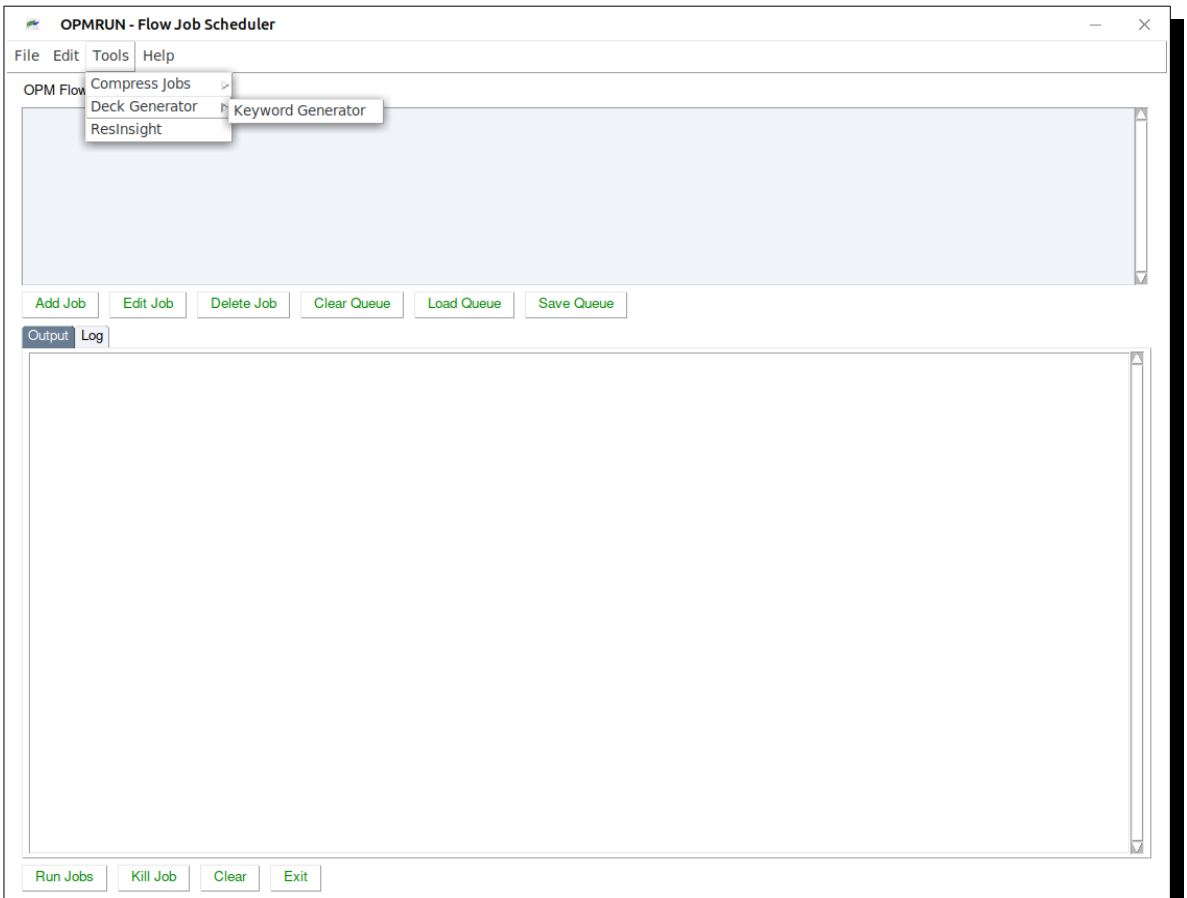


Figure 2.12: OPMRUN Tools: Keyword Generator - Menu Location

The application utilizes templates based on the Apache Velocity Template Language ("VTL"), a commonly used template language used by software engineers. The templates can therefore also be used with any editor that supports VTL, jEdit for example, a popular open source Java based editor and PyCharm, a Python integrated development environment used in computer programming, specifically for the Python language.

There is one template per keyword, with formatting of the keywords being the same as the OPM Flow manual. Currently there are over 450 templates implemented and the intention is for additional keywords to be added as the their usage is implemented within the simulator and documented within the manual. The application allows one to customize the existing templates as well as creating user defined templates by including the templates in the template directory and following the VTL language syntax.

The keywords can be filtered by Section in alphabetic order, and all keywords can be listed as a single alphabetic sorted list. Multiple keywords can be generated at a time and copied to the clipboard or saved to a file. Section keywords (RUNSPEC, GRID, EDIT, PROPS, SOLUTION, SUMMARY and SCHEDULE) can optionally generate a set of keywords for the section.

Figure 2.13 illustrates the main components of the Keyword Generator's display window, showing the keyword filter options, keyword list, and the Deck Element.

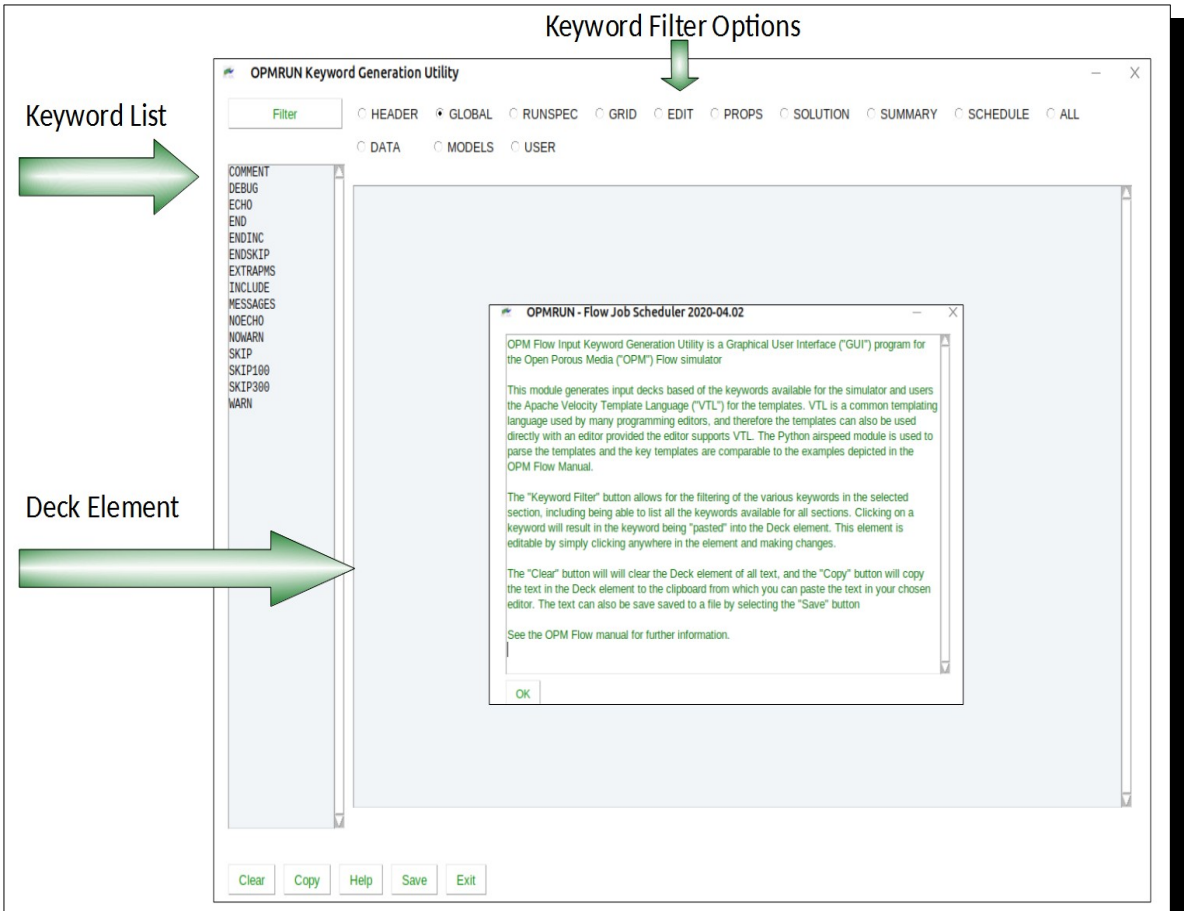


Figure 2.13: OPMRUN Tools: Keyword Generator - Dialog Window

The "Keyword Filter" button allows for the filtering of the various keywords in the selected section, including being able to list all the keywords available for all sections. For example, Figure 2.14 shows the HEADER section keyword list.

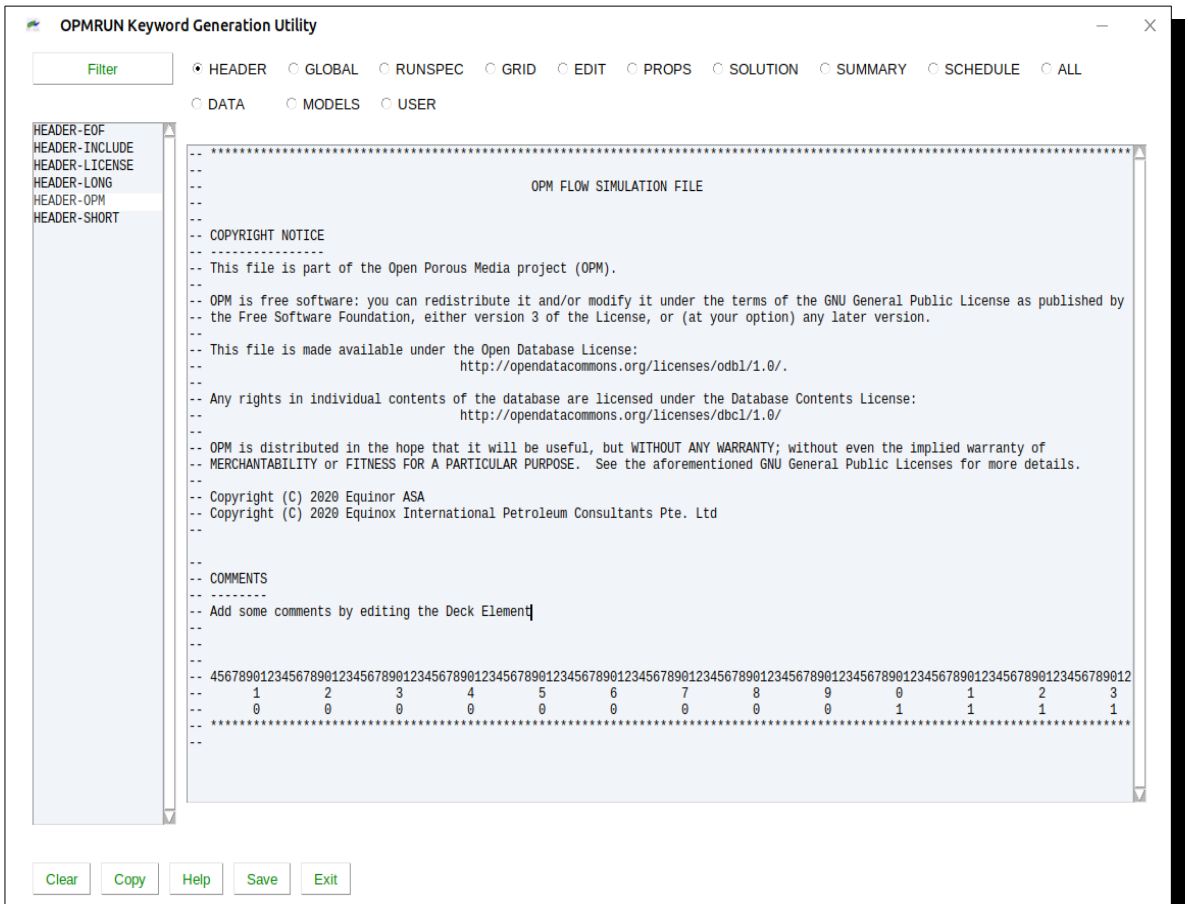


Figure 2.14: OPMRUN Tools: Keyword Generator - Keyword Filter Example.

The HEADER section is not an OPM Flow section per se, but a file header and an end of file section series of templates that allows for a start and end of file comment headers to be included in an input deck. The example shown in Figure 2.14 shows the standard OPM file header for OPM Flow examples and test input decks.

Simply clicking on a keyword will result in the keyword being "pasted" into the Deck Element.

The Deck Element is editable by simply clicking anywhere in the element and making changes by deleting or editing text contained within the Deck Element. One can use the "Clear" button to clear the Deck Element display of all text.

If a keyword requires a file as part of the keyword entry, for example, the INCLUDE and LOAD keywords, then a dialog box is presented to enable the file to be selected (Figure 2.15).

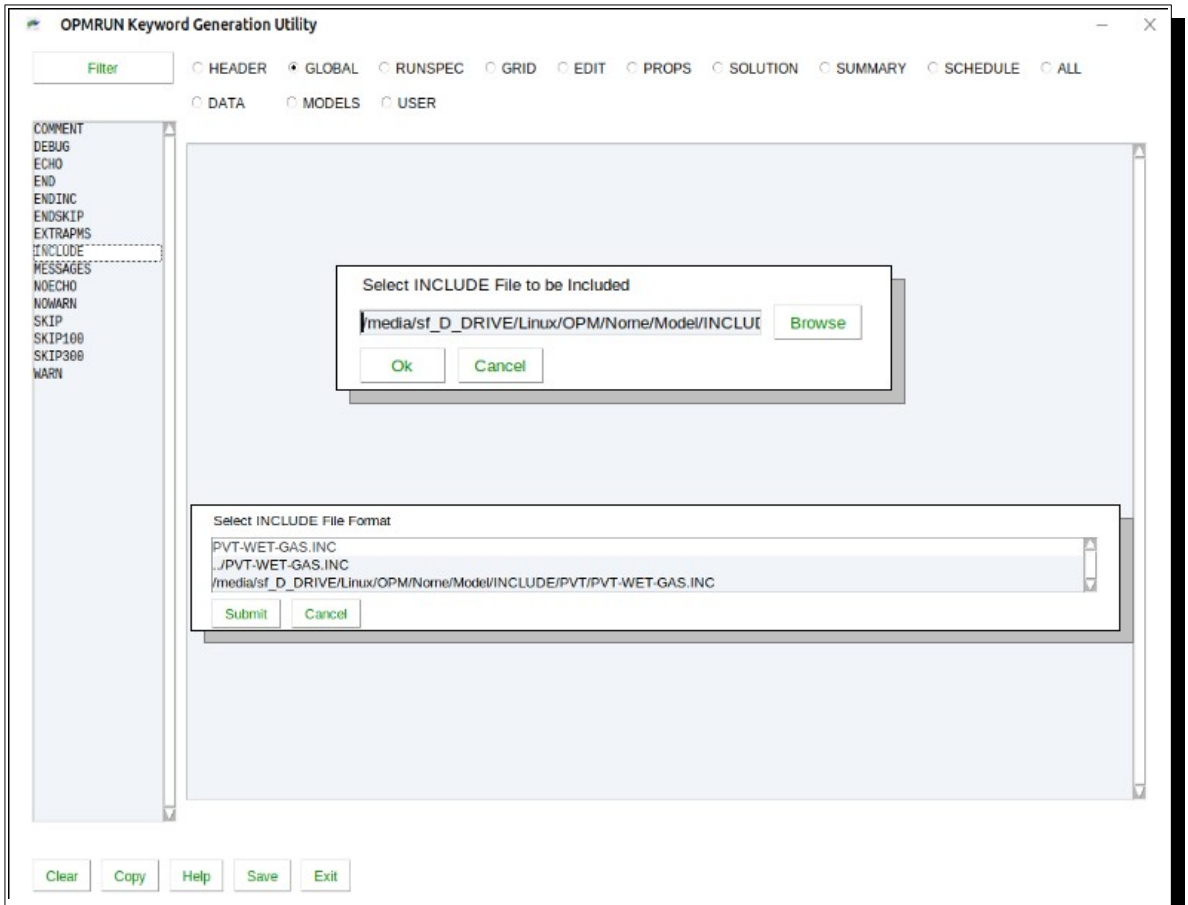


Figure 2.15: OPMRUN Tools: Keyword Generator - INCLUDE Keyword Example

In addition, the application will also allow one to select the file name format after the file has been selected.

Note that COMMENT template is not an actual keyword, but a comment block to make the deck more readable for the user.

Selecting a section keyword (RUNSPEC, GRID, EDIT, PROPS, SOLUTION, SUMMARY, and SCHEDULE) will give one an option to generate a representative set of keywords for that section, as illustrated in Figure 2.16 for the RUNSPEC keyword.

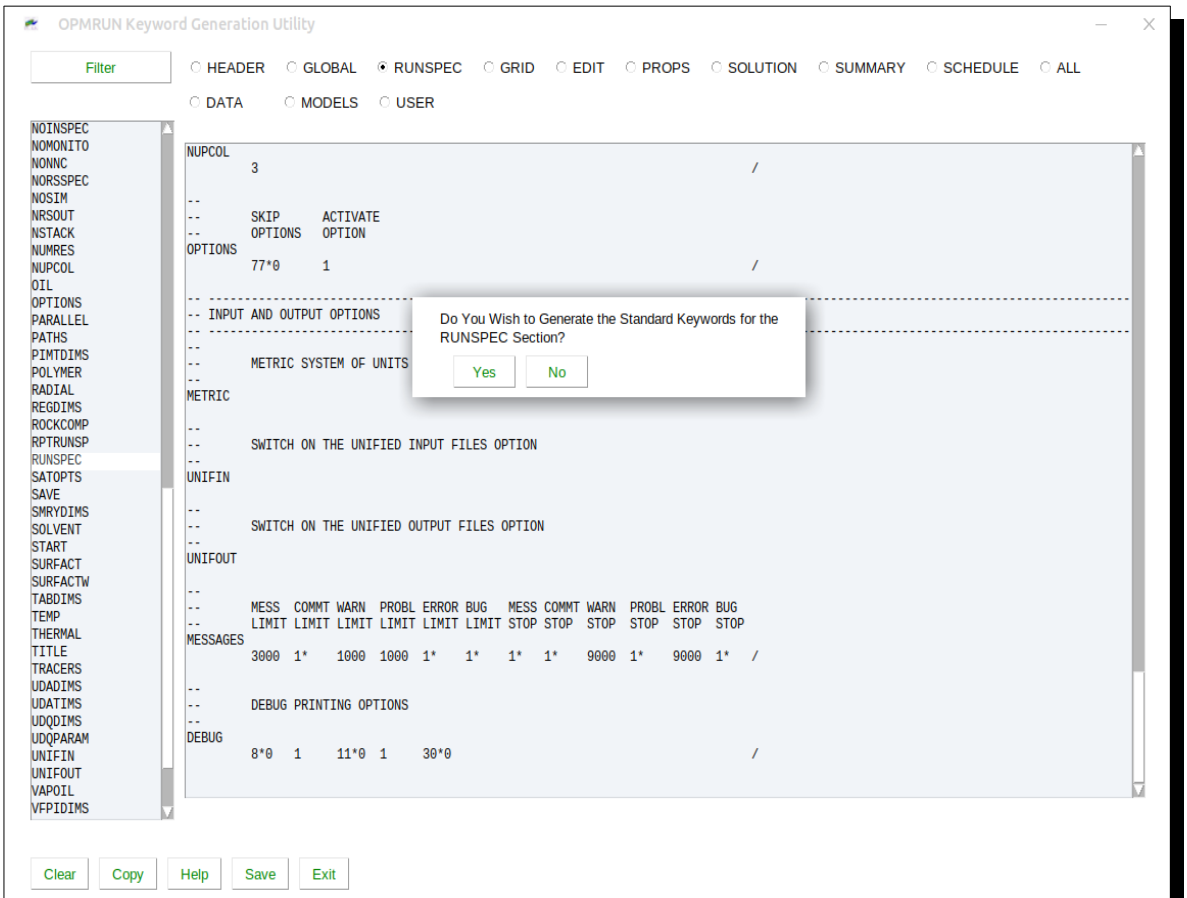


Figure 2.16: OPMRUN Tools: Keyword Generator - RUNSPEC Keyword Example

One can therefore generate a complete input deck in a matter of minutes. However, one still has to edit the generated keywords with your actual data.

For the SUMMARY section keyword, one can also generate various sets of summary variables based on the options being used in the model, as depicted in Figure 2.17.

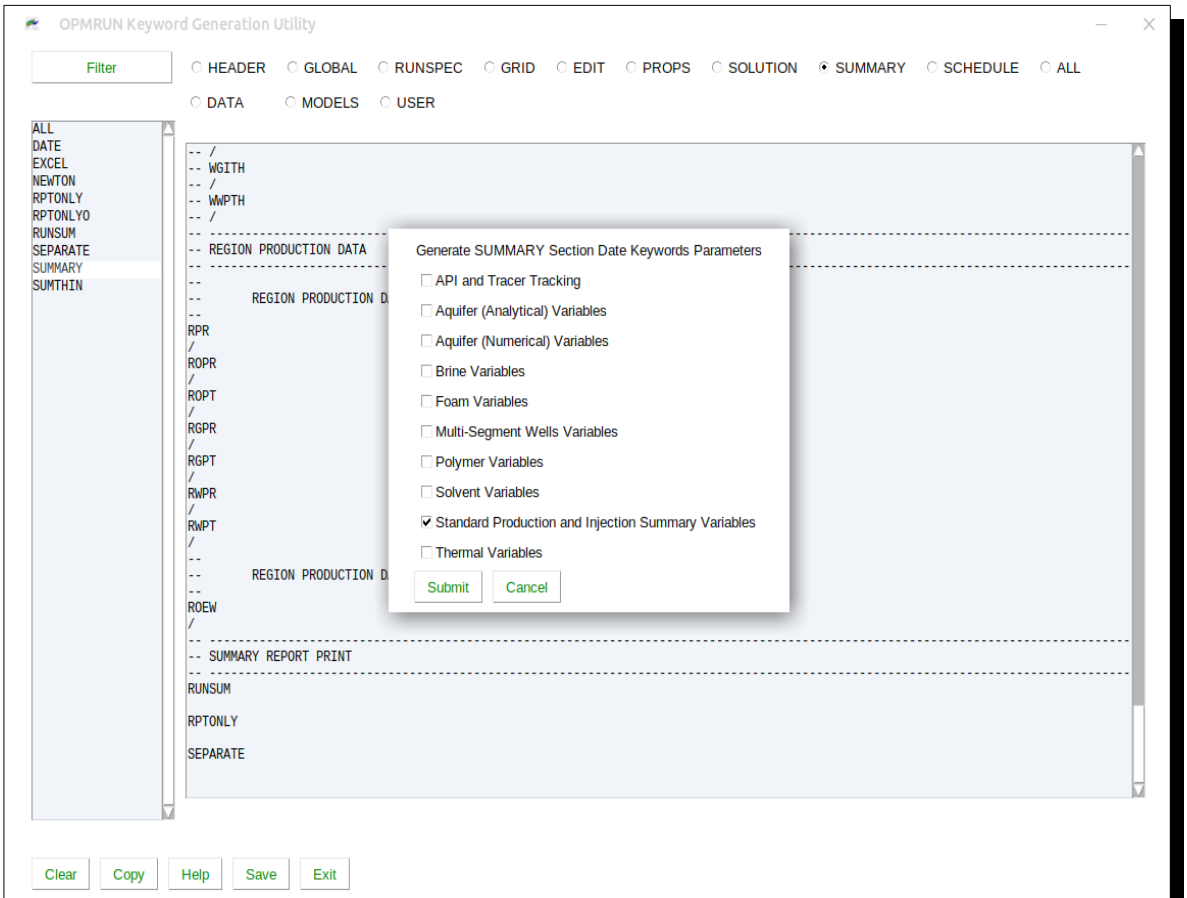


Figure 2.17: OPMRUN Tools: Keyword Generator - SUMMARY Keyword Example

Note that not all of the SUMMARY variables are currently available in OPM Flow, but are expected to be added in future versions. OPM Flow will ignored those variables not implemented.

For the SCHEDULE section keyword, one can also generate a date schedule from a start year to and end year, using annual, quarterly, or monthly time steps, as shown in Figure 2.18.

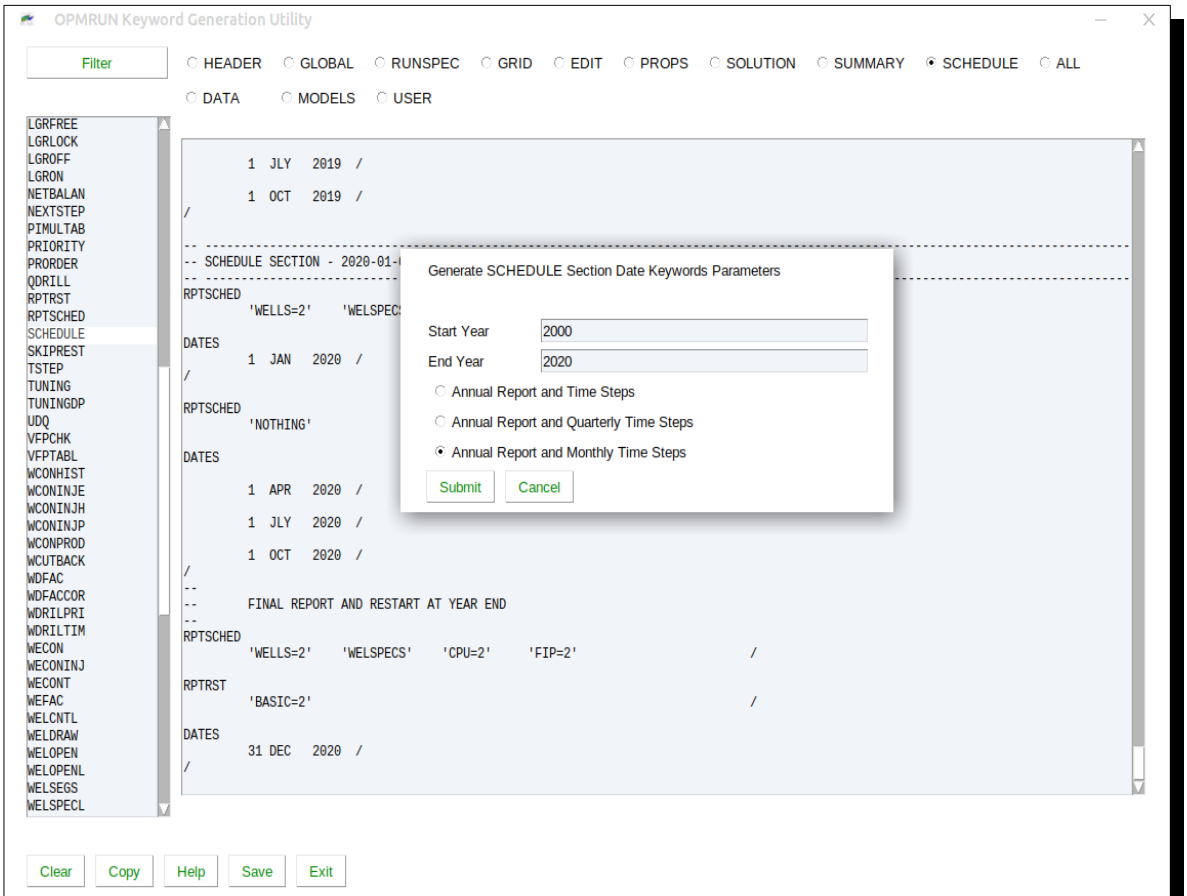


Figure 2.18: OPMRUN Tools: Keyword Generator - SCHEDULE Keyword Example

Note that a standard report is written at the beginning of each year and is subsequently switch off for intermediate quarterly and monthly time steps. A final report is written at the end of the run.

The DATA option is not an OPM Flow section but a series of data sets, as shown in Figure 2.19.

Data sets are complete examples for a given type of data used in OPM Flow, for example a PVT data set for a wet gas reservoir, or three phase relative permeability data set. The data sets are intended to be used as a guide for generating ones own keyword input, or for building models for testing.

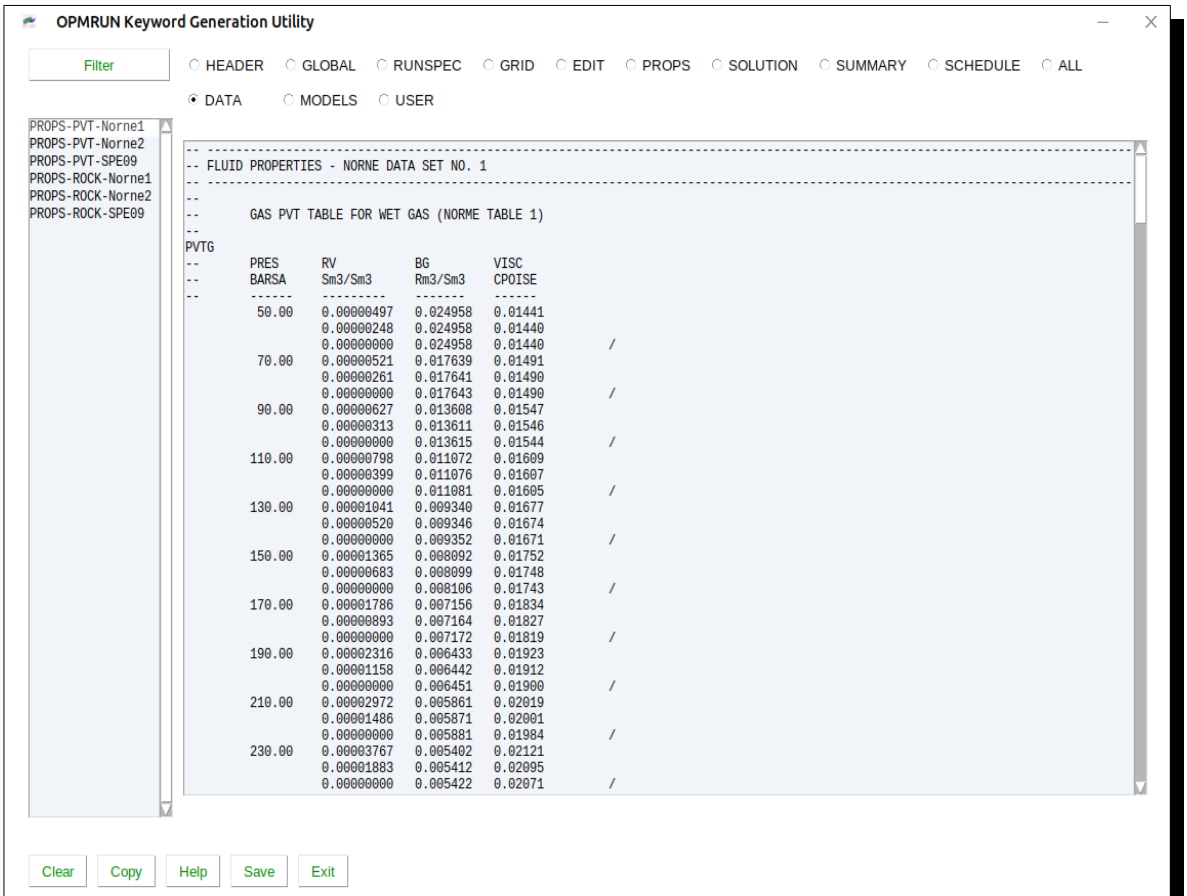


Figure 2.19: OPMRUN Tools: Keyword Generator – DATA Option Example

The intention is to expand the collection of data sets over time as more data becomes available.

Like the DATA option, the MODEL option is not an OPM Flow section, but is instead a collection of working models, as illustrated in Figure 2.20. The purpose of the models is to illustrate the functionality of various features implemented in OPM Flow.

Additional models will be added when available.

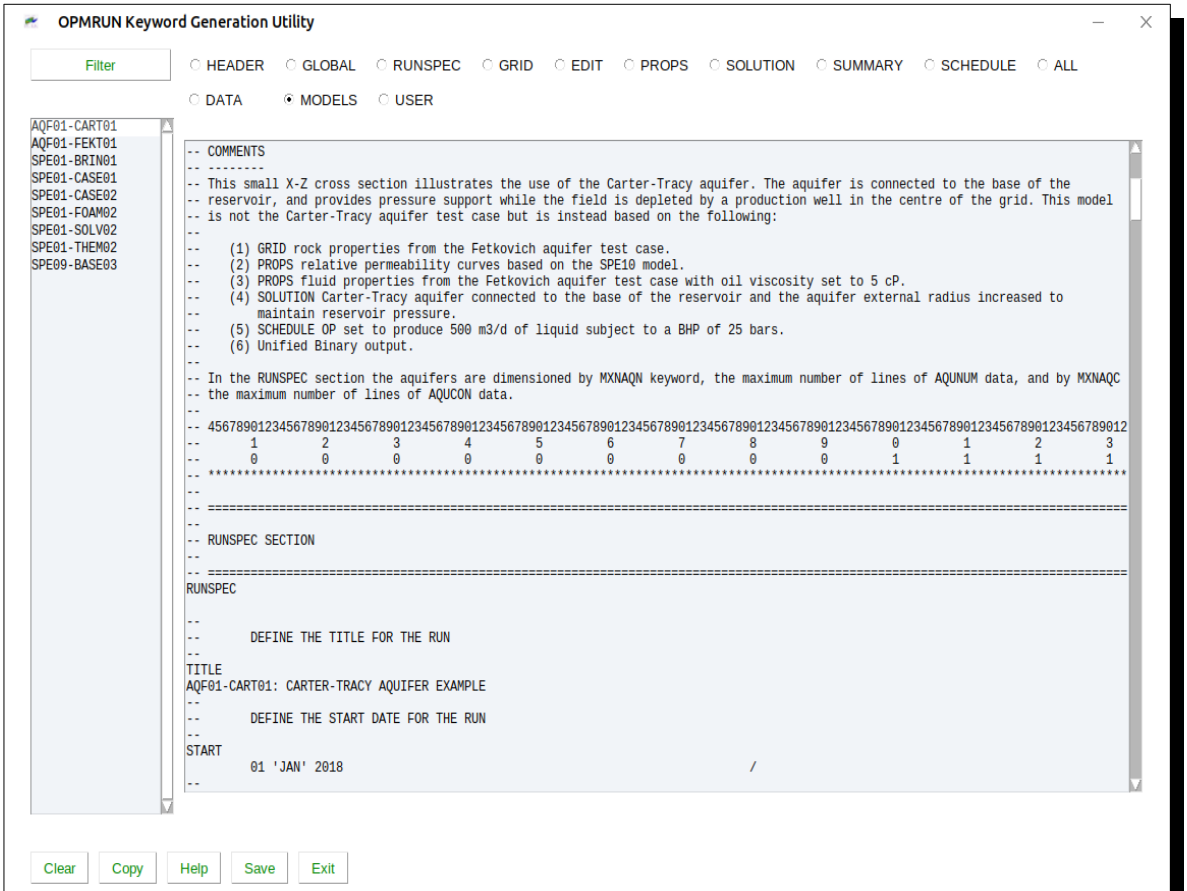


Figure 2.20: OPMRUN Tools: Keyword Generator – MODEL Option Example

Finally, there is a USER option that caters for user templates. All templates saved with "vm" in the "user" directory will automatically listed by the Filter option.

Use the "Copy" button to copy the data in the Deck Element to the clipboard, which you can then paste into your favorite editor.

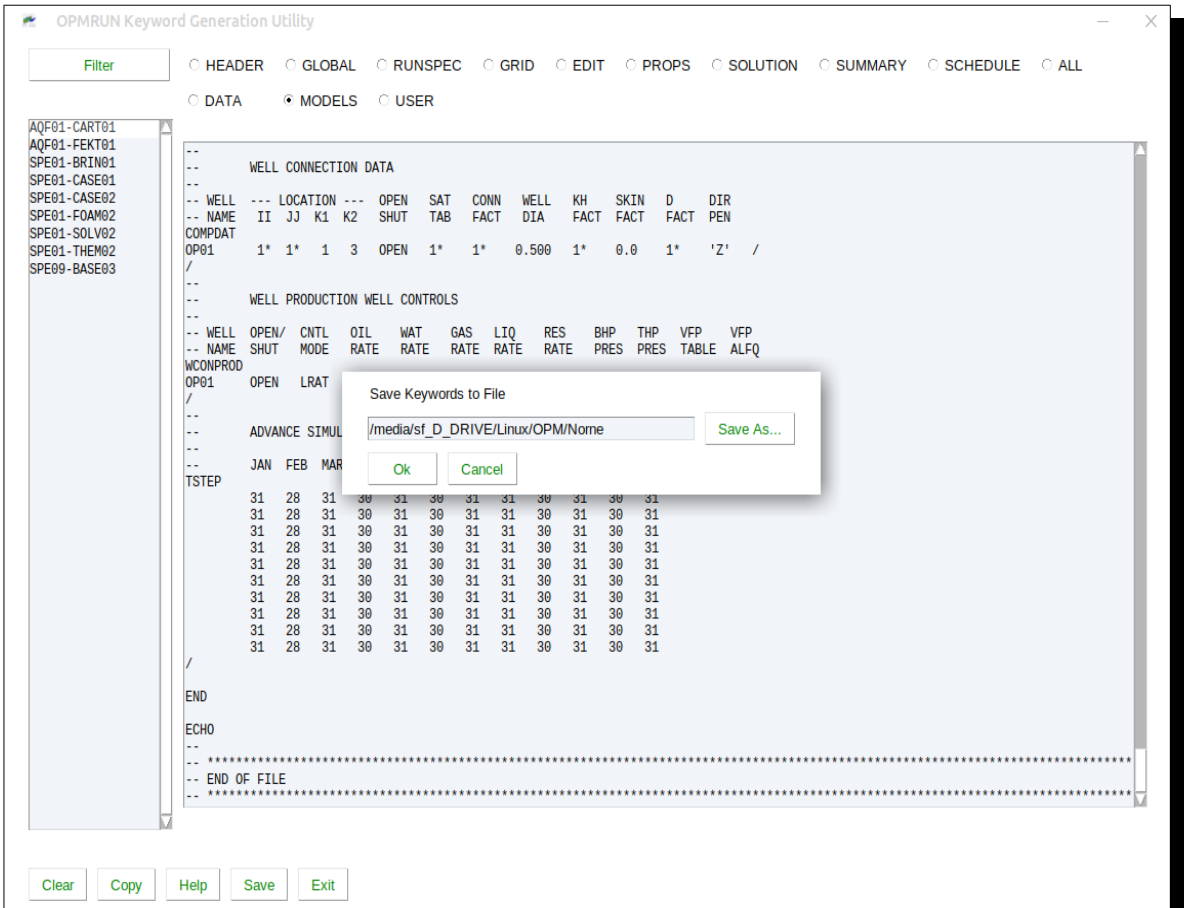


Figure 2.21: OPMRUN Tools: Keyword Generator - Saving the Keywords

Alternatively, one can save the file directly to a *.DATA or *.INC file for further editing and processing, as illustrated in Figure 2.21.

There is also the facility to modify and customize the standard templates. To edit a template first select the keyword in the Keyword List, then right click on the keyword to obtain the available options, and select Template to load the actual template for the keyword into the Deck element (Figure 2.22).

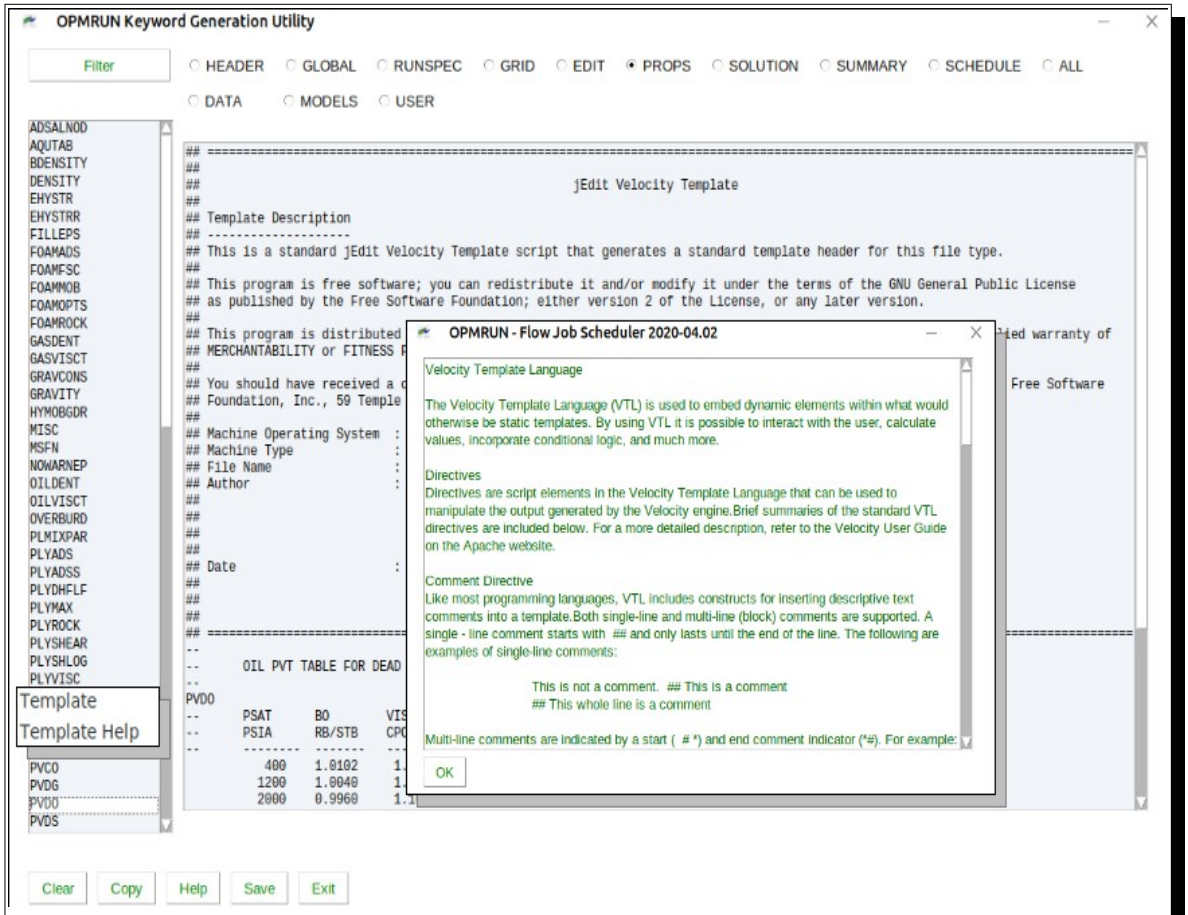


Figure 2.22: OPMRUN Tools: Keyword Generator - Edit a Template and Template Help

One can then edit the template and save the changes back to the same template or another template folder. The USER folder has been provided to save user templates and should be used to store user created and modified templates.

The Template Help option displays a brief introduction to VTL with some examples.

CHAPTER 3: KEYWORD DOCUMENTATION STRUCTURE

3.1 INTRODUCTION

The OPM Flow manual is constructed in a manner to enable the reader to reference various parts of the document by using the table contents or by imply by pressing on a link embedded in the text. This automatic cross referencing has been extensively employed to ensure effective documentation of the keywords used by the simulator.

3.2 KEYWORD DEFINITIONS

Each keyword is defined in it's own section that contains a section header, that contains the keyword name in capital letters followed by a brief description of the keyword's function. This is then followed by *Keyword Table Section* which defines the status of the keyword and which sections of the input deck the keyword can be utilized. Table 3.1 illustrates a typical *Keyword Table Section* defining the keyword status with the various OPM Flow sections.

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Table 3.1: Example Keyword Table Section

The cells are colored in such a manner as to quickly indicate to the reader the keyword's section availability and function availability, with green colored cells indicating the keyword is available for this section and is mostly or fully implemented. Cells colored gray indicate that keyword cannot be used in that particular section, and cells colored orange show that cell is only partially implemented within OPM Flow, for example OPM Flow may simple just recognize the keyword and ignore the keyword's function. Finally, cells colored red means that keyword is available in the commercial simulator but has not been implemented in OPM Flow. In this scenario the keyword should not be used in OPM Flow as it will result in unpredictable results, including causing the simulator to abort or throw an exception.

3.3 MULTI-SECTION KEYWORDS

As there are numerous keywords that can be used within multiple OPM Flow sections of the input file, for example the *ADD* and *EQUALS* keywords, there is a need to avoid duplication of the keyword definitions but at the same time attempt to define only those keywords for a given section. Thus for multi-section keywords, the keyword is defined in the first available section that the keyword can be found. The *Keyword Table Section* as shown below for the *ADD* keyword below, indicates which sections the keyword can be utilized.

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Table 3.2: ADD Keyword Table Section

Here the keyword can be used in the GRID, EDIT, PROPS, REGIONS and SOLUTION sections as indicated by those cells colored green and not for the cells colored in light gray. In subsequent section that the keyword can be used, there is a brief description description with a link to the full description of the keyword, as shown below for the ADD keyword.

The ADD keyword adds a constant to a specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the ADD keyword is being applied. See *ADD – Add a Constant to a Specified Array* in the GRID section for a full description.

A complete list of keywords in alphabetic order is given in section *APPENDIX A: KEYWORD INDEX - ALPHABETIC LISTING* and clicking on a specific keyword will take the reader to the keyword definition in a particular section.

3.4 KEYWORD FORMATS

All keywords in OPM Flow should be entered in capital case and start in column one, lowercase entry of keywords will be produce errors and keywords not starting in column one will not be recognized. There are three types of keyword format types used by OPM Flow for data input. The description of the three types is given in the next three section together with some examples.

3.4.1 KEYWORD FORMAT TYPE – COMMENT

Comments in the input deck can occur anywhere in the file are preceded by "--" in columns one and two, for example for the EQUL keyword:

```
--
--        MAX      MAX      RSVD     TVDP     TVDP
--        EQLNUM   DEPTH    NODES    TABLE    NODES
EQLDIMS
          9        1*       20       1*       1*                                    /
```

In addition, comments can be place after "/" that terminates a record entry as shown below;

```
--
-- -- ARRAY    CONSTANT --  ---------- BOX ---------
--                          I1  I2   J1  J2   K1  K2
MULTIPLY
   'PERMZ'     0.50000      1*  1*   1*  1*   1*  1* / PERMZ * 0.5
/
```

3.4.2 KEYWORD FORMAT TYPE – ACTIVATION

This type of keyword format only consists of the keyword itself and is usually used to invoke a feature or to switch on or off a processing feature. The keyword is document by describing the functionality or action the keyword performs, followed by an example. Examples of this type of keyword include API (to switch on API tracking), GAS (to activate the gas phase in the model), ECHO (to switching echoing of the input file to the output file), and SKIP (for skipping parts of the input deck). For example the GAS keyword in the RUNSPEC section would be described as:

Description

This keyword indicate that the gas phase is present in the model and must be used for oil-gas, gas-water, oil-water-gas input decks that contain the gas phase. The keyword will also invoke data input file checking to ensure that all the required gas phase input parameters are defined in the input deck.

There is no data required for this keyword.

Example

```
--
--        GAS PHASE IS PRESENT IN THE RUN
--
GAS
```

The above example declares that the gas phase is active in the model.

3.4.3 KEYWORD FORMAT TYPE - VECTOR (ROW VECTOR)

Vector based keywords consist of the keyword followed by a vector of parameters on a separate line and may consists of multiple lines of vectors with each line representing a data set (see the second example for this type of vector keyword). The vector may contain integer, real and character parameters depending on the keywords requirements. This type of keyword is documented by describing the functionality or action the keyword performs, a table describing the parameters associated with the keyword, followed by one or two examples on how to use the keyword. For example the DIMENS keyword in the RUNSPEC section would be described as:

Description

DIMENS defines the dimensions of the model entered as integer vector. The keyword can be used with all grid types.

No.	Name	Description	Default
1	NX	The number of grid blocks in the x direction for Cartesian grids or the number of grid blocks in the r direction for radial grids	None
2	NY	The number of grid blocks in the y direction for Cartesian grids or the number of grid blocks in the theta direction for radial grids.	None
3	NZ	The number of grid blocks in the z direction for both Cartesian and radial grids.	None
Notes: 1) The keyword is terminated by "/".			

Table 3.3: DIMENS Keyword Description

Note that NX, NY and NZ are **not maximum** values but the actual size of the grid. OPM Flow applies these parameters when reading in particular data sets. For example if NX, NY, and NZ are set to 10, 10 and 10 respectively, then for the grid property data like PORO; OPM Flow expects to read in 10 x 10 x 10 or 1,000 porosity values for the PORO array. If the number of porosity values is not equal to 1,000 then OPM Flow will produce an error.

Example

```
--
--        MAX      MAX      MAX
--        NDIVIX   NDIVIY   NDIVIZ
DIMENS
          46       112      22                                                    /
```

The above example defines the dimensions for the Norne model of 36 cells in the x direction, 122 cells in the y direction and 22 cells in the z direction.

For vector keywords that have parameters associated with units then there is a slightly different table format to that used above to take into account the documenting the defaults for the three sets of units supported by OPM Flow, for example for the ROCK keyword is describe as follows:

Description

ROCK defines the rock compressibility for various regions in the model. The number of ROCK vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the ROCK tables to different grid blocks in the model is done via the PVTNUM keyword in the REGION section. One data set consists of one record or line which is terminated by a "/".
This keyword must be defined in the OPM Flow input deck.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	Pref	Pref is a real number defining the reference pressure for the other parameters for this data set.			
		psia 1.032	barsa 1.032	atma 1.032	Default
2	Cf	Cf is a real number defining the rock compressibility at the reference pressure, Cf(Pref) and is defined as: $$C_f = -\frac{1}{V}\left(\frac{dV}{dP}\right)$$			
		1/psia 0.0	1/barsa 0.0	1/atma 0.0	Defined

Notes:
1) The each data set terminated by terminated by "/" at the end of the line, **there is no terminator for the keyword.**

Table 3.4: ROCK Keyword Description

Example

The following shows the PVTW keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to one.

```
--
-- ROCK COMPRESSIBILITY
--
-- (1) REFERENCE PRESSURE IS TAKEN FROM THE HCPV WEIGHTED RESERVOIR PRESSURE
--     AS THE PORV IS ALREADY AT RESERVOIR CONDITIONS (FLOW USES THE REFERENCE
--     PRESSURE) TO CONVERT THE GIVEN PORV TO RESERVOIR CONDITIONS USING THE DATA
--     ON THE ROCK KEYWORD)
--
ROCK
    3566.9    5.0E-06                          / ROCK COMPRESSIBILITY REGION 1
    3966.9    5.5E-06                          / ROCK COMPRESSIBILITY REGION 2
    4566.9    6.0E-06                          / ROCK COMPRESSIBILITY REGION 3
```

There is no terminating "/" for this keyword.

In this case the example shows a multiple data set entry of the vector format keyword, with three ROCK data sets being defined by the keyword.

3.4.4 KEYWORD FORMAT TYPE – VECTOR (COLUMNAR VECTOR)

Columnar vector based keywords consist of the keyword followed by a columnar vector of parameters in a separate column for each parameter. The vector may contain integer, real and character parameters depending on the keywords requirements. This type of keyword is documented by describing the functionality or action the keyword performs, a table describing the parameters associated with the keyword, followed by one or two examples on how to use the keyword. For example the SWFN keyword in the PROPS section would be described as:

Description

The SWFN keyword defines the water relative permeability and water-oil capillary pressure data versus water saturation tables for when water is present in the input deck. This keyword should only be used if water is present in the run.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWAT	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the water saturation.			None
		dimensionless	dimensionless	dimensionless	
2	KRW	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the water relative permeability with respect to gas saturation. The first value in the column should be zero.			None
		dimensionless	dimensionless	dimensionless	
3	PCWO	A columnar vector of real values that are either equal or increasing down the column that defines the water-oil relative capillary pressure. If the SWATINIT keyword has been used to initialize the model then columnar vector has to be strictly monotonically increasing.			None
		psia	bars	atm	

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 3.3: SWFN Keyword Description

Example

```
--
--        WATER RELATIVE PERMEABILITY TABLES (SWFN)
--
SWFN
--        SWAT        KRW         PCOW
--        FRAC        FRAC        PSIA
--        --------    --------    -------
             0.15      0.00000      1*
             0.30      0.00050      1*
             0.40      0.00390      1*
             0.50      0.01500      1*
             0.60      0.04100      1*
             0.65      0.06250      1*
             0.70      0.09150      1*
             0.80      0.17850      1*
```

```
            0.90      0.31640      1*
            0.95      0.40960      1*
            1.00      0.52200      1*                          / TABLE NO. 1
```

The example defines two SWFN tables for use when water is present in the run. In the tables the water-oil capillary pressure data has been defaulted with "1*" and will be set to zero as there are no other values for the water-oil capillary pressure columns.

3.4.5 KEYWORD FORMAT TYPE – ARRAY

This type of keyword defines a property for the grid or an area of the grid using a previously entered BOX keyword to define the area where the property will be defined. For array data a full set of values for each element in the array is required. For example, the documentation for the PORO array would be:

Description

PORO defines the porosity for all the cells in the model via an array. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PORO	PORO is an array of real numbers assigning the porosity values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*100.0.			None
		dimensionless	dimensionless	dimensionless	
Notes: 1) The keyword is terminated by "/".					

Table 3.3: PORO Keyword Description

See also the DX, DY and TOPS keywords to fully define a Cartesian Regular Grid.

Example

```
--
--  DEFINE GRID BLOCK POROSITY DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PORO
  300*0.300
/
```

3.5 INPUT FILE STRUCTURE

OPM Flow input files are similar to commercial simulators that are used in the oil and gas industry, that is the input file is separate into sections in an effort to avoid an engineer's input data errors and a computer programmer's code to interpret the data. OPM Flow has been designed, from an engineer's prospective and input structure to be similar to Schlumberger's industry wide ECLIPSE 100[4] simulator. Table 3.4 lists the various section together with a brief description of purpose of the section. As well as declaring if section is mandatory or not for a run to form a valid input deck

Section Name	Description	Required Optional
RUNSPEC	This is the first section in the OPM Flow input file and defines the key parameters for the simulator including the dimensions of the model, phases present in the model (oil, gas and water for example), number of tables for a given property and the maximum number of rows for each table, the maximum number of groups, wells and well completions, as well as various options to be invoked by OPM Flow.	Required
GRID	Defines the basic grid properties, including structure, faults and various static rock properties (porosity, permeability etc.). Upon completion of reading this section, the software calculates the pore volume (PORV) for each and the transmissibilities (TRANX, TRANY and TRANX,) between all the cells, as well as calculating the transmissibilities of the Non-Neighbor Connections ("NNC")	Required
EDIT	The properties calculated by OPM Flow in the GRID section are available for editing in this section (PORV, TRANX etc.).	Optional
PROPS	This section defines the fluid properties for all the phases present in the run, for example oil viscosity, oil formation volume factor etc. The section also defines the rock flow properties as per the relative permeabilities and the distribution of the fluids based on the capillary pressure functions.	Required
REGIONS	The REGIONS section allows the engineer to define various regions in the model for reporting purposes and to define how the fluid and rock property defined in the PROPS section are allocated throughout the model.	Required
SOLUTION	Defines the parameters to initialize the model, fluid contacts, reservoir pressures etc., together with the data from the previous sections. This section, if requested, reports the initial in-place volumes for phases present in the model, as well as the average pressure for the various defined regions.	Required
SUMMARY[1]	Defines the time vector property data to be written out to various report output files for reviewing the results of the simulation. This data includes field, group, well and well completion production and injection data, for example field oil rate versus time. Grid block data can also be reported versus time as well, for example grid block pressure versus time[2].	Optional
SCHEDULE	The final section is the SCHEDULE that the defines the field, group and well parameters, targets and constraints that should be applied to the field, group or wells, numerical controls, the operating schedule and reporting requirements.	Required

Notes:

1) Although the SUMMARY section is optional, it is nearly always included in order to obtain results from the simulation run.
2) The OPM ResInsight three-dimensional visualization software has a feature to display a grid block property change versus time, so it should not be necessary to export the grid block data to the SUMMARY report output files.

Table 3.4: OPM Flow Input Deck Sections

[4] *ECLIPSE Industry-Reference Reservoir Simulator – Reference Manual 2015.1, Schlumberger.*

CHAPTER 4: GLOBAL SECTION KEYWORDS

4.1 Introduction

Keywords used in this section can be used in all input file sections

4.2 Keyword Definitions

4.2.1 COLUMNS – Define Input File Column Margins

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COLUMNS keyword defines the input file column margins; characters outside the margins are ignored by the input parser.

This keyword is ignored by OPM Flow and has no effect on the simulation

4.2.2 DEBUG – DEFINE THE DEBUG DATA TO BE PRINTED TO FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the debug data to be written to the debug file (*.DBG), it is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

4.2.3 ECHO – ACTIVATE ECHOING OF USER INPUT FILES TO THE PRINT FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns on echoing of all the input files to the print file; note that this keyword is activated by default and can subsequently be switched off by the NOECHO activation keyword.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        SWITCH OFF ECHOING OF INPUT FILES
--
NOECHO
--
--        INCLUDE SIMULATION GRID WITH SLOPING FAULTS
--
INCLUDE
          './INCLUDE/GRID/IRAP_1005.GRDECL' /
--
--        SWITCH ON ECHOING OF INPUT FILES
--
ECHO
```

The examples deactivates the echoing of the input files, reads in the grid geometry data using the INCLUDE keyword, and then activates the echoing of the input files again.

Note

Especially for the large voluminous data sets in the GRID section, it is good practice to deactivate the echoing of the input files when loading this data to avoid the print output file becoming too large to view in a text editor.

4.2.4 END – DEFINE THE END OF THE INPUT FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword marks the end of the input file and can occur in any section. Any keywords and data after the END keyword are ignored.

There is no data required for this keyword.

Example

```
-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2006-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
'WELLS=2'    'WELSPECS'    'CPU=2'     'FIP=2'                                  /

DATES
 1  JAN   2006  /
/

RPTSCHED
'NOTHING'                                                                       /

DATES
 1  APR   2006  /
 1  JLY   2006  /
 1  OCT   2006  /
/
ECHO
--
-- ******************************************************************************
-- END OF FILE
-- ******************************************************************************
END
-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2007-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
'WELLS=2'    'WELSPECS'    'CPU=2'     'FIP=2'                                  /

DATES
 1  JAN   2007  /
/
```

In the above example OPM Flow will process the data up to October 1, 2006 only, and then start to run the simulation. All keywords after the END file keyword will not be read or processed.

4.2.5 ENDINC – DEFINE THE END OF AN INCLUDE FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword marks the end of an include file specified on the INCLUDE keyword. When the ENDINC keyword is encountered in the INCLUDE file, input data is read from the next keyword in the current file. Any keywords and data after the ENDINC keyword in the INCLUDE file are ignored.

There is no data required for this keyword.

Example

```
-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2006-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
'WELLS=2'    'WELSPECS'    'CPU=2'     'FIP=2'                                  /

DATES
 1  JAN   2006  /
/

RPTSCHED
'NOTHING'                                                                       /

DATES
 1  APR   2006  /
 1  JLY   2006  /
 1  OCT   2006  /
/
ECHO
--
-- ******************************************************************************
-- END OF INCLUDE FILE PROCESSING
-- ******************************************************************************
ENDINC
-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2007-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
'WELLS=2'    'WELSPECS'    'CPU=2'     'FIP=2'                                  /

DATES
 1  JAN   2007  /
/
```

In the above example OPM Flow will process the data up to October 1, 2006 only, and return control to the file that called the INCLUDE keyword, and then continue processing the input files. All keywords after the ENDINC keyword in the INCLUDE FILE will not be read or processed.

4.2.6 ENDSKIP – DEACTIVATE SKIPPING OF KEYWORDS AND INPUT DATA

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns off skipping of keywords that was activated by the SKIP, SKIP100, or SKIP300 keywords. Note that for each SKIP keyword activated there must be a corresponding ENDSKIP keyword.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        SWITCH ON SKIPPING OF KEYWORDS AND DATA
--
SKIP
--
--        INCLUDE SIMULATION GRID WITH SLOPING FAULTS
--
INCLUDE
          './INCLUDE/GRID/IRAP_1005.GRDECL' /
--
--        SWITCH ON READING OF KEYWORDS AND DATA
--
ENDSKIP
```

The example skips reading of the of the grid geometry data using the INCLUDE keyword, and then reverts back to reading the input files again.

4.2.7 EXTRAPMS – ACTIVATE EXTRAPOLATION WARNING MESSAGES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EXTRAPMS keyword activates extrapolation warning messages for when OPM Flow extrapolates the PVT or VFP tables. Frequent extrapolation warning messages should be investigated and resolved as this would indicate possible incorrect data and may result in the simulator extrapolating to unrealistic values.

No.	Name	Description	Default
1	EXTRAP	Defines a single integer that activates the extrapolation warning message options for PVT and VFP tables. EXTRAP can have the following values: 1) 0 – No warning messages are give (the default). 2) 1 – PVT table extrapolation warnings are printed. 3) 2 – VFP table extrapolation warnings are printed. 4) 3 – PVT and VFP table extrapolation warnings are printed. 5) 4 - PVT and VFP table extrapolation warnings are printed with additional information.	0

Notes:

1) In addition extrapolation warnings will also be given for Rs and Rv if options (1), (3), and (4) are requested.
2) The keyword is terminated by "/".

Table 4.1: EXTRAPMS Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        ACTIVATE EXTRAPOLATION MESSAGES
--
EXTRAPMS
          2                                                                    /
```

The above example activates the default the VFP table extrapolation warnings option.

4.2.8 FORMFEED – DEFINED THE PRINT FILE FORM-FEED CHARACTER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FORMFEED keyword defines the form-feed character, or carriage control character, for the output print (*.PRT) run summary (*.RSM) files. The keyword should be place at the very top of the input file.

No.	Name	Description	Default
1	FORMFEED	Defines a single integer that defines the carriage control character activates, and should be set to: 1) 1 – Standard FORTRAN (the default). 2) 2 – Form-feed character ASCII(12) 3) 3 – None.	0
Notes: 1) The keyword is terminated by "/".			

Table 4.2: FORMFEED Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        ACTIVATE EXTRAPOLATION MESSAGES
--
FORMFEED
          3                                                                    /
```

The above example sets the carriage return character to no form-feed character.

4.2.9 INCLUDE – LOAD ANOTHER DATA FILE AT THE CURRENT POSITION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The INCLUDE keyword informs OPM Flow to continue reading input data from the specified INCLUDE file. When the end of the INCLUDE file is reached, or the ENDINC keyword is encountered in the included file, input data is read from the next keyword in the current file. Although INCLUDE files can be nested, that is INCLUDE files within INCLUDE files etc., in practice this should be avoided due to the complexity of tracking the files.

No.	Name	Description	Default
1	FILENAME	A character string enclosed in quotes that defines a file to read in and be processed by OPM Flow.	None
Notes: 1) The keyword is terminated by "/".			

Table 4.3: INCLUDE Keyword Description

Examples

The first example shown below loads the grid file from the same directory as the data file.

```
--
--        LOAD INCLUDE FILE
--
INCLUDE
          'NOR-OPM-A00-GRID.inc'   /
```

The next example loads the same file one directory above from where the data file is located.

```
--
--        LOAD INCLUDE FILE
--
INCLUDE
          '../NOR-OPM-A00-FAULTS.inc'   /
```

The final example loads the same file from a separate include from where the data file is located.

```
--
--        LOAD INCLUDE FILE
--
INCLUDE
          '../INCLUDE/NOR-OPM-A00-FAULTS.inc'   /
```

4.2.10 MESSAGE – OUTPUT USER MESSAGE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MESSAGE keyword outputs a user message to the terminal, as well as to the print (*.PRT) and debug (*.DBG) files. Note this is different to the MESSAGE**S** keyword, that defines OPM Flows message print limits and stop limits generated by the simulator.

This keyword is ignored by OPM Flow and has no effect on the simulation.

4.2.11 MESSAGES – DEFINE MESSAGE PRINT LIMITS AND STOP LIMITS

Description

The MESSAGES keyword defines the print and stops levels for various messages. The "print limits" set the maximum number of messages that will be printed, after which no more messages will be printed and the "stop limits" terminate the run when these limits are exceeded. There are six levels of message that increase in severity from informative all the way to programming errors, as outlined in Table 4.4.

No.	Name	Description	Default
1	PRTSMESG	An integer defining the maximum number of MESSAGE type messages to be printed after which this type of message stops printing.	1,000,000
2	PRTSCOMT	An integer defining the maximum number of COMMENT type messages be printed after which this type of message stops printing.	1,000,000
3	PRTSWARN	An integer defining the maximum number of WARNING type messages be printed after which this type of message stops printing.	10,000
4	PRTSPROB	An integer defining the maximum number of PROBLEM type messages to be printed after which this type of message stops printing.	100
5	PRTSERRS	An integer defining the maximum number of ERROR type messages to be printed after which this type of message stops printing.	100
6	PRTSBUGS	An integer defining the maximum number of BUG type messages to be printed after which this type of message stops printing.	100
7	STOPMESG	An integer defining the maximum number of MESSAGE type messages to be printed after which OPM Flow terminates the run. Not used by OPM Flow.	1,000,000
8	STOPCOMT	An integer defining the maximum number of COMMENT type messages to be printed after which OPM Flow terminates the run. Not used by OPM Flow.	1,000,000
9	STOPWARN	An integer defining the maximum number of WARNING type messages to be printed after which OPM Flow terminates the run. Not used by OPM Flow.	10,000
10	STOPPROB	An integer defining the maximum number of PROBLEM type messages to be printed after which OPM Flow terminates the run. Not used by OPM Flow.	100
11	STOPERRS	An integer defining the maximum number of ERROR type messages to be printed after which OPM Flow terminates the run. Not used by OPM Flow.	10
12	STOPBUGS	An integer defining the maximum number of BUG type messages to be printed after which OPM Flow terminates the run. Not used by OPM Flow.	1
13	PRTGRPMS	An integer defining the maximum number of GROUP MESSAGE type messages to be printed after which this type of message stops printing. Not used by OPM Flow.	10

No.	Name	Description	Default
Notes:			
1)	MESSAGE type messages are informative messages.		
2)	COMMENT type messages are probably not data errors.		
3)	WARNING type message are possible data errors and should be investigated.		
4)	PROBLEM type errors messages are associated with numerical problems.		
5)	ERROR type messages are errors are need to be fixed before the simulator can run the input deck.		
6)	BUG type of messages are potential programming errors.		
7)	The keyword is terminated by "/".		

Table 4.4: MESSAGES Keyword Description

Example

```
--
--        MESS   COMMT WARN   PROBL ERROR BUG    MESS COMMT WARN   PROBL ERROR BUG
--        LIMIT  LIMIT LIMIT  LIMIT LIMIT LIMIT  STOP STOP  STOP   STOP  STOP  STOP
MESSAGES
          1*     1*    1*     1500  1*    1*     1*   1*    1*     1000  1*    1*   /
```

The above example sets the PROBLEM type message print limit to 1,500 and the stop limit to 1,000.

4.2.12 NOECHO – DEACTIVATE ECHOING OF USER INPUT FILES TO THE PRINT FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns off echoing of all the input files to the print file. Note by default echoing of the inputs files is active. but can subsequently be switched off by the NOECHO activation keyword.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        SWITCH OFF ECHOING OF INPUT FILES
--
NOECHO
--
--        INCLUDE SIMULATION GRID WITH SLOPING FAULTS
--
INCLUDE
          './INCLUDE/GRID/IRAP_1005.GRDECL' /
--
--        SWITCH ON ECHOING OF INPUT FILES
--
ECHO
```

The example deactivates the echoing of the input files, reads in the grid geometry data using the INCLUDE keyword, and then activates the echoing of the input files again.

Note

Especially for the large voluminous data sets in the GRID section, it is good practice to deactivate the echoing of the input files when loading this data to avoid the print output file becoming too large to view in a text editor.

4.2.13 NOWARN – DEACTIVATE WARNING MESSAGES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns off warning messages to be printed to the print file; note that this keyword is deactivated by default and can subsequently be switched off by the WARN activation keyword. The warning messages may be turned on and off using keywords WARN and NOWARN.

It is recommended that WARN should always be used and action taken if necessary. For subsequent runs, the warning messages can be turned off.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--      SWITCH OFF WARNING MESSAGES
NOWARN
--
--      INCLUDE SIMULATION GRID WITH SLOPING FAULTS
--
INCLUDE
     './INCLUDE/GRID/IRAP_1005.GRDECL' /
--
--      SWITCH ON WARNING MESSAGES
--
WARN
```

The example deactivates the warning messages before reading the grid geometry data using the INCLUDE keyword, and then activates the warning messages after reading the INCLUDE file.

4.2.14 SKIP – ACTIVATE SKIPPING OF ALL KEYWORDS AND INPUT DATE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SKIP keyword turns on skipping of keywords until the ENDSKIP activation keyword is encountered. All keywords and between the SKIP and ENDSKIP keywords are ignored by OPM Flow. See also the SKIP100 and SKIP300 keywords that skip only the "black-oil" and compositional keywords, respectively.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       SWITCH ON SKIPPING OF ALL KEYWORDS AND DATA
--
SKIP
--
--       INCLUDE SIMULATION GRID WITH SLOPING FAULTS
--
INCLUDE
         './INCLUDE/GRID/IRAP_1005.GRDECL' /
--
--       SWITCH ON READING OF ALL KEYWORDS AND DATA
--
ENDSKIP
```

The example skips reading of the of the grid geometry data using the INCLUDE keyword, and then reverts back to reading the input files again.

4.2.15 SKIP100 – ACTIVATE SKIPPING OF "BLACK-OIL" KEYWORDS AND INPUT DATE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword turns on skipping of "black-oil" keywords until the ENDSKIP activation keyword is encountered. All "black-oil" keywords between the SKIP100 and ENDSKIP keywords are ignored by OPM Flow. See also the SKIP and SKIP300 keywords that skip all and only the compositional keywords, respectively. There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       SWITCH ON SKIPPING OF BLACK-OIL KEYWORDS AND DATA
--
SKIP100
--
--       INCLUDE BLACK-OIL PVT DATA
--
INCLUDE
         './INCLUDE/'BLACK-OIL-PVT'         /
--
--       INCLUDE COMPOSITIONAL PVT DATA
--
INCLUDE
         './INCLUDE/'COMPOSITION-PVT-EOS'   /
--
--       SWITCH ON READING OF ALL KEYWORDS AND DATA
--
ENDSKIP
--
--       WATER PVT TABLE
--
PVTW
--       REF PRES  BW        CW        VISC     VISC
--       PSIA      RB/STB   1/PSIA    CPOISE   GRAD
--       --------  ------   -------   ------   ------
          4840.0    1.019    2.7E-6    0.370    1*         / WATER DATA REGION 1
--
--       OIL      WAT        GAS
--       DENSITY  DENSITY    DENSITY
--       -------  -------    -------
DENSITY
          39.0     62.37     0.04520                       / PVT DATA REGION 1
--       ROCK COMPRESSIBILITY
--
--       REF PRES  CF
--       PSIA      1/PSIA
--       --------  -------
ROCK
          3966.9   5.0E-06                                 / ROCK COMPRESSIBILITY
```

The example skips reading of the of the 'BLACK-OIL-PVT' data set and reads the 'COMPOSITION-PVT-EOS' file using the INCLUDE keyword, before proceeding to revert back to reading the input files again.

4.2.16 SKIP300 – ACTIVATE SKIPPING OF "COMPOSITIONAL" KEYWORDS AND INPUT DATE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns on skipping of "compositional" keywords until the ENDSKIP activation keyword is encountered. All "compositional" keywords between the SKIP300 and ENDSKIP keywords are ignored by OPM Flow. See also the SKIP and SKIP100 keywords that skip all and only the "black-oil" keywords, respectively. There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       SWITCH ON SKIPPING OF E300 KEYWORDS AND DATA
--
SKIP300
--
--       INCLUDE BLACK-OIL PVT DATA
INCLUDE
         './INCLUDE/'BLACK-OIL-PVT'         /
--
--       INCLUDE COMPOSITIONAL PVT DATA
--
INCLUDE
         './INCLUDE/'COMPOSITION-PVT-EOS'   /

--
--       SWITCH ON READING OF KEYWORDS AND DATA
--
ENDSKIP
--
--       WATER PVT TABLE
--
PVTW
--       REF PRES  BW        CW        VISC     VISC
--       PSIA      RB/STB   1/PSIA    CPOISE   GRAD
--       --------  ------   -------   ------   ------
          4840.0    1.019    2.7E-6    0.370    1*         / WATER DATA REGION 1

--
--       OIL      WAT        GAS
--       DENSITY  DENSITY    DENSITY
--       -------  -------    -------
DENSITY
          39.0     62.37     0.04520                       / PVT DATA REGION 1

--       ROCK COMPRESSIBILITY
--
--       REF PRES  CF
--       PSIA      1/PSIA
--       --------  -------
ROCK
          3966.9   5.0E-06                                 / ROCK COMPRESSIBILITY
```

The example reads the 'BLACK-OIL-PVT' file using the INCLUDE keyword, then skips reading of the 'COMPOSITION-PVT-EOS" data set, before proceeding to revert back to reading the input files again.

4.2.17 WARN – ACTIVATE WARNING MESSAGES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns on warning messages to be printed to the print file (*.PRT); note that this keyword is activated by default and can subsequently be switched off by the NOWARN activation keyword. The warning messages may be turned on and off using keywords WARN and NOWARN. OPM Flow always prints error messages.

It is recommended that WARN should always be used and action taken if necessary for the initial runs, once the run has been "cleaned up" the warning messages can be turned off.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        SWITCH OFF WARNING MESSAGES
--
NOWARN

--
--        INCLUDE SIMULATION GRID WITH SLOPING FAULTS
--
INCLUDE
          './INCLUDE/GRID/IRAP_1005.GRDECL' /

--
--        SWITCH ON WARNING MESSAGES
--
WARN
```

The example deactivates the warning messages before reading the grid geometry data using the INCLUDE keyword, and then activates the warning messages after reading the INCLUDE file.

CHAPTER 5: RUNSPEC SECTION

5.1 INTRODUCTION

This is the first section in the OPM Flow input file and defines the key parameters for the simulator including the dimensions of the model, phases present in the model (oil, gas and water for example), number of tables for a given property and the maximum number of rows for each table, the maximum number of groups, wells and well completions, as well as various options to be invoked by OPM Flow.

The section is defined by the RUNSPEC keyword and is terminated by the GRID keyword.

5.2 KEYWORD DEFINITIONS

5.2.1 ACTDIMS – ACTION KEYWORD DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ACTDIMS keyword defines the maximum number of properties associated with the ACTION keyword. The ACTION keyword allows the user to enter computational logic and calculations to the simulation run based on the how the simulation run is proceeding.

No.	Name	Description	Default
1	MXACTNS	A positive integer value that defines the maximum number of ACTION keywords defined in the input deck.	2
2	MXLINES	A positive integer value that defines the maximum number of lines in an ACTION statement.	50
3	MXCHARS	A positive integer value that defines the maximum characters in an ACTION statement.	80
4	MXSTATMS	A positive integer value that defines the maximum number of conditional statements in the ACTION statement.	3

Notes:

1) The keyword is terminated by "/".

Table 5.1: ACTDIMS Keyword Description

Although this keyword is read by OPM Flow, the ACTION and UDQ computational logic and calculations have not been fully implemented and therefore this keyword should not be used as it may result in OPM Flow terminating.

Example

```
--        ACTION    ACTION   ACTION   ACTION
--        MXACTNS   MXLINES  MXCHARS  MXSTATMS
ACTDIMS
          2         50       80       3                                    /
```

The above example defines the default values for the ACTDIMS keyword.

5.2.2 ACTPARAM – DEFINE ACTION FACILITY TARGET AND TOLERANCE PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ACTPARAM keyword defines the maximum target percent value for the ACTION series of keywords and the fractional equality tolerance for determining if two numbers are numerically equal when comparing values using the ACTION series of keywords. The ACTION keyword allows the user to enter computational logic and calculations to the simulation run based on the how the simulation run is proceeding.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	MXTOLS	A positive real value that defines the maximum target percent number for the ACTION series of keywords. The default value of 100 means the target is not applied.			
		percent 100.0	percent 100.0	percent 100.0	Defined
2	MXEQLS	MXEQLS a real positive number greater than zero and less than one that defines the tolerance used to determine if two real values are equal for comparing values in the ACTION series of keywords. Floating-point numbers (as implemented in computers) are never exact, one cannot compare floating point numbers for exact equality. Thus, MXEQLS defines a tolerance. For example, the default value of 1×10^{-4} means that if the difference between two real values is less than 1×10^{-4} then the values are considered equal.			
		fraction 1×10^{-4}	fraction 1×10^{-4}	fraction 1×10^{-4}	Defined

Notes:

1) The keyword is terminated by "/".

Table 5.2: ACTPARAM Keyword Description

Although this keyword is read by OPM Flow, the ACTION and UDQ computational logic and calculations have not been fully implemented and therefore this keyword should not be used as it may result in OPM Flow terminating.

Example

```
--
--        ACTION    ACTION
--        MXTOLS    MXEQLS
ACTPARAM
          5.0       1.0E-4                                                  /
```

The above example defines the maximum tolerance to be 5% and the equality tolerance to be the default value of 1.0×10^{-4}.

5.2.3 AITS – Activate Intelligent Time Stepping

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns on the commercial simulator's intelligent time stepping.

This keyword is ignored by OPM Flow and has no effect on the simulation

5.2.4 AITSOFF – Deactivate Intelligent Time Stepping

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns off the commercial simulator's intelligent time stepping.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.5 ALKALINE – ACTIVATE THE ALKALINE PHASE AND MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicates that an alkaline phase is present in the model and to activate the alkaline model in the run. The keyword will also invoke data input file checking to ensure that all the required alkaline model input parameters are defined in the input deck.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ALKALINE PHASE IS PRESENT IN THE RUN
--
ALKALINE
```

The above example declares that the alkaline phase is active in the model to activate alkaline model.

5.2.6 API – ACTIVATE API TRACKING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on API tracking so that the various "oil types" are tracked in the model.

In many reservoirs the initial API gravity of oil varies with depth due to the heavy viscous fractions occupying the deepest part of the reservoir whilst the lighter more mobile fractions will occupy the upper part of the reservoir. As a reservoir is depleted the API gravity of oil in a cell will gradually change as the different fluids mix.

In OPM Flow it is possible to define different PVT regions in a reservoir, as in all finite difference formulated simulators, oil moving from one region to another will suddenly assume the properties of that region it has moved to. The fluid type tracking option allows the smooth change of PVT properties in a cell to be simulated by correlating PVT properties against the API gravity of oil.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        ACTIVATE THE API TRACKING OPTION
--
API
```

The above example switches on the API tracking facility.

5.2.7 AQUDIMS – DEFINE AQUIFER DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUDIMS keyword defines the dimensions of the various aquifer property data. The data is normally entered on a single line and is terminated by a "/".

No.	Name	Description	Default
1	MXAQN	A positive integer value that defines the AQUNUM keyword maximum number of lines associated with this keyword.	1
2	MXNAQC	A positive integer value that defines the AQUCON keyword maximum number of lines of connection data associated with this keyword.	1
3	NIFTBL	A positive integer value that defines the AQUTAB keyword maximum number of Carter-Tracy aquifer tables associated with this keyword.	1
4	NRIFTB	A positive integer value that defines the AQUTAB keyword maximum number of rows in the Carter-Tracy aquifer tables associated with this keyword. NRIFTB must not be less than than 36 in order to accommodate the default infinite acting Carter-Tracy aquifer influence function.	36
5	NANAQ	A positive integer value that defines the AQUFET and AQUCT maximum number of analytical aquifers defined by these two keywords.	1
6	NCAMAX	A positive integer value that defines the maximum number of cells connected to an analytical aquifer	1
7	MXNALI	A positive integer value that defines the maximum number of aquifer lists.	0
8	MXAAQL	A positive integer value that defines the maximum number of analytic aquifers in any single aquifer list as defined by (7).	0

Notes:

1) The keyword is terminated by "/".

Table 5.3: AQUDIMS Keyword Description

Example

```
--
--        AQF     AQF     AQF     AQF     AQF     AQF     AQF     AQF
--        MXAQN   MXNAQC  NIFTBL  NRIFTB  NANAQ   NCAMAX  MXNALI  MXAAQL
AQUDIMS
          1*      1*      1*      1*      1*      1*      1*      1*              /
```

The above example defines the default values for the AQUDIMS keyword.

5.2.8 AUTOREF - Define Auto Refinement Options

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AUTOREF keyword activates the Auto Refinement option and defines the parameters for this feature.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.9 BIGMODEL – ACTIVATE BIG MODEL OPTION (RETIRED)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The original intention in the commercial simulator was to define an optimized memory allocation method to handle large models; this has since become redundant and has been retired in the commercial simulator.

This keyword is ignored by both OPM Flow and the commercial simulator and has no effect on the simulation but is documented here for completeness.

5.2.10 BLACKOIL – ACTIVATE BLACK OIL PHASES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the "black-oil" formulation, and is equivalent to setting the phases present in the model to be oil, vaporized oil, gas, and dissolved gas. Note if water is present in the model this needs to be explicitly stated via the WATER keyword in the RUNSPEC section (see also the DEADOIL and LIVEOIL keywords in the RUNSPEC section). The keyword is used by the commercial simulator's compositional THERMAL option to set the phases present in the model.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

The following example activates the "black-oil" phases in the model.

```
--
--        ACTIVATE BLACK-OIL PHASES
--
BLACKOIL
```

Alternatively one could explicitly declare the phases using the following keywords in the RUNSPEC section.

```
--
--        OIL PHASE IS PRESENT IN THE RUN
--
OIL
--
--        VAPORIZED OIL IN WET GAS IS PRESENT IN THE RUN
--
VAPOIL
--
--        GAS PHASE IS PRESENT IN THE RUN
--
GAS
--
--        DISSOLVED GAS IN LIVE OIL IS PRESENT IN THE RUN
--
DISGAS
```

The above example switches on the "black-oil" phases in the model.

5.2.11 BPARA – ACTIVATE BLOCK PARALLEL LICENSE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The BPARA keyword activates the block parallel license in the commercial simulator. There is no data required for this keyword; however the keyword should be followed by the PARALLEL keyword in the RUNSPEC section, as illustrated in the example below.

There is no data required for this keyword and there is no terminating "/" for this keyword.

OPM Flow is an open source project and therefore there is no license management of the various implemented options or the number of cores/threads that can be utilized; hence, this keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to run OPM Flow in parallel mode.

Example

```
--
--       ACTIVATE BLOCK PARALLEL LICENSE
--
BPARA
--
--       PARALLEL MULTI-CORE OPTIONS
--       NDMAIN     MACHINE TYPE
PARALLEL
           8      DISTRIBUTED                                                  /
```

The above example sets the number of domains (or processors) to eight and for the simulation to run in block parallel mode. This has no effect in OPM Flow input decks.

5.2.12 BPIDIMS – DEFINE THE DIMENSIONS OF THE INTERPOLATED BLOCK QUANTITIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The BPDIMS keyword defines the dimensions of the interpolated grid block quantities for the BPR_X, BHD_X,BHDF_X, BSCN_X and BCTRA_X, etc. variables declared in the SUMMARY section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

5.2.13 BRINE – ACTIVATE BRINE TRACKING OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The BRINE keyword activates the standard Brine Tracking model and optionally defines the water phase to have various salinities if the ECLMC keyword in the RUNSPEC section has been used to activate the Multi-Component Brine model, that allows for the water phase to have multiple water salinities.

No.	Name	Description	Default
1	SALTS	An optional character vector string that defines the salts to be tracked for when the Multi-Component Brine model has been activated by the ECLMC keyword in the RUNSPEC section. SALTS should be set to one or more of the following salt chemical formulae: Salt Name — Salt Chemical Formulae Sodium Chloride — $NaCl$ Potassium Chloride — KCl Calcium Chloride — $CaCl_2$ Magnesium Chloride — $MgCl_2$ Sodium Carbonate — Na_2CO_3 Potassium Carbonate — K_2CO_3 Calcium Carbonate — $CaCO_3$ Magnesium Carbonate — $MgCO_3$ Sodium Sulfate — Na_2SO_4 Potassium Sulfate — K_2SO_4 Calcium Sulfate — $CaSO_4$ Magnesium Sulfate — $MgSO_4$ Note that the ECLMC option is currently not available in OPM Flow, so only the BRINE keyword without the optional SALT variables should be declared in the input deck.	None

Notes:

1) There is no data required for this keyword if the standard Brine Tracking option is being activated and there should be no terminating "/" in this case. However, if the Multi-Component Brine Tracking option has been invoked by the ECLMC keyword, a list of SALTS must be supplied and in this case the keyword is terminated by "/".

Table 5.4: BRINE Keyword Description

See also the PRECSALT and VAPWAT keywords in the RUNSPEC section that activates OPM Flow's Salt Precipitation model, and the PVTWSALT keyword in the PROPS section to define the water properties with respect to salt concentration.

Example

The first example actives the standard Brine model and has not terminating "/".

```
--
--        ACTIVATE STANDARD BRINE MODEL IN THE RUN
--
BRINE
```

The second example illustrates how to activate OPM Flow's Salt Precipitation model which is under development, but is currently unavailable for this release.

```
--
--        ACTIVATE STANDARD BRINE MODEL IN THE RUN
--
BRINE
--
--        ACTIVATE THE OPM FLOW SALT PRECIPITATION MODEL (OPM FLOW KEYWORD)
--
PRECSALT
--
--        VAPORIZED WATER IN DRY/WET GAS IS PRESENT IN THE RUN (OPM FLOW KEYWORD)
--
VAPWAT
```

The third and final example activates the Multi-Component brine model with four different salts.

```
--
--        ACTIVATE MULTI-COMPONENT BRINE MODEL
--
ECLMC
--
--        DEFINE WATER PHASE MULTI-COMPONENT BRINE COMPONENTS
--
--        SALT1   SALT2   SALT3   SALT4   SALT5
BRINE
          NACL    CACL2   MGC03   K2CO3                                        /
```

This option is currently not available in OPM Flow.

5.2.14 CART – ACTIVATE CARTESIAN GEOMETRY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

CART activates the Cartesian grid geometry for the main model, as oppose to a radial geometry. This is the default geometry and therefore the keyword does have to be used to activate this type of geometry.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.15 CBMOPTS – Define Coal Bed Methane Options

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword sets the options for the Coal Bed Methane model which is activated via the COAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.16 COAL – ACTIVATE THE COAL PHASE (CBM MODEL)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COAL keyword actives the coal phase and the Coal Bed Methane ("CBM") model for the run.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        ACTIVATE THE COAL PHASE (CBM MODEL) IN THE MODEL
--
COAL
```

The above example declares that the Coal phase is active in the run and activates the CBM model option.

5.2.17 CPR – ACTIVATE CONSTRAINED PRESSURE RESIDUAL ("CPR") LINEAR SOLVER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns on the Constrained Pressure Residual ("CPR") linear solver. There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

Example

```
--
--        ACTIVATE CONSTRAINED PRESSURE RESIDUAL LINEAR SOLVER FOR THE RUN
--
CPR
```

The above example activates linear solver for the run.

5.2.18 DIFFUSE – Activate Molecular Diffusion Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFUSE keyword activates molecular diffusion option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.19 DIMENS – DEFINE THE DIMENSION OF THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DIMENS defines the dimensions of the model entered as integer vector. The keyword can be used with all grid types.

No.	Name	Description	Default
1	NX	A positive integer value that defines the number of grid blocks in the x direction for Cartesian grids or the number of grid blocks in the r direction for radial grids	None
2	NY	A positive integer value that defines the number of grid blocks in the y direction for Cartesian grids or the number of grid blocks in the theta direction for radial grids.	None
3	NZ	A positive integer value that defines the number of grid blocks in the z direction for both Cartesian and radial grids.	None
Notes: 1) The keyword is terminated by "/".			

Table 5.5: DIMENS Keyword Description

Note that NX, NY and NZ are **not maximum** values but the actual size of the grid. OPM Flow applies these parameters when reading in particular data sets. For example if NX, NY, and NZ are set to 10, 10 and 10 respectively, then for the grid property data like PORO; OPM Flow expects to read in 10 x 10 x 10 or 1,000 porosity values for the PORO array. If the number of porosity values is not equal to 1,000 then OPM Flow will produce an error.

Example

```
--
--        MAX      MAX      MAX
--        NDIVIX   NDIVIY   NDIVIZ
DIMENS
          46       112      22                                                    /
```

The above example defines the dimensions for the Norne model of 46 cells in the x direction, 112 cells in the y direction and 22 cells in the z direction.

5.2.20 DISGAS – ACTIVATE THE DISSOLVED GAS PHASE IN THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicates that dissolved gas is present in live[5] oil in the model and the keyword should only be used if the there is both oil and gas phases in the model. The keyword may be used for oil-water and oil-water-gas input decks that contain the oil and gas phases. The keyword will also invoke data input file checking to ensure that all the required oil and gas phase input parameters are defined in the input deck.

If the oil has a constant and uniform dissolved gas concentration, Gas-Oil Ratio ("GOR"), and if the reservoir pressure never drops below the saturation pressure (bubble point pressure), then the model can be run more efficiently by omitting the GAS and DISGAS keywords from the RUNSPEC section, treating the oil as a dead oil[6], and defining a constant Rs (GOR) value with keyword RSCONST or RSCONSTT in the PROPS section. This results in the model being run with as a dead oil problem with no active gas phase. However, OPM Flow takes into account the constant Rs in the calculations and reporting.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       DISSOLVED GAS IN LIVE OIL IS PRESENT IN THE RUN
--
DISGAS
```

The above example declares that the dissolved gas in the oil phase is active in the model.

[5] *"Live" oil is oil that contains gas in solution, which is normally the case for most conventional oil reservoirs. However, for oil reservoirs classified as heavy oil reservoirs, the in situ dissolved gas may be negligible and oil would then be classified as gas-free oil which is commonly referred to as "dead" oil.*

[6] *"Dead" oil is oil that it contains no dissolved gas or a relatively thick oil or residue that has lost its volatile components.*

5.2.21 DISPDIMS – Define the Maximum Number of Dispersion Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DISPDIMS key defines the maximum number of dispersion tables, and the maximum number of velocity and concentration elements per table.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.22 DUALPERM – ACTIVATE DUAL PERMEABILITY MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DUALPERM keyword activates the Dual Permeability option and the Dual Porosity option for the run. In a dual porosity system flow occurs between the matrix and the fracture only, whereas in a dual permeability system flow also occurs between the matrix grid blocks[7,8,9,10 and 11].

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       ACTIVATE DUAL PERMEABILITY MODEL
--
DUALPERM
```

The above example declares that the Dual Permeability option is active for the run.

[7] *Warren, J.E. and Root, P.J. 1963. The Behavior of Naturally Fractured Reservoirs. SPE J. 3 (3): 245–255. SPE-426-PA. http://dx.doi.org/10.2118/426-PA.*

[8] *Gringarten, A.C. 1984. Interpretation of Tests in Fissured and Multilayered Reservoirs With Double-Porosity Behavior: Theory and Practice. J Pet Technol 36 (4): 549-564. SPE-10044-PA. http://dx.doi.org/10.2118/10044-PA.*

[9] *Serra, K., Reynolds, A.C., and Raghavan, R. 1983. New Pressure Transient Analysis Methods for Naturally Fractured Reservoirs(includes associated papers 12940 and 13014). J Pet Technol 35 (12): 2271-2283. SPE-10780-PA. http://dx.doi.org/10.2118/10780-PA*

[10] *Barenblatt, G.E., Zheltov, I.P., and Kochina, I.N. 1960. Basic Concepts in the Theory of Homogeneous Liquids in Fissured Rocks. J. Appl. Math. Mech. 24: 1286-1303.*

[11] *Kazemi, H., Merrill JR., L. S., Porterfield, K. L., and Zeman, P. R. "Numerical Simulation of Water-Oil Flow in Naturally Fractured Reservoirs," paper SPE 5719, Society of Petroleum Engineers Journal(1976) 16, No. 6, 317-326.*

5.2.23 DUALPORO – ACTIVATE DUAL POROSITY MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DUALPORO keyword activates the Dual Porosity option for the run. In a dual porosity system flow occurs between the matrix and the fracture only, whereas in a dual permeability system flow also occurs between the matrix grid blocks[12,13,14,15 and 16].

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       ACTIVATE DUAL POROSITY MODEL
--
DUALPORO
```

The above example declares that the Dual Porosity option is active for the run.

[12] *Warren, J.E. and Root, P.J. 1963. The Behavior of Naturally Fractured Reservoirs. SPE J. 3 (3): 245–255. SPE-426-PA. http://dx.doi.org/10.2118/426-PA.*

[13] *Gringarten, A.C. 1984. Interpretation of Tests in Fissured and Multilayered Reservoirs With Double-Porosity Behavior: Theory and Practice. J Pet Technol 36 (4): 549-564. SPE-10044-PA. http://dx.doi.org/10.2118/10044-PA.*

[14] *Serra, K., Reynolds, A.C., and Raghavan, R. 1983. New Pressure Transient Analysis Methods for Naturally Fractured Reservoirs(includes associated papers 12940 and 13014). J Pet Technol 35 (12): 2271-2283. SPE-10780-PA. http://dx.doi.org/10.2118/10780-PA*

[15] *Barenblatt, G.E., Zheltov, I.P., and Kochina, I.N. 1960. Basic Concepts in the Theory of Homogeneous Liquids in Fissured Rocks. J. Appl. Math. Mech. 24: 1286-1303.*

[16] *Kazemi, H., Merrill JR., L. S., Porterfield, K. L., and Zeman, P. R. "Numerical Simulation of Water-Oil Flow in Naturally Fractured Reservoirs," paper SPE 5719, Society of Petroleum Engineers Journal(1976) 16, No. 6, 317-326.*

5.2.24 DYNRDIMS – DEFINE DYNAMIC REGION DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DYNRDIMS keyword defines the dimensions for the parameters used by the Dynamic Regions facility, including the maximum number of dynamic regions. The Dynamic Regions facility allows for property and reporting regions to vary as the run progresses, based on the parameters and logic defined by the DYNAMICR keyword in the SOLUTION and PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.25 ECLMC – ACTIVATE MULTI-COMPONENT BRINE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ECLM keyword activates the Multi-Component Brine model that allows for the water phase to have multiple water salinities. The keyword should be used in conjunction with the BRINE keyword in the RUNSPEC. Both keywords must be specified to activate the Multi-Component Brine model, whereas the BRINE keyword only is required to activate the standard brine tracking model.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

The first example activates the standard Brine Tracking model.

```
--
--        ACTIVATE STANDARD BRINE MODEL
--
BRINE
```

The next example shows the ECLMC and BRINE keywords for when the Multi-Component Brine model is required.

```
--
--        ACTIVATE MULTI-COMPONENT BRINE MODEL
--
ECLMC
--
--        DEFINE WATER PHASE MULTI-COMPONENT BRINE COMPONENTS
--
--        SALT1    SALT2    SALT3    SALT4    SALT5
BRINE
          NACL     CACL2    MGC03                                                  /
```

The above example activates the Multi-Component Brine model with three different water salinities.

5.2.26 ENDSCALE – ACTIVATE RELATIVE PERMEABILITY END-POINT SCALING OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ENDSCALE keyword activates OPM Flow's relative permeability end-point scaling option. The relative permeability functions are defined using the either the:

1) SWOF, SGOF, SLGOF series of saturation functions, or the

2) SWFN, SGFN, SGWFN, SOF2, SOF3, SOF32D series of functions.

And are allocated to the grid cells via the SATNUM keyword.

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWLX, SWLY and SWLZ instead of SWL etc. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWLX, SWLX-, SWLY, SWLY- SWLZ and SWLZ-, instead of SWL or the SWLX, SWLY and SWLZ set of keywords.

The keyword also defines the number of saturation end-point tables that allows for the re-scaling of the saturation functions to be tion of depth as oppose to being a grid property array. This is accomplished via the ENKRVD and ENPVTD keywords in the PROPS section.

No.	Name	Description	Default
1	DIRECT	A character string that activates or deactivates directional end-point scaling option. If DIRECT is set to NODIR then directional end-point scaling is switch off and the same saturation function is used in the x, y and z directions (unless activated otherwise by the SATOPS keyword in the RUNSPEC section). In this case the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR and SOGCR saturation grid arrays and the KRG, KROG, KROW and KRW relative permeability grid cell arrays should be use to enter the grid block end-point data. If DIRECT is to DIRECT then directional end-point scaling is switch on and the same saturation function is used in the x, y and z directions (unless activated otherwise by the SATOPS keyword in the RUNSPEC section). Here the directional form of the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR and SOGCR saturation grid arrays and the KRG, KROG, KROW and KRW relative permeability grid cell arrays should be use to enter the grid block end-point data. For example SWLX, SWLY and SWLZ for SWL. Activates or deactivates directional end-point scaling. Only the default option is supported by OPM Flow.	NODIR

No.	Name	Description	Default
2	IRREVERS	A character string that activates or deactivates non-reversible end-point scaling option. If IRREVERS is set to REVER then the end-point scaling is set to reversible and results in the same set of end-point arrays being used for flow from the xl to xl + 1 direction as for the flow from the xl to the xl – 1 for all directions (x, y and z). Here the SWLX, SWLY and SWLZ series of keywords should be used instead of SWL type of keywords. Alternatively, if IRREVERS is set to IRREVERS then the end-point scaling is set to non-reversible and results in different sets of end-point arrays being applied for flow from the xl to xl + 1 direction and the xl to the xl – 1 direction, for all directions (x, y, z). in this case the SWLX+, SWLX-, SWLY+, SWLY- SWLZ+ and SWLZ- series of keywords should be utilized instead of SWL or the SWLX, SWLY and SWLZ set of keywords. Only the default option is supported by OPM Flow.	REVERS
3	NTENDP	A positive integer that defines the maximum number of saturation end-point depth tables. The end-point depth tables are used to re-scale the saturation tables as a function of depth as oppose to being a grid block property. NTENDP may also be specified on the TABDIMS keyword, and if specified on both here and on the TABDIMS keyword the maximum value of the two is used. Only the default option is supported by OPM Flow.	1
4	NNODES	A positive integer the defines the maximum number entries for saturation end-point depth tables. Only the default option is supported by OPM Flow.	20
5	MODE	A positive integer that activates the options for temperature dependent saturation end-point scaling. Only the default value, MODE equal to zero, is implemented that means that scaling can only be performed by grid block end-point scaling properties or via saturation end-point depth tables.	0

Notes:

1) Note that the IRREVERS option can only be set to IRREVERS if the DIRECT parameter is set equal to DIRECT.
2) The keyword is terminated by "/".

Table 5.6: ENDSCALE Keyword Description

Example

```
--        DIRC    REVERSE  MAX     MAX
--        SCALE   SCALE    TABLES  NODES
ENDSCALE
          NODIR   REVERS   1*      1*                                    /
```

The above example invokes the end-point scaling option with end-point scaling being non-directional and reversible with the default number of saturation end-point depth tables (one) with 20 entries per table.

5.2.27 EQLDIMS – DEFINE THE EQUILIBRATION DATA DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EQLDIMS keyword defines the maximum number of properties associated with equilibrating the model, that is initializing the model. A reservoir grid can be separated into separate regions in order to apply different pressure regimes and/or fluid contacts. Care should be taken that the different regions are not in communication if the pressures or fluid contacts are different for the various regions, as this would lead to an unstable initialization and would also imply errors in the model description as implemented.

No.	Name	Description	Default
1	NTEQUL	A positive integer value that defines the number of equilibration regions entered using the EQLNUM keyword in the REGIONS section and the number of entries associated with the EQUIL keyword in the SOLUTION section.	1
2	NPRSVD	A positive integer value setting the number of pressure versus depth entries used by OPM Flow in determining equilibration parameters. Unless there is a requirement for a very fine equilibration this parameter should be defaulted.	100
3	NDRXVD	A positive integer value that the defines the maximum number of depth entries in equilibration property versus depth tables (RSVD, RVVD, PBVD or PDVD etc.) as defined in the SOLUTION section.	20
4	NTTRVD	A positive integer that defines the maximum number of TVDP tables that describe the initial tracer concentration versus depth. This option is ignored by OPM Flow.	1
5	NSTRVD	A positive integer that defines the maximum number of depth entries in the TVDP tables as described in (4). This option is ignored by OPM Flow.	20

Notes:

1) NTEQUL is the exact number of entries must be entered on the EQUIL keyword, otherwise OPM Flow will report an error. It is not a maximum number as for the other region arrays.
2) The keyword is terminated by "/".

Table 5.7: EQLDIMS Keyword Description

It is common that the EQLNUM and FIPNUM arrays are identical so that the fluid in-place reporting matches the equilibration regions. Thus, in order to avoid errors in this case, one should just use one array (say the FIPNUM property array) and use the COPY keyword to generate the EQLNUM array.

Example

```
--
--        MAX     MAX     RSVD    TVDP    TVDP
--        EQLNUM  DEPTH   NODES   TABLE   NODES
EQLDIMS
          9       1*      20      1*      1*                                /
```

The above example defines nine equilibration regions the default values for the remaining parameters on the EQLDIMS keyword.

5.2.28 EQLOPTS – ACTIVATE THE EQUILIBRATION OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EQLOPTS keyword defines the equilibration options by stating the character command to activate an option to be used for initializing the model. Multiple commands may be utilized to activate several equilibration options following the keyword.

No.	Name	Description	Default
1	MOBILE	A character string that activates the mobile fluid critical saturation end point correction. If the MOBILE command is stated then this option is activated. This option is not supported and should be defaulted with 1* on the keyword.	None
2	QUIESC	A character string that activates the initial quiescence option that modifies the equilibrium calculated phase pressures to ensure that a steady state solution is obtained. This options ensures that there is no flow potential between the grid blocks in a given region, which is the normal case when block-centered equilibration is used by setting BOINIT on the EQUIL keyword to zero in the SOLUTION section. If the QUIESC command is stated then this option is activated. This option is ignored by OPM Flow.	None
3	THRPRES	A character string that activates the inter-region equilibration flow option. This option allows for a threshold pressure variable entered via the THRPRES keyword to define a pressure which prevents flow between regions until the THRPRES value between regions is exceeded. If the THRPRES command is stated then this option is activated.	None
4	IRREVER	A character string that activates the irreversible inter-region equilibration flow option. This option can only be invoked if the THPRES command has been stated. The option allows for different THPRES values for different directions. If the IRREVER command is stated then this option is activated. This option is not supported and should be defaulted with 1* on the keyword.	None

Notes:

1) The keyword is terminated by "/".

Table 5.8: EQLOPTS Keyword Description

Example

```
--
--        ACTIVATE EQUILIBRATION OPTIONS
--        MOBILE END-POINT(MOBILE) STEADY STATE(QUIESC) THRESHOLD(THPRES)
--        IRREVERSIBLE THRESHOLD(IRREVERS)
EQLOPTS
          'THPRES'   'IRREVERS'                                                /
```

The above example activates the threshold pressure option with different threshold pressure for different directions.

5.2.29 FAULTDIM – DEFINE THE NUMBER OF FAULT SEGMENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FAULTDIM keyword defines the maximum number of records (or segments) that can be entered with the FAULTS keyword. The FAULTS keyword defines the faults in the grid than can be used for setting (or re-setting) transmissibility barriers across the fault planes.

No.	Name	Description	Default
1	MFSEGS	A positive integer value that defines the maximum number of records (segments) for the FAULTS keyword.	0

Notes:

1) The keyword is terminated by "/".

Table 5.9: FAULTDIM Keyword Description

Example

```
--
--        FAULT
--        SEGMS
--
FAULTDIM
          10000                                                                    /
```

The above example defines the maximum number of records that can be entered using the FAULT keyword to be 10,0000 segments.

5.2.30 FIELD – ACTIVATE THE OIL FIELD SYSTEM OF UNITS FOR THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the oil FIELD system of units for the model.

OPM Flow has three sets of units, namely: METRIC, FIELD and LAB and one of these keyword should be invoked in the RUNSPEC section to avoid any ambiguity. Both the simulator input and output units are controlled by including one of the METRIC, FIELD or LAB keywords in the RUNSPEC section of the input file.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       SWITCH ON THE FIELD SYSTEM OF UNITS FOR BOTH INPUT AND OUTPUT
--
FIELD
```

The above example switches on the FIELD system of units for the model.

5.2.31 FMTHMD – Activate The Format History Match Gradient File Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on formatted output for the History Match Gradient output file, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.32 FMTIN – ACTIVATE THE FORMAT INPUT FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the Format Input Files option for all input files. Similar to the commercial simulator, OPM Flow has various options for reading various input files and writing the resulting OPM Flow output files as described in Table 5.10.

Process	Keyword	Description	Files
Input	FMTIN	A character string that defines the input files to be formatted as ASCII i.e. text files, as oppose to binary files. The input deck file is always of this type. The option relates to the OPM Flow derived files that used as input, for for example when restarting from another case. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTIN	A character string that defines the input files to be non-unified multiple files, as opposed to unified files. In this case, one file is read in per reporting time step, as opposed to all time steps reports being read from one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001
	UNIFIN	A character string that defines the input files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. For this option a single summary file and a single restart file will be read. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY
Output	FMTOUT	A character string that sets all output files to be formatted as ASCII i.e. text files, as opposed to binary files. The *.PRT, *.LOG and *.DEBUG files are always of this type. The option relates to the OPM Flow output files only. In this case the files will be portable across operating systems, but will also be very large in terms of hard disk space. For this reason it is recommend that the default option is used so that binary files are outputted. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTOUT	A character string that defines the output files to be non-unified multiple files, as opposed to unified files. In this case, one file is written for each reporting time step, as opposed to all time steps reports being written in one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001

Process	Keyword	Description	Files
	UNIFOUT	A character string that defines the output files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single summary file and a single restart file will be generated, as opposed to one file per report time step. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY

Notes:

1) A binary file is computer-readable but not human-readable. All executable programs are stored in binary files, as are most numeric data files. In contrast, text files are stored in a form (usually ASCII) that is human-readable.
2) For unified files if the run terminates unexpectedly, or there is sufficient disk space, then the last report output is not stored. Their main advantage is that if a number of simulations reside in one directory, their output is organized. There is no limit on the number of reporting steps that a unified file can store.

Table 5.10: FMTIN Keyword Description

There is no data required for this keyword.

See also *OPM FLOW OUTPUT FILE FORMATS* for a more detailed description of the various file types (ASCII or binary) and file structure formats (unified or non-unified formats).

Example

```
--
--        SWITCH ON THE FORMAT INPUT FILES OPTION
--
FMTIN
```

The above example switches on the format input file option.

5.2.33 FMTOUT – ACTIVATE THE FORMAT OUTPUT FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the Format Output Files option for all output files. Similar to the commercial simulator, OPM Flow has various options for reading various input files and writing the resulting OPM Flow output files as described in Table 5.11.

Process	Keyword	Description	Files
Input	FMTIN	A character string that defines the input files to be formatted as ASCII i.e. text files, as oppose to binary files. The input deck file is always of this type. The option relates to the OPM Flow derived files that used as input, for for example when restarting from another case. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTIN	A character string that defines the input files to be non-unified multiple files, as opposed to unified files. In this case, one file is read in per reporting time step, as opposed to all time steps reports being read from one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001
	UNIFIN	A character string that defines the input files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. For this option a single summary file and a single restart file will be read. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY
Output	FMTOUT	A character string that sets all output files to be formatted as ASCII i.e. text files, as opposed to binary files. The *.PRT, *.LOG and *.DEBUG files are always of this type. The option relates to the OPM Flow output files only. In this case the files will be portable across operating systems, but will also be very large in terms of hard disk space. For this reason it is recommend that the default option is used so that binary files are outputted. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTOUT	A character string that defines the output files to be non-unified multiple files, as opposed to unified files. In this case, one file is written for each reporting time step, as opposed to all time steps reports being written in one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001

Process	Keyword	Description	Files
	UNIFOUT	A character string that defines the output files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single summary file and a single restart file will be generated, as opposed to one file per report time step. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY

Notes:

1) A binary file is computer-readable but not human-readable. All executable programs are stored in binary files, as are most numeric data files. In contrast, text files are stored in a form (usually ASCII) that is human-readable.
2) For unified files if the run terminates unexpectedly, or there is sufficient disk space, then the last report output is not stored. Their main advantage is that if a number of simulations reside in one directory, their output is organized. There is no limit on the number of reporting steps that a unified file can store.

Table 5.11: FMOUT Keyword Description

There is no data required for this keyword.

See also *OPM FLOW OUTPUT FILE FORMATS* for a more detailed description of the various file types (ASCII or binary) and file structure formats (unified or non-unified formats).

Example

```
--
--        SWITCH ON THE FORMAT OUTPUT FILES OPTION
--
FMTOUT
```

The above example switches on the format output file option.

5.2.34 FOAM – ACTIVATE THE FOAM PHASE AND MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the foam phase and modeling option. The keyword will also invoke data input file checking to ensure that all the required foam phase input parameters are defined in the input deck. Note in the commercial simulator the FOAM phase and model can be used in conjunction with the POLYMER and SURFACT phases; this is not the case for OPM Flow. OPM Flow's FOAM phase and model is a standalone implementation and cannot be used in conjunction with the either the POLYMER or SURFACT phases.

Foam flooding is an enhanced oil recovery flood process that attempts to control injected gas breakthrough in an oil reservoir by changing the mobility of the injected fluid.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       ACTIVATE THE FOAM PHASE IN THE MODEL
--
FOAM
```

The above example declares that the foam phase is active in the model.

5.2.35 FRICTION – ACTIVATE WELLBORE FRICTION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FRICTION keyword activates the Wellbore Friction option and defines the maximum number of wellbore friction wells together with the maximum number of well branches.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MXWELS	A positive integer defining the maximum number of wellbore friction wells for this model.	0
3	MXBRAN	A positive integer defining the maximum number of branches per well. The default value of one implies a standard well with no branches.	1
Notes: 1) The keyword is terminated by "/".			

Table 5.12: FRICTION Keyword Description

Example

```
--
--        WELL     BRANCH
--        MXWELS   MXBRAN
FRICTION
          5        1                                                    /
```

The above example defines the maximum number of wellbore friction wells to be five and the maximum number of branches set to one, for standard wells.

5.2.36 FULLIMP – ACTIVATE FULLY IMPLICIT SOLUTION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FULLIMP keyword activates the Fully Implicit Solution formulation and solution options. OPM Flow users a different numerical scheme which makes this keyword redundant; hence, OPM Flow ignores this keyword. It is documented here for completeness. The keyword as the same function as the IMPLICIT keyword in the RUNSPEC section.

There is no data required for this keyword and there is no terminating "/" for this keyword.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

Example

```
--
--       ACTIVATES THE FULLY IMPLICIT SOLUTION OPTION
--
FULLIMP
```

The above example switches on the fully implicit solution option; however, this has no effect in OPM Flow input decks.

5.2.37 GAS – ACTIVATE THE GAS PHASE IN THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicate that the gas phase is present in the model and must be used for oil-gas, gas-water, oil-water-gas input decks that contain the gas phase. The keyword will also invoke data input file checking to ensure that all the required gas phase input parameters are defined in the input deck.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        ACTIVATE THE GAS PHASE IN THE MODEL
--
GAS
```

The above example declares that the gas phase is active in the model.

5.2.38 GASFIELD – Define Gas Field Operations Options

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GASFIELD keyword activates and specifies the Gas Field Operations options and determines if extended compressors are present in the run and if the expedited first pass DCQ calculation should be used.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.39 GDIMS – ACTIVATE INSTANTANEOUS GRADIENT OPTION AND DEFINE DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GDIMS keyword activates the Instantaneous Gradient option and defines the maximum dimensions as used by the GWRTWCV keyword in the SCHEDULE section. The Instantaneous Gradient option calculates derivatives of solution quantities at the current time step with respect to variations in the variables at the current time step. This is different to Gradient option that calculates the derivatives of solution quantities at the current time step with respect to variations in the variables at the initial time step, that is a time equal to zero. Consequently, the Instantaneous Gradient option can be switched on and off by the GUPFREQ keyword in the SCHEDULE section, whereas the Gradient option cannot.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.40 GIMODEL – ACTIVATE GI PSEUDO COMPOSITIONAL OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GIMODEL, activates the Gi Pseudo Compositional option for gas condensate and volatile oil fluids.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

The accuracy of gas condensate and volatile oil modeling using a "black-oil" reservoir simulator is now firmly accepted in the industry; both depletion and gas cycling above the saturation point can be modeled and yield an acceptable match compared with compositional simulators. The main deficiency with the existing "black-oil" formulation is the treatment of gas injection below the saturation point, where the compositional effect of the stripping of liquid components is inversely proportional to their molecular weights, is not considered. This is because the "black-oil" model assumes that the saturated hydrocarbon fluid properties are only functions of pressure. Thus, when dry gas is injected into a condensate reservoir below the saturation pressure the injected gas continues to re-vaporize liquid at a rate governed only by the cell pressures. Compositional modeling indicate that this not the case.

The GI option attempts to overcome the limitation of the standard "black-oil" approach by extending the "black-oil" model using the method of Cook et al.[17] to take into account the fluid property changes occurring during gas injection. This is done by extending the fluid property treatment so that the saturated fluid properties depend on pressure (as per the standard "black-oil" formulation) and also on an additional parameter which characterizes the compositional changes in the reservoir liquid and vapor phases at constant pressure.

There is no data required for this keyword.

Example

```
--
--       ACTIVATE THE GI PSEUDO COMPOSITIONAL OPTION
--
GIMODEL
```

The above example switches on the Gi Pseudo Compositional option.

[17] *Cook, R. E., Jacoby, R. H., and Ramesh, A. B. "A Beta-type Reservoir Simulator for Approximating Compositional Effects During Gas Injection" paper SPE 4272, Society of Petroleum Engineers Journal (1974) 14, No. 5, 471-481.*

5.2.41 GRAVDR – ACTIVATE GRAVITY DRAINAGE AND IMBIBITION FOR DUAL POROSITY MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on gravity drainage and imbibition modeling between the matrix and the fracture grid blocks in dual porosity and dual permeability runs. Note that either DZMTRX or DZMTRXV keywords in the GRID section should be used to set the matrix vertical dimensions if this option is activated.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

Example

```
--
--        ACTIVATE GRAVITY DRAINAGE AND IMBIBITION FOR DUAL POROSITY MODEL
--
GRAVDR
```

The above example switches on the gravity drainage and imbibition option for the run.

5.2.42 GRAVDRB - ACTIVATE VERTICAL DISCRETIZED GRAVITY DRAINAGE AND IMBIBITION FOR DUAL POROSITY MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on vertical discretized gravity drainage and imbibition modeling between the matrix and the fracture grid blocks in dual porosity and dual permeability runs. Note that the geometry of the matrix sub-cells should be set to VERTICAL on the NMATOPS keyword in the GRID section if this option is activated.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        ACTIVATE VERTICAL DISCRETIZED GRAVITY DRAINAGE AND IMBIBITION
--
GRAVDRB
```

The above example switches on the vertical discretized gravity drainage and imbibition option for the run.

5.2.43 GRAVDRM - ACTIVATE ALTERNATIVE GRAVITY DRAINAGE AND IMBIBITION FOR DUAL POROSITY MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the alternative gravity drainage and imbibition modeling between the matrix and the fracture grid blocks in dual porosity and dual permeability runs. Either the GRAVDRM or GRAVDR keywords should be used to activate this standard or alternative type of formulation.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	OPTION1	A defined character string that sets the matrix flow in and out of the matrix block option, and should be set to one of the following: 1) YES: oil flow is bi-directional, that is oil can flow into and out of the matrix block. 2) NO: oil flow is uni-directional, that is oil can flow out of the matrix block.	YES
Notes: 1) The keyword is terminated by "/".			

Table 5.13: GRAVDRM Keyword Description

Example

```
--
--        ACTIVATE ALTERNATIVE GRAVITY DRAINAGE AND IMBIBITION MODEL
--
--        MATRIX
--        OPTION
GRAVDRM
          YES                                                                  /
```

The above example switches on the alternative gravity drainage and imbibition option for the run and sets oil flow to be bi-directional, that is oil can flow into and out of the matrix block.

5.2.44 GRIDOPTS - GRID PROCESSING OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

GRIDOPTS activates the negative directional dependent transmissibility multipliers option, defines the maximum number of MULTNUM regions and the number of PINCHNUM regions for the model.

No.	Name	Description	Default
1	TRANMULT	A character string that activates the negative directional dependent transmissibility multipliers option by setting TRANMULT to YES. Setting the value to NO switches off this option. OPM Flow users a positive directional dependent transmissibility formulation to describe the flow between two cells, that is for cell (I, J, K) OPM Flow calculates the x face transmissibility between (I, J, K) and (I +1, J, K) cell face. Modification to the transmissibilities in this case is accomplished by the MULTX, MULTY and MULTZ. Keywords. Setting TRANMULT to YES invokes the option to use a negative directional dependent multiplier scheme using the MULTX-, MULTY and MULTZ- keywords. In this case OPM Flow applies the x face transmissibility between (I - 1, J, K) and (I, J, K) cell face when using the MULTX-, MULTY and MULTZ- keywords. This option is not supported and should be defaulted with 1* or NO on the keyword.	NO
2	NRMULT	A positive integer value that defines the maximum number of MULTNUM regions for the MULTNUM array. The MULTNUM array is used in the GRID section to define various inter-region transmissibility regions in the model and NRMULT sets the maximum number of regions which is the maximum value of an element in the MULTNUM array. Inter-region MULTNUM transmissibility multipliers can be defined using the MULTREGT and regional pore volumes multipliers can be set using the MULTREGP keyword.	0
3	NRPINC	A positive integer value that defines the maximum number of PINCHNUM regions for the PINCHNUM array. The PINCHNUM array is used in the GRID section to define various regions in the model and NRPINC sets the maximum of regions which is the maximum value of an element in the PINCHNUM array. Each regions criteria for setting the pinch out criteria is set by the PINCHREG keyword.	0

Table 5.14: GRIDOPTS Keyword Description

See also the MULTNUM, MULTREGPV, MULTREGT, PINCHNUM, and PINCHREG keywords.

Example

```
--
--      NEG      MAX     MAX
--      MULTS    MULTNUM PINCHNUM
GRIDOPTS
        NO       9       1*                                                  /
```

The above example switches off the negative directional dependent transmissibility multipliers option and defines the maximum of MULTNUM regions to be nine,. The NRPINC parameter is defaulted which means there the maximum number of PINCHREG regions is zero.

5.2.45 HMDIMS – Define History Match Gradient Parameter Dimensions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, HMDIMS, defines the maximum parameter dimensions for the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.46 HYST – Activate the Hysteresis Option (Retired)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HYST keyword activates the hysteresis option, the keyword should be avoided and the hysteresis option should be enabled by the HYSER parameter on the SATOTPS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.47 IMPES – ACTIVATE IMPLICIT PRESSURE EXPLICIT SATURATION SOLUTION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IMPES keyword activates the Implicit Pressure Explicit Saturation formulation and solution options, commonly know as IMPES. OPM Flow users a different numerical scheme which makes this keyword redundant; hence, OPM Flow ignores this keyword. It is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

Example

```
--
--       ACTIVATE THE IMPES SOLUTION OPTION
--
IMPES
```

The above example switches on the IMPES solution option; however, this has no effect in OPM Flow input decks.

5.2.48 IMPLICIT – ACTIVATE FULLY IMPLICIT SOLUTION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IMPLICIT keyword activates the Fully Implicit Solution formulation and solution options. OPM Flow users a different numerical scheme which makes this keyword redundant; hence, OPM Flow ignores this keyword. It is documented here for completeness. The keyword as the same function as the FULLIMP keyword in the RUNSPEC section.

There is no data required for this keyword and there is no terminating "/" for this keyword.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

Example

```
--
--       ACTIVATES THE FULLY IMPLICIT SOLUTION OPTION
--
IMPLICIT
```

The above example switches on the fully implicit solution option; however, this has no effect in OPM Flow input decks.

5.2.49 INSPEC – ACTIVATE THE INSPEC FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the writing of the INIT Index file that specifies and defines the format and data type written to the INIT Data file. The INIT Data file that contains the static data specified in the GRID, PROPS and REGIONS sections. For example, the PORO, PERM and NTG arrays from the GRID section. The data is used in post-processing software, for example ResInsight, to visualize the static grid properties.

The INIT Index file can either be written out in formatted form as ASCII i.e. text files, if the FMTOUT keyword has been activated (*.FINSPEC), or binary format (*.INSPEC) if the FMTOUT keyword has not been activated. If the INIT keyword in the RUNSPEC section has been used to switch on the writing of the INIT Data file then a binary INIT Index file is automatically written out as well, unless the NOINSPEC keyword in the RUNSPEC section has been used to switch off the writing of the INIT Index file. Note that most post-processing software require the *.INSPEC file to load the *.INIT data set.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

Example

```
--
--       ACTIVATE WRITING THE INIT INDEX FILE FOR POST-PROCESSING
--
INSPEC
```

The above example switches on the writing of the INIT Index file for post-processing in ResInsight.

5.2.50 LAB - ACTIVATE THE LABORATORY SYSTEM OF UNITS FOR THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the LABORATORY system of units for the model.

OPM Flow has three sets of units, namely: METRIC, FIELD and LAB and one of these keyword should be invoked in the RUNSPEC section to avoid any ambiguity. Both the simulator input and output units are controlled by including one of the METRIC, FIELD or LAB keywords in the RUNSPEC section of the input file.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        SWITCH ON THE LABORATORY SYSTEM OF UNITS FOR BOTH INPUT AND OUTPUT
--
LAB
```

The above example switches on the LABORATORY system of units for the model.

5.2.51 LICENSES – DEFINE REQUIRED LICENSES FOR RUN

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the additional software licenses that are required to invoke various licensed options in the commercial simulator at the start of the run. The commercial simulator requests a license when keywords associated with a licensed option is encountered in the input deck, this may result in the license being unavailable at the time of request and after the simulation has been initiated, resulting in the run terminating. This keyword avoids this scenario by reserving the license at the start of the run.

OPM Flow is an open source project and therefore there is no license management of the various implemented options; hence, this keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

5.2.52 LIVEOIL – ACTIVATE THE LIVE OIL PHASE (OIL WITH FREE AND DISSOLVED GAS)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates oil, free and dissolved gas in the model and therefore makes the oil phase live oil[18] in the "black-oil" formulation, and is equivalent to setting the phases present in the model to be oil, dissolved gas, gas and water phases. Note if water is present in the model this needs to be explicitly stated via the WATER keyword in the RUNSPEC section (see also the BLACKOIL and DEADOIL keywords in the RUNSPEC section). The keyword is used by the commercial simulator's compositional THERMAL option to set the phases present in the model.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

The following example activates the "black-oil" phases in the model.

```
--
--        ACTIVATE LIVE-OIL PHASE
--
LIVEOIL
```

Alternatively one could explicitly declare the phases using the following keywords in the RUNSPEC section.

```
--
--        OIL PHASE IS PRESENT IN THE RUN
--
OIL
--
--        DISSOLVED GAS IN LIVE OIL IS PRESENT IN THE RUN
--
DISGAS
--
--        GAS PHASE IS PRESENT IN THE RUN
--
GAS
--
--        WATER PHASE IS PRESENT IN THE RUN
--
WATER
```

The above example switches on the oil, dissolved gas, gas and water phases in the model.

[18] *"Live" oil is oil that contains gas in solution, which is normally the case for most conventional oil reservoirs. However, for oil reservoirs classified as heavy oil reservoirs, the in situ dissolved gas may be negligible and oil would then be classified as gas-free oil which is commonly referred to as "dead" oil.*

5.2.53 LGR – DEFINE LOCAL GRID REFINEMENT DIMENSIONS AND PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, LGR, defines maximum dimensions and parameters for the Local Grid Refinement ("LGR") option.

Currently, OPM Flow does not support the local grid refinement feature and therefore this keyword is ignored by the simulator, but is documented here for completeness.

No.	Name	Description	Default
1	MAXLGR	A positive integer value that defines the maximum number of LGRs in the model.	0
2	MAXCLS	A positive integer value that defines the maximum number of grid blocks in all the LGRs.	0
3	MCOARS	A positive integer value that defines the maximum number of amalgamated coarse grid blocks in the model.	0
4	MAMALG	A positive integer value that defines the maximum number of LGR amalgamations in the model.	0
5	MXLALG	A positive integer value that defines the maximum number of LGRs in any amalgamation in the model.	0
6	LSTACK	A positive integer that defines the maximum number of previous search directions stored by the linear solver for the LGR. See the NSTACK keyword in the RUNSPEC section for a full description.	10
7	INTOPT	A character string set to either INTERP to activate the Quandalle[19] pressure correction, or NOINTERP to deactivate this option. The option applies bi-linear interpolation to the global cells surrounding an LGR in order to improve the accuracy of the flow calculations between the LGR and the host cells.	NOINTERP
8	NCHCOR	A positive integer value that defines the maximum number of grid blocks within a coarsened grid that overlap parallel domain boundaries for when the Parallel option has been invoked by the PARALLEL keyword in the RUNSPEC section. OPM Flow users a different numerical scheme which makes this parameter redundant, see section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to run OPM Flow in parallel mode.	0

Notes:

1) The keyword is terminated by "/".

Table 5.15: LGR Keyword Description

[19] *Quandalle, Philippe & Besset, P. (1985). Reduction of Grid Effects Due to Local Sub-Gridding in Simulations Using a Composite Grid. 10.2118/13527-MS.*

Example

```
--
--       LOCAL GRID REFINEMENT DIMENSIONS AND PARAMETERS
--
--       LGR     LGR     LGR     LGR     LGR     LGR    LGR     LGR
--       MAXLGR  MAXCLS  MCOARS  MAMALG  MXLALG  LSTACK INTOPT  NCHCOR
LGR
         10      1000    1*      1*      1*      1*     INTERP  1*            /
```

The above example sets the maximum number of LGRs to 10 and the maximum number of grid blocks a LGR may contain to 1,000, and that Quandalle pressure correction should be used to improve the flow calculation.

5.2.54 LGRCOPY – ACTIVATE LOCAL GRID REFINEMENT INHERITANCE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LGRCOPY keyword actives Local Grid Refinement ("LGR") Inheritance option that allows the LGR to inherit the properties of the global or host cell containing a LGR grid block at the start of the GRID section, as oppose to the normal process of applying this transform at the end of the GRID section. LGRCOPY can be used in the RUNSPEC, GRID and EDIT sections. If used in the RUNSPEC section then the option is applied to all LGRs defined in the input file, whereas if used in the GRID and EDIT sections the keyword must be placed inside a LGR definition section, that is between a CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) and the ENDFIN keyword. In the latter case inheritance is applied on an individual LGR basis.

Currently, OPM Flow does not support the local grid refinement feature and therefore this keyword is ignored by the simulator.

Example

The following example activates the LGR Inheritance option for all LGRs in the model.

```
-- ==============================================================================
--
-- RUNSPEC SECTION
--
-- ==============================================================================
RUNSPEC
--
--       ACTIVATE LOCAL GRID REFINEMENT INHERITANCE
--
LGRCOPY
```

5.2.55 LOAD – Load a SAVE File for a Fast Restart

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LOAD keyword loads a previously generated SAVE file to enable a fast restart. A SAVE file contains all the data from a previous run's RUNSPEC, GRID, EDIT, PROPS and REGIONS sections, and thus there is no need for the simulator to calculate various parameters, including grid block transmissibilities etc. This allows for the current run to restart quicker than a conventional restart run using the RESTART keyword in the SOLUTION section via a RESTART file (*.UNRST or *.FUNRST etc.). The keyword should be the first keyword in the input deck and the RUNSPEC, GRID, EDIT, PROPS and REGIONS sections should be deleted from the input deck.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.56 LOWSALT – Activate the Low Salt Brine Phase in the Brine Model

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, LOWSALT, activates the low salt brine phase for the Brine option and also activates the Brine option. See also the BRINE keyword in the RUNSPEC section.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ACTIVATE THE LOW SALT BRINE PHASE FOR THE BRINE OPTION
--
LOWSALT
```

The above example declares that the low salt brine phase is active in the model for the Brine option.

5.2.57 MEMORY – Define Allocated Memory (Retired)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the memory allocation for the run.

OPM Flow and now the commercial simulator users dynamic memory allocation and therefore the keyword has no effect and is ignored by both simulators.

5.2.58 MESSSRVC - Activate or Deactivate Database Message File Output

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MESSSRVC keyword activates or deactivates output to the database message file (*.DBPRTX). The file contains all the messages from run in binary format and is used in some post-processing software to annotate production line plots from the run.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.59 METRIC – ACTIVATE THE METRIC SYSTEM OF UNITS FOR THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the METRIC system of units for the model.

OPM Flow has three sets of units, namely: METRIC, FIELD and LAB and one of these keyword should be invoked in the RUNSPEC section to avoid any ambiguity. Both the simulator input and output units are controlled by including one of the METRIC, FIELD or LAB keywords in the RUNSPEC section of the input file.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        SWITCH ON THE METRIC SYSTEM OF UNITS FOR BOTH INPUT AND OUTPUT
--
METRIC
```

The above example switches on the METRIC system of units for the model.

5.2.60 MISCIBLE – DEFINE MISCIBILITY TODD-LONGSTAFF PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MISCIBLE keyword defines the options associated with the Todd-Longstaff[20] mixing parameters used for when polymer flooding or CO_2 EOR simulation cases are being run.

No.	Name	Description	Default
1	NTMISC	A positive integer value that declares the number miscible residual oil saturations versus water saturations tables for SORWMIS keyword and the number Todd-Longstaff mixing parameters entries on the TLMIXPAR keyword.	1
2	NSMISC	A positive integer value that sets the maximum number of entries (or rows) for each SORWMIS table defined by the SORWMIS keyword.	20
3	MISOPT	A character string that defines the numerical dispersion control options for the oil and gas relative permeability curves, set to either NONE or TWOPOINT: 1) NONE – standard single point up streaming, that is using the immediate neighbor 2) TWOPOINT – two-point up streaming, that is using the immediate neighbor plus one cell for better numerical dispersion control but with a higher computational cost. Only the default value of NONE is supported.	NONE
Notes: 1) The keyword is terminated by "/".			

Table 5.16: MISCIBLE Keyword Description

Example

```
--
--        NTAB     MAX      UPSTRM
--        NTMISC   NSMISC   MISOPT
MISCIBLE
          1        20       NONE                                                    /
```

The above example defines the default values for the MISCIBLE keyword, that is one table with a maximum of 20 rows per table using the standard one cell upstream option.

[20] *M. R. Todd and W. J Longstaff, The Development, Testing, and Application Of a Numerical Simulator for Predicting Miscible Flood Performance". In: J. Petrol.Tech. 24.7 (1972), pages 874{882.*

5.2.61 MONITOR – Activate Output of the Monitoring Data and File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MONITOR keyword activates the writing out of the run time monitoring information used by post-processing graphics software to display run time information, for example the simulated production and injection rates and cumulative values. OPM Flow does not have this functionality.

Hence, OPM Flow ignores this keyword but it is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       ACTIVATE MONITORING OUTPUT DATA AND FILES
--
MONITOR
```

The above example switches on the output required for run time monitoring required by post-processing graphics software to review the simulation results in real time as the run progresses; however, this has no effect in OPM Flow input decks.

5.2.62 MSGFILE – ACTIVE OR DEACTIVATE MESSAGE FILE OUTPUT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MSGFILE keyword activates or deactivates the message file output used by pre- and post-processing software. Note that message file processing is not available in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MSGOPT	A positive integer set to 0 for to deactivate message file output or 1 to activate message file output.	1
Notes: 1) The keyword is terminated by "/".			

Table 5.17: MSGFILE Keyword Description

Example

```
--
--        OUTPUT
--        OPTN
MSGFILE
          0                                                                    /
```

The above example deactivates the message file output, but the keyword is ignored by OPM Flow.

5.2.63 MULTIN – ACTIVATE THE NON-UNIFIED MULTIPLE INPUT FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the Multiple Input Files option for all input files. Similar to the commercial simulator, OPM Flow has various options for reading various input files and writing the resulting OPM Flow output files as described in Table 5.18.

Process	Keyword	Description	Files
Input	FMTIN	A character string that defines the input files to be formatted as ASCII i.e. text files, as oppose to binary files. The input deck file is always of this type. The option relates to the OPM Flow derived files that used as input, for for example when restarting from another case. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTIN	A character string that defines the input files to be non-unified multiple files, as opposed to unified files. In this case, one file is read in per reporting time step, as opposed to all time steps reports being read from one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001
	UNIFIN	A character string that defines the input files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. For this option a single summary file and a single restart file will be read. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY
Output	FMTOUT	A character string that sets all output files to be formatted as ASCII i.e. text files, as opposed to binary files. The *.PRT, *.LOG and *.DEBUG files are always of this type. The option relates to the OPM Flow output files only. In this case the files will be portable across operating systems, but will also be very large in terms of hard disk space. For this reason it is recommend that the default option is used so that binary files are outputted. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTOUT	A character string that defines the output files to be non-unified multiple files, as opposed to unified files. In this case, one file is written for each reporting time step, as opposed to all time steps reports being written in one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001

Process	Keyword	Description	Files
	UNIFOUT	A character string that defines the output files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single summary file and a single restart file will be generated, as opposed to one file per report time step. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY

Notes:

1) A binary file is computer-readable but not human-readable. All executable programs are stored in binary files, as are most numeric data files. In contrast, text files are stored in a form (usually ASCII) that is human-readable.
2) For unified files if the run terminates unexpectedly, or there is sufficient disk space, then the last report output is not stored. Their main advantage is that if a number of simulations reside in one directory, their output is organized. There is no limit on the number of reporting steps that a unified file can store.

Table 5.18: MULTIN Keyword Description

There is no data required for this keyword.

See also *OPM FLOW OUTPUT FILE FORMATS* for a more detailed description of the various file types (ASCII or binary) and file structure formats (unified or non-unified formats).

Example

```
--
--       ACTIVATE THE MULTIPLE INPUT FILES OPTION
--
MULTIN
```

The above example switches on the multiple input file option.

5.2.64 MULTOUT – ACTIVATE THE NON-UNIFIED MULTIPLE OUTPUT FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the Multiple Output Files option for all output files. Similar to the commercial simulator, OPM Flow has various options for reading various input files and writing the resulting OPM Flow output files as described in Table 5.19.

Process	Keyword	Description	Files
Input	FMTIN	A character string that defines the input files to be formatted as ASCII i.e. text files, as oppose to binary files. The input deck file is always of this type. The option relates to the OPM Flow derived files that used as input, for for example when restarting from another case. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTIN	A character string that defines the input files to be non-unified multiple files, as opposed to unified files. In this case, one file is read in per reporting time step, as opposed to all time steps reports being read from one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001
	UNIFIN	A character string that defines the input files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. For this option a single summary file and a single restart file will be read. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY
Output	FMTOUT	A character string that sets all output files to be formatted as ASCII i.e. text files, as opposed to binary files. The *.PRT, *.LOG and *.DEBUG files are always of this type. The option relates to the OPM Flow output files only. In this case the files will be portable across operating systems, but will also be very large in terms of hard disk space. For this reason it is recommend that the default option is used so that binary files are outputted. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTOUT	A character string that defines the output files to be non-unified multiple files, as opposed to unified files. In this case, one file is written for each reporting time step, as opposed to all time steps reports being written in one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001

Process	Keyword	Description	Files
	UNIFOUT	A character string that defines the output files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single summary file and a single restart file will be generated, as opposed to one file per report time step. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY

Notes:

1) A binary file is computer-readable but not human-readable. All executable programs are stored in binary files, as are most numeric data files. In contrast, text files are stored in a form (usually ASCII) that is human-readable.
2) For unified files if the run terminates unexpectedly, or there is sufficient disk space, then the last report output is not stored. Their main advantage is that if a number of simulations reside in one directory, their output is organized. There is no limit on the number of reporting steps that a unified file can store.

Table 5.19: MULTOUT Keyword Description

There is no data required for this keyword.

See also *OPM FLOW OUTPUT FILE FORMATS* for a more detailed description of the various file types (ASCII or binary) and file structure formats (unified or non-unified formats).

Example

```
--
--       ACTIVATE THE MULTIPLE OUTPUT FILES OPTION
--
MULTOUT
```

The above example switches on the multiple output file option.

5.2.65 MULTOUTS – ACTIVATE NON-UNIFIED MULTIPLE SUMMARY OUTPUT FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the Multiple Output Files option for SUMMARY files only, and overwrites the UNIFOUT keyword in the RUNSPEC section that activates the Unified Output Files option for all output files.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

See also *OPM FLOW OUTPUT FILE FORMATS* for a more detailed description of the various file types (ASCII or binary) and file structure formats (unified or non-unified formats).

Example

```
--
--       ACTIVATE MULTIPLE OUTPUT SUMMARY FILES ONLY OPTION
--
MULTOUTS
```

The above example switches on the multiple output file option.

5.2.66 MULTREAL – ACTIVATE COMMERCIAL SIMULATOR'S MULTI-REALIZATION LICENSE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MULTREAL keyword activates the commercial simulator's Multi-Realization License option.

OPM Flow is an open source project and therefore there is no license management of the various implemented options; hence, this keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

5.2.67 NETWORK – ACTIVATE THE EXTENDED NETWORK OPTION AND DEFINE PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the Extended Network option and defines the maxixum number on nodes and links (branches) in the network. The Extended Network option is a different facility to the Standard Network facility, as such, this keyword should only be used if the former network is required for the run.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	NODMAX	NODMAX is a positive integer that defines the maximum number of nodes in the Extended Network model.	None
2	NBRMAX	NBRMAX is a positive integer that defines the maximum number of links in the Extended Network model.	None
3	NBCMAX	Not Used	1*

Notes:

1) The keyword is terminated by "/".

Table 5.20: Network Keyword Description

Example

```
--
--        ACTIVATE THE EXTENDED NETWORK OPTION AND DEFINE PARAMETERS
--
--        MAX.     MAX      NOT
--        NODE     LINK     USED
NETWORK
          10        12      1*                                                  /
```

In the above example the maximum number of nodes is set equal to ten and the maximum number of links (or branches) is set equal to 12, for the Extended Network option.

5.2.68 NINEPOIN – ACTIVATE THE NINE-POINT DISCRETIZATION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NINEPOIN keyword activates the Nine-Point Discretization formulation for the whole grid. If the keyword is absent from the run then the conventional standard five-point discretization formulation is used for the model. The nine-point scheme is based on adding additional non-neighbor connections between the diagonal neighbors in the areal plane, in order to reduce grid orientation effects[21].

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

In none Local Grid Refinement runs the NINENUM keyword in the GRID section may be use to optionally set parts of the grid to use nine-point discretization and the remaining regions to use the conventional standard five-point discretization formulation.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       ACTIVATE THE NINE-POINT DISCRETIZATION OPTION
--
NINEPOIN
```

The above example switches on the Nine-Point Discretization option for the whole grid.

[21] *Yanosik, J. L. and McCracken, T. A. "A Nine-Point, Finite-Difference Reservoir Simulator for Realistic Prediction of Adverse Mobility Ratio Displacements," paper SPE 5734, Society of Petroleum Engineers Journal (1979) 19, No. 4, 253-262.*

5.2.69 NMATRIX – ACTIVATE THE DISCRETIZED MATRIX DUAL POROSITY OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NMATRIX keyword activates the Discretized Matrix Dual Porosity option and specifies the number of sub-grid blocks in the actual matrix grid blocks. See also the NMATOPS keyword in the GRID section that defines various parameters for this option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description	Default
1	NMATRIX	A positive integer value that specifies the number of sub-grid blocks in the actual matrix grid blocks.	1
Notes: 1) The keyword is terminated by "/".			

Table 5.21: NMATRIX Keyword Description

Note the keyword cannot be used in conjunction with the TRPLPORO keyword, which is also in the RUNSPEC section.

Example

```
--
--        SUB-GRIDS
--        NMATRIX
NMATRIX
          4                                                    /
```

The above example activates the Discretized Matrix Dual Porosity option and specifies the number of sub-grid blocks in the actual matrix grid block to be four.

5.2.70 NNEWTF – ACTIVATE THE NON-NEWTONIAN FLUID MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the Non-Newtonian Fluid phase and model for when the polymer phase is present in the model, as indicated by the POLYMER keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	NTHRBL	A positive integer that defines the maximum number of Herschel-Bulkley versus polymer concentration tables to be used with the polymer model, as entered via the FHERCHBL keyword in the PROPS section. The tables are allocated to different parts of the grid by the HBNUM keyword in the REGION section	NTPVT
2	NLNHBL	A positive integer that defines the maximum number of rows for each table entered by the FHERCHBL keyword in the PROPS section.	2

Notes:

1) The exact number of NTHRBL tables are required to completed the data set. For example, if NTHRBL is set equal to three, then there must be three tables entered for the FHERCHBL keyword.
2) The keyword is terminated by "/".

Table 5.22: NNEWTF Keyword Description

Example

```
--
--        MAX      MAX
--        NTHRBL   NLNHBL
NNEWTF
           3       5                                                    /
```

The above example defines maximum number of Herschel-Bulkley tables to be three with a maximum number of rows for each table set to five.

5.2.71 NOCASC – ACTIVATE LINEAR SOLVER TRACER ALGORITHM

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

NOCASC keyword activates the linear solver tracer algorithm for single phase tracers.

OPM Flow users a different numerical scheme which makes this keyword redundant; hence, OPM Flow ignores this keyword. It is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        TRACER SOLVER OPTION
--
NOCASC
```

The above example switches on the linear solver tracer algorithm; however, this has no effect in OPM Flow input decks.

5.2.72 NODPPM – DEACTIVATE FRACTURE POROSITY-PERMEABILITY CALCULATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NODPPM keyword deactivates the default behavior of multiplying the fracture porosity by the fracture permeability to calculate the effective fracture permeability in dual porosity and dual permeability runs. Either the DUALPORO or DUALPERM keywords in the RUNSPEC section must be declared in the input file in order to use this keyword. If the default calculation is switched off by this keyword, then the effective fracture permeability is taken to be those entered for the fracture using the PERMX, PERMY and PERMZ keywords in the GRID section. If the keyword is absent from the input deck, then the entered PERMX, PERMY and PERMZ arrays for the fractures are multiplied by fracture PORO array values in order to obtain the effective fracture permeability.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        DEACTIVATE FRACTURE POROSITY-PERMEABILITY CALCULATION
--
NODPPM
```

The above example switches off the default behavior of multiplying the fracture porosity by the fracture permeability to calculate the effective fracture permeability.

5.2.73 NOHYST - DEACTIVATE THE HYSTERESIS OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NOHYST keyword deactivates the Hysteresis option and informs the simulator to ignore the IMBNUM array in the REGIONS section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        DEACTIVATE THE HYSTERESIS OPTION
--
NOHYST
```

The above example switches off the default behavior of multiplying the fracture porosity by the fracture permeability to calculate the effective fracture permeability.

5.2.74 NOINSPEC – DEACTIVATE OUTPUT OF THE INIT INDEX FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NOINSPEC keyword deactivates the writing out of the INIT index file (*.INSPEC). The initialization data (or static data) is written out to two files one file contains the data, *.INIT, and the second file contains an index of the data (*.INSPEC) stored in the *.INIT file. This functionality is redundant as most post-processing software require the *.INSPEC file to load the *.INIT data set.

Hence, OPM Flow ignores this keyword. It is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       DEACTIVATE OUTPUT OF THE INIT INDEX FILE *.INSPEC
--
NOINSPEC
```

The above example switches off the writing of the INIT index file (*.INSPEC); however, this has no effect in OPM Flow input decks.

5.2.75 NOMONITO – Deactivate Output of the Monitoring Data and File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NOMONITO keyword deactivates the writing out of the run time monitoring information used by post-processing graphics software to display run time information, for example the simulated production and injection rates and cumulative values. OPM Flow does not have this functionality.

Hence, OPM Flow ignores this keyword but it is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        DEACTIVATE MONITORING OUTPUT DATA AND FILES
--
NOMONITO
```

The above example switches off the output required for run time monitoring required by post-processing graphics software to review the simulation results in real time as the run progresses; however, this has no effect in OPM Flow input decks.

5.2.76 NONNC – DEACTIVATE NON-NEIGHBOR CONNECTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NONNC keyword deactivates non-neighbor connections ("NNCs") in the current run. NNCs create off-diagonal elements in the Jacobi matrix that impact the numerical efficiency of the solution algorithms, and thus if the run does not contain NNC's then there is the potential for greater computation efficiency. Unfortunately, nearly all models, except for the most simple models, generate NNCs via for example:

1) aquifer connections,
2) faults, and
3) manually entered NNCs, including those automatically generate by pre-processing software.

Due to the limited application of this option, the feature has not been implemented in OPM Flow and hence OPM Flow ignores this keyword. It is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       DEACTIVATE NON-NEIGHBOR CONNECTIONS
--
NONNC
```

The above example switches off the NNCs; however, this has no effect in OPM Flow input decks.

5.2.77 NORSSPEC – DEACTIVATE OUTPUT OF THE RESTART INDEX FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NORSSPEC keyword deactivates the writing out of the RESTART index file (*.RSSPEC). The restart data (pressure, saturations etc. through time for each active cell) are written out to two files one file contains the data, *.UNRST for example, and the second file contains an index of the data (*.RSSPEC) stored in the *.UNRST file. This functionality is redundant as most post-processing software require the *.RSSPEC file to load the *.UNRST data set.

Hence, OPM Flow ignores this keyword. It is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        DEACTIVATE OUTPUT OF THE RESTART INDEX FILE *.RSSPEC
--
NORSSPEC
```

The above example switches off the writing of the restart index file (*.RSSPEC); however, this has no effect in OPM Flow input decks.

5.2.78 NOSIM – ACTIVATE THE NO SIMULATION MODE FOR DATA FILE CHECKING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

NOSIM switches the mode of OFM Flow to data input checking mode. In this mode the input file is read and all messages and print instructions are sent to the respective output files. The SCHEDULE section is read but the simulation is not performed.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

The example below switches OPM Flow to no simulation mode for data checking of the input deck.

```
--
--        SWITCH NO SIMULATION MODE FOR DATA CHECKING COMMENT OUT TO RUN THE MODEL
--
NOSIM
```

And the next example shows how to commented out the NOSIM activation keyword so that the simulation will proceed.

```
--
--        SWITCH NO SIMULATION MODE FOR DATA CHECKING COMMENT OUT TO RUN THE MODEL
--
-- NOSIM
```

Note

Simulation input decks are complex and are therefore prone to typing errors, thus before submitting a run that will take over 15 minutes or so, it is a good idea to run the model with the NOSIM option. If no errors are found then the NOSIM keyword should be commented out by placing "--" before the keyword, and then re-running the model.

Alternatively, one could use OPMRUN to run all the jobs in the queue in NOSIM mode and have software re-run jobs in simulation mode if there are no errors.

5.2.79 NRSOUT – DEFINED MAXIMUM NUMBER OF RESTART ELEMENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NRSOUT keyword specifies the maximum number of elements that can be written to the RESTART file at each reporting time step.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	NRSOUT	A positive integer value that specifies the maximum number of elements that can be written to the RESTART file at each reporting time step.	3600

Notes:

1) The keyword is terminated by "/".

Table 5.23: NRSOUT Keyword Description

Example

```
--
--        MAX
--        NRSOUT
NRSOUT
          6000                                                    /
```

The above example sets the maximum number of elements that can be written to the RESTART file at each reporting time step to 6000.

5.2.80 NSTACK – DEFINE THE STACK LENGTH FOR THE ITERATIVE LINEAR SOLVER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NSTACK keyword defines the maximum number of previous search directions stored by the linear solver. Increasing the value of NSTACK may improve the efficiency of the solver on difficult problems, but will increase the memory requirements of the simulator. The default value of 10 should be sufficient for most problems; however, if OPM Flow is having issues with the convergence of the linear questions then increasing NSTACK and LITMAX on the TUNING keyword may improve performance.

OPM Flow users a different numerical scheme which makes this keyword redundant; see section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	NSTACK	A positive integer that defines the maximum number of previous search directions stored by the linear solver.	10

Notes:

1) NSTACK and LITMAX on the TUNING keyword are related such that NSTACK should always be less than or equal to LITMAX.
2) The keyword is terminated by "/".

Table 5.24: NSTACK Keyword Description

Example

```
--
--          SET STACK SIZE FOR LINEAR SOLVER
--
NSTACK
            30                                                                  /
```

The above example sets maximum number of previous search directions stored by the linear solver to 30, this has no effect in OPM Flow input decks.

Note

If the run is suffering from linear convergence problems, then check the data first for any data issues before manipulating the numerical control parameters. For example, if OPM Flow has written some WARNING messages with respect to end-point scaling, etc., then resolve these messages first before adjusting the numerical controls.

5.2.81 NUMRES – DEFINE THE NUMBER OF RESERVOIR GRIDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NUMRES keyword defines the number of reservoir grids (COORD data sets) that the simulator should process. Currently, this should only be set to one in OPM Flow

No.	Name	Description	Default
1	NUMRES	A positive integer greater than one that defines the maximum number COORD data sets to be processed by OPM Flow. This should be set to one.	1
Notes: 1) The keyword is terminated by "/".			

Table 5.25: NUMRES Keyword Description

Example

```
--
--        DEFINE THE NUMBER OF RESERVOIR GRIDS (COORD DATA SETS)
--
NUMRES
          1                                                                    /
```

The above example sets the maximum number of COORD data sets to be processed to one, this is the only value that can currently be used in OPM Flow.

5.2.82 NUPCOL – DEFINE THE NUMBER OF NEWTONIAN ITERATIONS USED TO UPDATE WELL TARGETS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NUPOL keyword defines the maximum number of Newtonian iterations within a time step that may be used to update the well production and injection targets, after which the well targets will be frozen until the time step calculations have converged and the time step is complete.

Wells under group control may suffer from some dependency with other wells in the same group that are under group control. This may cause some oscillation in the production and injection well rates within the group. In order to avoid this, after the number Newtonian iterations within a time step surpasses NUPCOL, the group well rates are frozen until the time step has converged. Reducing the potential of well rate oscillations within the time step may result in the group targets and limits not being exactly being met in this case. Increasing the value of NUPCOL to greater than the default value of three, will improve the accuracy of the group targets and limits at the expense of computational efficiency.

See also section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to set various other numerical control parameters for OPM Flow.

No.	Name	Description	Default
1	NUPCOL	A positive integer that defines the maximum number of Newtonian iterations used to update well targets within a time step. Note that default value of 12 is different to the commercial simulator's default value of three.	12
Notes: 1) The keyword is terminated by "/".			

Table 5.26: NUPCOL Keyword Description

Example

```
--
--        DEFINE THE NUMBER OF ITERATIONS TO UPDATE WELL FLOW TARGETS
--
NUPCOL
         4                                                                    /
```

The above example sets the default NUPCOL value to four

5.2.83 OIL – ACTIVATE THE OIL PHASE IN THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicate that the oil phase is present in the model and must be used for oil-gas, oil-water, oil-water-gas input decks that contain the oil phase. The keyword will also invoke data input file checking to ensure that all the required oil phase input parameters are defined in the input deck.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        OIL PHASE IS PRESENT IN THE RUN
--
OIL
```

The above example declares that the oil phase is active in the model.

5.2.84 OPTIONS – ACTIVATE VARIOUS PROGRAM OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The OPTIONS keyword activates various OPM Flow program options; however only the options known to be available and tested are documented out of the over 200 activation operations available in the commercial simulator.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Description	Default
1 - 273	Undefined.	0
Notes: 1) The keyword is terminated by "/".		

Table 5.27: OPTIONS Keyword Description

Examples

```
--
--        SKIP      ACTIVATE
--        OPTIONS   OPTION
OPTIONS
          77*0      1                                                    /
```

The above example activates the use of scratch files for pre-processing grid geometry data for non-neighbor connections. Note if multiple options are required then one can just repeat the format of the example to activate multiple options as the keyword does not overwrite previous entries. So for example:

```
--
--        SKIP      ACTIVATE
--        OPTIONS   OPTION
OPTIONS
           7*0      1                                                    /
--
--        SKIP      ACTIVATE
--        OPTIONS   OPTION
OPTIONS
          77*0      1                                                    /
--
--        SKIP      ACTIVATE
--        OPTIONS   OPTION
OPTIONS
          177*0     1                                                    /
```

Could be used to activate the 8, 78 and 178 options if they were available.

5.2.85 PARALLEL – DEFINE PARALLEL RUN CONFIGURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PARALLEL keyword defines the run to use parallel processing and sets the domain decomposition options. See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to run OPM Flow in parallel mode.

No.	Name	Description	Default
1	NPROCS	A positive integer that defines the number of domains or parallel processors to use for this run.	1
2	RTYPE	A character string set to either SERIAL to run the parallel code in serial mode for testing the code, or DISTRIBUTED to full utilize parallel processing.	PARALLEL
Notes: 1) The keyword is terminated by "/".			

Table 5.28: PARALLEL Keyword Description

OPM Flow users a different numerical scheme which makes this keyword redundant; hence, OPM Flow ignores this keyword. It is documented here for completeness.

Example

```
--
--        PARALLEL MULTI-CORE OPTIONS
--        NDMAIN     MACHINE TYPE
PARALLEL
            2        DISTRIBUTED                                                    /
```

The above example sets the number of domains (or processors) to two and for the simulation to run in parallel mode. This has no effect in OPM Flow input decks.

5.2.86 PARTTRAC – Activate and Define Partitioned Tracer Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PARTTRAC keyword activates the Partitioned Tracer option and defines the maximum number of partitioned tracers, the number of TRACERKP or TRACERKM partitioning tables in the PROPS section, and the maximum number of number of rows in the TRACERKP or TRACERKM partitioning tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.87 PATHS – DEFINE FILENAME DIRECTORY PATH ALIASES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PATHS allows the user to define alias directory filenames to avoid long filenames with the INCLUDE, IMPORT, RESTART or GDFILE. keywords. To use the alias with the aforementioned keywords PATHS should be prefixed with the $ symbol.

No.	Name	Description	Default
1	NPROCS	A character string enclosed in quotes defining the alias.	None
2	RTYPE	A character string enclosed in quotes defining the directory filename.	None

Notes:

1) Multiple entries must be on separate lines (see the example).
2) The keyword is terminated by "/".

Table 5.29: PATHS Keyword Description

Examples

```
--
--       PATH       PATH
--       ALIAS      DIRECTORY FILENAME
PATHS
        'GRID'      '/DISK1/NORNE/2017/GRID-INCLUDES'                    /
        'SCHD'      '/DISK1/NORNE/2017/SCHD-INCLUDES'                    /
/
```

The above example defines "GRID" and "SCHD" aliases in the RUNSPEC section than can be used in the GRID and SCHEDULE sections of the input deck. The next example shows how to use the "GRID" alias with the INCLUDE keyword in the GRID section.

```
--
--       LOAD INCLUDE FILES
--
INCLUDE
         '$GRID/PORO.INC'                                                /

INCLUDE
         '$GRID/PERMX.INC'                                               /

INCLUDE
         '$GRID/NTG.INC'                                                 /
```

Here the porosity, permeability and net-to-gross arrays are loaded in the GRID section using the directory filename aliases declared in the RUNSPEC section.

5.2.88 PEDIMS – DEFINE PETRO-ELASTIC MODEL REGIONS AND TABLE DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PEDIMS keyword defines the number of petro-elastic regions to be used with the PENUM keyword in the REGIONS section and the number of rows in the PEGTAB0 to PEGTAB7 keywords, as well as the number of rows in the PEKTAB0 to PEKTAB7 keywords in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.89 PETOPTS – Define Petrel and Generic Simulation File Options

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PETOPTS keyword defines various Petrel and Generic Simulation (*.GSG) file options.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.90 PIMTDIMS – DEFINE WELL PRODUCTIVITY SCALING TABLE DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PIMTDIMS keyword defines the maximum number of PIMULTAB tables and the maximum number of entries (or rows) per PIMULTAB table. The PIMULTAB keyword is used to define a well's productivity index factor as a function of a well's producing water cut, and the PIMULTAB keyword defined in the SCHEDULE section of the input deck.

No.	Name	Description	Default
1	NTPIMT	A positive integer value that defines the maximum number of PIMULTAB keywords defined in the input deck.	0
2	NRPIMT	A positive integer value defining the maximum number of entries (rows) in the PIMULTAB keyword.	0

Notes:

1) The keyword is terminated by "/".

Table 5.30: PIMTDIMS Keyword Description

Example

```
--
--        MAX      MAX
--        TABLES   ENTRIES
PIMTDIMS
          1        51                                                    /
```

The above example defines that there is one PIMULTAB table with a maximum number of 51 rows.

5.2.91 POLYMER – ACTIVATE THE POLYMER PHASE IN THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicates that the polymer phase is present in the model and to activate the polymer flooding model. The keyword will also invoke data input file checking to ensure that all the required polymer phase input parameters are defined in the input deck.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        ACTIVATE THE POLYMER PHASE IN THE MODEL
--
POLYMER
```

The above example declares that the polymer phase is active in the model.

5.2.92 PRECSALT – ACTIVATE THE OPM FLOW SALT PRECIPITATION MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the OPM Flow Salt Precipitation model that accounts for salt precipitating out of the water phase when the water is being vaporized into the gas phase and the dissolved salt reaches the solubility limit as the pressure in the reservoir is being depleted (see the VAPWAT keyword in the RUNSPEC section). This facility is an extension to the standard Brine model, and as such the BRINE keyword in the RUNSPEC must also be present in the input deck. In general, if the PRECSALT keyword has been activated in the input deck then the VAPWAT keyword should also be activated. The keyword should only be used if both water and gas phases are active in the model.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note

This is an OPM Flow specific keyword for the simulator's Salt Precipitation model, note that this is an extension to the commercial simulator's Brine model.

If the keyword is present in the input deck then the SALTSOL keyword in the PROPS section also needs to be present in the input deck to define the salt solubility. In addition, SALTPVD keyword in the SOLUTION section should be used to define the initial salt precipitated concentration versus depth tables.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        ACTIVATE THE GAS PHASE IN THE MODEL
--
GAS
--
--        VAPORIZED WATER IN DRY/WET GAS IS PRESENT IN THE RUN (OPM FLOW KEYWORD)
--
VAPWAT
--
--        WATER PHASE IS PRESENT IN THE RUN
--
WATER
--
--        ACTIVATE STANDARD BRINE MODEL IN THE RUN
--
BRINE
--
--        ACTIVATE THE OPM FLOW SALT PRECIPITATION MODEL (OPM FLOW KEYWORD)
--
PRECSALT
```

The above example declares that the gas, vaporized water and water phases are present in the model, and activates the Brine and Salt Precipitation models.

5.2.93 PSTEADY – ACTIVATE PSEUDO STEADY STATE FLOW CALCULATION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PSTEADY keyword activates Pseudo Steady State Flow Calculation option by advancing the simulator until it reaches a pseudo steady state flow and then sets the date to the date defined on this keyword, that is written to the RESTART file. Keyword also includes parameters defining the conditions for pseudo steady flow state.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.94 RADIAL – RADIAL GRID ACTIVATION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RADIAL[22] activates the radial grid geometry option for the model, if this keyword is omitted then Cartesian geometry is assumed by OPM Flow.

Although this keyword is read by OPM Flow, radial grids have not been fully implemented and therefore this type of grid should not be used.

[22] *Radial grids are not currently implemented in this version of OPM Flow but are expected to be incorporated in a future release.*

5.2.95 REGDIMS – DEFINE THE MAXIMUM NUMBER OF REGIONS FOR A REGION ARRAY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The REGDIMS keyword defines the maximum number of regions for various region arrays used in the model. Note that the maximum number of FIPNUM regions can be defined both on this keyword and the TABDIMS keyword, if it set in both locations the maximum value is used. The reason for this type of inconsistency is due to the commercial simulator evolving with time as new features were added, but at the same time having to maintain backward input deck compatibility.

No.	Name	Description	Default
1	NTFIP	A positive integer defining the maximum number of regions in the FIPNUM region array. Note that this parameter may also be set on the TABDIMS keyword as well. If NTFIP is set in both places then the maximum value is used.	1
2	NMFIPR	A positive integer defining the total maximum number of regions. The FIPNUM regions are defined by (1). if additional sets of fluid in-place regions are required, as per the FIPxxx series of fluid in-place region keywords, then these are to be defined here by adding to the value in (1). So for example, if NTFIP equals 5 and the number of distinct FIPxx regions is three, then the value to enter for NMFIPR is eight.	1
3	NRFREG	A positive integer defining the maximum number of independent reservoir regions in the ISOLNUM region array.	0
4	MXNFLX	A positive integer defining the maximum number of flux regions in the FLUXNUM region array. MXNFLN can also be defined on the TABDIMS keywords as well. If MXNFLX is defined both here and on the TABDIMS keyword then the maximum value of the two is used.	0
5	NUSREG	A positive integer defining the maximum user defined regions in a commercial simulator's compositional model. This parameter is included for compatibility and should be defaulted as it is not used in OPM Flow.	0
6	NTCREG	A positive integer defining the maximum number of regions in the COALNUM region array.	1
7	NOPREG	A positive integer defining the maximum number of regions in the OPERNUM region array.	0
8	NWKDREG	A positive integer defining the maximum maximum of real double-precision work arrays for use with the OPERATE and OPERATER keywords	0
9	NWKIREG	A positive integer defining the maximum number of integer work arrays for use with the OPERATE and OPERATER keywords	0
10	NPLMIX	A positive integer defining the maximum number of regions in the PLMIXNUM region array.	1

Notes:

1) The keyword is terminated by "/".

Table 5.31: REGDIMS Keyword Description

Example

```
--
--        MAX      TOTAL    INDEP    FLUX     TRACK    CBM      OPERN    WORK     WORK     POLY
--        FIPNUM   REGNS    REGNS    REGNS    REGNS    REGNS    REGNS    REAL     INTG     REGNS
REGDIMS
          9        12       1*       1*       1*       1*       1*       1*       1*       1*    /
```

The above example defines the number of FIPNUM regions to be nine and the number of FIPxxx type of regions to be three (12 – 9), the rest of the region sizes are set to the default values.

5.2.96 RIVRDIMS – Define the River Dimensions and Associated Data

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RIVRDIMS defines the river system array dimensions used with the REACHES keyword and other river keywords in the SOLUTION and SCHEDULE sections. The keyword also enables the River option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.97 ROCKCOMP – ACTIVATE ROCK COMPACTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCKCOMP keyword activates rock compaction and defines various rock compaction options for the run. By default OPM Flow models rock compaction via pore volume compressibility as entered on the ROCK keyword in the PROPS section. This keyword enables pressure dependent pore volume and transmissibility multipliers for rock compaction that are entered in the PROPS section using the ROCKTAB keyword. Currently OPM Flow only supports the default options for rock compaction.

No.	Name	Description	Default
1	ROCKOPT	A character string that defines the rock compaction option based on one of the following character strings: 1) REVERS: Rock compaction is reversible with increasing pressure. The rock compaction multipliers should be entered via the ROCKTAB keyword in the PROPS section. Note that this is the default value and is the only option currently supported by OPM Flow. 2) IRREVERS: Rock compaction is irreversible, that is the rock expansion does not occur when the pressure subsequently decreases. 3) HYSTER: Invokes the hysteresis rock compaction option. 4) BOBERG: Rock compaction hysteresis is modeled using the Boberg formulation[23]. 5) REVLIMIT: Activates the reversible hysteresis rock compaction option that limits the pore volume subject to reversibility based on the minimum pressure in a grid block and the initial water saturation. This option is only intended to be used with the water induced compaction model, neither of which are currently supported by OPM Flow.. 6) PALM-MAN: Rock compaction hysteresis is modeled using the Palmer-Mansoori[24] and [25] formulation for coal bed methane reservoirs, neither of which are supported by OPM Flow. 7) NONE: Deactivates rock compaction, unless the water induced compaction model has been invoked. Only the default option is supported by OPM Flow.	REVERS
2	NTROCC	A positive integer that defines the number of rock compaction tables, that is the number of ROCKTAB tables to be used by OPM Flow.	1
3	WATINOPT	A character string that states if the water induced rock compaction option should be used (YES) or not (NO). If set to YES then the either the ROCKTABW or the ROCK2D and ROCKWNOD keywords should be entered in the PROPS section Only the YES option is currently supported by OPM Flow.	NO

[23] *Beattie, C.I., Boberg, T.C., and McNab, G.S. "Reservoir Simulation of Cyclic Steam Stimulation in the Cold Lake Oil Sands," paper SPE 18752, Society of Petroleum Engineers Journal, (1991) 6, No. 2, 200-206.*

[24] *Palmer, I. and Mansoori, J. "How Permeability Depends on Stress and Pore Pressure in Coalbeds: A New Model," paper SPE 52607, SPE Reservoir Evaluation & Engineering (1998) 1, No. 6, 539-544.*

[25] *Clarkson, C.R., Pan, Z., Palmer, I. and Harpalani, S. "Predicting Sorption-Induced Strain and Permeability Increase With Depletion for Coalbed-Methane Reservoirs", SPE 114778-PA, SPE Journal (2010) 15, No. 1, 152–159.*

No.	Name	Description	Default
4	PORTXROP	A character string that specifies the model to be used for the porosity dependence transmissibility dependence for when transmissibility is dependent on porosity, should be set to either: 1) EXP: An exponential porosity-transmissibility relationship should be used. 2) CZ: The Carmen-Kozeny[26, 27 and 28] porosity-transmissibility relationship should be used. This option is currently ignored by OPM Flow.	1*
Notes: 1) The keyword is terminated by "/".			

Table 5.32: ROCKCOMP Keyword Description

Example

```
--
--        ROCK    NUMBER   WAT      POR-TRAN
--        OPTN    TABLES   INDUCE   OPTION
ROCKCOMP
          REVERS 5         NO       1*                                        /
```

The above example defines the default values for the ROCKCOMP keyword with five rock compaction tables.

[26] *J. Kozeny, "Ueber kapillare Leitung des Wassers im Boden." Sitzungsber Akad.Wiss.,Wien, 136(2a): 271-306, 1927.*

[27] *P.C. Carman, "Fluid flow through granular beds." Transactions, Institution of Chemical Engineers, London, 15: 150-166, 1937.*

[28] *P.C. Carman, "Flow of gases through porous media." Butterworths, London, 1956*

5.2.98 RPTCPL – ACTIVATE COUPLE SIMULATION REPORTING

FRUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the couple simulation reporting, that results in the simulator writing out various initialization data and simulation data in order for external "controlling programs" to interactively manage the simulation. There is no data required for this keyword but the keyword should be terminated by a "/".

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

Example

```
--
--       ACTIVATE COUPLE SIMULATION REPORTING
--
RPTCPL
/
```

The above example switches on couple simulation reporting; however, this has no effect in OPM Flow input decks.

5.2.99 RPTHMD - Define Well History Match Gradient Reporting Options

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, RPTHMD, defines the options and level of history match output that should be written to history match file (*.HMD), for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.100 RPTRUNSP – ACTIVATE RUNSPEC REPORTING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates reporting of all the RUNSPEC options utilized in the run. There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

Example

```
--
--       ACTIVATE RUNSPEC SECTION REPORTING
--
RPTRUNSP
```

The above example switches on RUNSPEC reporting; however, this has no effect in OPM Flow input decks.

5.2.101 RSSPEC – ACTIVATE OUTPUT OF THE RESTART INDEX FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RSSPEC keyword activates the writing out of the RESTART index file (*.RSSPEC). The restart data (pressure, saturations etc. through time for each active cell) are written out to two files one file contains the data, *.UNRST for example, and the second file contains an index of the data (*.RSSPEC) stored in the *.UNRST file. This keyword is somewhat redundant as the RESTART index file is written out by default. See the NORSSPEC keyword in the RUNSPEC section that deactivates the writing out of the file.

Hence, OPM Flow ignores this keyword. It is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        ACTIVATE OUTPUT OF THE RESTART INDEX FILE *.RSSPEC
--
RSSPEC
```

The above example switches on the writing of the restart index file (*.RSSPEC); however, this has no effect in OPM Flow input decks.

5.2.102 RUNSPEC - DEFINE THE START OF THE RUNSPEC SECTION OF KEYWORDS

Description

The RUNSPEC activation keyword marks the start of the RUNSPEC section that defines the key parameters for the simulator including the dimensions of the model, phases present in the model (oil, gas and water for example), number of tables for a given property and the maximum number of rows for each table, the maximum number of groups, wells and well completions, as well as various options to be invoked by OPM Flow.

Apart from COMMENTS entered by "--" in columns one and two, this keyword should be the first keyword in the input deck.

There is no data required for this keyword and there is no keyword terminating "/"

Example

```
-- ==============================================================================
--
-- RUNSPEC SECTION
--
-- ==============================================================================
RUNSPEC
```

The above example marks the start of the RUNSPEC section in the OPM Flow data input file.

5.2.103 SAMG – ACTIVATE ALGEBRAIC MULTI-GRID LINEAR SOLVER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword actives the algebraic multi-grid linear solve; note this solver is not available to the general public in the commercial simulator.

This keyword is ignored by OPM Flow and has no effect on the simulation.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

5.2.104 SATOPTS – ACTIVATE RELATIVE PERMEABILITY ASSIGNMENT OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SATOPTS keyword activates OPM Flow's relative permeability assignment options. The relative permeability functions are defined using the either the:

1) SWOF, SGOF, SLGOF series of saturation functions, or the

2) SWFN, SGFN, SGWFN, SOF2, SOF3, SOF32D series of functions.

The allocation of the relative permeability tables to the grid cells is dependent on the options selected on this keyword (SATOPTS).

If the DIRECT option as been activated and the IRREVERS **has not been invoked** on the SATOPTS keyword, then **different relative permeability functions are used for each x, y, and z directions.** Here the KRNUMX, KRNUMX and KRNUMZ keywords are used for Cartesian grids to allocate the relative permeability tables to the cells. For Radial grids the KRNUMR, KRNUMT and KRNUMZ keywords should be used. This results in the same relative permeability curves being used in both the x_i to x_{i-1} and the x_i to x_{i+1} flow directions. Similarly for the y direction the same curves are used for the y_i to y_{i-1} and the y_i to y_{i+1} flow directions. And again for the z direction, the same relative permeability function is used for flow in the z_i to z_{i-1} and the z_i to z_{i+1} flow directions.

If the DIRECT option as been activated and the IRREVERS **has been invoked** on the SATOPTS keyword, then KRNUMX, KRNUMY and KRNUMZ keywords are used for Cartesian grids to allocate the relative permeability tables in the x_i to x_{i+1}, y_i to y_{i+1}, z_i to z_{i+1}, flow directions, respectively. For Radial grids the KRNUMR, KRNUMT and KRNUMZ keywords should be used. For flow in the x_i to x_{i-1} flow directions, etc., the KRNUMX-, KRNUMY- and KRNUMZ- keywords are used for Cartesian grids and the KRNUMR-, KRNUMT- and KRNUMZ- are used for radial grids.

The HYSTER option activates the relative permeability hysteresis option of the non-wetting phases (liquid and vapour) may show hysteretic behavior in that their values depend on whether the non-wetting phase saturation is increasing or decreasing. For this option the user specifies two sets of saturation functions, one for a drainage process (decreasing wetting phase saturation) and one for an imbibition process (increasing wetting phase saturation). For a process starting at the maximum wetting phase saturation, on the drainage curve, with the wetting phase saturation decreasing, the drainage curve is followed. Similarly for a process starting at the minimum wetting phase saturation with the wetting phase saturation increasing, the imbibition curve is followed. If the drainage or imbibition process is reversed at some point, then the data does not necessarily run back over its previous values. In OPM Flow the Carlson[29] is used to describe relative permeability hysteresis and the Killough[30] model is used for capillary pressure.

If the DIRECT option as been activated and the IRREVERS **has not been invoked** on the SATOPTS keyword, then the same set are keywords as for the DIRECT only option are used to assign the drainage relative permeability curves, that is: KRNUMX, KRNUMY, etc., plus the IMBNUMX, IMBNUMY, and IMBNUMZ, keywords for the imbibition curves. If the DIRECT option as been activated and the IRREVERS **has been invoked** on the SATOPTS keyword, then the same set are keywords as for the DIRECT and IRREVERS option are used to assign the drainage relative permeability curves, that is: KRNUMX, KRNUMX-, etc., plus the IMBNUMX, IMBNUMY, MBNUMZ, IMBNUMX-, IMBNUMY-, IMBNUMZ- keywords for the imbibition curves. See Table 5.34 for the various relative permeability table allocation keywords for the various combination of DIRECT, IRREVERS and HYSTER command options.

The keyword should be followed by one or more of the following keyword options.

[29] *Carlson, F. M. (1981) SPE 10157, presented at the 56th Annual SPE Fall Meeting, San Antonio, 1981*

[30] *Killough, J. E. "Reservoir Simulation with History-dependent Saturation Functions," paper SPE 5106, Society of Petroleum Engineers Journal (1976) 16, No. 1, 37-48.*

No.	Name	Description	Default
1	DIRECT	A character string that activates the directional relative permeability assignment option. If the DIRECT command is stated then directional relative permeability assignment is activated and different relative permeability function are assigned to the x, y and z directions. In this case the KRNUMX, KRNUMY and KRNUMZ keywords are used for Cartesian grids to allocate the relative permeability tables. For Radial grids the KRNUMR, KRNUMT and KRNUMZ keywords should be used. Only the default option is supported by OPM Flow.	None
2	IRREVERS	A character string the activates reversible directional relative permeability assignment option. If IRREVERS is stated then the relative permeability assignment is set to non-reversible and results in different sets of relative permeability tables being applied for flow from the x_I to x_{I+1} direction and the x_I to the x_{I-1} direction, for all directions (x, y, z). in this case the KRNUMX, KRNUMY and KRNUMZ keywords are used for Cartesian grids to allocate the relative permeability tables in the x_i to x_{i+1} flow directions etc. For Radial grids the KRNUMR, KRNUMT and KRNUMZ keywords should be used. For flow in the x_i to x_{i-1} flow directions, etc., the KRNUMX-, KRNUMY- and KRNUMZ- keywords are used for Cartesian grids and the KRNUMR-, KRNUMT- and KRNUMZ- are used for radial grids. Only the default option is supported by OPM Flow.	None
3	HYSTER	A character string that activates the hysteresis option. If the HYSTER and DIRECT options have activated and the IRREVERS **has not been invoked** on the SATOPTS keyword, then **different relative permeability functions are used for each x, y, and z directions and for the drainage and imbibition processes.** Here the drainage relative permeability curves are allocated via the KRNUMX, KRNUMX and KRNUMZ keywords for Cartesian grids and the KRNUMR, KRNUMT and KRNUMZ keywords for radial grids. The imbibition relative permeability curves are allocated via the IMBNUMX, IMBNUMY and IMBNUMZ keywords for Cartesian grids and the IMBNUMR, IMBNUMT and IMBNUMZ keywords for radial grids. If the HYSTER, DIRECT and IREVERS options have activated, then **different relative permeability functions are used for each x, y, and z directions, flow direction and for the drainage and imbibition processes.** Then in addition to aforementioned relative permeability curves allocation keywords for the x_i to x_{i+1} flow direction etc., the x_i to x_{i-1} flow directions keywords, KRNUMX-, KRNUMY- and KRNUMZ- are used for Cartesian grids and the KRNUMR-, KRNUMT- and KRNUMZ- are used for radial grids. The imbibition relative permeability curves are allocated via the IMBNUMX-, IMBNUMY- and IMBNUMZ keywords for Cartesian grids and the IMBNUMR, IMBNUMT and IMBNUMZ keywords for radial grids. Only the default option is supported by OPM Flow.	None
4	SURFTENS	A character string that activates the capillary pressure surface tension pressure dependency option. Only the default option is supported by OPM Flow.	None

No.	Name	Description	Default
Notes: 1) Note that the IRREVERS command can only been activated if the DIRECT command is activated at the same time. See Table 5.34 for the various relative permeability table allocation keywords. 2) The keyword is terminated by "/".			

Table 5.33: SATOPTS Keyword Description

For clarity the following table outlines the keywords that should be used in allocating the relative permeability tables for the various SATOPTS options.

Option	Cartesian		Radial	
DIRECT Flow in all directions	KRNUMX KRNUMY KRNUMZ		KRNUMR KRNUMT KRNUMZ	
DIRECT and IRREVERS Flow in the i to i +1 directions. Flow in the i to i -1 directions.	 KRNUMX, KRNUMY KRNUMZ KRNUMX- KRNUMY- KRNUMZ-		 KRNUMR KRNUMT KRNUMZ KRNUMR- KRNUMT- KRNUMZ-	
DIRECT and HYSTER Flow in all directions.	**Drainage** KRNUMX KRNUMY KRNUMZ	**Imbibition** IMBNUMX IMBNUMY IMBNUMZ	**Drainage** KRNUMR KRNUMT KRNUMZ	**Imbibition** IMBNUMR IMBNUMT IMBNUMZ
DIRECT, IRREVERS and HYSTER Flow in the i to i +1 directions. Flow in the i to i -1 directions.	**Drainage** KRNUMX KRNUMY KRNUMZ KRNUMX-, KRNUMY- KRNUMZ-	**Imbibition** IMBNUMX IMBNUMY IMBNUMZ IMBNUMX- IMBNUMY- IMBNUMZ-	**Drainage** KRNUMR KRNUMT KRNUMZ KRNUMR- KRNUMT- KRNUMZ-	**Imbibition** IMBNUMR IMBNUMT IMBNUMZ IMBNUMR- IMBNUMT- IMBNUMZ-
Notes: 1) Note the drainage and imbibition classification is related to the wetting phase, that may be either oil or water; however, water is normally assumed in most cases but there are exceptions to this, especially for heavy oils.				

Table 5.34: SATOPTS Relative Permeability Function Allocation Keywords.

Examples

The first example actives the directional relative permeability assignment option only and hence the following keywords are used to allocate the relative permeability arrays for Cartesian grids: KRNUMX, KRNUMY, and KRNUMZ.

```
--
--       ACTIVATE RELATIVE PERMEABILITY ASSIGNMENT HYSTERESIS OPTIONS
--       DIRECTTIONAL(DIRECT) IRREVERSIBLE(IRREVERS) HYSTERESIS(HYSTER)
SATOPTS
         'DIRECT'                                                      /
```

The next example actives the directional irreversible relative permeability assignment options, and hence the following keywords are used to allocate the relative permeability arrays for Cartesian grids: KRNUMX, KRNUMY, KRNUMZ, KRNUMX-, KRNUMY- and KRNUMZ-.

```
--
--       ACTIVATE RELATIVE PERMEABILITY ASSIGNMENT HYSTERESIS OPTIONS
--       DIRECTTIONAL(DIRECT) IRREVERSIBLE(IRREVERS) HYSTERESIS(HYSTER)
SATOPTS
         'DIRECT'   'IRREVERS'                                         /
```

Finally, the last option invokes all three assignment options.

```
--
--       ACTIVATE RELATIVE PERMEABILITY ASSIGNMENT HYSTERESIS OPTIONS
--       DIRECTTIONAL(DIRECT) IRREVERSIBLE(IRREVERS) HYSTERESIS(HYSTER)
SATOPTS
         'DIRECT'   'IRREVERS'   'HYSTER'                              /
```

In this case the drainage relative permeability curves are allocated by the KRNUMX, KRNUMY, KRNUMZ, KRNUMX-, KRNUMY-, KRNUMZ- keywords, and the imbibition relative permeability curves are allocated by the IMBNUMX, IMBNUMY, IMBNUMZ, IMBNUMX-, IMBNUMY-, IMBNUMZ- keywords.

Note

This keyword activates how relative permeability curves are assigned in the model. The ENDSCALE keyword allows the end-point scaling also to vary with direction, flow direction and hysteresis process, resulting in a great deal of flexibility.

Whether or not all these features should be used though is another question.

5.2.105 SAVE – Activate Output of a SAVE File for Fast Restarts

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates output of a SAVE file for fast restarts. There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

Example

```
--
--        WRITE OUT SAVE FILE FOR FAST RESTARTS
--
SAVE
```

The above example requests that a SAVE file be written out; however, this has no effect in OPM Flow input decks.

5.2.106 SCDPDIMS – DEFINE SCALE DEPOSITION AND DAMAGE TABLE DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SCDPDIMS keyword defines the number of tables used in the Scale Deposition option and the maximum number of entries for the various tables.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	NTSCDP	NTSCDP is a positive integer that defines the number of SCDPTAB scale deposition tables used in the Scale Deposition option.	0
2	NPSCDP	NPSCDP is a positive integer that defines the maximum number of entries (or rows) in any one SCDPTAB scale deposition table defined in the input deck.	0
3	NTSCDA	NTSCDA is a positive integer that defines the number of SCDATAB scale damage tables used in the Scale Deposition option.	0
4	NPSCDA	NPSCDA is a positive integer that defines the maximum number of entries (or rows) in any one SCDATAB scale damage table defined in the input deck.	0
5	Not Used		1*
6	Not Used		1*
7	NTSCDE	NTSCDE is a positive integer that defines the number of SCDETAB karst aquifer dissolution tables used in the Scale Deposition option.	0

Notes:

1) The keyword is terminated by "/".

Table 5.35: SCDPDIMS Keyword Description

Example

```
--
--        NO.      MAX      NO.      MAX      NOT    NOT    NO.
--        NTSCDP   NPSCDP   NTSCDA   NPSCDA   USED   USED   NTSCDE
SCDPDIMS
          5        10       4        10       1*     1*     3                        /
```

The above example defines the number of SCDPTAB scale deposition tables to be five with a maximum number of rows for each table set to 10, the maximum number of SCDATAB scale damage tables to be four with a maximum number of 10 rows per table, and the maximum number of SCDETAB karst aquifer dissolution tables to be three.

5.2.107 SMRYDIMS – DEFINE MAXIMUM NUMBER OF SUMMARY VECTORS TO BE WRITTEN

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SMRYDIMS keyword defines the maximum number of summary vectors to be written out to the SUMMARY file (*.SUMMARY).

OPM Flow users dynamic memory allocation and therefore the keyword has no effect and is ignored by the simulator, but is documented here for completeness.

No.	Name	Description	Default
1	NSUMMX	A positive integer that defines the maximum number of summary vectors to be written out to the SUMMARY file (*.SUMMARY).	10000
Notes: 1) The keyword is terminated by "/".			

Table 5.36: SMRYDIMS Keyword Description

Example

```
--
--        SET THE MAXIMUM NUMBER OF SUMMARY VECTORS THAT CAN BE WRITTEN OUT
--
SMRYDIMS
         10000                                                                /
```

The above example sets maximum number of summary vectors that can be written out to the SUMMARY file to the default value of 10,000; however, this has no effect in OPM Flow input decks.

5.2.108 SOLVDIMS – DEFINE PEBI GRID NESTED FACTORIZATION SOLVER DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOLVDIMS defines the unstructured Perpendicular Bisector ("PEBI")[31] and [32] grid nested factorization solver dimensions. This keyword is generated by an external pre-processing program for generating simulation grids.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[31] *Heinemann, Z.E. and Brand, C.W. 1988. Gridding Techniques in Reservoir Simulation. Proc., First Intl. Forum on Reservoir Simulation, Alpbach, Austria, 339.*

[32] *Heinemann, Z.E., Brand, C.W., Munka, M. et al. 1991. Modeling Reservoir Geometry With Irregular Grids. SPE Res Eng 6 (2): 225–232. SPE-18412-PA. http://dx.doi.org/10.2118/18412-PA*

5.2.109 SOLVENT – ACTIVATE THE SOLVENT PHASE IN THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicates that the solvent phase is present in the model and to activate the four component solvent model for this run. In addition to this keyword, the oil, water and gases phases should also be declared for the run using the OIL, WATER and GAS keywords. The keyword will also invoke data input file checking to ensure that all the required Solvent phase input parameters are defined in the input deck.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       SOLVENT PHASE IS PRESENT IN THE RUN
--
SOLVENT
```

The above example declares that the solvent phase is active in the model.

5.2.110 START – SIMULATION START DATE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword sets the start date for the simulation switches. If the DATES keyword is to be used during the simulation, then a start date should be entered.

No.	Name	Description	Default
1	DAY	A positive integer that defines the day of the month, the value should be greater than or equal to one and less than or equal to 31.	None
2	MONTH	Character string for the month and should be one of the following 'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL' (or 'JLY'), 'AUG', 'SEP', 'OCT', 'NOV', or 'DEC'	None
3	YEAR	A positive four digit integer value of the start year, which must be specified fully by four digits, that is 1986.	None
Notes: 1) The keyword is terminated by "/".			

Table 5.37: START Keyword Description

Example

```
--
--        DEFINE THE START DATE FOR THE RUN
--
START
          01 'JAN' 2014                                                    /
```

The above example sets the start date for the run to be January 1, 2014.

Note

Whenever possible it is a good idea to always set the start date to be at the beginning of the year as per the example. As like most simulators, OPM Flow reports are always stated at the number of days from the start date (and sometimes at a given date). If the start date is at the beginning of the year, then calculating the actual date is relatively straight forward and simple.

5.2.111 SURFACT – ACTIVATE THE SURFACTANT PHASE IN THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicates that the surfactant phase is present in the model and to activate the surfactant flooding model. The keyword will also invoke data input file checking to ensure that all the required surfactant phase input parameters are defined in the input deck. See also the SURFACTW keyword in the RUNSPEC section that actives the surfactant phase, but with the changes to the wettability option activated as well.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

Example

```
--
--        ACTIVATE THE SURFACTANT PHASE IN THE MODEL
--
SURFACT
```

The above example declares that the surfactant phase is active in the model.

5.2.112 SURFACTW – Activate the Surfactant Phase with Wettability Changes in the Model

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicates that the surfactant phase is present in the model and to activate the surfactant flooding mode with Changes to Wettability option activated as well. The keyword will also invoke data input file checking to ensure that all the required surfactant phase input parameters are defined in the input deck. See also the SURFACT keyword in the RUNSPEC section that actives the surfactant phase only, that is without the Changes to the Wettability option.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

Example

```
--
--       ACTIVATE THE SURFACTANT PHASE WITH WETTABILITY CHANGES IN THE MODEL
--
SURFACTW
```

The above example declares that the surfactant phase is active in the model together with the wettability changes.

5.2.113 TABDIMS – DEFINE THE NUMBER OF TABLES AND THE TABLE DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TABDIMS keyword defines the maximum number of tables for a given table type dataset and the maximum number of entries for the various tables. The commercial simulator combines both the "black-oil" and compositional simulator variables on this keyword; however, although all the parameters are explained below only the "black-oil" parameters are used by OPM Flow.

No.	Name	Description	Default
1	NTSFUN	A positive integer that defines the maximum number of relative permeability table sets defined in the input deck. The tables are allocated to different parts of the grid by the SATNUM keyword.	1
2	NTPVT	A positive integer that defines the maximum number of fluid property table sets defined in the input deck. The tables are allocated to different parts of the grid by the PVTNUM keyword.	1
3	NSSFUN	A positive integer that defines the maximum number of saturation entries in the relative permeability tables defined in the input deck.	20
4	NPPVT	A positive integer that defines the maximum number of pressure entries in the PVT tables.	20
5	NTFIP	A positive integer defining the maximum number of regions in the FIPNUM region array. Note that this parameter may also be set on the REGDIMS keyword as well. If NTFIP is set in both places then the maximum value is used.	1
6	NRPVT	A positive integer that defines the maximum number of Rs and Rv entries in the PVT tables. If the DISGAS and VAPOIL options have not been activated then this parameter is ignored.	20
7	NRVPVT	A positive integer that defines the maximum number of Rv entries in the PVT tables for the compositional commercial simulator.	1*
8	NTENDP	A positive integer that defines the maximum number of saturation end-point depth tables. The end-point depth tables are used to re-scale the saturation tables as a function of depth as oppose to being a grid block property. NTENDP may also be specified on the ENDSCALE keyword, and if specified on both here and on the ENDSCALE keyword the maximum value of the two is used.	1
9	NMEOSR	A positive integer that defines the maximum number of reservoir equations of states for the compositional commercial simulator.	1
10	NMEOSS	A positive integer that defines the maximum number of separator or surface equations of states for the compositional commercial simulator.	1
11	MXNFLN	A positive integer defining the maximum number flux regions in the FLUXNUM region array. MXNFLN can also be defined on the REGDIMS keywords as well. If MXNFLX is defined both here and on the REGDIMS keyword then the maximum value of the two is used.	10
12	MXNTHR	A positive integer that defines the maximum number of thermal regions for the compositional commercial simulator.	1

No.	Name	Description	Default
13	NTROCC	A positive integer that defines the maximum number of rock compressibility entries enter by the ROCK keyword defined in the input deck. The tables are allocated to different parts of the grid by the PVTNUM keyword.	1*
14	MXNPMR	A positive integer that defines the maximum number of pressure maintenance regions for the compositional commercial simulator.	0
15	NTABKT	A positive integer that defines the maximum number of temperature dependent K-value tables for the when the thermal option is activated in the compositional commercial simulator.	0
16	NTALPHA	A positive integer that defines the maximum number of transport coefficient tables for the compositional commercial simulator.	0
17	NASPKA	A positive integer that defines the maximum number of maximum number of entries in the ASPKDAM keyword tables for the compositional commercial simulator.	0
18	MXRAWG	A positive integer that defines the maximum number of maximum number of entries in the ASPREWG keyword tables for the compositional commercial simulator.	0
19	MXRASO	A positive integer that defines the maximum number of pressure maintenance regions for the compositional commercial simulator.	0
20		Not Used	1*
21	MCASPP	A positive integer that defines the maximum number of column entries in the ASPPW2D keyword tables for the compositional commercial simulator.	0
22	MRASPP	A positive integer that defines the maximum number of row entries in the ASPPW2D keyword tables for the compositional commercial simulator.	0
23	MXRATF	A positive integer that defines the maximum number of entries in the ASPWETF table for the compositional commercial simulator.	0
24	MXNKVT	A positive integer that defines the maximum number of composition dependent K-value tables for the compositional commercial simulator.	0
25	RESVED	Not Used	1*

Notes:

1) Table sets are groups of keywords that need to be defined to complete a table set. For example if NTPVT is set to three, then there must be three PVTO tables and three PVTG tables to complete the three PVT data set.

2) The keyword is terminated by "/".

Table 5.38: TABDIMS Keyword Description

Example

```
--
--        MAX      MAX      MAX      MAX      MAX      MAX     E300
--        NTSFUN   NTPVT    NSSFUN   NPPVT    NTFIP    NRPVT   BLANK   NTEND
TABDIMS
          15       9        40       30       1*       1*      1*      1               /
```

The above example defines maximum number of relative permeability tables to be 15 with a maximum number of rows for each table set to 40, and the maximum number of PVT tables to be nine with a maximum number of 30 rows per table.

5.2.114 TEMP – ACTIVATE THE TEMPERATURE MODELING OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the temperature modeling option. There is no data required for this keyword.

The temperature option (TEMP keyword) and the thermal option (THERMAL keyword) are two separate modeling facilities in the commercial simulator, although some keywords can be used by both options, for example the RTEMP keyword. OPM Flow's thermal implementation is based on solving the energy equation fully coupled with the "black-oil" equations so the results are not directly equivalent to the commercial simulator's "black-oil" TEMP or compositional THERMAL formulations. To activate OPM Flow's thermal implementation use the THERMAL keyword in the RUNSPEC section.

The reservoir temperature can be set to a constant or to be varying with depth utilizing the keywords in the following table:

Input Section	Constant Temperature	Temperature Variation With Depth
PROPS	RTEMP and RTEMPA	
SOLUTION	RTEMP and RTEMPA	RTEMPVD and TEMPVD
Notes: 1) The TEMP option is not implemented in OPM Flow; however, some of the above keywords can be used with OPM Flow's THERMAL option.		

Table 5.39: Reservoir Temperature Keywords

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness. See the THERMAL keyword in the RUNSPEC section to activate OPM Flow's THERMAL option instead.

Example

```
--
--        ACTIVATE THE TEMPERATURE MODELING OPTION (NOT SUPPORTED BY OPM FLOW)
--
TEMP
```

The above example activates the temperature modeling option, although the keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.115 THERMAL– ACTIVATE THE THERMAL MODELING OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the thermal modeling option. There is no data required for this keyword. The energy "black-oil" implementation in OPM Flow is a mixture of the commercial simulators "black-oil" and the commercial simulators "compositional thermal" keywords, as well as some OPM Flow specific keywords.

The temperature option (TEMP keyword) and the thermal option (THERMAL keyword) are two separate modeling facilities in the commercial simulator, although some keywords can be used by both options, for example the RTEMP keyword. OPM Flow's thermal implementation is based on solving the energy equation fully coupled with the "black-oil" equations so the results are not directly equivalent to the commercial simulator's "black-oil" TEMP or compositional THERMAL formulations.

Keywords specifically associated with both OPM Flow's THERMAL and the commercial simulators TEMP and THERMAL options are listed in Table 5.40 for easy of reference.

Section	Keyword	Function	OPM Flow	Commercial	
			THERMAL MODEL	TEMP MODEL	THERMAL MODEL
RUNSPEC	TEMP	Activate the Temperature Modeling Option			
	THERMAL	Activate the Thermal Modeling Option			
GRID	HEATCR	Rock Heat Capacity.			
	HEATCRT	Rock Heat Capacity Temperature.			
	THCGAS	Gas Phase Thermal Conductivity.			
	THCOIL	Oil Phase Thermal Conductivity.			
	THCONR	Thermal Conductivity of liquids and reservoir rock.			
	THCONSF	Thermal Conductivity of liquids and reservoir rock scaling factor applied to THCONR to account for gas saturation.			
	THCROCK	Rock Thermal Conductivity.			
	THCSOLID	Solid Phase Thermal Conductivity.			
	THCWATER	Water Thermal Conductivity.			
PROPS	GASDENT	Gas Density Temperature Coefficients (OPM Flow keyword).			
	GASVISCT	Gas Viscosity versus Temperature Functions (OPM Flow keyword).			
	OILDENT	Oil Density Temperature Coefficients (OPM Flow keyword).			
	OILVISCT	Oil Viscosity versus Temperature Functions (OPM Flow keyword).			
	RTEMP	Constant Initial Reservoir Temperature.			
	RTEMPA	Constant Initial Reservoir Temperature.			
	RTEMPVD	Initial Reservoir Temperature versus Depth.			
	TEMPVD	Initial Reservoir Temperature versus Depth.			
	SPECHEAT	Specific Heat of Oil, Water and Gas			

Section	Keyword	Function	OPM Flow	Commercial	
			THERMAL MODEL	TEMP MODEL	THERMAL MODEL
	SPECROCK	Specific Heat of the Reservoir Rock			
	THERMEX1	Liquid Components Thermal Expansion Coefficient			
	WATDENT	Oil Density Temperature Coefficients.			
	WATVISCT	Oil Viscosity versus Temperature Function.			
REGION	THERMNUM	Thermal Region Numbers.			
SOLUTION	RTEMP	Constant Initial Reservoir Temperature.			
	RTEMPA	Constant Initial Reservoir Temperature.			
	TEMPI	Initial Reservoir Temperature for All Cells.			
SCHEDULE	WTEMP	Set An Injection Well's Fluid Temperature			
	WINJTEMP	Define Injection Fluid Thermal Properties			

Notes:

1) Cells colored green implies the keyword can be used with is model formulation.
2) Cells colored orange means the keyword is recognized by OPM Flow's parser but is ignored and not used by OPM Flow.
3) Cells colored red should not be used with this model formulation.
4) The list is focused on the OPM Flow implementation of the energy and "black-oil" formulation and therefore does not necessary include all the commercial simulator's compostional keywords.

Table 5.40: OPM Flow's THERMAL Option Associated Keywords

Example

```
--
--       ACTIVATE THE THERMAL MODELING OPTION (OPM FLOW THERMAL OPTION ONLY)
--
THERMAL
```

The above example activates the thermal modeling option.

5.2.116 TITLE – DEFINE THE TITLE FOR THE INPUT DECK

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TITLE keyword defines the title for the input deck. The title text will be printed on all reports so as to act as a reference for the run.

No.	Name	Description	Default
1	TITLE	A character string that defines the TITLE for the input deck	None

Notes:

1) All the characters on the line are processed as a string and therefore there is no need to enclose the TITLE in quotes.
2) There is no terminator '/' for the keyword.

Table 5.41:TITLE Keyword Description

Note

It is good practice to include the name of the input file in the tittle (without the extension) for when cross checking results from multiple cases.

Example

```
--
--        DEFINE THE TITLE FOR THE RUN
TITLE
SPE01-THEM01-OPM1810-R01 - OPM THERMAL OPTION RUN
```

The above example defines the title for the run to be "*SPE01-THEM01-OPM1810-R01 - OPM THERMAL OPTION RUN*".

5.2.117 TRPLPORO – ACTIVATE THE TRIPLE POROSITY MODEL OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TRPLPORO keyword activates the Triple Porosity Model option that models matrix, fractures and vuggy porosity for carbonate reservoirs, and specifies the number of matrix porosity systems

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description	Default
1	TRPLPORO	A positive integer value that specifies the number of matrix porosity systems in the model. TRPLPORO should be set to either: 1) TRPLPORO set equal to 2, if the vugs are only connected to the fractures, so that the porosity system is matrix and connected vugs, or, 2) TRPLPORO set equal to 3, if the vugs are connected to the fractures and the matrix, so that the porosity system is matrix, connected vugs, and isolated vugs.	1
Notes: 1) The keyword is terminated by "/".			

Table 5.42: TRPLPORO Keyword Description

Note the keyword cannot be used in conjunction with the NMATRIX keyword, which is also in the RUNSPEC section.

Example

```
--
--        TRPLPORO
--        OPTION
TRPLPORO
          3                                                    /
```

The above example activates the Triple Porosity Model option and specifies the porosity system is matrix, connected vugs, and isolated vugs.

5.2.118 TRACERS – ACTIVATE TRACER OPTIONS AND SET TRACER ARRAY DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TRACER keyword defines the number of tracers in the model and the various passive tracer tracking options.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MXOILTR	A positive integer defining the maximum number of passive oil tracers defined using the TRACER keyword.	0
2	MXWATTR	A positive integer defining the maximum number of passive water tracers defined using the TRACER keyword.	0
3	MXGASTR	A positive integer defining the maximum number of passive gas tracers defined using the TRACER keyword.	0
4	MXENVTR	A positive integer defining the maximum number of passive environmental tracers defined using the TRACER keyword.	0
5	DIFFOPT	A character string defining the numerical diffusion option for tracer tracking runs that should be set to: 1) DIFF activates the numerical diffusion control options. 2) NODIFF deactivates the numerical diffusion control options.	NODIFF
6	MXITRTR	A positive integer defining the maximum number of non-linear iterations to be used when the tracer option is activated.	12
7	MNITRTR	A positive integer defining the minimum number of non-linear iterations to be used when the tracer option is activated.	1
8	NONLIN	A character string stating if passive tracers as should be linear (NO) or non-linear (YES).	No
9	LNCONFAC	A real value defining the initial linear convergence factor. The default value of 1* means the parameter will not be utilized.	1*
10	NLCONFAC	A real value defining the initial non-linear convergence factor. The default value of 1* means the parameter will not be utilized.	1*
11	CONFAC	A real value defining the LNCONFAC and NLCONFAC convergence factors to be used after the initial convergence factor has been applied.	1.0
12	NUMCONF	A positive integer defining the maximum number of times CONFAC can be used.	0

Notes:

1) The keyword is terminated by "/".

Table 5.43: TRACERS Keyword Description

Example

```
--
--       NO OIL  NO WAT  NO GAS  NO ENV  DIFF    MAX    MIN    TRACER
--       TRACERS TRACERS TRACERS TRACERS CONTL   NONLIN NONLIN NONLIN
TRACERS
         0       7       1       0      'NODIFF' 1*     1*     1*             /
```

The above example defines seven tracers in the water phase and one tracer in the gas phase.

5.2.119 UDADIMS – DEFINE THE DIMENSIONS OF THE USER DEFINED ARGUMENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the dimensions of the User Defined Arguments ("UDA") used by OPM Flow that can be applied to various connection, group, and well keywords in the SCHEDULE section. UDAs are defined by the UDQ keyword that is used to specify values to be constants, SUMMARY variables, as defined in SUMMARY section, or a formula using various mathematical functions together with constants and SUMMARY variables.

Although this keyword is read by OPM Flow and the ACTION and UDQ computational logic and calculations have been implemented, one should used caution using this facility as it may result in OPM Flow aborting.

No.	Name	Description	Default
1	NMUDA	NMUDA is a positive integer that defines the number of augments in a keyword that are replaced by numeric UDQ values.	0
2	NULL	Not Used	1*
3	MXUDA	MXUDA is a positive integer that defines the maximum number of unique augments in a keyword that are replaced numeric UDQ values. Note that MXUDA differs from NMUDA, for example: 1) If only the oil rate argument of, say the WCONPROD keyword is specified by a UDQ, then both NMUDA and NMUDA equal one. 2) However, if a second WCONPROD uses a different UDQ, then NMUDA equals two, but MXUDA would can still be one. 3) Finally, if the same UDQ is used separately in two lines of WCONPROD data, then both NMUDA and MXUDA must be set to two. As MXUDA's default value is 100 then this only needs to be increased where the same UDQ is used as a UDA more than 100 times.	100
Notes: 1) The keyword is terminated by "/".			

Table 5.44: UDADIMS Keyword Description

Note that OPM Flow has a more restricted UDQ feature set than the commercial simulator, so not all options and functions are currently available.

Example

```
--
--        USER DEFINED ARGUMENT DIMENSIONS
--        NO.      NOT      TOTAL
--        ARGS     USED     UDQ
UDADIMS
          10        1*      10                                                  /
```

In the above example both NMUDA and MXUDA are set equal to ten.

5.2.120 UDQDIMS – DEFINE THE DIMENSIONS OF THE USER DEFINED UDQ FEATURE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the dimensions associated with the UDQ keyword used in OPM Flow to calculate various user defined values in the SCHEDULE section. The UDQ keyword defined variables can be constants, SUMMARY variables, as defined in the SUMMARY section, or a formula using various mathematical functions together with constants and SUMMARY variables.

Although this keyword is read by OPM Flow and the ACTION and UDQ computational logic and calculations have been implemented, one should used caution using this facility as it may result in OPM Flow aborting.

No.	Name	Description	Default
1	MXFUNS	A positive integer that defines the maximum number of functions that can be included when defining a UDQ definition. This should also include any brackets that will be used in the UDQ definition.	16
2	MXITEMS	MXITEMS is a positive integer that defines the maximum number of ITEMS allowed in an UDQ definition.	16
3	MXUDC	MXUDC is a positive integer that defines the maximum number of user defined CONNECTION quantities allowed in an UDQ definition.	0
4	MXUDF	MXUDF is a positive integer that defines the maximum number of user defined FIELD quantities allowed in an UDQ definition.	0
5	MXUDG	MXUDG is a positive integer that defines the maximum number of user defined GROUP quantities allowed in an UDQ definition.	0
6	MXUDR	MXUDR is a positive integer that defines the maximum number of user defined REGION quantities allowed in an UDQ definition.	0
7	MXUDS	MXUDS is a positive integer that defines the maximum number of user defined SEGMENT quantities allowed in an UDQ definition.	0
8	MXUDW	MXUDW is a positive integer that defines the maximum number of user defined WELL quantities allowed in an UDQ definition.	0
9	MXUDA	MXUDA is a positive integer that defines the maximum number of user defined AQUIFER quantities allowed in an UDQ definition.	0
10	MXUDB	MXUDB is a positive integer that defines the maximum number of user defined BLOCK quantities allowed in an UDQ definition.	0
11	RSEED	RSEED is a character string that determines if a new random number seed should be generated for restart runs for use in the UDQ functions RANDN, RANDU RRNDN and RRNDU. If RSEED is set to Y than a new seed will be generated and if set to the default value of N or 1* then the same seed of the "base" simulation will be employed. See also the RSEED integer variable on the UDQPARAM keyword in the RUNSPEC section to set the random number seed for the current run. This feature is not supported by OPM Flow.	N

Notes:

1) The keyword is terminated by "/".

Table 5.45: UDQDIMS Keyword Description

Note that OPM Flow has a more restricted UDQ feature set than the commercial simulator, so not all options and functions are available.

Example

```
--
--        USER DEFINED ARGUMENT DIMENSIONS FACILITY
--        MAX      MAX      MAX     MAX     MAX     MAX    MAX    MAX    MAX   MAX     RAND
--        FUNCS    ITEMS    CONNS   FIELD   GROUP   REGS   SEGTM  WELL   AQUF  BLCKS   OPT
UDQDIMS
          50       25       0       50      50      0      0      0      0     0       N  /
```

In this case the maximum number of functions that can be included when defining a UDQ definition is set to 50, maximum number of items allowed in an UDQ definition is 25, the maximum number of user defined field quantities allowed in an UDQ definition is 50, and the maximum number of user defined group quantities allowed in an UDQ definition is also 50. All other parameters are defaulted including the RSEED variable (the same seed of the "base" simulation will be employed).

5.2.121 UDQPARAM – DEFINE PARAMETERS FOR THE USER DEFINED QUANTITY FEATURE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the dimensions of the User Defined Arguments ("UDA") used by OPM Flow that can be applied to various connection, group, and well keywords in the SCHEDULE section. UDAs are defined by the UDQ keyword that is used to specify values to be constants, SUMMARY variables, as defined in SUMMARY section, or a formula using various mathematical functions together with constants and SUMMARY variables.

Although this keyword is read by OPM Flow and the ACTION and UDQ computational logic and calculations have been implemented, one should used caution using this facility as it may result in OPM Flow aborting.

No.	Name	Description	Default
1	RSEED	RSEED is a positive integer greater than zero that sets a new random number seed for use in the UDQ functions RANDN, RANDU RRNDN and RRNDU. See also the RSEED character variable on the UDQDIMS keyword in the RUNSPEC section to default the random number seed for a restart run. This feature is not supported by OPM Flow.	1
2	RANGE	RANGE is areal positive value greater than or equal to one and less than or equal to 1.0×10^{20}, that sets the absolute range for user define quantities. The default value of 1×10^{20} sets the range from -1×10^{20} to $+1 \times 10^{20}$.	1×10^{20}
3	DEFAULT	DEFAULT is real value that is the default numerical value given to undefined UDQ variables and should be in the same range as RANGE.	0.0
4	TOLUDQ	TOLUDQ a real positive number greater than zero and less than one that defines the tolerance used to determine if two real values are equal. Floating-point numbers (as implemented in computers) are never exact, one cannot compare floating point numbers for exact equality. Thus, TOLUDQ defines a tolerance. For example, the default value of 1×10^{-4} means that if the difference between two real values is less than 1×10^{-4} then the values are considered equal.	1×10^{-4}

Notes:

1) The keyword is terminated by "/".

Table 5.46: UDQPARAM Keyword Description

Note that OPM Flow has a more restricted UDQ feature set than the commercial simulator, so not all options and functions are available.

Example

```
--
--       USER DEFINED DEFAULT VALUES
--       SEED    RANGE    UNDEFINED   COMPARISON
--       INTG    -AND+    VALUE       TOLERANCE
UDQPARAM
         1      1.0E20    0.0         1.0E-4                                  /
```

The example explicitly sets the default values for all four variables on the UDAPARAM keyword, namely the random seed to one, the range to 1×10^{20}, the undefined UDQ variables to zero, and the comparison tolerance to 1.0×10^{-4}.

5.2.122 UDTDIMS – DEFINE THE DIMENSIONS OF THE USER DEFINED TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the dimensions of the User Defined Tables ("UDT") used by OPM Flow that can be applied to various connection, group, and well keywords in the SCHEDULE section. UDAs are defined by the UDQ keyword that is used to specify values to be constants, SUMMARY variables, as defined in SUMMARY section, or a formula using various mathematical functions together with constants and SUMMARY variables.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MXUDT	MXUDA is a positive integer that defines the maximum number of User Defined Tables	0
2	NUDT	NUDT is a positive integer that defines the maximum number of rows in any given User Defined Table.	0
3	MXINTP	MXINTP is a positive integer that defines the maximum number of interpolation points allowed in any given dimension.	0
4	MXDIMS	MXDIMS is a positive integer that defines the maximum number of dimensions in any given User Defined Table.	0

Notes:

1) The keyword is terminated by "/".

Table 5.47: UDTDIMS Keyword Description

Example

```
--
--        USER DEFINED TABLE DIMENSIONS
--
--        MAX      MAX    MAX      MAX
--        TABLES   ROWS   INTPOL   DIMS
UDTDIMS
          3        20     3        2                                          /
```

In the above example the maximum number of UDT tables is set to three and the maximum number of rows for each table is 20, the maximum number of interpolation points in any given dimension is set to three and the maximum number of dimensions is defined as two.

5.2.123 UNCODHMD – ACTIVATE HISTORY MATCH GRADIENT UNENCODED OUTPUT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

UNCODHMD activates the history match gradient unencoded output for the history match gradient output file. Unencoded files allows external programs to read this file type.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ACTIVATE HISTORY MATCH GRADIENT UNENCODED OUTPUT
--
UNCODHMD
```

The above example switches on the unified output file option.

5.2.124 UNIFIN – ACTIVATE THE UNIFIED INPUT FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the Unified Input Files option for all input files. Similar to the commercial simulator, OPM Flow has various options for reading various input files and writing the resulting OPM Flow output files as described in Table 5.48.

Process	Keyword	Description	Files
Input	FMTIN	A character string that defines the input files to be formatted as ASCII i.e. text files, as oppose to binary files. The input deck file is always of this type. The option relates to the OPM Flow derived files that used as input, for for example when restarting from another case. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTIN	A character string that defines the input files to be non-unified multiple files, as opposed to unified files. In this case, one file is read in per reporting time step, as opposed to all time steps reports being read from one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001
	UNIFIN	A character string that defines the input files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. For this option a single summary file and a single restart file will be read. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY
Output	FMTOUT	A character string that sets all output files to be formatted as ASCII i.e. text files, as opposed to binary files. The *.PRT, *.LOG and *.DEBUG files are always of this type. The option relates to the OPM Flow output files only. In this case the files will be portable across operating systems, but will also be very large in terms of hard disk space. For this reason it is recommend that the default option is used so that binary files are outputted. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTOUT	A character string that defines the output files to be non-unified multiple files, as opposed to unified files. In this case, one file is written for each reporting time step, as opposed to all time steps reports being written in one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001

Process	Keyword	Description	Files
	UNIFOUT	A character string that defines the output files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single summary file and a single restart file will be generated, as opposed to one file per report time step. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY

Notes:

1) A binary file is computer-readable but not human-readable. All executable programs are stored in binary files, as are most numeric data files. In contrast, text files are stored in a form (usually ASCII) that is human-readable.
2) For unified files if the run terminates unexpectedly, or there is sufficient disk space, then the last report output is not stored. Their main advantage is that if a number of simulations reside in one directory, their output is organized. There is no limit on the number of reporting steps that a unified file can store.

Table 5.48: UNIFIN Keyword Description

There is no data required for this keyword and there is no terminating "/" for this keyword.

See also *OPM FLOW OUTPUT FILE FORMATS* for a more detailed description of the various file types (ASCII or binary) and file structure formats (unified or non-unified formats).

Example

```
--
--       SWITCH ON THE UNIFIED INPUT FILES OPTION
--
UNIFIN
```

The above example switches on the unified input file option.

5.2.125 UNIFOUT – ACTIVATE THE UNIFIED OUTPUT FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the Unified Output Files option for all output files. Similar to the commercial simulator, OPM Flow has various options for reading various input files and writing the resulting OPM Flow output files as described in Table 5.49.

Process	Keyword	Description	Files
Input	FMTIN	A character string that defines the input files to be formatted as ASCII i.e. text files, as oppose to binary files. The input deck file is always of this type. The option relates to the OPM Flow derived files that used as input, for for example when restarting from another case. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTIN	A character string that defines the input files to be non-unified multiple files, as opposed to unified files. In this case, one file is read in per reporting time step, as opposed to all time steps reports being read from one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001
	UNIFIN	A character string that defines the input files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. For this option a single summary file and a single restart file will be read. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY
Output	FMTOUT	A character string that sets all output files to be formatted as ASCII i.e. text files, as opposed to binary files. The *.PRT, *.LOG and *.DEBUG files are always of this type. The option relates to the OPM Flow output files only. In this case the files will be portable across operating systems, but will also be very large in terms of hard disk space. For this reason it is recommend that the default option is used so that binary files are outputted. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTOUT	A character string that defines the output files to be non-unified multiple files, as opposed to unified files. In this case, one file is written for each reporting time step, as opposed to all time steps reports being written in one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001

Process	Keyword	Description	Files
	UNIFOUT	A character string that defines the output files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single summary file and a single restart file will be generated, as opposed to one file per report time step. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY

Notes:

1) A binary file is computer-readable but not human-readable. All executable programs are stored in binary files, as are most numeric data files. In contrast, text files are stored in a form (usually ASCII) that is human-readable.
2) For unified files if the run terminates unexpectedly, or there is sufficient disk space, then the last report output is not stored. Their main advantage is that if a number of simulations reside in one directory, their output is organized. There is no limit on the number of reporting steps that a unified file can store.

Table 5.49: UNIFOUT Keyword Description

There is no data required for this keyword and there is no terminating "/" for this keyword.

See also *OPM FLOW OUTPUT FILE FORMATS* for a more detailed description of the various file types (ASCII or binary) and file structure formats (unified or non-unified formats).

Example

```
--
--       SWITCH ON THE UNIFIED OUTPUT FILES OPTION
--
UNIFOUT
```

The above example switches on the unified output file option.

5.2.126 UNIFOUTS – ACTIVATE THE UNIFIED OUTPUT SUMMARY FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The UNIFOUTS keyword causes the SUMMARY file output files to be a unified file, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single SUMMARY file will be generated, as opposed to one file per report time step. See also the MULTOUT keyword in the RUNSPEC section that sets both the SUMMARY and RESTART files to be non-unified multiple files, as opposed to unified files. Note also that UNIFOUTS keyword has precedence over the MULTOUT keyword for SUMMARY files.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ACTIVATE THE UNIFIED OUTPUT SUMMARY FILE OPTION
--
UNIFOUTS
```

The above example switches on the unified SUMMARY output files.

5.2.127 UNIFSAVE – ACTIVATE THE UNIFIED OUTPUT SAVE FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The UNIFSAVE keyword causes the SAVE file output file to be a unified file, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single SAVE file will be generated, as opposed to one file per report time step. See also the MULTOUT keyword in the RUNSPEC section that sets both the SUMMARY and RESTART files to be non-unified multiple files, as opposed to unified files.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--      ACTIVATE THE UNIFIED OUTPUT SAVE FILE OPTION
--
UNIFSAVE
```

The above example switches on the unified SUMMARY output files.

5.2.128 VAPOIL – ACTIVATE THE VAPORIZE OIL IN WET GAS PHASE IN THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicates that vaporized oil (more commonly referred to as condensate) is present in wet[33] gas in the model and the keyword should only be used if the there is both oil and gas phases in the model. The keyword may be used for gas-water and oil-water-gas input decks that contain the oil and gas phases. The keyword will also invoke data input file checking to ensure that all the required oil and gas phase input parameters are defined in the input deck.

If the gas has a constant and uniform vaporized oil concentration, Condensate-Gas Ratio ("CGR"), and if the reservoir pressure never drops below the saturation pressure (dew point pressure), then the model can be run more efficiently by omitting the OIL and VAPOIL keywords from the RUNSPEC section, treating the gas as a dry gas[34], and defining a constant Rv (CGR) value with keyword RVCONST or RVCONSTT in the PROPS section. This results in the model being run with as a dry gas problem with no active oil (condensate) phase. However, OPM Flow takes into account the constant Rv in the calculations and reporting.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       VAPORIZED OIL IN WET GAS IS PRESENT IN THE RUN
--
VAPOIL
```

The above example declares that the vaporized oil, i.e. condensate, in the gas phase is active in the model.

[33] *Natural gas that contains significant heavy hydrocarbons such as propane, butane and other liquid hydrocarbons is known as wet gas or rich gas. The general rule of thumb is if the gas contains less methane (typically less than 85% methane) and more ethane, and other more complex hydrocarbons, it is labeled as wet gas. Wet gas normally has GOR's less than 100,000 scf/stb or 18,000 Sm3/m3, with the condensate having a gravity greater than 50 °API.*

[34] *Natural gas that occurs in the absence of condensate or liquid hydrocarbons, or gas that had condensable hydrocarbons removed, is called dry gas. It is primarily methane with some intermediates. The hydrocarbon mixture is solely gas in the reservoir and there is no liquid (condensate surface liquid) formed either in the reservoir or at surface. The term dry indicates that the gas does not contain heavier hydrocarbons to form liquids at the surface conditions. Dry gas typically has GOR's greater than 100,000 scf/stb or 18,000 Sm3/m3.*

5.2.129 VAPWAT – ACTIVATE VAPORIZE WATER IN THE DRY AND WET GAS PHASES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicates that vaporized water is present in the gas phase and the keyword should only be used if both water and gas phases are present in the model. VAPWAT should also be used in conjunction with the PRECSALT keyword in the RUNSPEC section in order to activate OPM Flow's Salt Precipitation model. VAPWAT may be used for gas-water and oil-water-gas input decks that contain the oil, gas and water phases.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note

This is an OPM Flow specific keyword for the simulator's Water Vaporization Model that is activated by declaring that vaporized water is present in the run.

Note that if the VAPWAT keyword is in the input deck then either the PVTGW or PVTGWO keywords in PROPS section should be used to defined the gas and water PVT properties.

Secondly, if both the VAPWAT keyword and the PRECSALT keyword (used to activate the OPM Flow's Salt Precipitation model) are present in the input deck, then the RWGSALT keyword in the PROPS section also needs to be present.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       VAPORIZED WATER IN DRY/WET GAS IS PRESENT IN THE RUN (OPM FLOW KEYWORD)
--
VAPWAT
```

The above example declares that the vaporized water is present in the gas phase and is active in the model.

5.2.130 VE – Activate Vertical Equilibrium Model (Global)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword actives the Vertical Equilibrium ("VE") model for the global grid and optionally specifies the type of VE model. The VE model type can either be compressed for merging columns of grid blocks into a single grid block, or uncompressed for the standard VE model.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.131 VFPIDIMS – INJECTION VERTICAL FLOW PERFORMANCE TABLE DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

VFPIDIMS keyword defines the maximum dimensions of the injection well Vertical Lift Performance ("VFP") tables defined by VFPINJ keyword. The VFP tables for the producing wells are defined by the VFPPDIMS keyword.

No.	Name	Description	Default
1	MXMFLO	A positive integer that defines the maximum number of injection rate entries for the VFPINJ keyword.	0
2	MXMTHP	A positive integer that defines the maximum number of THP entries for the VFPINJ keyword.	0
3	MXVFPTAB	A positive integer that defines the maximum number of VFPINJ tables entered through the VFPINJ keyword.	0
Notes: 1) The keyword is terminated by "/".			

Table 5.50:VFPIDIMS Keyword Description

Example

```
--        INJECTING VFP TABLES
--        VFP      VFP      VFP
--        MXMFLO   MXMTHP   NMMVFT
VFPIDIMS
          10       10       12                                                    /
```

The above example defines that the maximum number of injection rates and THP entries on the VFPINJ keyword is 10, and the maximum number of BHP entries is 12.

5.2.132 VFPPDIMS – PRODUCTION VERTICAL FLOW PERFORMANCE TABLE DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

VFPPDIMS keyword defines the maximum dimensions of the production well Vertical Lift Performance ("VFP") tables defined by VFPPROD keyword. The VFP tables for the injection wells are defined by the VFPIDIMS keyword.

No.	Name	Description	Default
1	MXMFLO	A positive integer that defines the maximum number of production flow rate entries for the VFPPROD keyword.	0
2	MXMTHP	A positive integer that defines the maximum number of THP entries for the VFPPROD keyword.	0
3	MXMWFR	A positive integer that defines the maximum number of water fraction entries (WOR, WCUT, GWR etc.) entries for the VFPPROD keyword.	0
4	MXMGFR	A positive integer that defines the maximum number of gas fraction entries (GOR, GLR, OGR etc.) entries for the VFPPROD keyword.	0
5	MXMALQ	A positive integer that defines the maximum number of artificial lift quantity entries for the VFPPROD keyword.	0
6	MXVFPTAB	A positive integer that defines the maximum number of VFPPROD tables entered through the VFPPROD keyword.	0

Notes:

1) The keyword is terminated by "/".

Table 5.51:VFPPDIMS Keyword Description

Example

```
--        PRODUCING VFP TABLES
--        VFP      VFP      VFP      VFP      VFP      VFP
--        MXMFLO   MXMTHP   MXMWFR   MXMGFR   MXMALQ   NMMVFT
VFPPDIMS
          20       10       10       10       6        9                    /
```

Here the example shows that there are a maximum of 20 flow rates, 10 THP entries, 10 water and gas fraction entries, and six artificial lift entries for the nine VFPPROD VFP production tables.

5.2.133 VISAGE - Activate External Reservoir Geo-Mechanics VISAGE Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The VISAGE keyword activates the External Reservoir Geo-Mechanics VISAGE option. The keyword should not be used in input decks as the associated data is generated by an external program.

This keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.134 VISCD – ACTIVATE DUAL POROSITY VISCOUS DISPLACEMENT OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The VISCD keyword activates the Dual Porosity Viscous Displacement option for dual porosity and dual permeability models, and therefore requires either the DUALPORO or DUALPERM keyword to be entered in the RUNSPEC section to activate either one of these options. The VISCD option is used to model the viscous displacement of fluids from the matrix by the fracture pressure gradient, for when the fracture system has a more moderate permeability, and flow to and from the matrix caused by the fracture pressure gradient acts as an additional production mechanism[35]. Normally this mechanism is ignored as the pressure gradient in the fracture system is small due to the very high permeability of the fracture system. See the LX, Lyand LZ keywords in the GRID section that define representative matrix grid block sizes.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ACTIVATE DUAL POROSITY VISCOUS DISPLACEMENT OPTION
--
VISCD
```

The above example activates the dual porosity viscous displacement option.

[35] *Gilman, J. R. and Kazemi, H. "Improved Calculation for Viscous and Gravity Displacement in Matrix Blocks in Dual-Porosity Simulators," paper SPE 16010 (includes a number of associated papers), Journal of Petroleum Technology (1988) 40, No. 1, 60-70.*

5.2.135 WATER – Activate the Water Phase in the Model

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicate that the water phase is present in the model and must be used for gas-water, oil-gas, oil-water, oil-water-gas input decks that contain the water phase. The keyword will also invoke data input file checking to ensure that all the required water phase input parameters are defined in the input deck.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        WATER PHASE IS PRESENT IN THE RUN
--
WATER
```

The above example declares that the oil phase is active in the model.

5.2.136 WELLDIMS – DEFINE THE WELLS AND GROUP DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WELLDIMS defines various well and group dimensions for the run. The commercial simulator combines both the "black-oil" and compositional simulator variables on this keyword; however, although all the parameters are explained below only the "black-oil" parameters are used by OPM Flow.

No.	Name	Description	Default
1	MXWELS	A positive integer defining the maximum number of wells for this model.	0
2	MXCONS	A positive integer defining the maximum number of grid block connections per well for this model.	0
3	MXGRPS	A positive integer defining the maximum number of groups for this model.	0
4	MXGRPW	A positive integer defining the maximum number of wells that can belong to a group in the model and the maximum number of child groups in a group. Note that MXGRPW sets both the maximum number of wells in a group and the maximum number of child groups in a group. The former applies to groups that contain wells and the latter applies to groups that contain other groups. See also the GRUPTREE keyword in the SCHEDULE section to define group hierarchy.	0
5	MXSTAGE	A positive integer defining the maximum number of stages per separator for this model. This option is ignored by OPM Flow.	5
6	MXSTRMS	A positive integer defining the maximum number of well streams for this model. This option is ignored by OPM Flow.	10
7	MXMIXS	A positive integer defining the maximum number of mixtures for this model. This option is ignored by OPM Flow.	5
8	MXSEPS	A positive integer defining the maximum number of separators for this model. This option is ignored by OPM Flow.	4
9	MXCOMPS	A positive integer defining the maximum number of mixture components in a mixture for the model. This option is ignored by OPM Flow.	3
10	MXDOCOMP	A positive integer defining the maximum number of well completions that can cross a parallel run domain boundary when the PARALLEL option has been activated. This option is ignored by OPM Flow.	0
11	MXWSLIST	A positive integer defining the maximum number of well lists that a well may be concurrent belong to at one time for this model. This option is ignored by OPM Flow.	1
12	MXWLISTS	A positive integer defining the maximum number of dynamic well lists for this model. This option is ignored by OPM Flow.	1

No.	Name	Description	Default
13	MXWSECD	A positive integer defining the maximum number of secondary wells for this model. This option is ignored by OPM Flow.	10
14	MXNGPP	A positive integer defining the maximum number of entries per completion in the generalized pseudo-pressure tables used for to calculate the blocking factor associated with condensate drop-out in gas condensate reservoirs. If the generalized pseudo-pressure option has not been activated then this is ignored. This option is ignored by OPM Flow.	201

Notes:

1) Only parameters (1) to (4) are used by OPM Flow.
2) The keyword is terminated by "/".

Table 5.52: WELLDIMS Keyword Description

Example

```
--
--        WELL     WELL     GRUPS    GRUPS
--        MXWELS   MXCONS   MXGRPS   MXGRPW
WELLDIMS
          60       110      18       40                                        /
```

The above example defines the maximum number of wells to be 60 with 110 completions per well, and maximum number of groups to be 18 with maximum number of wells per group of 40. All other parameters are defaulted.

5.2.137 WPOTCALC – Well Potential Calculation Options

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WPOTCALC defines how shut-in and stopped wells should have their well potentials calculated. Well potentials for wells under these conditions need to have their potentials calculated if they are in a Priority Drilling Queue via the WDRILPRI keyword in the SCHEDULE section, or the Prioritization option has been enabled by the PRIORITY keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

5.2.138 WSEGDIMS – DEFINE MULTI-SEGMENT WELL DIMENSIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGSDIMS keyword defines the multi-segment well dimensions for the multi-segment well model and the keyword is obligatory if multi-segment wells are being employed in the model.

No.	Name	Description	Default
1	MXWELS	A positive integer defining the maximum number of multi-segment wells for this model.	0
2	MXSEGS	A positive integer defining the maximum number of segments per well for this model.	1
3	MXBRAN	A positive integer defining the maximum number of branches per multi-segment well, including the main branh groups for this model.	1
4	MXLINKS	A positive integer defining the maximum number of segment links per multi-segment well.	0

Notes:

1) The keyword is terminated by "/".

Table 5.53: WESEGDIMS Keyword Description

Example

```
--
--        WELL    WELL    BRANCH  SEGMENT
--        MXWELS  MXSEGS  MXBRAN  MXLINKS
WSEGDIMS
          5       100     10      10                                    /
```

The above example defines the maximum number of multi-segment wells to be five with up to 100 segments per multi-segment well, a maximum number of 10 branches per multi-segment well, and up to 10 segment links per multi-segment well.

CHAPTER 6: GRID SECTION

6.1 INTRODUCTION

The GRID section defines the basic grid properties, including structure, faults and various static rock properties (porosity, permeability etc.). The information in this section will be used by the software to calculate the pore volume (PORV) for each cell, the cell mid-point depths, and the regular transmissiblities (TRANX, TRANY and TRANX) between all the cells, as well as across faults. The OPM Flow calculated parameters can then be edited in the EDIT section.

All models can be classified by the number of dimensions as show in Figure 6.1 (after Mattax[36]). The zero and one dimension models are employed in analytical modeling, while the higher dimensions are used in numerical modeling. The term 4D modeling refers to a 3D model with the fourth dimension being the time domain derived from time-lapse seismic, that is the comparison of 3D seismic surveys at two or more points in time.

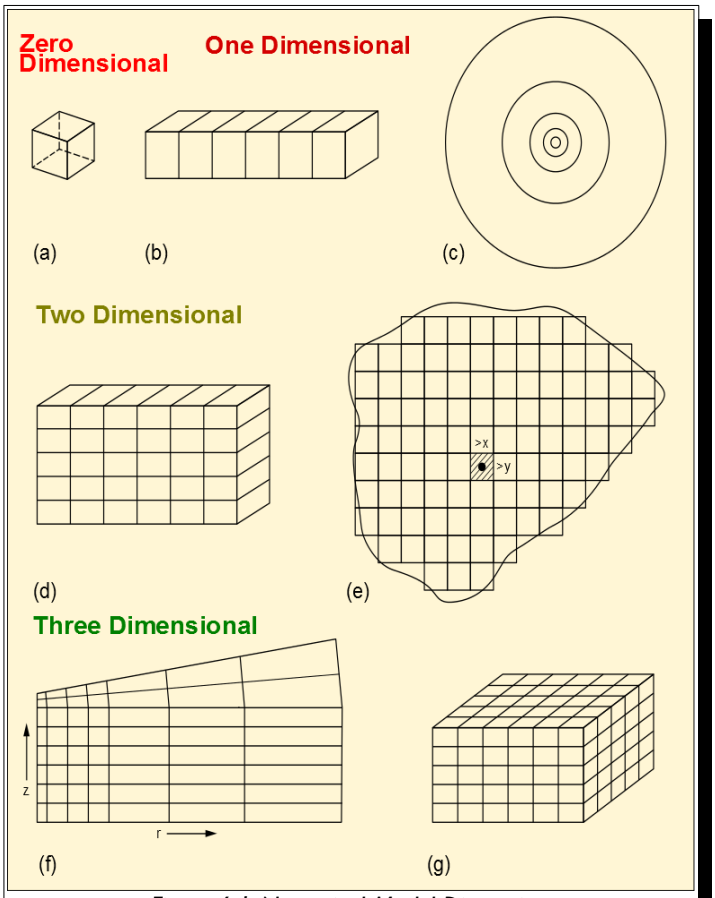


Figure 6.1: Numerical Model Dimensions

OPM Flow enables the user to define 1D, 2D and 3D models using three types of grids: Cartesian Regular Grid, Radial Grid[37], and Irregular Corner-Point Grids. The first two type of grids are rather limited in their ability to describe the structural complexity of oil and gas reservoirs; however, this simplicity allows the engineer to quickly build simple models to investigate reservoir performance. Indeed in the early days of numerical modeling back in the late 1970's two-dimensional cross-section and radial models were the main models used to predict reservoir performance due to limited computer resources at the time. That is not to say that full field models were not developed, but that these full field models were very coarse in comparison to what is designed and built today using static earth modeling software.

A brief introduction to the three types of grids and the data requirements to fully defined the structural element of the grid together with the rock properties necessary to complete the GRID section data requirements is outlined in the following section. This is then followed by the keyword definitions applicable to this section.

[36] *Mattax, C.C. and Dalton R.L. 1990. Reservoir Simulation. Society of Petroleum Engineers, Henry L. Doherty Series, Monograph Vol. 13*

[37] *Radial grids are not currently implemented in this version of OPM Flow, but is expected to be incorporated in a future release.*

6.2 DATA REQUIREMENTS

6.2.1 CARTESIAN REGULAR GRID

This type of grid defines a regular orthogonal grid based on defining the x, y and z dimensions of all the cells and is normally employed when a complex structural model is not required. Figure 6.2 shows the SPE Comparative Solution Project Number 1 ("SPE-CSP01") as documented by Odeh[38].

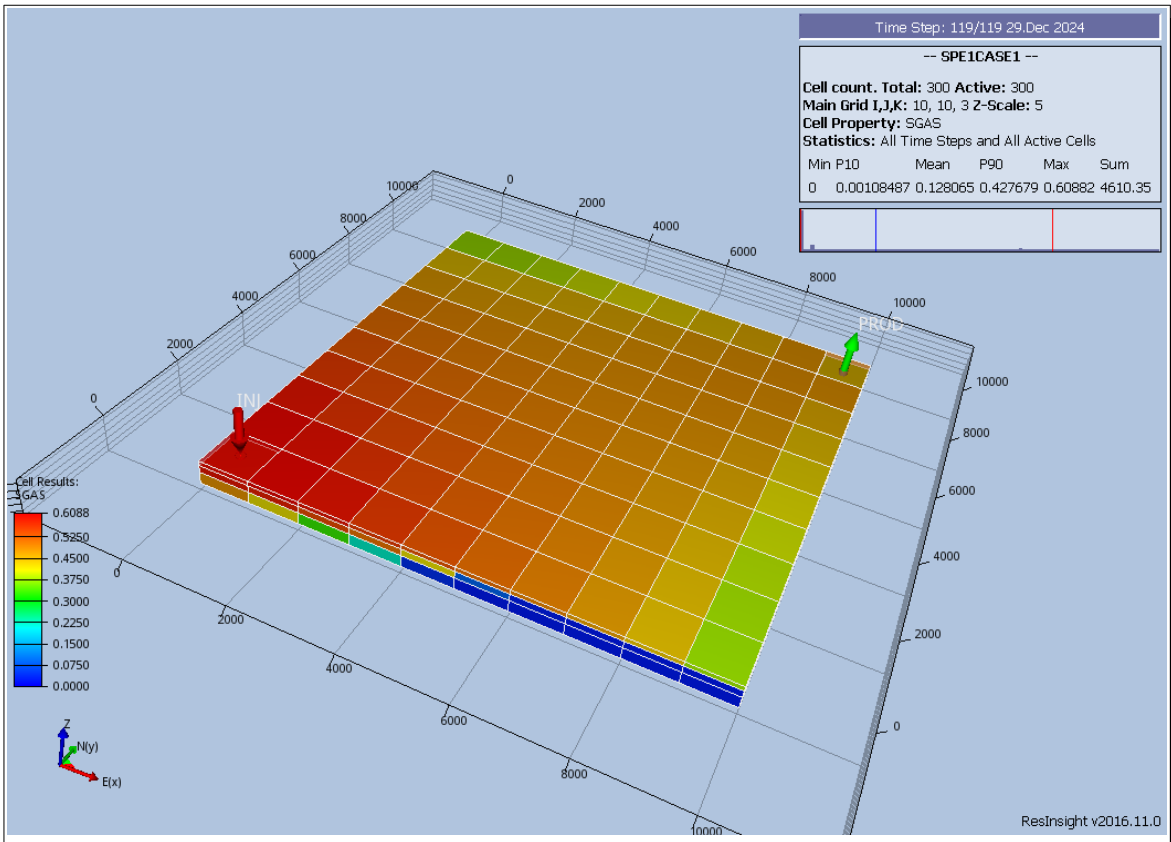


Figure 6.2: SPE Simulation Case #01 Cartesian Regular Grid

The model consists of a simple 10 x 10 x 3 (NX, NY, NY) grid and is defined using the following GRID section keywords to define the grid geometry:

```
--
--  DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NX x NY x NZ = 300)
-- (There Are In Total 300 Cells With Length 1000ft In X-Direction)
DX
   300*1000                                                                /
--
--  DEFINE GRID BLOCK Y DIRECTION CELL SIZE (BASED ON NX x NY x NZ = 300)
-- (There Are In Total 300 Cells With Length 1000ft In Y-Direction)
DY
   300*1000                                                                /
--
--  DEFINE GRID BLOCK Z DIRECTION CELL SIZE (BASED ON NX x NY x NZ = 300)
-- (The Layers Are 20, 30 And 50 Ft Thick, In Each Layer There Are 100 Cells)
DZ
  100*20.0   100*30.0   100*50.0                                           /
```

[38] *Odeh, A. "Comparison of Solutions to a Three Dimensional Black-Oil Reservoir Simulation Problem." JPT 33 (1981):13-25.*

```
--
--  DEFINE GRID BLOCK TOPS FOR THE TOP LAYER (BASED ON NX = 100, NY = 100)
--  (Layer 2 and 3 TOPS Calculated by Simulator)
TOPS
 25*3100  25*3105  25*3110                                                /
```

The rock property data required to complete the GRID section is as follows:

```
--
--  DEFINE GRID BLOCK POROSITY DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PORO
  300*0.300                                                               /
--
--  DEFINE GRID BLOCK PERMY DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PERMX
  100*500.0   100%50.0   100*200.0                                        /
--
--  DEFINE GRID BLOCK PERMY DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PERMY
  100*500.0   100%50.0   100*200.0                                        /
--
--  DEFINE GRID BLOCK PERMZ DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--  (Not Defined in Original Paper So Assume That PERMX = PERMY = PERMZ)
PERMZ
  100*500.0   100%50.0   100*200.0                                        /
```

The above keywords define all the properties required for the GRID section for this type of grid geometry.

6.2.2 RADIAL GRID

To be written in a future release of the manual.

6.2.3 IRREGULAR CORNER-POINT GRIDS

This type of grid is an industry standard grid used to formulate the structure of complex reservoirs. Here static modeling software is used to build the model which is then exported and imported into a numerical model. Figure 6.3 illustrates the skeleton grid for the Norne Field which has dimensions of 46 x 112 x 22 in the x, y and z dimensions respectively. This results in a total number of cells of 113,344 although not all of these cells will be active in the model.

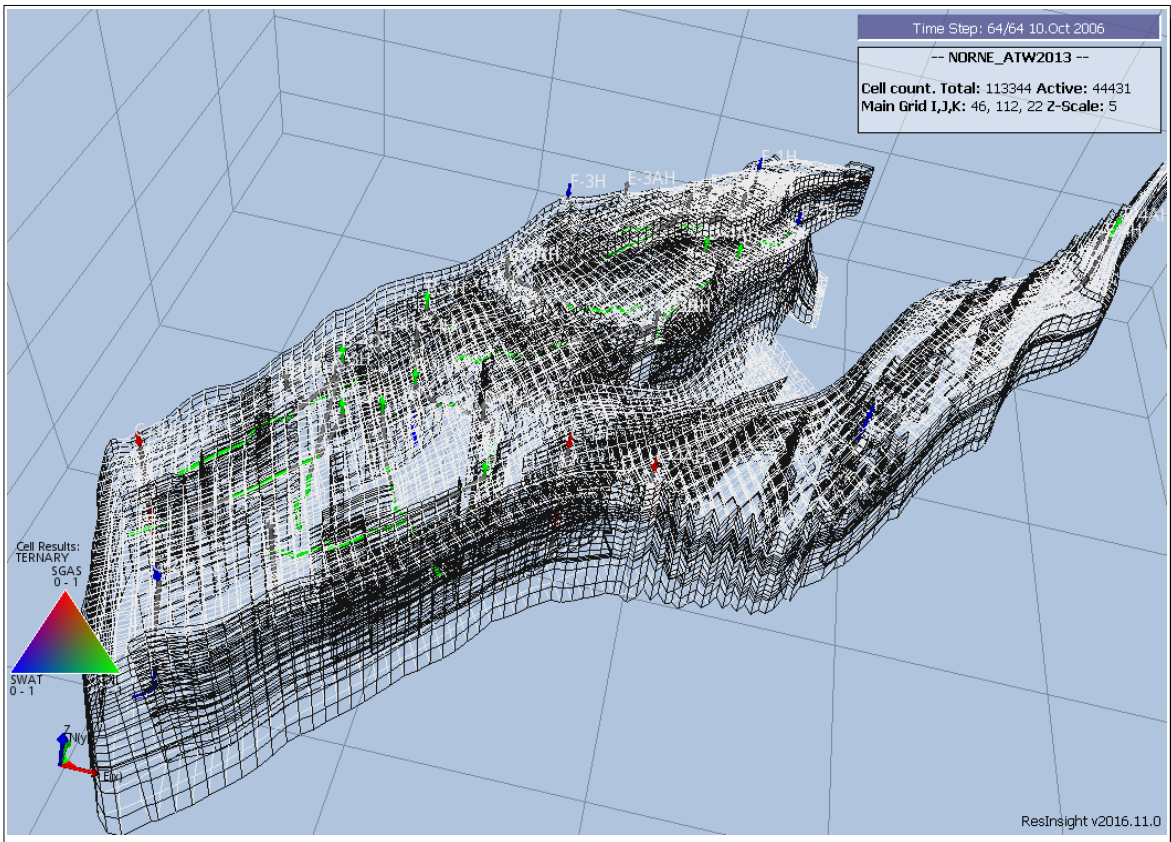


Figure 6.3: Norne Field Grid Skeleton

Similar to Cartesian Regular Grid the grid geometry must be defined for each cell and the properties for each cell defined. The formulation of the grid geometry is based on *corner-point geometry*, basically coordinate lines or pillars are given, then top and bottom surfaces for the cell are given by specifying the depth (z-coordinates) of the cell's corner points along each of the four adjacent pillars. The cell then forms an irregular hexahedron as depicted in Figure 6.4. Note that the figure shows a corner-point cell which is more or less orthogonal, which is ideally is what we want to minimize grid orientation effects.

The data required to define this type of grid consists of the SPECGRID to define the dimensions of the grid, that is:

```
--        MAX      MAX      MAX      MAX      GRID
--        NDIVIX   NDIVIY   NDIVIZ   NUMRES   TYPE
SPECGRID
          46       112      22       1        F                                    /
```

A portion of the coordinate line data defined by the COORD keyword from the Norne model is shown on the next page.

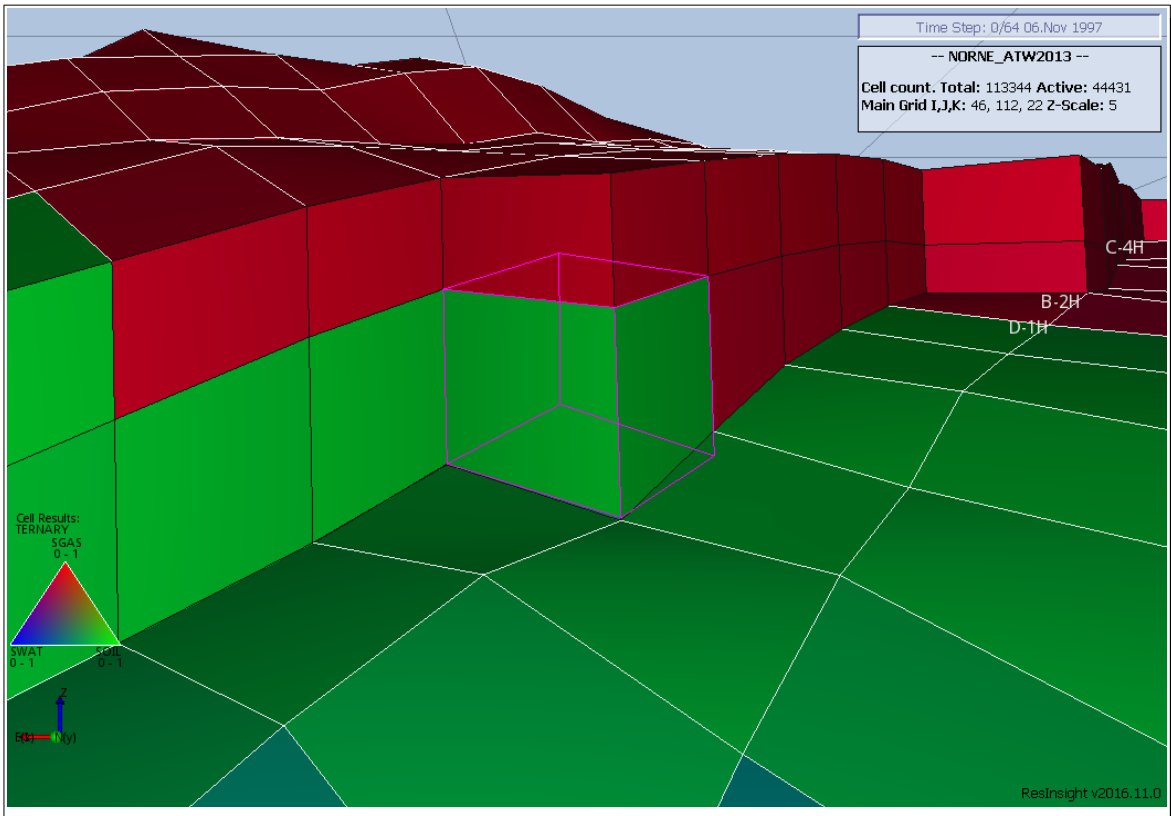


Figure 6.4: Norne Field Corner-Point Geometry Example

```
COORD
-- X1          Y1          Z1          X2          Y2          Z2
-- ---         ---         ----        ---         ---         ----
   453114.000  7319921.000 3037.473    453114.000  7319921.000 3132.831
   453155.031  7319840.000 2983.933    453142.750  7319864.000 3173.572
   453196.094  7319759.000 3005.969    453171.500  7319807.500 3215.836
   453237.156  7319678.000 3000.265    453200.250  7319751.000 3217.250
   453278.188  7319597.000 2989.348    453229.031  7319694.000 3213.951
   453319.250  7319516.500 2995.680    453257.781  7319637.500 3215.323
   453356.250  7319443.500 3000.855    453308.750  7319537.000 3220.549
   453393.250  7319370.500 3005.252    453359.688  7319436.500 3210.393
   453423.969  7319310.000 3030.862    453394.219  7319368.500 3203.438
   453454.688  7319249.500 3036.870    453428.719  7319300.500 3190.770
   453485.406  7319189.000 3038.017    453463.219  7319232.500 3190.660
   453516.125  7319128.000 3045.027    453497.750  7319164.500 3188.813
   453546.844  7319067.500 3055.410    453532.250  7319096.500 3185.966
   453577.562  7319007.000 3066.541    453566.750  7319028.500 3184.325
   453608.281  7318946.500 3076.624    453601.250  7318960.500 3183.584
   453639.000  7318886.000 3086.938    453635.781  7318892.500 3184.057
   453669.719  7318825.500 3096.153    453670.281  7318824.500 3185.988
   453700.438  7318765.000 3104.703    453704.781  7318756.500 3188.598
   453731.156  7318704.500 3097.016    453739.281  7318688.500 3180.484
   453761.875  7318644.000 3088.539    453773.812  7318620.500 3177.091
   453780.000  7318608.000 3098.118    453796.562  7318575.500 3176.401
   453798.125  7318572.500 3096.691    453819.344  7318530.500 3172.299
.......................................
/
```

The final keyword to define an Irregular Corner-Point geometry grid is the ZCORN keyword that defines the depths of the cell corners. A portion of the ZCORN data from the Norne model is shown below.

```
ZCORN
   3037.473    2983.933    2983.933    3005.969    3005.969    3000.265
   3000.265    2989.348    2989.348    2995.680    2995.680    3000.855
   3000.855    3005.252    3005.252    3030.862    3030.862    3036.870
   3036.870    3038.017    3038.017    3045.027    3045.027    3055.410
   3055.410    3066.541    3066.541    3076.624    3076.624    3086.938
   3086.938    3096.153    3096.153    3104.703    3104.703    3097.016
   3097.016    3088.539    3088.539    3098.118    3098.118    3096.691
   3096.691    3093.886    3093.886    3085.393    3085.393    3081.957
   3081.957    3080.645    3080.645    3115.021    3115.021    3130.474
   3130.474    3204.674    3204.674    3193.187    3193.187    3169.512
   3169.512    3101.928    3101.928    3044.277    3044.277    3023.930
   3023.930    2964.244    2964.244    2900.178    2900.178    2875.715
   2875.715    2864.913    2864.913    2855.256    2855.256    2841.119
   2841.119    2826.261    2826.261    2806.556    2806.556    2781.052
   2781.052    2791.720    2791.720    2817.940    2817.940    2813.308
   2813.308    2788.492
.......................................................................
/
```

The rock property data required to complete the GRID section is the same as for a Cartesian Regular grid, as defined in section *6.2.1 Cartesian Regular Grid* and the data is defined using the same keywords. The resulting Norne model showing the ternary solution variable is displayed in Figure 6.5.

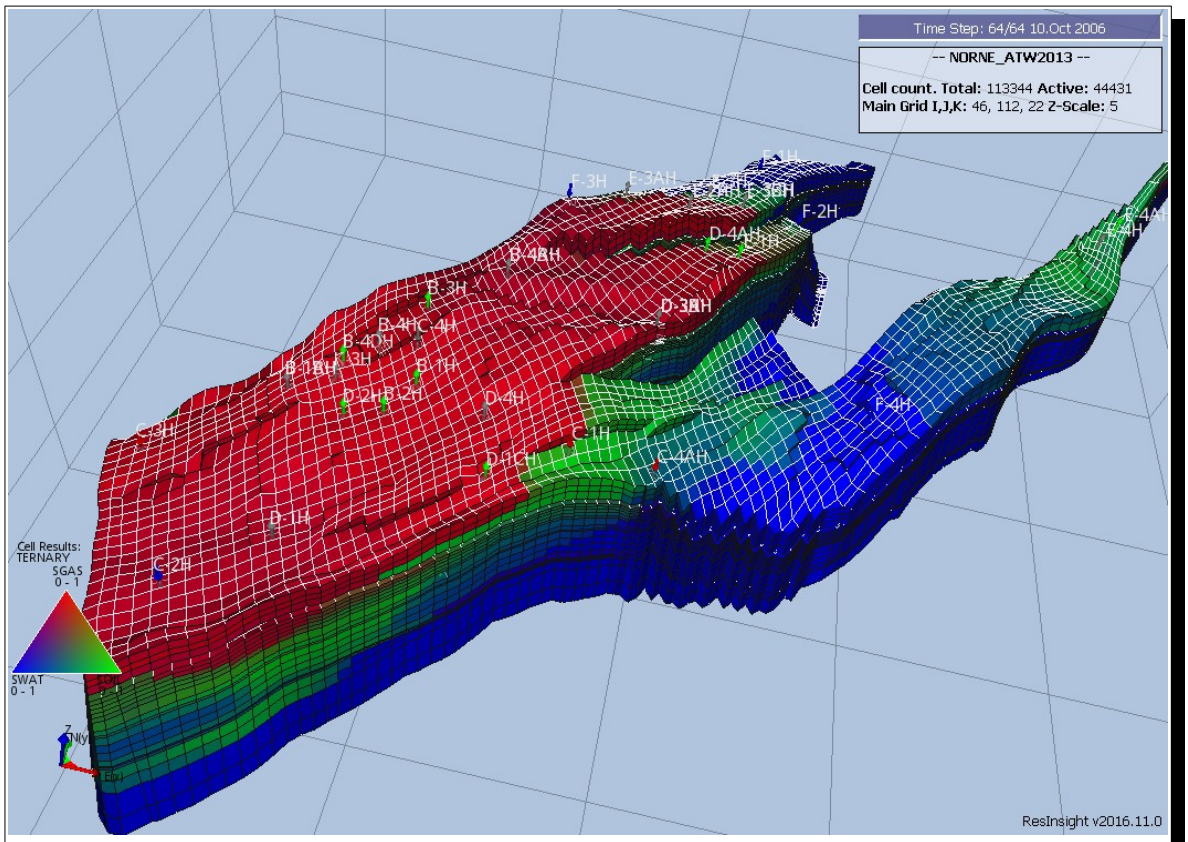


Figure 6.5: Norne Grid Ternary Solution Display

6.2.4 ROCK PROPERTIES

Irrespective of the grid type used to define the structural component of the model various static properties need to be defined in order for the model to have a complete grid definition, these properties include the identification of active and inactive grid blocks, porosity, permeability, and the reservoir quality via the net-to-gross fraction ("NTG"). These parameters must be set for each cell in the model

Property	Description	Cartesian And Irregular Corner-Point Grids Keywords	Radial Grid Keywords
Active and Inactive cells	Defines if a cell in the model is active by setting the ACTNUM property for a cell to either one or inactive by setting the value to zero. Cells that are inactive in the model are ignored computationally and can act as barriers to flow. Thus, a shale in a conventional reservoir is normally treated as non-reservoir and is made inactive either by setting the ACTNUM, PORO, or NTG to zero for the cells representing the shale.	ACTNUM	
Porosity	Porosity is a measure of the space in a reservoir rock. It is defined as the fraction of the total bulk volume of the rock not occupied by solids, that is it is the fraction of the cell that is porous and contains the reservoir fluids.	PORO	
Reservoir Quality	Reservoir quality of the cell in terms of the gross volume derived from the structural grid and the net volume available for fluid flow in the model expressed as a fraction from zero to one. A zero values means the cell does contribute to flow and therefore is made inactive. A value of one means the gross and net volumes are identical for the cell	NTG	
Permeability	Permeability is a measure of the ease with which a fluid will flow through a porous medium. In numerical models permeability is dependent on the direction of flow, that is x, y and z directions in Cartesian and Irregular Corner-Point Grids, and the radial, theta and z directions in radial grids. There are various formulations for permeability, absolute permeability, effective permeability, gas permeability, liquid permeability etc., and the values are saturation dependent. Thus, values entered should be consistent with the relative permeability entered in the PROPS section. Normally Kair (Sg=1.0) should be entered for the cell permeability and the values may or not be corrected for overburden or humidity drying effects. Correcting for liquid flow and saturation end points etc., is accomplished by the relative permeability curves. For example, if Kair (Sg=1.0) has been entered for the cell permeability when Krg (Sg=1-Swc) should be less than one.	PERMX PERMY PERMZ	PERMR PERMTHT PERMZ

Table 6.1: Key Static Grid Properties

Note

Static grid properties are frequently generated from a static earth model using petrophysical evaluation of the well logs and propagated through the model based on a variety of geostatistical techniques.

Petrophysical evaluations are conducted in either in the "Total" or the "Effective" porosity domain, and is important that all the rock property data is entered into the model is of the same basis. It is not important which porosity domain is used, as long as all the data is in the same domain.

Pore volume and transmissibility are common terms in the reservoir simulation vernacular. Pore volume is self-explanatory, that is, given the grid property data the pore volume for each cell is calculated using:

$$PV = Cell\ Gross\ Volume \times PORO \times NTG \times ACTNUM \tag{6.1}$$

Where

PV	= the pore volume of a cell,
Cell Gross Volume	= the gross volume (or bulk volume) calculated from the structural parameters of the cell,
PORO	= cell porosity,
NTG	= cell net-to-gross ratio, and
ACTNUM	= active and inactive cell indicator.

Any cell with a pore volume equal to zero is made inactive automatically in the model. However, there may be some cells that have small pore volumes than may negatively impact computational performance of the model. If this is the case then the MINPV keyword in the GRID section can be used to make these cells inactive.

There has been a trend in the industry in recent years to not apply petrophysical cut-offs in static models. This results in large models with numerous cells with very low porosity values (less than 0.01 for example) and corresponding very low permeabilities. The theory behind this approach is that the numerical model will determine the effective (or net) reservoir. This may be appropriate in unconventional reservoirs as all the cells in the model will have similar values of porosity and permeability, but in conventional reservoirs as this methodology will lead to severe computational issues when attempting to run the model, due to very tight cells being next to relative high permeability cells. Again, the MINPV keyword can be used to resolve this issue.

Transmissibility on the other hand is more complex as it relates the flow from one cell face to another cell face and is a function of the area open to flow, the direction of flow, the permeability, saturation and viscosity of the phases flowing between the cells. For a single phase flow in a Cartesian grid the x-direction transmissibility is of the form:

$$T_{x_{i+½,\ j}} = \left[\frac{k_x\ h\ (\Delta y)}{\mu\ (\Delta x)} \right]_{i+½,\ j} \tag{6.2}$$

As transmissibility is a property of the flow between two cell faces, not a block centered grid cell property like porosity or permeability, then the nomenclature for transmissibility is different. In OPM Flow, the transmissible of cell face $T_x(i, j, k)$ is the transmissibility between cells (i, j, k) and (i+1, j, k). In some simulators it would be between (i, j, k) and (i-1, j, k). This is important to note if manual modifications to cell connections are to be made in the model.

Note that modifications to grid property data can only be done in the GRID section, thereafter only the calculated pore volumes and transmissibilities are available for adjustment.

6.3 Keyword Definitions

6.3.1 ACTNUM – SET THE STATUS OF A GRID BLOCK TO ACTIVE OR INACTIVE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ACTNUM specifies which grid blocks are active or inactive. A value of 1 indicates the block is active and a value of 0 indicates the block is inactive. A grid block is inactive if its pore volume is less than the value entered using keyword MINPV. This keyword can be used to make blocks with a pore volume greater than MINPV inactive. Note that a value must be entered for each grid block in the model. Grid blocks are ordered with the I index cycling fastest, followed by the J and K indices. As for all array data repeat counts may be used, for example 100*1; however the full array must be specified.

Note that a cells activity can also be set using the EQUALS keyword by selection only those cells that are required to be made inactive.

No.	Name	Description	Default
1	ACTNUM	An array of integers that define the activity of a cell by setting it to 1 for being active or 0 for inactive, for each grid block in the model.	1*

Notes:

1) A total of NX x NY x NZ integer values, as defined by the DIMENS in the RUNSPEC section, must be specified for the array.

2) The keyword is terminated by "/".

Table 6.2: ACTNUM Keyword Description

Examples

The example below sets several cells to be inactive for a 4 x 5 x 2 model.

```
ACTNUM

0 0 1 1 # layer 1
0 0 1 1
1 1 1 1
1 1 1 1
1 1 1 1

1 1 1 1 # layer 2
1 1 1 1
1 1 1 1
1 1 1 1
0 0 0 0
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--        -- ARRAY    CONSTANT --  ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          'ACTNUM'    1.0000       1*  1*   1*  1*   1*  1* / SET ACTIVE CELLS
          'ACTNUM'    0.0000       1   2    1   2    1   1  / SET INACTIVE CELLS
          'ACTNUM'    0.0000       1   4    4   4    2   2  / SET INACTIVE CELLS
/
```

6.3.2 ADD – ADD A CONSTANT TO A SPECIFIED ARRAY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ADD keyword adds a constant to a specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the ADD keyword is being applied.

No.	Name	Description	Default
1	ARRAY	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	CONSTANT	An integer or real value to be added to the ARRAY in the same units as the ARRAY property.	0
3	I1	A positive integer that defines the lower bound of the array in the I-direction to be modified must be greater than or equal 1 and less than or equal to I2 and NX.	1
4	I2	A positive integer that defines the upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
5	J1	A positive integer that defines the lower bound of the array in the J-direction to be modified must be greater than or equal 1 and less than or equal to J2 and NY.	1
6	J2	A positive integer that defines the upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
7	K1	A positive integer that defines the lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
8	K2	A positive integer that defines the upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.

2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.3: ADD Keyword Description

The applicable arrays for each section are defined in Table 6.4 on the following page.

ADD Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.4: ADD Keyword Applicable Arrays by Section

Example

```
--
--        ARRAY       CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
ADD
          PERMX       20.000         1*  1*   1*  1*   1*  1* / ADD 20 mD TO PERMX
/
```

The above example ADDS 20 units to the PERMX array in the GRID section to all grid blocks in the model.

6.3.3 ADDREG – ADD A CONSTANT TO AN ARRAY BASED ON A REGION NUMBER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ADDREG keyword adds a constant to a specified array or part of an array based on cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the ADDREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the ADDREG keyword is being used.

No.	Name	Description	Default
1	ARRAY	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	CONSTANT	An integer or real value to be added to the ARRAY in the same units as the ARRAY property for a given REGION	0
3	REGION NUMBER	REGION NUMBER is a positive integer representing the region for which the CONSTANT in (2) should be applied	None
4	REGION ARRAY	The REGION ARRAY to use for applying the CONSTANT in (2) based on the REGION NUMBER in (3). REGION ARRAY can have the following values: 1) F for the FLUXNUM array 2) M for the MULTNUM array 3) O for the OPERNUM array	M

Notes:

1) Where the REGION NUMBER should be less than or equal to the maximum number of regions as defined on the REGDIMS keyword for the FIPNUM and OPERNUM arrays or the GRIDOPTS keyword for the MULTNUM array in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.5: ADDREG Keyword Description

The applicable arrays for each section are defined in Table 6.6 on the following page.

ADDREG Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		

ADDREG Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.6: ADDREG Keyword Applicable Arrays by Section

Example

```
--
-- FIRST DEFINE THE PROPERTY ARRAYS AND MULTNUM ARRAYS FOR 10 X 10 X 20 MODEL
--
--  ARRAY    CONSTANT --  ---------- BOX ---------
--                         I1  I2   J1  J2   K1  K2
EQUALS
    PORO      0.2000       1*  1*   1*  1*   1*  1*  / PORO  TO 0.20 IN MODEL
    PERMX     100.00       1*  1*   1*  1*   1*  1*  / PERMX TO 0.10 IN MODEL
    MULTNUM   1            1*  1*   1*  1*   1*  1*  / MULTNUM IN MODEL
    MULTNUM   2            1*  5    1   5    6   6   / MULTNUM IN MODEL
    MULTNUM   3            1*  1*   1*  1*   10  10  / MULTNUM IN MODEL
/
--
–        NOW RESET PORO AND PERMX BASED ON THE MULTNUM REGION NUMBER
--
--       ADD A CONSTANT TO AN ARRAY BASED ON A REGION NUMBER
--
--       ARRAY     CONSTANT  REGION   REGION ARRAY
--                 VALUE     NUMBER    M / F / O
ADDREG
     'PORO         0.050     1         M               /
      PORO         0.100     2         M               /
      PORO        -0.050     3         M               /
      PERMX        25.00     1         M               /
      PERMX        100.0     2         M               /
      PERMX       -50.00     3         M               /
/
```

The example first defines the PORO and PERMX property arrays for the model and then sets the MULTNUM array to 1 for all cells in the model, after which selected areas of model are assigned various MULTNUM integer values. The ADDREG can then be invoked to add or subtract constant values from the PORO and PERMX arrays for the various MULTNUM regions.

6.3.4 ADDZCORN – Add a Constant to the ZCORN Depth Array

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ADDZCORN keyword adds a constant to the ZCORN array or part of the array based on cells defined in the specified input box. The constant can be real or integer and can be negative or positive.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.5 AMALGAM – DEFINE LGR AMALGAMATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AMALGAM keyword defines a Cartesian Local Grid Refinements ("LGR") amalgamations, that is merging several LGRs into one amalgamated LGR.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.6 AQUANCON – DEFINE ANALYTICAL CONNECTIONS TO THE GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUANCON keyword defines how analytical aquifers are connected to the simulation grid, this includes Carter-Tracy and Fetkovich analytical aquifers, both of which are implemented in OPM Flow.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	AQUNUM	AQUNUM is a positive integer greater than or equal to one and less than the maximum number of analytical aquifers as defined by the NANAQ variable on the AQUDIMS keyword in the RUNSPEC section, that defines the aquifer to be connected to the grid.			None
2	I1	A positive integer that defines the lower bound of the cells in the I-direction to be connected to the aquifer and must be greater than or equal to one and less than or equal to I2 and NX.			1
3	I2	A positive integer that defines the upper bound of the of the cells in the I-direction to be connected to the aquifer and must be greater than or equal to I1 and less than or equal to NX			NX
4	J1	A positive integer that defines the lower bound of the cells in the J-direction to be connected to the aquifer and must be greater than or equal to one and less than or equal to J2 and NY.			1
5	J2	A positive integer that defines the upper bound of the cells in the J-direction to be connected to the aquifer and must be greater than or equal to J1 and less than or equal to NY.			NY
6	K1	A positive integer that defines the lower bound of the cells in the K-direction to be to be connected to the aquifer and must be greater than or equal to one and less than or equal to K2 and NZ.			1
7	K2	A positive integer that defines the upper bound of the cells in the K-direction to be connected to the aquifer and must be greater than or equal to K1 and less than or equal to NZ.			NZ
8	AQUFACE	AQUFACE is a character string that sets the connection "face" of the cells declared by this record and should be set to one of the following: 1) X+, Y+, or Z+ for the positive direction, or X-, Y- or Z- for the negative direction transmissibilities. 2) I+, J+, or K+ for the positive direction, or I-, J- or K- for the negative direction transmissibilities.			None
9	AQUFLUX	AQUFLUX is a positive real value that sets the fraction of the total influx between the aquifer and the defined cells declared on this keyword. If defaulted the cell face for each cell is applied and if a values is declared then then this values is applied to all cells declared by this record.			
		ft^2	m^2	cm^2	1*
10	AQUCOEF	AQUCOEF is a real positive values that scales the calculated connection between the aquifer and the cells declared on this record.			
		dimensionless	dimensionless	dimensionless	1.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
11	AQUOPT	AQUOPT is a character string that sets the cell face connection and should be set to one of the following: 1) YES: Aquifer connections can adjoin to active cells allowing for connections inside the reservoir grid. It is not recommended to use this option without thoroughly checking the connections in the model. 2) NO: Aquifer connections cannot adjoin to active cells preventing connections inside the reservoir grid. This is the recommended and the default value.			NO

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.7: AQUANCON Keyword Description

Example

The following example defines aquifer number one connected to the I+ face of various cells in the model.

```
--
--                        ANALYTIC AQUIFER CONNECTION
--
--        ID      ---------- BOX ---------    CONNECT  AQF     AQF      ADJOIN
--        NUMBER I1   I2    J1   J2    K1   K2    FACE     INFLX   MULTI    CELLS
AQUANCON
          1      57   57    28   36    46   58    'I+'     1*      1*       'NO'        /
          1     111  111    38   41    22   31    'I+'     1*      1*       'NO'        /
          1      96   96    44   49    22   31    'I+'     1*      1*       'NO'        /
          1      43   43    28   35    54   58    'I+'     1*      1*       'NO'        /
          1      98   98    38   42    32   40    'I+'     1*      1*       'NO'        /
          1      79   79    41   67     5   11    'I+'     1*      1*       'NO'        /
          1      61   61    48   72    12   17    'I+'     1*      1*       'NO'        /
/
```

See the AQUCT keyword in the GRID section for a complete example on defining and connecting a Carter-Tracy aquifer to a simulation grid.

6.3.7 AQUCON – Define Numerical Aquifer Connections to the Grid

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

AQUCON keyword defines how numerical aquifers are connected to the simulation grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.8 AQUCT – DEFINE CARTER-TRACY ANALYTICAL AQUIFERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUCT keyword defines Carter-Tracy[39] analytical aquifers, the properties of the aquifer, including the Carter-Tracy aquifer influence function associated with the aquifer, defined by the AQUTAB keyword in the PROPS section.

Each row entry in the AQUCT keyword defines one Carter-Tracy aquifer.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	AQUID	A positive integer greater than or equal to one and less than or equal to NANAQ on the AQUDIMS keyword in the RUNSPEC section, that defines the Carter-Tracy aquifer number.			1
2	DATUM	DATUM is a single positive value that defines the Carter-Tracy reference datum depth for PRESS.			
		feet	m	cm	None
3	PRESS	PRESS is a single positive value that defines the aquifer pressure at DATUM. If PRESS is defaulted then the simulator will set the aquifer's initial reservoir pressure to be in equilibrium with the cells the aquifer is contacted to.			
		psia	barsa	atma	1*
4	PERM	PERM is a real positive number that assigns the permeability to the aquifer.			
		mD	mD	mD	None
5	PORO	PORO is a real positive number greater than zero and less than or equal to one that assigns the porosity to the aquifer.			
		dimensionless	dimensionless	dimensionless	None
6	RCOMP	RCOMP is a real number defining the total (rock and water) compressibility (Ct) at the DATUM pressure.			
		1/psia	1/barsa	1/atma	None
7	RE	RE is a real positive number that defines the Carter-Tracy aquifer external radius.			
		feet	m	cm	None
8	DZ	DZ is a real positive number that defines the Carter-Tracy aquifer average net thickness.			
		feet	m	cm	None
9	ANGLE	ANGLE is a real positive number that defines the angle of influence, that is the angular connection between the aquifer and the hydrocarbon reservoir. A value of 360° degrees, the default value, indicates that the aquifer complete surrounds the hydrocarbon reservoir.			
		degrees	degrees	degrees	360.0

[39] *Carter, R. D. and Tracy, G.W. "An Improved Method for Calculating Water Influx," Transactions of AIME (1960) 219, 215-417.*

No.	Name	Description			Default
		Field	Metric	Laboratory	
10	PVTNUM	PVTNUM is positive integer greater than zero and less than the NTPVT variable on the TABDIMS keyword in the RUNSPEC section, that defines the PVTW table allocated to the Carter-Tracy aquifer.			1
11	AQUTAB	AQUTAB is positive integer greater than zero and less than the NIFTBL variable as declared on the AQUDIMS keyword in the RUNSPEC section, that defines the AQUTAB table allocated to this Carter-Tracy aquifer. The default value of one sets the internal infinite acting Carter-Tracy aquifer influence table not the first table in the AQUTAB keyword in the PROPS section The first table in the AQUTAB keyword is considered to be table number two.			1
12	SALTCON	SALTCON is a real positive number that defines the initial salt concentration in the aquifer. This variable is ignored by OPM Flow.			
		lb/stb	kg/sm^3	gm/scc	0.0
13	TEMP	TEMP is a real positive number that defines the initial temperature of the aquifer at DATUM. This variable is ignored by OPM Flow.			
		°F	°C	°C	1*

Notes:

1) The keyword is followed by up to NANAQ records as defined on the AQUDIMS keyword in the RUNSPEC section
2) Each record is terminated by a "/" and the keyword should be terminated by a "/".

Table 6.8: AQUCT Keyword Description

Note

OPM Flow includes the infinite acting Carter-Tracy aquifer influence table as a default for table number one; thus data entered on AQUTAB keyword starts from table number two.

In order to full define a Carter-Tracy aquifer one has to define the aquifer properties via the AQUCT keyword, the Carter-Tracy influence functions via the AQUTAB keyword in the PROPS section, if the default infinite acting table is not being employed, and how the aquifer is connected to the reservoir using the AQUANCON keyword in the GRID or SOLUTION sections.

Example

Given the following grid and aquifer dimensions in the RUNSPEC section:

```
--
--       MAX      MAX      MAX
--       NDIVIX   NDIVIY   NDIVIZ
DIMENS
         20       1        5                                                  /

--       AQF      AQF      AQF      AQF      AQF      AQF     AQF     AQF
--       MXAQN    MXNAQC   NIFTBL   NRIFTB   NANAQ    NCAMAX  MXNALI  MXAAQL
AQUDIMS
         1*       1*       5        100      1        1*      1*      1*          /
```

And AQUTAB in the PROPS section

```
--
--       CARTER-TRACY AQUIFER INFLUENCE TABLES
--       (STARTS FROM TABLE NO. 2, AS DEFAULT IS TABLE NO. 1)
--
AQUTAB
--       DIMLESS     DIMLESS
--       TIME        PRESSURE
--       -------     ---------
          0.01         0.112
          0.05         0.229
          0.10         0.315
          0.15         0.376
          0.20         0.424
          0.22         0.443
          0.24         0.459
          0.26         0.476
          0.28         0.492
          0.30         0.507
          0.32         0.522
          0.34         0.536
          0.36         0.551
          0.38         0.565
          0.40         0.579
          0.42         0.593
          0.44         0.607
          0.46         0.621
          0.48         0.634
          0.50         0.648
          0.60         0.715
          0.70         0.782
          0.80         0.849
          0.90         0.915
          1.00         0.982
          2.00         1.649
          3.00         2.316
          5.00         3.649
         10.00         6.982
         20.00        13.649
         30.00        20.316
         50.00        33.649
        100.00        66.982
        200.00       133.649
        300.00       200.316
        500.00       333.649
       1000.00       666.982 /
```

The Carter-Tracy aquifer is defined in the GRID or SOLUTION sections as:

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION  --
--                      CARTER-TRACY AQUIFER DESCRIPTION
--
--      ID   DATUM   AQF    AQF    AQF    AQF     AQF   AQF   INFL   PVT  AQU
--      NUM  DEPTH   PRESS  PERM   PORO   RCOMP   RE    DZ    ANGLE  NUM  TAB
--
AQUCT
         1   2000.0  269    100.0  0.30   3.0e-5  330   10.0  360.0   1    2   /
/
```

And the connection of the aquifer is set in the GRID or SOLUTION sections as:

```
--
--                      ANALYTIC AQUIFER CONNECTION
--
--       ID     ---------- BOX ---------   CONNECT  AQF    AQF      ADJOIN
--       NUMBER I1  I2   J1  J2   K1  K2   FACE     INFLX  MULTI    CELLS
AQUANCON
         1      1   1    1   1    1   1     J-      1.0    1.0      'NO'        /
/
```

Here one Carter-Tracy aquifer is connected to a single cell (1, 1, 1) at the J- face (or X- face) of the cell.

6.3.9 AQUNNC – Define Numerical Aquifer Non-Neighbor Connections

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUNNC keyword defines Numerical Aquifer Non-Neighbor Connections.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.10 AQUNUM – Define Numerical Aquifer Properties

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUNUM keyword defines the properties of Numerical Aquifers, including which grid blocks in the model should be utilized as part of the numerical aquifer.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.11 AUTOCOAR - Define Auto Refinement Grid Coarsen Area

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AUTOCOAR keyword defines an area in the global grid that should be coarsen for when the AUTOREF keyword has been declared in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.12 BOUNDARY – Define a Boundary Box for Printing

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The BOUNDARY keyword defines a rectangular grid for printing various arrays to the output print file (*.PRT); thus, avoiding printing all the elements in the selected array.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

6.3.13 BOX - DEFINE A RANGE OF GRID BLOCKS TO ENTER PROPERTY DATA

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

BOX defines a range of grid blocks for which subsequent data is assigned for all the cells in the defined BOX. Note that the BOX grid is reset by the keyword ENDBOX by resetting the current defined BOX to be the whole grid. The keyword can be used for any array and for all grid types.

No.	Name	Description	Default
1	I1	A positive integer that defines the lower bound of the array in the I-direction to be modified must be greater than or equal 1 and less than or equal to I2 and NX.	1
2	I2	A positive integer that defines the upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
3	J1	A positive integer that defines the lower bound of the array in the J-direction to be modified must be greater than or equal 1 and less than or equal to J2 and NY.	1
4	J2	A positive integer that defines the upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
5	K1	A positive integer that defines the lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
6	K2	A positive integer that defines the upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) The keyword is terminated by "/".

Table 6.9: BOX Keyword Description

See also the ADD, COPY, ENDBOX, EQUALS, and MULTIPLY keywords can also be used to enter data in a subset of the model.

Examples

```
--
--        DEFINE A BOX GRID FOR THE BOTTOM LAYER OF A 100 X 100 X 20 MODEL
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   20  20 / SELECT THE BOTTOM LAYER
--
--        DEFINE THE POROSITY AND OTHER PROPERTIES ON THE BOX GRID
--
PORO
          10000*0.300
/
PERMX
          5000*100.0   5000*75.0
/
NTG
          10000*0.500
/
--
--        RESET THE INPUT BOX TO BE THE FULL MODEL
--
ENDBOX
```

The above example set the BOX grid to be the last layer in the model which means that 100 x 100, that is 10,000 values need to entered for each property.

Alternatively, one could use the EQUALS keyword to accomplish the same thing.

```
-- -- ARRAY    CONSTANT --  ---------- BOX ---------
--                         I1  I2   J1  J2   K1  K2
EQUALS
   'PORO'      0.3000      1*  1*   1*  1*   20  20 / PORO  TO 0.30 IN LAYER 20
   'PERMX'     0.1000      1   50   1*  1*   20  20 / PERMX TO 100. IN LAYER 20
   'PERMX'     0.1000      50 100   1*  1*   20  20 / PERMX TO 75.0 IN LAYER 20
   'NTG'       0.0500      1*  1*   1*  1*   20  20 / NRT   TO 0.50 IN LAYER 20
/
```

Note

It is good practice to always use the ENDBOX keyword to reset the input back to the full grid when all the modifications for a sub-grid have been completed.

6.3.14 BTOBALFA – Dual Porosity Matrix to Fracture Multiplier (All Cells)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The BTOBALFA keyword defines a dual porosity matrix to fracture multiplier that is applied to all cells, for when the Dual Porosity model has been activated by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section.

See also the BTOBALFVV keyword in the GRID section that applies a multipliers to individual cells.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.15 BTOBALFV – Dual Porosity Matrix to Fracture Multiplier (Individual Cells)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The BTOBALFV keyword defines a dual porosity matrix to fracture multiplier that is applied to individual cells, for when the Dual Porosity model has been invoked by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section.

See also the BTOBALFAV keyword in the GRID section that applies a constant multiplier to all cells.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.16 CARFIN – DEFINE A CARTESIAN LOCAL GRID REFINEMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

CARFIN defines a Cartesian Local Grid Refinement ("LGR") in a cell or a group of cells in the host grid, for when LGRs have been activated for the input deck using the LGR keyword in the RUNSPEC section. The keyword marks the start of an LGR description section and all subsequent keywords between the CARFIN and ENDFIN keywords are deemed to be associated with the current LGR and not the host grid.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which the LGR is being being defined.	None
2	I1	A positive integer that defines the lower index of the global or host grid in the I-direction to be refined; must be greater than or equal 1 and less than or equal to I2 and NX on the DIMENS keyword in the RUNSPEC section.	None
3	I2	A positive integer that defines the upper index of the global or host grid in the I-direction to be refined; must be greater than or equal I1 and II, and less than or equal to NX on the DIMENS keyword in the RUNSPEC section.	None
4	J1	A positive integer that defines the lower index of the global or host grid in the J-direction to be refined; must be greater than or equal 1 and less than or equal to J2 and NY on the DIMENS keyword in the RUNSPEC section.	None
5	J2	A positive integer that defines the upper index of the global or host grid in the J-direction to be refined; must be greater than or equal 1 and JI, and less than or equal to NY on the DIMENS keyword in the RUNSPEC section.	None
6	K1	A positive integer that defines the lower index of the global or host grid in the K-direction to be refined; must be greater than or equal 1 and less than or equal to K2 and NZ on the DIMENS keyword in the RUNSPEC section.	None
7	K2	A positive integer that defines the upper index of the global or host grid in the K-direction to be refined; must be greater than or equal 1 and KI, and less than or equal to NZ on the DIMENS keyword in the RUNSPEC section.	None
8	NX	A positive integer value that defines the number of LGR grid blocks in the x direction for Cartesian grids or the number of grid blocks in the r direction for radial grids	None
9	NY	A positive integer value that defines the number of LGR grid blocks in the y direction for Cartesian grids or the number of grid blocks in the theta direction for radial grids.	None
10	NZ	A positive integer value that defines the number of LGR grid blocks in the z direction for both Cartesian and radial grids.	None
11	MXWELS	A positive integer defining the maximum number of wells contained in this LGR.	None
12	HOSTNAME	A character string of up to eight characters in length that defines the host grid name for nested refinements. The default value of "GLOBAL" sets the host name to the global grid, that is for a conventional LGR. A nested refinement is when the HOSTNAME is a previously declared LGR for which the current LGR is specifying a further LGR refinement.	GLOBAL

No.	Name	Description	Default
Notes: 1) The keyword is terminated by "/".			

Table 6.10: CARFIN Keyword Description

Note that if the Dual Porosity option has be activated by either the DUALPORO or DUALPERM keywords in the RUNSPEC section, then the host grid definition (I1-I2, J1-J2, K1-K2) applies only to the matrix cells; however, the LGR NZ parameter in this case must include the fracture blocks, similar to the NZ parameter on the DIMENS keyword. This means that all property data should be entered for both the matrix and fracture cells in the LGR description.

Example

The example below defines an LGR in the global grid, named LGR-OP01 with a maximum of one well allowed in the LGR.

```
--
--        CARFIN LGR GRID COMMANDS
--
--        LGR         ----- HOST GRID ------    -- CARFIN GRID --   MAX      HOST
--        NAME        I1  I2  J1  J2  K1  K2      NX     NY     NZ   WELLS    NAME
CARFIN
          LGR-OP01    24  24  87  87   1  50      3      3     50     1      GLOBAL /


ENDFIN
```

Here the one global cell in the areal plane (24, 87) is divided into three LGR cells in the x-direction and three cells in the y-direction. Since no other property data is given, then the LGR cells take their properties from the host grid, that is the global grid.

6.3.17 COALNUM – DEFINE THE COAL REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COALNUM keyword defines the coal region numbers for each grid block used with the Coal Bed Methane option ("CBM"). OPM Flow does not have a CBM option; however, the keyword is documented here for completeness.

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description	Default
1	COALNUM	COALNUM defines an array of positive integers assigning a grid cell to a particular coal region. The maximum number of COALNUM regions is set by the NTCREG variable on REGDIMS keywords in the RUNSPEC section.	1

Notes:

1) A total of NX x NY x NZ integer values, as defined by the DIMENS in the RUNSPEC section, must be specified for the array.
2) If a cell is not assigned a COALNUM region then the default value of 1 will be used.
3) COALNUM value of 0 sets the cell be a non-coal region.
4) The keyword is terminated by "/".

Table 6.11: COALNUM Keyword Description

Example

The example below sets three COALNUM regions for a 4 x 5 x 2 model.

```
--
--        DEFINE COALNUM REGIONS FOR ALL CELLS
--
COALNUM
          2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

The above will no effect in an OPM Flow input deck.

6.3.18 COARSEN – Define Grid Coarsening Cells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COARSEN keyword defines how a set of cells should be coarsened for when the Local Grid Refinement ("LGR") option has been activated by LGR keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.19 COLLAPSE – DEFINE COMPRESSED VERTICAL EQUILIBRIUM CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COLLAPSE keyword defines the which cells can be collapsed in a collapsed Vertical Equilibrium ("VE") run when the VE option has been invoked via the VE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation

6.3.20 COORD – DEFINE A SET OF COORDINATES LINES FOR A RESERVOIR GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

COORD defines a set of coordinate lines or pillars for a reservoir grid via an array. A total of 6 x (NX+1) x (NY+1) lines must be specified for each coordinate data set (or reservoir). For multiple reservoirs, where NUMRES is greater than one, there must be 6 x (NX+1) x (NY+1) x NUMRES values. In OPM Flow NUMRES can only be set to one.

For Cartesian geometry, each line is defined by the (x, y, z) coordinates of two distinct points on the line. The lines are entered with I cycling fastest then J. For radial geometry, each line is defined by the (r, theta) coordinates of two distinct points on the line. The lines are entered with R cycling fastest then THETA.

The keyword can only be used with Irregular Corner-Point Grids.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	X1-Column	Top X coordinate			
2	Y1-Column	Top Y coordinate			
3	Z1-Column	Top Z coordinate			
4	X2-Column	Base X coordinate			
5	Y2-Column	Base Y coordinate			
6	Z2-Column	Base Z coordinate			
		feet	metres	cm	None

Notes:

1) THETA values are in degrees for all units.
2) Regular Cartesian and Radial grid keywords cannot be used with this keyword, that is: DR, DRV, DTHETA, DTHETAV, DX, DXV, DY, DYV, DZ, INRAD, and TOPS.
3) The keyword is terminated by "/".

Table 6.12: COORD Keyword Description

See also the SPECGRID, COORDSYS and ZCORN keywords to fully define an Irregular Corner-Point Grid.

Example

```
--
--       SPECIFY VERTICAL COORDINATE LINES FOR A REGULAR 3 x 2 GRID
--       (DX = 100 and DY = 200)
--
--       X1     Y1    Z1      X2     Y2    Z2
--       ---    ---   ----    ---    ---   ----
COORD
           0      0   1000      0      0   5000
         100      0   1000    100      0   5000
         200      0   1000    200      0   5000
         300      0   1000    300      0   5000
           0    200   1000      0    200   5000
         100    200   1000    100    200   5000
         200    200   1000    200    200   5000
         300    200   1000    300    200   5000
           0    400   1000      0    400   5000
         100    400   1000    100    400   5000
         200    400   1000    200    400   5000
         300    400   1000    300    400   5000
/
```

The above example defines vertical coordinate lines for a regular 3 by 2 grid with DX equal to 100 and DY equal to 200.

6.3.21 COORDSYS – Define Coordinate Grid Options

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword sets various options for when multiple grid systems are being used.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.22 COPY – COPY ARRAY DATA TO ANOTHER ARRAY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COPY keyword copies an array (or part of an array) to another array or part of an array. The arrays can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the COPY keyword is being used.

No.	Name	Description	Default
1	ARRAY-1	The name of the array to be copied from. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	ARRAY-2	The name of the array to be copied to. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
3	I1	A positive integer that defines the lower bound of the array in the I-direction to be modified must be greater than or equal 1 and less than or equal to I2 and NX.	1
4	I2	A positive integer that defines the upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
5	J1	A positive integer that defines the lower bound of the array in the J-direction to be modified must be greater than or equal 1 and less than or equal to J2 and NY.	1
6	J2	A positive integer that defines the upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
7	K1	A positive integer that defines the lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
8	K2	A positive integer that defines the upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.13: COPY Keyword Description

The applicable arrays for each section are defined in Table 6.14 on the following page.

COPY Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.14: COPY Keyword Applicable Arrays by Section

Example

```
--
--        SOURCE       DESTIN.       ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
COPY
          PERMX        PERMY         1*  1*   1*  1*   1*  1* / CREATE PERMY
          PERMX        PERMZ         1*  1*   1*  1*   1*  1* / CREATE PERMZ
/

--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
MULTIPLY
          PERMZ        0.50000       1*  1*   1*  1*   1*  1* / PERMZ * 0.5
/
```

The above example copies PERMX array to the PERMY and PERMZ arrays in the GRID section for all grid blocks in the model. The PERMZ array is then multiplied by 0.5 for all grid blocks in the model.

6.3.23 COPYBOX – COPY ARRAY DATA DEFINED BY A BOX

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COPYBOX keyword copies an array (or part of an array) to another part of the same array. The array can be real or integer depending on the array type; however, the array that can be operated on is dependent on which section the COPYBOX keyword is being used.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	ARRAY-1	The name of the array to be copied This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	I1	A positive integer that defines the SOURCE lower bound of the array in the I-direction to be modified must be greater than or equal 1 and less than or equal to I2 and NX.	1
3	I2	A positive integer that defines the SOURCE upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
4	J1	A positive integer that defines the SOURCE lower bound of the array in the J-direction to be modified must be greater than or equal 1 and less than or equal to J2 and NY.	1
5	J2	A positive integer that defines the SOURCE upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
6	K1	A positive integer that defines the SOURCE lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
7	K2	A positive integer that defines the SOURCE upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ
8	I3	A positive integer that defines the DESTINATION lower bound of the array in the I-direction to be modified must be greater than or equal 1 and less than or equal to I2 and NX.	1
9	I4	A positive integer that defines the DESTINATION upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
10	J3	A positive integer that defines the DESTINATION lower bound of the array in the J-direction to be modified must be greater than or equal 1 and less than or equal to J2 and NY.	1
11	J4	A positive integer that defines the DESTINATION upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
12	K3	A positive integer that defines the DESTINATION lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1

No.	Name	Description	Default
13	K4	A positive integer that defines the DESTINATION upper bound of the array in the K-direction to be modified must be greater than or equal to KI and less than or equal to NZ.	NZ

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.15: COPYBOX Keyword Description

Note that he SOURCE and DESTINATION arrays must be of the same size in all dimensions and the applicable arrays for each section are defined in Table 6.16.

COPYBOX Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX		SWL	ENDNUM			
DY		SWCR	EQLNUM			
DZ		SWU	FIPNUM			
PERMX		SGL	IMBNUM			
PERMY		SGCR	MISCNUM			
PERMZ		SGU	PVTNUM			
MULTX		KRW	ROCKNUM			
MULTY		KRO	SATNUM			
MULTZ		KRG	WH2NUM			
DR		PCG				
THETA		PCW				
PERMR						
PERMTHT						
DZNET						
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.16: COPYBOX Keyword Applicable Arrays by Section

Example

```
--
--       SOURCE    ------ SOURCE BOX ------    ---- DESTINATION BOX ----
--       ARRAY     I1  I2   J1  J2   K1  K2    I1  I2   J1  J2   K1  K2
COPYBOX
          PORO     1*  1*   1*  1*   12  14    1*  1*   1*  1*   15  17 / PORO
          PERMX    1*  1*   1*  1*   12  14    1*  1*   1*  1*   15  17 / PERMX
/
```

The above example copies all the PORO and PERMX values in layers 12 to 14 to layers 15 and 17.

6.3.24 COPYREG – COPY AN ARRAY TO ANOTHER ARRAY BASED ON A REGION NUMBER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COPYREG keyword copies a specified array or part of an array based on cells with a specific region number to another array. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the COPYREG keyword is read by the simulator. The property arrays can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the COPYREG keyword is being used.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	ARRAY-1	The name of the array to be copied from. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	ARRAY-2	The name of the array to be copied to. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
3	REGION NUMBER	Integer REGION NUMBER is the region for which the array data in (1) should be copied to array data in (2).	None
4	REGION ARRAY	The REGION ARRAY to use for selecting the REGION NUMBER in (3) for selecting the data to be copied. REGION ARRAY can have the following values: 1) F for the FLUXNUM array 2) M for the MULTNUM array 3) O for the OPERNUM array	M

Notes:

1) Where the REGION NUMBER should be less than or equal to the maximum number of regions as defined on the REGDIMS keyword for the FIPNUM and OPERNUM arrays or the GRIDOPTS keyword for the MULTNUM array in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.17: COPYREG Keyword Description

The applicable arrays for each section are defined in Table 6.18 on the following page.

COPYREG Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.18: COPYREG Keyword Applicable Arrays by Section

Example

```
--
--        COPY AN ARRAY TO ANOTHER ARRAY BASED ON A REGION NUMBER
--
--        ARRAY     ARRAY     REGION    REGION ARRAY
--        FROM      TO        NUMBER     M / F / O
COPYREG
          PERMX     PERMY     1          M                    / COPY PERMX TO PERMY
          PERMX     PERMZ     1          M                    / COPY PERMX TO PERMZ
/
--
--        NOW RESET PERMZ BASED ON THE MULTNUM REGION NUMBER
--
--
--        MULTIPLY AN ARRAY BY A CONSTANT BASED ON A REGION NUMBER
--
--        ARRAY     CONSTANT  REGION    REGION ARRAY
--                  VALUE     NUMBER     M / F / O
MULTIREG
          PERMX     0.95      1          M                    /
/
```

The above example first copies the PERMX property array for region number one to the PERMY and PERMZ property arrays for region one using the MULTNUM array to define the region numbers. After which PERMZ property array for region one is multiplied by 0.5 using the MULTIREG keyword.

6.3.25 CRITPERM – Define Minimum Permeability for Vertical Equilibrium Grid Cell Compression

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The CRITPERM keyword is used to define the minimum permeability for Vertical Equilibrium("VE") grid cell compression, for when the Vertical Equilibrium formulation has been activated by the VE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.26 DIFFMR – Define Grid Block Radial Direction Diffusivity Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMR keyword defines the radial direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.27 DIFFMR- – DEFINE GRID BLOCK NEGATIVE RADIAL DIRECTION DIFFUSIVITY MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMR- keyword defines the negative radial direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.28 DIFFMTHT – Define Grid Block Theta Direction Diffusivity Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMTHT keyword defines the theta direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.29 DIFFMTH- – DEFINE GRID BLOCK NEGATIVE THETA DIRECTION DIFFUSIVITY MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMR- keyword defines the negative theta direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.30 DIFFMX – Define Grid Block X-Direction Diffusivity Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMX keyword defines the x-direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.31 DIFFMX- – Define Grid Block Negative X-Direction Diffusivity Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMX- keyword defines the negative x-direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.32 DIFFMY – Define Grid Block Y-Direction Diffusivity Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMY keyword defines the y-direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.33 DIFFMY- – Define Grid Block Negative Y-Direction Diffusivity Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMY- keyword defines the negative y-direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.34 DIFFMZ – Define Grid Block Z-Direction Diffusivity Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMZ keyword defines the z-direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.35 DIFFMZ- – Define Grid Block Negative Z-Direction Diffusivity Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFMZ- keyword defines the negative z-direction diffusivity multipliers for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.36 DOMAINS – DEFINE THE PARALLEL DOMAIN PROPERTIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DOMAINS keyword defines the parallel domain properties for when parallel processing has been invoked by the PARALLEL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to run OPM Flow in parallel mode.

6.3.37 DPGRID – Activate The Matrix Cell to Fracture Cell Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DPGRID keyword activates the matrix cell to fracture cell option for dual porosity runs for when a Dual Porosity model has been activated by either the DUALPORO or DUALPERM keywords in the RUNSPEC section. The keyword allows for only the matrix grid data to be entered and the missing fracture cells are set to the inputted matrix cells.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.38 DPNUM – Define Dual and Single Porosity Grid Block Array

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

In dual porosity runs only, that is not dual permeability runs, the DPNUM keyword defines which wells should be treated as single porosity cells and which cells should be treated as dual porosity cells, for when the Dual Porosity model has been activated by the DUALPORO keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.39 DR - DEFINE THE SIZE OF GRID BLOCKS IN THE R DIRECTION FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DR defines the size of all grid blocks in the R direction via an array for each cell in a Radial Grid model.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DR	DR is an array of real numbers describing the cell size in the R direction for each cell in the model in a radial grid. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.19: DR Keyword Description

See also the DRV, DTHETAV, DZ and TOPS keywords in the GRID section to fully define a radial grid model.

Example

Given the dimensions of the grid in the RUNSPEC section to be 10, 1, 8 for NX, NY and NZ respectively, then DR should be defined as:

```
--
--        INNER RADIUS OF FIRST GRID BLOCK IN THE RADIAL DIRECTION
--
INRAD
          0.25
/
--
--        DEFINE GRID BLOCK R DIRECTION CELL SIZE
--
DR
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0
/
```

The above example defines the size of the cells in the R direction based on 80 cells in the model as defined by the DIMENS keyword in the RUNSPEC section. Note the INRAD keyword to define the inner radius of the radial grid.

6.3.40 DRV - DEFINE THE SIZE OF GRID BLOCKS IN THE R DIRECTION VIA A VECTOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DRV[40] defines the size of grid blocks in the R direction via a vector as opposed to defining the property for each cell for a Radial Grid. The RADIAL keyword in the RUNSPEC section should be activated to indicate that radial geometry is being used.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DRV	DRV is a vector of real numbers describing the cell size for the grid blocks in the R direction in a radial grid. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	None

Notes:

1) The number of entries should correspond to the NX parameter on the DIMENS keyword in the RUNSPEC section

2) The keyword is terminated by "/".

Table 6.20: DRV Keyword Description

See also the DR, DTHETAV, DZ and TOPS keywords in the GRID section to fully define a radial grid model.

Example

```
--
--        INNER RADIUS OF FIRST GRID BLOCK IN THE RADIAL DIRECTION
--
INRAD
          0.25
/
--
--        DEFINE GRID BLOCK SIZES IN THE R DIRECTION
--
DRV
          1.75  2.32  5.01  10.84  23.39  50.55  109.21  235.92  509.68  1101.0  /
```

The above example defines the size of the cells in the R direction based on NX equals 10 on the DIMENS keyword in the RUNSPEC section. Note the INRAD keyword to define the inner radius of the radial grid.

[40] *Radial grids are not currently implemented in this version of OPM Flow, but is expected to be incorporated in a future release.*

6.3.41 DTHETA - DEFINE THE SIZE OF GRID BLOCKS IN THE THETA DIRECTION FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DTHETA defines the size of all grid blocks in the R direction via an array for each cell in a Radial Grid model.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DR	DTHETA is an array of real numbers describing the cell size in the THETA direction in radial grids for each cell in the model. Repeat counts may be used, for example 10*25.0			
		degrees	degrees	degrees	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.21: DTHETA Keyword Description

See also the DRV, DTHETAV, DZ and TOPS keywords in the GRID section to fully define a radial grid model.

Example

Given the dimensions of the grid in the RUNSPEC section to be 10, 6, 1 for NX, NY and NZ respectively, then DTHETA should be defined as:

```
--
--        DEFINE GRID BLOCK SIZES IN THE THETA DIRECTION
--
DTHETA
          10*60.0
          10*60.0
          10*60.0
          10*60.0
          10*60.0
          10*60.0
/
```

The above example defines the size of the cells in the R direction based on 60 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.42 DTHETAV - SETS THE SIZE OF GRID BLOCKS IN THETA DIRECTION VIA A VECTOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DTHETAV[41] defines the size of grid blocks in the THETA direction via a vector as opposed to defining the property for each cell for a Radial Grid. The RADIAL keyword in the RUNSPEC should be activated to indicate that radial geometry is being used.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DTHETAV	DTHETAV is a vector of real numbers describing the cell size for the grid blocks in the THETA direction in a radial grid. Repeat counts may be used, for example 10*100.0.			
		degrees	degrees	degrees	None

Notes:

1) The number of entries should correspond to the NY parameter of the DIMENS keyword in the RUNSPEC section.

2) The keyword is terminated by "/".

Table 6.22: DTHETA Keyword Description

See also the DRV, DZV and TOPS keywords to fully define a radial grid model.

Example

```
--
--        DEFINE GRID BLOCK SIZES IN THE THETA DIRECTION (BASED ON NY = 6)
--
DTHETAV
          60.0  60.0  60.0  60.0  60.0  60.0                                  /
```

The above example defines the size of the cells in the THETA direction based on NY equals six in the DIMENS keyword in the RUNSPEC section.

[41] *Radial grids are not currently implemented in this version of OPM Flow, but is expected to be incorporated in a future release.*

6.3.43 DUMPFLUX – ACTIVATE WRITING OUT OF A FLUX FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the writing out of a full field (the full grid) FLUX file for later processing in a Flux Boundary run. The Flux Boundary feature allows for the segmentation of the full grid into flux boundary areas which allow for a sub-area of the grid to be run and at the same time model the flux across the boundary derived from the main grid. The object of this feature is to be able to investigate the performance of various areas of the model without having to run the full field, thus improving computational efficiency and run times, but still obtain "reasonable" results due to the incorporation of the fluxes across the boundary.

This feature is not available in OPM Flow; however it is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       ACTIVATE WRITING OUT OF A FLUX FILE
--
DUMPFLUX                                                                    /
```

The above example switches on the writing of the FLUX output file; the keyword has no effect and is ignored by the simulator.

6.3.44 DX - DEFINE THE SIZE OF GRID BLOCKS IN THE X DIRECTION FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DX defines the size of all grid blocks in the X direction via an array for each cell in a Cartesian Regular Grid model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DX	DX is an array of real numbers describing the cell size in the X direction for each cell in the model. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.23: DX Keyword Description

See also the DY, DZ and TOPS keywords to fully define a Cartesian Regular Grid.

Example

```
--
--        DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NX x NY x NZ = 300)
--
DX
          300*1000                                                          /
```

The above example defines the size of the cells in the X direction based on 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.45 DXV - DEFINE THE SIZE OF GRID BLOCKS IN THE X DIRECTION VIA A VECTOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DXV defines the size of grid blocks in the X direction via a vector as opposed to defining the X direction cell size for each cell for a Cartesian Regular Grid.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DXV	DXV is a vector of real numbers describing the cell size for the grid blocks in the X direction. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	None

Notes:

1) The number of entries should correspond to the NX parameter on the DIMENS keyword in the RUNSPEC section.

2) The keyword is terminated by "/".

Table 6.24: DXV Keyword Description

See also the DYV, DZV and TOPS keywords to fully define a Cartesian Regular Grid.

Example

```
--
--        DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NX = 5)
--
DXV
          5*100                                                          /
```

The above example defines the size of the cells in the X direction based on NX equals 5 on the DIMENS keyword in the RUNSPEC section.

6.3.46 DY - DEFINE THE SIZE OF GRID BLOCKS IN THE Y DIRECTION FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DY defines the size of all grid blocks in the Y direction via an array for each cell in a Cartesian Regular Grid model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DY	DY is an array of real numbers describing the cell size in the Y direction for each cell in the model. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.25: DY Keyword Description

See also the DX, DZ and TOPS keywords to fully define a Cartesian Regular Grid.

Example

```
--
--        DEFINE GRID BLOCK Y DIRECTION CELL SIZE (BASED ON NX x NY x NZ = 300)
--
DY
          300*1000                                                          /
```

The above example defines the size of the cells in the Y direction based on 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.47 DYV - DEFINE THE SIZE OF GRID BLOCKS IN THE Y DIRECTION VIA A VECTOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DYV defines the size of grid blocks in the Y direction via a vector as opposed to defining the Y direction cell size for each cell for a Cartesian Regular Grid.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DYV	DYV is a vector of real numbers describing the cell size for the grid blocks in the Y direction. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	None

Notes:

1) The number of entries should correspond to the NY parameter on the DIMENS keyword in the RUNSPEC section.

2) The keyword is terminated by "/".

Table 6.26: DYV Keyword Description

See also the DXV, DZV and TOPS keywords to fully define a Cartesian Regular Grid.

Example

```
--
--        DEFINE GRID BLOCK Y DIRECTION CELL SIZE (BASED ON NY = 5)
--
DYV
          5*100                                                    /
```

The above example defines the size of the cells in the Y direction based on NY equals 5 on the DIMENS keyword in the RUNSPEC section.

6.3.48 DZ - DEFINE THE SIZE OF GRID BLOCKS IN THE Z DIRECTION FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DZ defines the size of all grid blocks in the Z direction via an array for each cell in a Cartesian Regular Grid model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DZ	DZ is an array of real numbers describing the cell size in the Z direction for each cell in the model. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.27: DZ Keyword Description

See also the DX, DY and TOPS keywords to fully define a Cartesian Regular Grid.

Example

```
--
--        DEFINE GRID BLOCK Z DIRECTION CELL SIZE (BASED ON NX x NY x NZ = 300)
--
DZ
          100*20.0   100*30.0   100*50.0                                        /
```

The above example defines the size of the cells in the Z direction based on 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.49 DZMATRIX - Matrix Block Height for Gravity Drainage Model For All Cells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DZMATRIX keyword defines the matrix block height for the gravity drainage model by grid block for when the Dual Permeability or Dual Porosity models are activated by the DUALPERM and DUALPORO keywords and the Gravity Drainage option is invoked via the GRAVDR and GRAVDRM keywords. All keywords are in the RUNSPEC section.

The keyword is identical to the DZMTRXV keyword in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.50 DZMTRX - Matrix Block Height for Gravity Drainage Model for the Grid

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DZMTRX keyword defines a constant matrix block height for the gravity drainage model for the entire grid for when the Dual Permeability or Dual Porosity models are activated by the DUALPERM and DUALPORO keywords and the Gravity Drainage option is invoked via the GRAVDR and GRAVDRM keywords. All keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.51 DZMTRXV - Matrix Block Height for Gravity Drainage Model For All Cells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DZMATRIX keyword defines the matrix block height for the gravity drainage model by grid block for when the Dual Permeability or Dual Porosity models are activated by the DUALPERM and DUALPORO keywords and the Gravity Drainage option is invoked via the GRAVDR and GRAVDRM keywords. All keywords are in the RUNSPEC section.

The keyword is identical to the DZMATRIX keyword in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.52 DZNET – DEFINE GRID BLOCK NET THICKNESS FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DZNET defines the net thickness of all grid blocks in the Z direction via an array for each cell in a Cartesian Regular Grid model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DZNET	DZNET is an array of real numbers describing the net thickness in the Z direction for each cell in the model. Repeat counts may be used, for example 10*100.0. If the value for a grid block is not defined then the grid block size (DZ) is assigned to the missing values.			
		feet	m	cm	DZ

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.28: DZNET Keyword Description

See also the DX, DY, DZ, NTG and TOPS keywords to fully define a Cartesian Regular Grid.

Example

```
--
--        DEFINE GRID BLOCK Z DIRECTION NET THICKNESS(BASED ON NX x NY x NZ = 300)
--
DZNET
          100*15.0   100*25.0   00*45.0                                          /
```

The above example defines the net thickness of the cells in the Z direction based on 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.53 DZV - DEFINE THE SIZE OF GRID BLOCKS IN THE Z DIRECTION VIA A VECTOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DZV defines the size of grid blocks in the Z direction via a vector as opposed to defining the thickness property for each cell. The keyword is used for both Cartesian Regular Grids and Radial Grids.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DZV	DZV is a vector of real numbers describing the cell size for the grid blocks in the Z direction. Repeat counts may be used, for example 10*20.0.			
		feet	m	cm	None

Notes:

1) The number of entries should correspond to the NZ parameter on the DIMENS keyword in the RUNSPEC section..
2) he keyword is terminated by "/".

Table 6.29: DZV Keyword Description

See also the DXV, DXY and TOPS keywords for a Cartesian Regular Grid and DRV, DTHETAV and TOPS keywords to fully define a Radial Grid model.

Example

```
--
--        DEFINE GRID BLOCK SIZES IN THE Z DIRECTION (BASED ON NZ = 20)
--
DZV
          3.0   5.0   3.0   2.0   5.0  15*3.0                                  /
```

The above example defines the size of the cells in the Z direction based on NZ equals 20 on the DIMENS keyword in the RUNSPEC section.

6.3.54 ENDBOX – DEFINE THE END OF THE BOX DEFINED GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword marks the end of a previously defined BOX sub-grid as defined by a previously entered BOX keyword. The keyword resets the input grid to be the full grid as defined by the NX, NY, and NZ variables on the DIMENS keyword in the RUNSPEC section.

There is no data required for this keyword.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--
--        DEFINE GRID BLOCK PERMZ DATA FOR THE INPUT BOX
--
PERMZ
          6*0.01                                            /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a subset of the grid and sets the cells PERMZ values to 0.01 for that area. After which the ENDBOX keyword resets the input to be the full grid.

Note

It is good practice to always use the ENDBOX keyword to reset the input back to the full grid when all the modifications for a sub-grid have been completed.

6.3.55 ENDFIN – END THE DEFINITION OF A LOCAL GRID REFINEMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ENDFIN keyword defines the end of a Cartesian or radial local grid refinement ("LGR") definition and a LGR property definition data set. In the GRID section the CARFIN, RADFIN, and RADFIN4 keywords defines the start of an LGR description section, whereas the REFINE keyword in the EDIT, PROPS, REGIONS, SOLUTION and SCHEDULE section defines the start. The REFINE keyword can also be used in the GRID section provided the LGR has been previously specified by the CARFIN, RADFIN, or RADFIN4 keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

The example below is based on using the CARFIN keyword in the GRID section to define an LGR in the global grid, named LGR-OP01 with a maximum of one well allowed in the LGR.

```
--
--       CARFIN LGR GRID COMMANDS
--
--       LGR        ----- FINE GRID ------   -- CARFIN GRID --  MAX     HOST
--       NAME       I1  I2  J1  J2  K1  K2     NX    NY    NZ   WELLS   NAME
CARFIN
         LGR-OP01   24  24  87  87   1  50      3     3    50     1     GLOBAL /


ENDFIN
```

Here the one global cell in the areal plane (24, 87) is divided into three LGR cells in the x-direction and three cells in the y-direction. Since no other property data is given, then the LGR cells take their properties from the host grid, that is the global grid.

6.3.56 EQLZCORN - Modify the Depth of the Corner-Point Depth Array

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EQLZCORN keyword modifies the depth of a corner point of a grid block on the pillars defining the reservoir grid. The keyword can be only used be used with Irregular Corner-Point Grids.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.57 EQUALREG – SETS AN ARRAY TO A CONSTANT BY REGION NUMBER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EQUALREG keyword sets a specified array to a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the EQUALREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the EQUALREG keyword is being used.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	ARRAY	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	CONSTANT	An integer or real value to be assigned to the ARRAY in the same units as the ARRAY property for a given REGION	0
3	REGION NUMBER	REGION NUMBER is a positive integer representing the region for which the CONSTANT in (2) should be applied	None
4	REGION ARRAY	The REGION ARRAY to use for applying the CONSTANT in (2) based on the REGION NUMBER in (3). REGION ARRAY can have the following values: 1) F for the FLUXNUM array 2) M for the MULTNUM array 3) O for the OPERNUM array	M

Notes:

1) Where the REGION NUMBER should be less than or equal to the maximum number of regions as defined on the REGDIMS keyword for the FIPNUM and OPERNUM arrays or the GRIDOPTS keyword for the MULTNUM array in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.30: EQUALREG Keyword Description

The applicable arrays for each section are defined in Table 6.31 on the following page.

EQUALREG Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.31: EQUALREG Keyword Applicable Arrays by Section

Example

```
-- FIRST DEFINE MULTNUM ARRAYS FOR 10 X 10 X 20 MODEL
--
--      ARRAY     CONSTANT    ---------- BOX ---------
--                            I1  I2   J1  J2   K1  K2
EQUALS
        MULTNUM    1          1*  1*   1*  1*   1*  1*     / MULTNUM IN MODEL
        MULTNUM    2          1*  1*   1*  1*   6   6      / MULTNUM IN MODEL
        MULTNUM    3          1*  1*   1*  1*   10  10     / MULTNUM IN MODEL
/
--    NOW SET PORO AND PERMX BASED ON THE MULTNUM REGION NUMBER
--
--       SETS A CONSTANT TO AN ARRAY BASED ON A REGION NUMBER
--
--       ARRAY     CONSTANT  REGION   REGION ARRAY
--                 VALUE     NUMBER    M / F / O
EQUALREG
         PORO      0.200     1         M                  /
         PORO      0.150     2         M                  /
         PORO      0.120     3         M                  /
         PERMX    100.00     1         M                  /
         PERMX     75.00     2         M                  /
         PERMX     50.00     3         M                  /
/
```

The example first defines the MULTNUM array to 1 for all cells in the model, after which selected areas of model are assigned various MULTNUM integer values. The EQUALREG can then be invoked to set a constant values for the PORO and PERMX arrays for the various MULTNUM regions.

6.3.58 EQUALS – SETS A SPECIFIED ARRAY TO A CONSTANT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EQUALS keyword sets a specified array or part of an array to a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the EQUALS keyword is being used.

No.	Name	Description	Default
1	ARRAY	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	CONSTANT	An integer or real value that the ARRAY will be set to in the same units as the ARRAY property.	None
3	I1	A positive integer that defines the lower bound of the array in the I-direction to be modified must be greater than or equal to one and less than or equal to I2 and NX.	1
4	I2	A positive integer that defines the upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
5	J1	A positive integer that defines the lower bound of the array in the J-direction to be modified must be greater than or equal to one and less than or equal to J2 and NY.	1
6	J2	A positive integer that defines the upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
7	K1	A positive integer that defines the lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
8	K2	A positive integer that defines the upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.32: EQUALS Keyword Description

The applicable arrays for each section are defined in Table 6.33 on the following page.

EQUALS Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.33: EQUALS Keyword Applicable Arrays by Section

Note

Unlike the commercial simulator, using the EQUALS keyword to setup the structure of the grid using the DX, DY, DZ and TOPS keywords should be avoided as it may cause OPM Flow to prematurely fail during the initialization.

See the second example on the correct way to setup this type of grid.

Examples

The first example resets the PERMX, PERMY and PERMZ, arrays to 0.10, 0.10, and 0.01 for all cells in layer five, respectively.

```
--
--   ARRAY      CONSTANT       ---------- BOX ---------
-                              I1  I2   J1  J2   K1  K2
EQUALS
     PERMX      0.1000         1*  1*   1*  1*   5   5  / PERMX TO 0.10 IN LAYER 5
     PERMY      0.1000         1*  1*   1*  1*   5   5  / PERMY TO 0.10 IN LAYER 5
     PERMZ      0.0100         1*  1*   1*  1*   5   5  / PERMZ TO 0.01 IN LAYER 5
/
```

The second example illustrates how to correctly setup a Cartesian Regular Grid in OPM Flow, given the DIMENS keyword in the RUNSPEC section is set to:

```
--
--        MAX      MAX      MAX
--        NDIVIX   NDIVIY   NDIVIZ
DIMENS
          10        10       3                                                    /
```

and the following keywords in the GRID section:

```
--
--        ACTIVATE IRREGULAR CORNER-POINT GRID TRANSMISSIBILITIES
--
OLDTRAN
--
--        DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NX = 5)
--
DX
          300*1000                                                               /
--
--        DEFINE GRID BLOCK Y DIRECTION CELL SIZE (BASED ON NY = 5)
--
DY
          300*1000                                                               /
--
--        DEFINE GRID BLOCK SIZES IN THE Z DIRECTION
--
DZ
          100*20  100*30  100*50                                                 /
--
--        DEFINE GRID BLOCK TOPS FOR THE TOP LAYER
--
TOPS
          100*8325                                                               /
--
--        ARRAY    CONSTANT        ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          PERMX     500.000        1*  1*   1*  1*    1   1 / Layer #01 Properties
          PERMY     500.000                                  /
          PERMZ      20.000                                  /
          PORO        0.300                                  /
          NTG         1.000                                  /

          PERMX      50.000        1*  1*   1*  1*    2   2 / Layer #02 Properties
          PERMY      50.000                                  /
          PERMZ      50.000                                  /
          PORO        0.300                                  /
          NTG         1.000                                  /

          PERMX     200.000        1*  1*   1*  1*    3   3 / Layer #03 Properties
          PERMY     200.000                                  /
          PERMZ     200.000                                  /
          PORO        0.300                                  /
          NTG         1.000                                  /
/
```

Notice that the DX, DY, DZ and TOPS keywords are defined separately, that is they are not included in the EQUALS keyword.

6.3.59 EXTFIN - Define an External Unstructured Local Grid Refinement

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EXTFIN keyword defines an external Unstructured Local Grid Refinement ("LGR") in a cell or a group of cells in the global grid, and for when LGRs have been activated for the model using the LGR keyword in the RUNSPEC section. Note the global grid can be either structured, see the EXTREPL keyword in the GRID section for global structure grids, or unstructured, see the EXTHOST keyword in the GRID section for unstructured global grids.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.60 EXTHOST - Define Host Cells for External LGRs

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EXTHOST keyword defines the host global grid blocks for an external Local Grid Refinement ("LGR") for when LGRs have been activated for the model using the LGR keyword in the RUNSPEC section, and the global grid is an unstructured grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.61 EXTREPGL - DEFINE HOST CELLS FOR EXTERNAL UNSTRUCTURED LGRS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EXTREPGL keyword defines the host global grid blocks for an external Unstructured Local Grid Refinement ("LGR") for when LGRs have been activated for the model using the LGR keyword in the RUNSPEC section, and the global grid is a structured grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.62 FAULTS – DEFINE FAULTS IN THE GRID GEOMETRY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FAULTS keyword defines the faults in the grid geometry and the keyword is normally exported with the grid geometry COORD and ZCORN data sets from static earth modeling software. Note that the FAULT keyword is not required to describe the structural geometry as this is already accounted for in the COORD and ZCORN data sets, but instead lists the fault traces with respect to the grid. Once the fault traces have been defined with the FAULTS keyword then the fault transmissibilities can be modified by the MULTFLT keyword. Note that without the FAULTS keyword one would still get proper cross-fault transmissibilities but they would not be modifiable using MULTFLT keyword.

No.	Name	Description	Default
1	FLTNAME	FLTNAME is a character string enclosed in quotes with a maximum length of eight characters, that defines the name of the fault.	None
2	I1	The lower bound of the fault's I-direction range must be greater than or equal to one and less than or equal to I2 and NX.	None
3	I2	The upper bound of the fault's I-direction range must be greater than or equal to I1 and less than or equal to NX	None
4	J1	The lower bound of the fault's J-direction range must be greater than or equal to one and less than or equal to J2 and NY.	None
5	J2	The upper bound of the fault's J-direction range must be greater than or equal to J1 and less than or equal to NY.	None
6	K1	The lower bound of the fault's K-direction range must be greater than or equal to one and less than or equal to K2 and NZ.	None
7	K2	The upper bound of the fault's K-direction range must be greater than or equal to K1 and less than or equal to NZ.	None
8	FLTFACE	FLTFACE is a character string enclosed in quotes with a maximum length of two characters, that classifies the fault face. 1) If TRANMULT on the GRIDOPTS keyword in the RUNSPEC section is set to NO then FLTFACE can have values of X, Y, or Z. 2) Alternatively, if TRANMULT on the GRIDOPTS keyword in the RUNSPEC section is set to YES then FLTFACE can have values of X, Y, or Z for the positive direction, or X-, Y- or Z- for the negative direction transmissibilities.	None

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) The FAULTDIM keyword in the RUNSPEC defines the maximum number of records (or segments) that can be entered with the FAULTS keyword.
3) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.34: FAULTS Keyword Description

Example

The example below defines two fault traces, the first being the 'M_WEST' fault and the second the 'BC' fault trace.

```
--
--        DEFINE FAULTS IN THE GRID GEOMETRY
--
--        FAULT        ------------ FAULT TRACE -------------
--        NAME          I1   I2    J1   J2    K1   K2    FACE
FAULTS
          'M_WEST'       5    5     3    3    1    22    'X' /
          'M_WEST'       5    5     4    4    1    22    'X' /
          'M_WEST'       5    5     5    5    1    22    'X' /
          'M_WEST'       5    5     6    6    1    22    'X' /
          'M_WEST'       5    5     7    7    1    22    'X' /
          'M_WEST'       5    5     8    8    1    22    'X' /
          'M_WEST'       5    5     9    9    1    22    'X' /
          'M_WEST'       5    5    10   10    1    22    'X' /
          'M_WEST'       5    5    11   11    1    22    'X' /
.............................................

          'BC'          43   43     8    8    1    22   'Y'  /
          'BC'          42   42     9    9    1    22   'X'  /
          'BC'          44   44     8    8    1    22   'Y'  /
          'BC'          45   45     8    8    1    22   'Y'  /
          'BC'          46   46     8    8    1    22   'Y'  /
          'BC'          31   31     9    9    1    22   'Y'  /
          'BC'          30   30    10   10    1    22   'X'  /
          'BC'          32   32     9    9    1    22   'Y'  /
          'BC'          33   33     9    9    1    22   'Y'  /
          'BC'          34   34     9    9    1    22   'Y'  /
          'BC'          35   35     9    9    1    22   'Y'  /
          'BC'          36   36     9    9    1    22   'Y'  /
          'BC'          37   37     9    9    1    22   'Y'  /
          'BC'          38   38     9    9    1    22   'Y'  /
          'BC'          39   39     9    9    1    22   'Y'  /
          'BC'          40   40     9    9    1    22   'Y'  /
.............................................
/
```

6.3.63 FILEUNIT – ACTIVATE UNIT CONSISTENCY CHECKING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FILEUNIT keyword defines the units of the of the data set, and is used to verify that the units in the input deck and any associated include files are consistent grid data. The keyword does not provide for the conversion between different sets of units.

No.	Name	Description	Default
1	FILEUNIT	A character string that defines the units of the coordinates stated on the MAPAXES keyword, and should be set to: 1) FIELD for field units, 2) METRIC for metric units, or 3) LAB for laboratory units	None
Notes: 1) No unit conversion is performed. 2) The keyword is terminated by "/".			

Table 6.35: FILEUNIT Keyword Description

OPM Flow's behavior is controllable through the "UNIT_SYSTEM_MISMATCH" environment variable. The default behavior if the check fails (i.e., if one of the INCLUDE files has a unit system different from the main run specification) is to terminate the simulation with an error.

Example

```
--
--       ACTIVATE UNIT CONSISTENCY CHECKING
--
FILEUNIT
         FIELD                                                                  /
```

The above example defines the data set units to be FIELD units.

6.3.64 FLUXNUM – DEFINE THE FLUX REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FLUXNUM keyword defines the flux region numbers for each grid block, as such there must be one entry for each cell in the model. The array is used with the Flux Boundary option to define the various flux regions; however, the Flux Boundary option has not been implemented in OPM Flow. In addition, the array can be used with the EQUALREG, ADDREG, COPYREG, MULTIREG, MULTREGP and MULTREGT keywords in calculating various grid properties in the GRID section. This facility has been implemented in OPM Flow.

No.	Name	Description	Default
1	FLUXNUM	FLUXNUM defines an array of positive integers assigning a grid cell to a particular flux region. The maximum number of flux regions is set by the MXNFLX variable on the REGDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.36: FLUXNUM Keyword Description

Examples

The example below sets three FLUXNUM regions for a 4 x 5 x 2 model.

```
--
--        DEFINE FLUXNUM REGIONS FOR ALL CELLS
--
FLUXNUM
          2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--        ARRAY     CONSTANT        ---------- BOX ---------
--                                  I1  I2   J1  J2   K1  K2
EQUALS
          FLUXNUM    1              1*  1*   1*  1*   1*  1* / SET REGION 1
          FLUXNUM    2              1   2    1   2    1   1  / SET REGION 2
          FLUXNUM    3              1   2    1   2    2   2  / SET REGION 3
/
```

6.3.65 FLUXREG – Define Active Flux Regions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FLUXREG is used in conjunction with the USEFLUX keyword in runs with have multiple flux regions, to reduce the number of flux regions, that is the keyword specifies which flux regions are active and which are not in the current run.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.66 FLUXTYPE – Defines the Flux Boundary Type

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FLUXTYPE keyword defines the type of flux boundary to be used in the run.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

6.3.67 GDFILE – LOAD A GRID FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GDFILE keyword loads a GRID file that contains the structural data for the grid as a set of topological cuboidal cells, and EGRID files that contain structural and property data. Note OPM Flow only supports reading in EGRID files at this time.

No.	Name	Description	Default
1	GRIDFILE	A character string enclosed in quotes that defines the GRID or EGRID file to be read in and be processed by OPM Flow. Again, OPM Flow only supports reading in EGRID files.	None
2	FMTOPT	A defined character string that defines the format of the GRID or EGRID file to be read and should be set to one of the following: 1) FORMATTED: If the file is formatted as ASCII i.e. a text file, as oppose to a binary file. The option can be abbreviated to just the letter F. 2) UNFORMATTED: If the file is in binary format, note this option can be abbreviated to just the letter U. This type of file is operating system dependent, that is a Microsoft Windows generated binary file cannot be read in by a Linux based system unlike formatted files. If the variable FMTOPT is omitted then the default is for binary file input.	U
Notes: 1) The keyword is terminated by "/".			

Table 6.37: GDFILE Keyword Description

See also the GRIDFILE keyword in the GRID section for exporting the GRID and EGRID files from the current simulation run.

Examples

The first example shown below loads the NOR-OPM-A00-GRID.EGRID file in binary format from the same directory as the data file.

```
--
--        LOAD A GRID FILE
--
GDFILE
          'NOR-OPM-A00-GRID.EGRID'      /
```

The next example loads the same EGRID file one directory above from where the data file is located.

```
--
--        LOAD a GRID FILE
--
GDFILE
          '../NOR-OPM-A00-GRID.EGRID'   /
```

6.3.68 GDORIENT - Define Grid Orientation Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the grid orientation parameters for post-processing applications.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.69 GETDATA – Load and Assign Data Array from INIT or RESTART Files

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GETDATA keyword loads a data array from a previously generated INIT or RESTART file and assigns the loaded array to either same array in the run or another property array.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.70 GRID - Define the Start of the GRID Section of Keywords

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRID activation keyword marks the end of the RUNSPEC section and the start of the GRID section that defines the key grid property data for the simulator including the grid structure, porosity, permeability and other relevant grid property data.

There is no data required for this keyword.

Example

```
-- ==============================================================================
--
-- GRID SECTION
--
-- ==============================================================================
GRID
```

The above example marks the end of the RUNSPEC section and the start of the GRID section in the OPM Flow data input file.

6.3.71 GRIDFILE – SET THE GRID FILE OUTPUT OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword controls the output of a standard GRID or extended GRID file, as well as the extensible EGRID file for post-processing applications. The extended and extensible GRID formats are comparable; however, the extensible GRID format is more compact and is the only format supported by OPM Flow.

No.	Name	Description	Default
1	NGRID	A positive integer that controls the output of the of the GRID geometry file: 0) - for no GRID file to be written out. 1) - for the standard GRID file to be written out. 2) - for the extended GRID file to be written out. Only the default value of zero is supported.	0
2	NEGRID	A positive integer that controls the output of the of the EGRID geometry file: 0) - for no extensible GRID file to be written out. 1) - for the extensible GRID file to be written out. Only the default value of one is supported.	1
Notes: 1) The keyword is terminated by "/".			

Table 6.38: GRIDFILE Keyword Description

Example

```
--
--        GRID FILE OUTPUT OPTIONS
--        GRID    EGRID
--        OPTN    OPTN
GRIDFILE
          0       1                                                    /
```

The above example defines that no GRID file will be written out and that the extensible GRID (that is the EGRID geometry format) file will be produced. This is the only configuration that OPM Flow supports

6.3.72 GRIDUNIT – DEFINE THE GRID UNITS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRIDUNIT keyword defines the units of the grid data. It is usually output by pre-processing software when exporting the grid geometry. The data is not used by OPM Flow intrinsically, but is merely written to the output EGRID file, as specified by the GRIDFILE keyword, for the use of post-processing software like OPM ResInsight.

No.	Name	Description	Default
1	GRIDUNIT	A character string that defines the units of the coordinates stated on the MAPAXES keyword, and should be set to: 1) FIELD for field units, 2) METRES for metric units, or 3) LAB for laboratory units	METRES
2	MAPOPT	A character string that defines if the grid data are measured relative to the map, or relative to the origin as stated on the MAPAXES keyword. MAPOPT should either be left blank (the default) indicating the origin is relative to the origin on the MAPAXES keyword, or set equal to MAP measured relative to the map.	1*
Notes: 1) Note the alternative spelling METRES, that is METERS is not recognized. 2) The keyword is terminated by "/".			

Table 6.39: GRIDUNIT Keyword Description

Example

```
--
--        SET THE GRID UNITS FOR THE GRID
--
GRIDUNIT
         METRES                                                    /
```

The above example defines that the GRID units to be metric.

6.3.73 HALFTRAN – Activate Half Block Transmissibility Calculations

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HALFTRAN keyword activates the half block transmissibility calculation option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.74 HEATCR – DEFINE RESERVOIR ROCK HEAT CAPACITY FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HEATCR keyword defines the reservoir rock volumetric heat capacity for all cells for when OPM Flow's thermal calculation is activated by the THERMAL keywords in the RUNSPEC section.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	HEATCR	HEATCR is an array of real positive numbers that define reservoir rock volumetric heat capacity of a grid block. Repeat counts may be used, for example 3000*25.0			
		Btu/ft^3/°R	kJ/m^3/K	J/cm^3/K	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.40: HEATCR Keyword Description

Note this keyword is incompatible with SPECROCK keyword in the PROPS section.

Example

```
--
--        DEFINE GRID BLOCK RESERVOIR ROCK HEAT CAPACITY
--        FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--        KEYWORD IS INCOMPATIBLE WITH THE SPECROCK KEYWORD
--        (OPM FLOW THERMAL OPTION ONLY)
--
HEATCR
          300*32.0                                                    /
```

The above example defines the reservoir rock volumetric heat capacity of 32.0 for each cell in the 300 grid block model.

6.3.75 HEATCRT – DEFINE RESERVOIR ROCK HEAT CAPACITY TEMPERATURE DEPENDENCE FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HEATCRT keyword defines the reservoir rock volumetric heat capacity temperature dependence for all cells for when OPM Flow's thermal calculation is activated by the THERMAL keywords in the RUNSPEC section.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	HEATCRT	HEATCRT is an array of real positive numbers that define reservoir rock volumetric heat capacity temperature dependence of a grid block. Repeat counts may be used, for example 3000*0.05			
		Btu/ft^3/°R^2	kJ/m^3/K^2	J/cm^3/K^2	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.41: HEATCRT Keyword Description

Note this keyword is incompatible with SPECROCK keyword in the PROPS section.

The data for this keyword and the HEATCR keyword are use to calculate the reservoir rock volumetric heat capacity temperature dependence using the following relationship:

$$\text{Heat Capacity of Rock} = \text{HEATCR}\left(Temp - Temp_{ref}\right) + \frac{\text{HEATCRT}\left(Temp - Temp_{ref}\right)^2}{2} \quad \textbf{(6.3)}$$

Example

```
--
--        DEFINE RESERVOIR ROCK HEAT CAPACITY TEMPERATURE DEPENDENCE
--        FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--        KEYWORD IS INCOMPATIBLE WITH THE SPECROCK KEYWORD
--        (OPM FLOW THERMAL OPTION ONLY)
--
HEATCRT
          300*0.05                                                    /
```

The above example defines the reservoir rock volumetric heat capacity temperature dependence of 0.05 for each cell in the 300 grid block model.

6.3.76 HMFAULTS – History Match Fault Gradient Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMFAULTS keyword defines the history match faults gradient parameters for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section, and for when the FAULTS keyword in the GRID section has been used to define faults in the model.

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of faults that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.77 HMAQUNUM - History Match Numerical Aquifer Gradient Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMAQUNUM keyword defines the history match numerical aquifer gradient parameters for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section, and numerical aquifers have been specified in the model via the AQUNUM keyword and connected to the grid using AQUCON keyword. All keywords are in the GRID section.

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of aquifers that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.78 HMMLAQUN – History Match Numerical Aquifer Gradient Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMMLAQUN keyword defines the history match numerical aquifer gradient multipliers for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section, and numerical aquifers have been specified in the model via the AQUNUM keyword and connected to the grid using the AQUCON keyword. All keywords are in the GRID section.

Multipliers can be declared for numerical aquifers' pore volume, permeability, and aquifer to grid connection factors.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.79 HMMLT – HISTORY MATCH GRID PERMEABILITY GRADIENT CUMULATIVE MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMMLT series of keywords defines the history match gradient cumulative permeability multipliers, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The keyword consists of the first five characters of "HMMLT" followed by a two or three character string shown in Table 6.42, that determines the permeability direction, for example, HMMLTPX.

This keyword is ignored by OPM Flow and has no effect on the simulation.

Mnemonic	Cartesian Grid		Radial Grid	
	Grid Keyword	HMMULT Keyword	Grid Keyword	HMMULT Keyword
PX/PR	PERMX	HMMLTPX	PERMR	HMMLTPR
PXY	PERMXY	HMMLTPXY		
PY/THT	PERMY	HMMLTPY	PERMTHT	HMMLTTH
PZ	PERMZ	HMMLTPZ	PERMZ	HMMLTPZ

Table 6.42: HMMLT Keyword List

See also the HMMULT keyword in the EDIT section

6.3.80 HMMMREGT - History Match Region Transmissibility Gradient Cumulative Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMMMREGT keyword multiplies the transmissibility between two regions by a constant, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The constant should be a real number. Unlike the MULTREGT keyword in the GRID section, the HMMMREGT keyword modifications are cumulative.

Note that the HMMMREGT keyword only declares the two regions and the multiplier between those regions, the transmissibility direction (DIR on the MULTREGT keyword), type of transmissibility multiplier (TYPE on the MULTREGT keyword), and the region number array to use (ARRAY on the MULTREGT keyword), are all taken from the MULTREGY keyword. For example, the region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGT keyword is read by the simulator, and before the HMMMREGT keyword is used.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.81 HMMULRGT – HISTORY MATCH REGION TRANSMISSIBILITY PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HMMULRGT defines the transmissibility between two regions gradient parameters, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of gradient regions that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.82 HMMULTFT – History Match Fault Transmissibility Gradient Cumulative Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HMMULTFT defines the history match fault transmissibility gradient cumulative multipliers to be applied to the fault transmissibilities for faults declared by the FAULT keyword in the GRID section, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The keyword allows for the re-scaling of the existing fault transmissibilities calculated by OPM Flow, or if the MULTFLT keyword has been entered, then HMMULTFT is applied to the existing MULTFLT multipliers.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.83 HMMULTSG – History Match Dual porosity Sigma Gradient Cumulative Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HMMULTSG defines the history match dual porosity sigma parameter gradient cumulative multipliers applied to the dual porosity sigma value declared by the SIGMAV and SIGMAGDV keywords in the PROPS section, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. In addition to the HMDIMS keyword, either the DUALPERM keyword that activates the Dual Permeability option, or the DUALPORO keyword that activates the Dual Porosity option for the run, must be declared in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.84 HRFIN - DEFINE THE RATIO OF LGR GRID BLOCKS IN THE R-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HRFIN[42] defines the ratio of grid blocks for the DRV keyword in the r-direction via a vector within a Local Grid Refinement ("LGR") as opposed to defining the size for each cell for a Radial LGR Grid. The LGR keyword in the RUNSPEC section should be activated to indicate an LGR is being used, and the keyword HRFIN should be placed in between the RADIN (or RAFDIN4) and ENDFIN keywords in the GRID section. The DRV keyword in the GRID section defines the radial grid size in terms of the length, that is feet for field units, this keyword defines the length as the ratio of the previous cell size, staring with the inner radius (INRAD).

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	HRFIN	HRFIN is a vector of real numbers describing the ratio of cell size for the grid blocks in the r-direction in a radial LGR for the DRV keyword. Repeat counts may be used, for example 2*1.5.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NR parameter minus one on the RADFIN or RADFIN4 keywords in the GRID section
2) The keyword is terminated by "/".

Table 6.43: HRFIN Keyword Description

See also the DR, DRV, DTHETAV, and DZ keywords in the GRID section to fully define a radial LGR model.

Example

```
--
--        INNER RADIUS OF FIRST GRID BLOCK IN THE RADIAL DIRECTION
--
INRAD     0.25                                                          /
--
--        DEFINE GRID BLOCK DRV RATIOS IN THE R DIRECTION
--
HRFIN
          1.50  2.00  3.00  5.00  7.00  10.00                           /
```

The above example defines the size of the cells in the R direction based on NR equals 7, resulting in NR-1 values on the RADFIN keyword in the GRID section. Note the INRAD keyword to define the inner radius of the radial grid.

[42] *Radial grids are not currently implemented in this version of OPM Flow, but is expected to be incorporated in a future release.*

6.3.85 HXFIN - DEFINE THE RATIO OF LGR GRID BLOCKS IN THE X-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HXFIN defines the split ratio of grid blocks for the DXV keyword in the x-direction via a vector within a Local Grid Refinement ("LGR") as opposed to defining the size for each cell for a Cartesian LGR Grid. The LGR keyword in the RUNSPEC section should be activated to indicate an LGR is being used, and the keyword HXFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section. The DXV keyword in the GRID section defines the grid size in terms of the length, that is feet for field units, this keyword defines the length as the ratio of the coarse cells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	HXFIN	HXFIN is a vector of real numbers describing the ratio of cell size for the grid blocks in the x-direction in a Cartesian LGR grid. Repeat counts may be used, for example 2*2.0.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX parameter on the CARFIN keyword in the GRID section.
2) The keyword is terminated by "/".

Table 6.44: HXFIN Keyword Description

See also the CARFIN, ENDFIN, HYFIN, and HZFIN keywords in the GRID section to fully define a Cartesian LGR grid model.

Example

```
--
--        CARFIN LGR GRID COMMANDS
--
--        LGR         ----- HOST GRID ------    -- CARFIN GRID --   MAX      HOST
--        NAME        I1   I2   J1   J2   K1   K2      NX     NY     NZ    WELLS    NAME
CARFIN
          LGR-OP01    24   25   86   87    1   50       5      3     50      1      GLOBAL /
--
--        DEFINE LGR GRID BLOCK IN THE X-DIRECTION
NXFIN
          3   2                                                                    /
--
--        DEFINE GRID BLOCK LGR RATIOS IN THE X-DIRECTION
--
HXFIN
          1.00   2.00   3.00   2.00   1.00                                         /
ENDFIN
```

The above example defines the size of the cells in the x-direction based on NX equals five on the CARFIN keyword in the GRID section.

6.3.86 HYFIN - DEFINE THE RATIO OF LGR GRID BLOCKS IN THE Y-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HYFIN defines the split ratio of grid blocks for the DYV keyword in the y-direction via a vector within a Local Grid Refinement ("LGR") as opposed to defining the size for each cell for a Cartesian LGR Grid. The LGR keyword in the RUNSPEC section should be activated to indicate an LGR is being used, and the keyword HYFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section. The DYV keyword in the GRID section defines the grid size in terms of the length, that is feet for field units, this keyword defines the length as the ratio of the coarse cells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	HYFIN	HYFIN is a vector of real numbers describing the ratio of cell size for the grid blocks in the y-direction in a Cartesian LGR grid. Repeat counts may be used, for example 2*2.0.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NY parameter on the CARFIN keyword in the GRID section.
2) The keyword is terminated by "/".

Table 6.45: HYFIN Keyword Description

See also the CARFIN, ENDFIN, HXFIN, and HZFIN keywords in the GRID section to fully define a Cartesian LGR grid model.

Example

```
--
--        CARFIN LGR GRID COMMANDS
--
--        LGR         ----- HOST GRID ------    -- CARFIN GRID --   MAX     HOST
--        NAME        I1   I2   J1   J2   K1   K2      NX     NY     NZ    WELLS   NAME
CARFIN
          LGR-OP01    24   25   86   87    1   50       3      5     50      1     GLOBAL /
--
--        DEFINE LGR GRID BLOCK IN THE Y-DIRECTION
NYFIN
          3   2                                                                   /
--
--        DEFINE GRID BLOCK LGR RATIOS IN THE Y-DIRECTION
--
HYFIN
          1.00   2.00   3.00   2.00   1.00                                        /
ENDFIN
```

The above example defines the size of the cells in the y-direction based on NY equals five on the CARFIN keyword in the GRID section.

6.3.87 HZFIN - DEFINE THE RATIO OF LGR GRID BLOCKS IN THE Z-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HZFIN defines the split ratio of grid blocks for the DZV keyword in the z-direction via a vector within a Local Grid Refinement ("LGR") as opposed to defining the size for each cell for a Cartesian LGR Grid. The LGR keyword in the RUNSPEC section should be activated to indicate an LGR is being used, and the keyword HYFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section. The DZV keyword in the GRID section defines the grid size in terms of the length, that is feet for field units, this keyword defines the length as the ratio of the coarse cells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	HYZIN	HZFIN is a vector of real numbers describing the ratio of cell size for the grid blocks in the z-direction in a Cartesian LGR grid. Repeat counts may be used, for example 2*2.0.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NZ parameter on the CARFIN keyword in the GRID section.
2) The keyword is terminated by "/".

Table 6.46: HZFIN Keyword Description

See also the CARFIN, ENDFIN, HXFIN, and HYFIN keywords in the GRID section to fully define a Cartesian LGR grid model.

Example

```
--
--        CARFIN LGR GRID COMMANDS
--
--        LGR         ----- HOST GRID ------    -- CARFIN GRID --   MAX     HOST
--        NAME        I1   I2   J1   J2   K1   K2      NX     NY     NZ    WELLS   NAME
CARFIN
          LGR-OP01    24   25   86   87    1   50       5      3    100     1     GLOBAL /
--
--        DEFINE LGR GRID BLOCK IN THE Z-DIRECTION
NZFIN
          50*2                                                                    /
--
--        DEFINE GRID BLOCK LGR RATIOS IN THE Z-DIRECTION
--
HZFIN
          50*2.0                                                                  /
ENDFIN
```

The above example defines the size of the cells in the z-direction based on NZ equals 100 on the CARFIN keyword in the GRID section.

6.3.88 IHOST – Assign LGRs to Parallel Process Number

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IHIST keyword assigns Local Grid Refinements ("LGR") to a parallel process number, for when the PARALLEL keyword has been invoked in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.89 IMPORT – IMPORT GRID FILE DATA AT THE CURRENT POSITION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IMPORT keyword informs the simulator to continue reading input data from the specified IMPORT file. When the end of the IMPORT file is reached, input data is read from the next keyword in the current file. Normally IMPORT files are generated by grid pre-processoring software and the keyword allows for both formatted and unformatted (binary) files to be loaded.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.90 INIT – ACTIVATE THE INIT FILE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the writing of the INIT file that contains the static data specified in the GRID, PROPS and REGIONS sections. For example, the PORO, PERM and NTG arrays from the GRID section. The data is used in post-processing software, for example OPM ResInsight, to visualize the static grid properties.

The INIT file can either be written out in formatted form as ASCII i.e. text files, if the FMTOUT keyword has been activated, or binary format if the FMTOUT keyword has not been activated. Normally, this option is always activated by the user and when activated the binary form of the file is used.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       ACTIVATE WRITING THE INIT FILE FOR POST-PROCESSING
INIT
```

The above example switches on the writing of the INIT file for post-processing in ResInsight.

6.3.91 INRAD – DEFINE THE INNER RADIUS OF A RADIAL GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

INRAD[43] defines the inner radius of the reservoir model for a radial grid geometry. The RADIAL keyword in the RUNSPEC should be activated to indicate that radial geometry is being used.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	INRAD	A single real positive number defining the inner radius of a radial grid.			
		feet	m	cm	None

Notes:

1) The keyword is terminated by "/".

Table 6.47: INRAD Keyword Description

See also the DR, DRV, DTHETA, DTHETAV and TOPS keywords to fully define a Radial Grid.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        INNER RADIUS OF FIRST GRID BLOCK IN THE RADIAL DIRECTION
--
INRAD
          0.25                                                                  /
```

The above example defines the inner radius of a radial grid to be 0.25 feet.

[43] *Radial grids are not currently implemented in this version of OPM Flow, but is expected to be incorporated in a future release.*

6.3.92 IONROCK – DEFINE THE ION EXCHANGE CAPACITY FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IONROCK keyword defines the ion exchange capacity for all the cells in the model, for when the brine phase has been activated by the BRINE keyword and the Multi-Component Brine model, that allows for the water phase to have multiple water salinities, has been activated by the ECLMC keyword. Both keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.93 ISOLNUM – DEFINE THE INDEPENDENT RESERVOIR REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ISOLNUM keyword defines areas of the grid that consists of isolated reservoirs where the only form of communication between the reservoirs is via wellbore connections This enables the reservoir flow equations to be solved independently for greater computational efficiency.

No.	Name	Description	Default
1	ISOLNUM	ISOLNUM defines an array of positive integers assigning a grid cell to a particular isolated reservoir region. The maximum number of ISOLNUM regions is set by the NRFREG variable on the REGDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) Setting ISOLNUM for a cell to zero makes the cell inactive.
3) The keyword is terminated by "/".

Table 6.48: ISOLNUM Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

The example below defines three separate independent reservoirs; the first reservoir covers the whole grid and layers 1 to 50, reservoir two cover the whole grid and layers 52 to 150, and finally the third reservoir again covers the whole grid but with layers 152 to 300. The layers 51 and 151 are shale layers made inactive by setting ISOLNUM to zero.

```
--
--        ARRAY      CONSTANT        ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          ISOLNUM     1              1*  1*   1*  1*   1   50 / DEFINED RESERVOIR 1
          ISOLNUM     0              1*  1*   1*  1*   51  51 / DEFINED A SHALE
          ISOLNUM     2              1*  1*   1*  1*   52 150 / DEFINED RESERVOIR 2
          ISOLNUM     0              1*  1*   1*  1*  151 151 / DEFINED A SHALE
          ISOLNUM     3              1*  1*   1*  1*  152 300 / DEFINED RESERVOIR 3
/
```

Note the above example has no effect as the keyword is ignored by the simulator.

6.3.94 JFUNC - ACTIVATE THE LEVERETT J-FUNCTION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

JFUNC keyword activates Leverett-J-Function[44] option which is a commonly used technique to normalize capillary pressure base on laboratory measured core plugs porosity and permeability values and the resulting capillary pressure data. The keyword performs the calculation based on the parameters on the this keyword combined with a cells porosity and permeability to perform the scaling globally.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	JFOPT	A character string that defines which capillary data sets the J-Function option should be applied to, based on the following options: 1) WATER: apply the J-Function option to the water-oil capillary pressure data only. 2) GAS: apply the J-Function option to the gas-oil capillary pressure data only. 3) BOTH: apply the J-Function option to the water-oil and the gas-oil capillary pressure data.			BOTH
2	OWSTEN	A positive real number that defines oil-water surface tension used to de-normalized J-Function data entered in the PROPS section.			
		dynes/cm	dynes/cm	dynes/cm	None
3	OGSTEN	A positive real number that defines oil-gas surface tension used to de-normalized J-Function data entered in the PROPS section.			
		dynes/cm	dynes/cm	dynes/cm	None
4	ALPHA	A positive real value that defines an alternative power value for the porosity term in the J-Function equation, that is instead of $\sqrt{\frac{k}{\varphi}}$ use $\frac{k^{0.5}}{\varphi^{\alpha}}$ instead in the transformation.			0.5
5	BETA	A positive real number that defines an alternative power value for the permeability term in the J-Function equation, that is instead of $\sqrt{\frac{k}{\varphi}}$ use $\frac{k^{\beta}}{\varphi^{0.5}}$ instead in the transformation.			0.5

[44] *Leverett, M. C.; "Capillary Behaviour in Porous Solids", Trans. AIME (1941) 142, 152-168.*

No.	Name	Description			Default
		Field	Metric	Laboratory	
6	PERM	PERM is a character string that sets the permeability array to be used in the transform, based on the following options: 1) X: use the PERMX array. 2) XY: use the average of the PERMX and PERMY arrays. 3) Y: use the PERMY array. 4) Z: use the PERMZ array. 5) U: use the PERMJFUN array			XY
Notes: 1) The keyword is terminated by "/".					

Table 6.49: JFUNC Keyword Description

Just like the relative permeability data capillary pressure data are measured on core plugs with varying quality and perhaps from different reservoirs. It is therefore necessary to determine averaged data, before employing the data in engineering calculations. This is commonly done by using the Leverett J-function[45], which is defined as:

$$J\left(S_w\right) = \frac{P_{c,res}\left(S_w\right)\sqrt{\frac{k}{\varphi}}}{\sigma} \tag{6.4}$$

Where:

$J(S_w)$	=	dimensionless function of water saturation
$P_c(S_w)$	=	capillary pressure (kPa)
k	=	permeability, (m^2)
φ	=	porosity (fraction)
σ	=	interfacial tension (mN/m)
Θ	=	contact angle

Sometimes the equation is stated with the cos θ term included, that is:

$$J\left(S_w\right) = \frac{P_{c,res}\left(S_w\right)\sqrt{\frac{k}{\varphi}}}{\sigma\cos\Theta} \tag{6.5}$$

Since the above function is just a normalizing function, then units are not important, as long as when we de-normalize the *average* curve we use the same unit set. Secondly, if all the capillary pressure data has been converted to reservoir conditions, we actually ignore the denominator as it is a constant, and we can therefore just use:

$$J\left(S_w\right) = P_{c,res}\left(S_w\right)\sqrt{\frac{k}{\varphi}} \tag{6.6}$$

However, in the simulator it is necessary to use the formal definition as outlined in equation (6.4). In addition to the standard the equation the keyword allows for de-normalizing the curve to use alternative power functions instead of the standard 0.5 used in equation (6.4), that is:

[45] *Leverett, M. C.; "Capillary Behaviour in Porous Solids", Trans. AIME (1941) 142, 152-168.*

$$J\left(S_w\right) = \frac{P_{c,res}\left(S_w\right)\left(\frac{k^{\beta}}{\varphi^{\alpha}}\right)}{\sigma} \tag{6.7}$$

Where:

$J(S_w)$	=	dimensionless function of water saturation
$P_c(S_w)$	=	capillary pressure (kPa)
k	=	permeability, (m^2)
φ	=	porosity (fraction)
σ	=	interfacial tension (mN/m)
Θ	=	contact angle
α	=	porosity power value
β	=	permeability value

The JFUNC keyword allows the data entered as capillary pressure in the saturation tables, for example, by using the SGFN and SWFN keywords in the PROPS section to be treated as J-functions instead, and to de-normalize these curves for each active cell in the model using the options and values defined with the JFUNC keyword combined with a cells porosity and permeability values.

Note

If either the JFUNC or JFUNCR keywords are used to activate J-Function scaling then the capillary pressure data entered on the SWFN, SGFN or the SWOF, SGOF, SLGOF keywords, should be replaced by dimensionless J-function values.

See also the JFUNCR keyword in the GRID section that performs similar calculations based on the saturation tables.

Example

```
--
--        DEFINE LEVERETT J-FUNCTION PARAMETERS
--        JFUN    OILWAT  GASOIL  PORO    PERM    PERM
--        OPTN    SDENS   SDEN    ALPHA   BETA    OPTN
JFUNC
          WATER   22.5    1*      0.5     0.5     XY                      /
```

The above example results in the oil-water capillary pressure data entered on the SWFN keyword in the PROPS section being treated as J-Functions, and that the J-Function should be de-normalized using an oil-water surface density of 22.5 dynes/cm, using the default power values and the average of the PERMX and PERMY values for each grid block.

6.3.95 JFUNCR - ACTIVATE THE LEVERETT J-FUNCTION SATURATION TABLE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

JFUNCR keyword activates Leverett-J-Function[46] Saturation Table option which is a commonly used technique to normalize capillary pressure base on laboratory measured core plugs porosity and permeability values and the resulting capillary pressure data. This keyword is an extension of the JFUNC keyword in the GRID section that uses the parameters on the JFUNC keyword combined with a cells porosity and permeability to perform the scaling globally. In comparison, the JFUNCR allows for the J-Function parameters to be declared per saturation table number, resulting in greater flexibility.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness. See the JFUNC keyword in the GRID section to activate J-Function scaling based on global parameters.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	JFOPT	A character string that defines which capillary data sets the J-Function option should be applied to, based on the following options: 1) WATER: apply the J-Function option to the water-oil capillary pressure data only. 2) GAS: apply the J-Function option to the gas-oil capillary pressure data only. 3) BOTH: apply the J-Function option to the water-oil and the gas-oil capillary pressure data.			BOTH
2	OWSTEN	A positive real number that defines oil-water surface tension used to de-normalized J-Function data entered in the PROPS section.			
		dynes/cm	dynes/cm	dynes/cm	None
3	OGSTEN	A positive real number that defines oil-gas surface tension used to de-normalized J-Function data entered in the PROPS section.			
		dynes/cm	dynes/cm	dynes/cm	None
4	ALPHA	A positive real value that defines an alternative power value for the porosity term in the J-Function equation, that is instead of $\sqrt{\frac{k}{\varphi}}$ use $\frac{k^{0.5}}{\varphi^{\alpha}}$ instead in the transformation.			0.5
5	BETA	A positive real number that defines an alternative power value for the permeability term in the J-Function equation, that is instead of $\sqrt{\frac{k}{\varphi}}$ use $\frac{k^{\beta}}{\varphi^{0.5}}$ instead in the transformation.			0.5

[46] *Leverett, M. C.; "Capillary Behaviour in Porous Solids", Trans. AIME (1941) 142, 152-168.*

No.	Name	Description			Default
		Field	Metric	Laboratory	
6	PERM	PERM is a character string that sets the permeability array to be used in the transform, based on the following options: 1) X: use the PERMX array. 2) XY: use the average of the PERMX and PERMY arrays. 3) Y: use the PERMY array. 4) Z: use the PERMZ array. 5) U: use the PERMJFUN array			XY

Notes:

1) The keyword is followed by exactly NTSFUN rows of data, as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each row is terminated by "/" and there is no "/" terminator for the keyword.

Table 6.50: JFUNCR Keyword Description

Just like the relative permeability data capillary pressure data are measured on core plugs with varying quality and perhaps from different reservoirs. It is therefore necessary to determine averaged data, before employing the data in engineering calculations. This is commonly done by using the Leverett J-function[47], which is defined as:

$$J\left(S_w\right) = \frac{P_{c,res}\left(S_w\right)\sqrt{\frac{k}{\varphi}}}{\sigma} \tag{6.8}$$

Where:

$J(S_w)$	=	dimensionless function of water saturation
$P_c(S_w)$	=	capillary pressure (kPa)
k	=	permeability, (m^2)
φ	=	porosity (fraction)
σ	=	interfacial tension (mN/m)
Θ	=	contact angle

Sometimes the equation is stated with the cos θ term included, that is:

$$J\left(S_w\right) = \frac{P_{c,res}\left(S_w\right)\sqrt{\frac{k}{\varphi}}}{\sigma\cos\Theta} \tag{6.9}$$

Since the above function is just a normalizing function, then units are not important, as long as when we de-normalize the *average* curve we use the same unit set. Secondly, if all the capillary pressure data has been converted to reservoir conditions, we actually ignore the denominator as it is a constant, and we can therefore just use:

$$J\left(S_w\right) = P_{c,res}\left(S_w\right)\sqrt{\frac{k}{\varphi}} \tag{6.10}$$

[47] *Leverett, M. C.; "Capillary Behaviour in Porous Solids", Trans. AIME (1941) 142, 152-168.*

However, in the simulator it is necessary to use the formal definition as outlined in equation (6.8). In addition to the standard the equation the keyword allows for de-normalizing the curve to use alternative power functions instead of the standard 0.5 used in equation (6.8), that is:

$$J\left(S_w\right) = \frac{P_{c,res}\left(S_w\right)\left(\frac{k^{\beta}}{\varphi^{\alpha}}\right)}{\sigma} \tag{6.11}$$

Where:

$J(S_w)$	=	dimensionless function of water saturation
$P_c(S_w)$	=	capillary pressure (kPa)
k	=	permeability, (m^2)
φ	=	porosity (fraction)
σ	=	interfacial tension (mN/m)
Θ	=	contact angle
α	=	porosity power value
β	=	permeability value

The JFUNC keyword allows the data entered as capillary pressure in the saturation tables, for example, by using the SGFN and SWFN keywords in the PROPS section to be treated as J-functions instead, and to de-normalize these curves for each active cell in the model using the options and values defined with the JFUNC keyword combined with a cells porosity and permeability values.

Note

If either the JFUNC or JFUNCR keywords are used to activate J-Function scaling then the capillary pressure data entered on the SWFN, SGFN or the SWOF, SGOF, SLGOF keywords, should be replaced by dimensionless J-function values.

Example

The example below assumes NTSFUN is equal to five on the TABDIMS keyword in the RUNSPEC section.

```
--
--        DEFINE LEVERETT J-FUNCTION PARAMETERS BY SATURATION TABLES
--        JFUN    OILWAT  GASOIL  PORO    PERM    PERM
--        OPTN    SDENS   SDEN    ALPHA   BETA    OPTN
JFUNCR
          WATER   22.5    1*      0.5     0.5     XY                          /
          WATER   22.5    1*      0.5     0.5     XY                          /
          WATER   22.5    1*      0.5     0.5     XY                          /
          WATER   22.5    1*      0.5     0.5     XY                          /
          WATER   22.5    1*      0.5     0.5     XY                          /
```

Here the oil-water capillary pressure data entered on the SWFN keyword in the PROPS section are treated as J-Functions, and that the J-Function should be de-normalized using an oil-water surface density of 22.5 dynes/cm, using the default power values and the average of the PERMX and PERMY values for each grid block, for all five tables. Note that since all the JFUNCR parameters are the same for all saturation tables then the JFUNC keyword could be used instead in this instance.

6.3.96 LGRCOPY – ACTIVATE LOCAL GRID REFINEMENT INHERITANCE

The LGRCOPY keyword actives Local Grid Refinement ("LGR") Inheritance option that allows the LGR to inherit the properties of the global or host cell containing a LGR grid block at the start of the GRID section, as oppose to the normal process of applying this transform at the end of the GRID section. LGRCOPY can be used in the RUNSPEC, GRID and EDIT sections. If used in the RUNSPEC section then the option is applied to all LGRs defined in the input file, whereas if used in the GRID and EDIT sections the keyword must be placed inside a LGR definition section, that is between a CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) and the ENDFIN keyword. In the latter case inheritance is applied on an individual LGR basis.

See *LGRCOPY – Activate Local Grid Refinement Inheritance* in the RUNSPEC section for a full description.

6.3.97 LINKPERM - ASSIGN CELL PERMEABILITIES TO CELL FACES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LINKPERM keyword assigns the grid cell permeabilities entered via the PERMX, PERMY and PERMZ keywords to a cell face (I±, J±, or K±) and results in the simulator using these values directly in the calculating the transmissibility between grid blocks. This is different to the conventional way of entering permeability data that consists of entering the cell centered permeability and the simulator calculating a weighted average transmissibility based on the cell centered permeability of the up-stream and down-stream grid blocks.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.98 LTOSIGMA - Dual Porosity Viscous Displacement Sigma Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LTOSIGMA keyword defines parameters to calculate the sigma factor in conjunction with the data entered via the LX, LY and LZ keywords in the GRID section, for when the VISCD keyword has been used in the RUNSPEC section to activate the Dual Porosity Viscous Displacement option. In addition, either the DUALPORO or DUALPERM keyword should be entered in the RUNSPEC section to activate the dual porosity or dual permeability models.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.99 LX - DUAL POROSITY VISCOUS DISPLACEMENT X DIRECTION MATRIX SIZE FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LX keyword defines the size of "representative" matrix grid blocks in the X direction via an array in dual porosity and dual permeability runs, for when the VISCD keyword has been used in the RUNSPEC section to activate the dual porosity viscous displacement option. In addition, either the DUALPORO or DUALPERM keyword should be entered in the RUNSPEC section to activate the dual porosity or dual permeability models. The VISCD option is used to model the viscous displacement of fluids from the matrix by the fracture pressure gradient, for when the fracture system has a more moderate permeability, and flow to and from the matrix caused by the fracture pressure gradient acts as an additional production mechanism.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	LX	LX is an array of real numbers describing the "representative" cell size in the X direction for each cell in the model. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	0

Notes:

1) The number of entries should correspond to the NX x NY x (NZ/2) parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.51: LX Keyword Description

If the VISCD keyword has been used to activate the Dual Porosity Viscous Displacement option and LX has not been specified then LX is set to zero in the calculation of the viscous displacement term.
See also the LY, LZ and LTOSIGMA keywords in the GRID section.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--        DEFINE DUAL POROSITY VISCOUS DISPLACEMENT X DIRECTION MATRIX SIZE
--
LX
          6*10.0                                            /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a subset of the grid and the size of the "representative" matrix cells in the X direction to 10.0 ft.; after which the ENDBOX keyword resets the input to be the full grid.

6.3.100 LXFIN – DEFINE LOGARITHMIC LGR GRID BLOCK SPACING IN THE X-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LXFIN keyword defines the parameters for automatically generating a Local Grid Refinement ("LGR") grid in the X direction based on logarithmic block spacing, for when the LGR option has been activated by the LGR keyword in the RUNSPEC section. LXFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.101 LY - DUAL POROSITY VISCOUS DISPLACEMENT Y DIRECTION MATRIX SIZE FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LY keyword defines the size of "representative" matrix grid blocks in the Y direction via an array in dual porosity and dual permeability runs, for when the VISCD keyword has been used in the RUNSPEC section to activate the dual porosity viscous displacement option. In addition, either the DUALPORO or DUALPERM keyword should be entered in the RUNSPEC section to activate the dual porosity or dual permeability models. The VISCD option is used to model the viscous displacement of fluids from the matrix by the fracture pressure gradient, for when the fracture system has a more moderate permeability, and flow to and from the matrix caused by the fracture pressure gradient acts as an additional production mechanism.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	LY	LY is an array of real numbers describing the "representative" cell size in the Y direction for each cell in the model. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	0

Notes:

1) The number of entries should correspond to the NX x NY x (NZ/2) parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.52: LY Keyword Description

If the VISCD keyword has been used to activate the Dual Porosity Viscous Displacement option and LY has not been specified then LY is set to zero in the calculation of the viscous displacement term.
See also the LX, LZ and LTOSIGMA keywords in the GRID section.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--        DEFINE DUAL POROSITY VISCOUS DISPLACEMENT Y DIRECTION MATRIX SIZE
--
LY
          6*15.0                                            /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a subset of the grid and the size of the "representative" matrix cells in the Y direction to 15.0 ft.; after which the ENDBOX keyword resets the input to be the full grid.

6.3.102 LYFIN – DEFINE LOGARITHMIC LGR GRID BLOCK SPACING IN THE Y-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LYFIN keyword defines the parameters for automatically generating a Local Grid Refinement ("LGR") grid in the Y direction based on logarithmic block spacing, for when the LGR option has been activated by the LGR keyword in the RUNSPEC section. LYFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.103 LZ - DUAL POROSITY VISCOUS DISPLACEMENT Z DIRECTION MATRIX SIZE FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LZ keyword defines the size of "representative" matrix grid blocks in the Z direction via an array in dual porosity and dual permeability runs, for when the VISCD keyword has been used in the RUNSPEC section to activate the dual porosity viscous displacement option. In addition, either the DUALPORO or DUALPERM keyword should be entered in the RUNSPEC section to activate the dual porosity or dual permeability models. The VISCD option is used to model the viscous displacement of fluids from the matrix by the fracture pressure gradient, for when the fracture system has a more moderate permeability, and flow to and from the matrix caused by the fracture pressure gradient acts as an additional production mechanism.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	LZ	LZ is an array of real numbers describing the "representative" cell size in the Z direction for each cell in the model. Repeat counts may be used, for example 10*100.0.			
		feet	m	cm	0

Notes:

1) The number of entries should correspond to the NX x NY x (NZ/2) parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.53: LZ Keyword Description

If the VISCD keyword has been used to activate the Dual Porosity Viscous Displacement option and LZ has not been specified then LZ is set to zero in the calculation of the viscous displacement term.
See also the LX, LY and LTOSIGMA keywords in the GRID section.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--        DEFINE DUAL POROSITY VISCOUS DISPLACEMENT Z DIRECTION MATRIX SIZE
--
LZ
          6*3.0                                             /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a subset of the grid and the size of the "representative" matrix cells in the Y direction to 15.0 ft.; after which the ENDBOX keyword resets the input to be the full grid.

6.3.104 LZFIN – DEFINE LOGARITHMIC LGR GRID BLOCK SPACING IN THE Z-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LZFIN keyword defines the parameters for automatically generating a Local Grid Refinement ("LGR") grid in the Z direction based on logarithmic block spacing, for when the LGR option has been activated by the LGR keyword in the RUNSPEC section. LZFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.105 MAPAXES- DEFINE THE MAP ORIGIN INPUT DATA

Description

MAPAXES specifies the origin of the map used to create the grid. It is usually output by pre-processing software when exporting the grid geometry. The data is not used by OPM Flow intrinsically, but is merely written to the output EGRID file, as specified by the GRIDFILE keyword, for the use of post-processing software like OPM ResInsight.

No.	Name	Description			Default
		Field (feet)	Metric (metres)	Laboratory (metres)	
1	X1	X1 is a real number that defines the x co-ordinate of a point on the y-axis.			None
2	Y1	Y1 is a real number that defines the y co-ordinate of a point on the y-axis.			None
3	X2	X2 is a real number that defines the x co-ordinate of the origin.			None
4	Y2	Y2 is a real number that defines the y co-ordinate of the origin.			None
5	X3	X3 is a real number that defines the x co-ordinate of a point on the x-axis.			None
6	Y3	Y3 is a real number that defines the y co-ordinate of a point on the x-axis.			None

Notes:

1) The keyword is terminated by "/".

Table 6.54: MAPAXES Keyword Description

Example

```
--
--          ---------------- MAPAXES -----------------
--          X1       Y1       X2       Y2       X3       Y3
MAPAXES
            0.0      100.0    0.0      0.0      100.0    0.0    /
```

The above example defines the map axes to be exported to the grid file for use by post-processing software.

6.3.106 MAPUNITS – DEFINE THE MAP AXES UNITS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MAPUNITS keyword defines the units of the coordinates stated on the MAPAXES keyword. It is usually output by pre-processing software when exporting the grid geometry. The data is not used by OPM Flow intrinsically, but is merely written to the output EGRID file, as specified by the GRIDFILE keyword, for the use of post-processing software like OPM ResInsight.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MAPUNITS	A character string that defines the units of the coordinates stated on the MAPAXES keyword, and should be set to: 1) FIELD for field units 2) METRES for metric units, or 3) LAB for laboratory units	METRES
Notes: 1) Note the alternative spelling of METRES, that is METERS is not recognized. 2) The keyword is terminated by "/".			

Table 6.55: MAPUNITS Keyword Description

Example

```
--
--        SET THE MAP UNITS FOR THE MAPAXES KEYWORD
MAPUNITS
          METRES                                                          /
```

The above example specifies the units on the MAPAXES to be the default METRES.

6.3.107 MAXVALUE – SETS A MAXIMUM VALUE FOR AN ARRAY ELEMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MAXVALUE keyword sets a maximum value for the specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the MAXVALUE keyword is being used.

No.	Name	Description	Default
1	ARRAY	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	CONSTANT	CONSTANT is a positive integer or positive real value that an ARRAY element will be reset to if an element in the defined input BOX, as defined by items (3) to (8), is grater than CONSTANT. CONSTANT has in the same units as the ARRAY property.	None
3	I1	The lower bound of the array in the I-direction to be modified must be greater than or equal to one and less than or equal to I2 and NX.	1
4	I2	The upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
5	J1	The lower bound of the array in the J-direction to be modified must be greater than or equal to one and less than or equal to J2 and NY.	1
6	J2	The upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
7	K1	The lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
8	K2	The upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.56: MAXVALUE Keyword Description

The applicable arrays for each section are defined in Table 6.57 on the following page.

MAXVALUE Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL				
DY	PORV	SWCR				
DZ	TRANX	SWU				
PERMX	TRANY	SGL				
PERMY	TRANZ	SGCR				
PERMZ	DIFFX	SGU				
MULTX	DIFFY	KRW				
MULTY	DIFFZ	KRO				
MULTZ	TRANR	KRG				
DR	TRANTHT	PCG				
THETA	DIFFR	PCW				
PERMR	DIFFTHT					
PERMTHT						
DZNET						
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.57: MAXVALUE Keyword Applicable Arrays by Section

Example

```
--
--        ARRAY      CONSTANT        ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
MAXVALUE
          PERMX      1.0E2           1*  1*   1*  1*   1*  1* / MAX VALUE FOR PERMX
          PERMY      1.0E2           1*  1*   1*  1*   1*  1* / MAX VALUE FOR PERMY
          PERMZ      1.0E1           1*  1*   1*  1*   1*  1* / MAX VALUE FOR PERMZ
/
```

The above example resets the maximum values for the PERMX, PERMY and PERMZ, arrays to 100.0, 100.0 and 10.0, respectively, for all cells in layer five.

6.3.108 MINNNCT – Set a Minimum Non-Neighbor Connection Transmissibility

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MINNNCT keyword defines a minimum non-neighbor connection transmissibility below which the non-neighbor connection is deleted. The keyword allows for three minimum values, one for the transmissibility, one for the diffusivity and one for the thermal transmissibility. If the keyword is absent from the input deck then no minimum cut-off is applied.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.109 MINPORV – SET A MINIMUM GRID BLOCK PORE VOLUME THRESHOLD FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MINPORV defines a minimum threshold pore volume that makes all grid blocks whose pore volume is below this value inactive in the model (inactive cells are not used in OPM Flow calculations). Note this keyword is different to the MINPVV keyword in the GRID section that sets a minimum threshold pore volume for individual cells in the model.

This keyword is ignored by OPM Flow and has no effect on the simulation, but see the MINPV keyword in the GRID section that provides the same functionality.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	MINPORV	MINPORV is a real positive number that defines the minimum pore volume for a cell to be active in the model.			
		rb 1.0e-6	rm^3 1.0e-6	rcc 1.0e-6	Defined
Notes: 1) The keyword is terminated by "/".					

Table 6.58: MINPORV Keyword Description

See also the PINCH keyword for the treatment of inactive grid cells and pinch-outs.

Example

```
--
--        MINIMUM PORE VOLUME FOR ACTIVE CELLS
--
MINPORV
         500.0                                                                  /
```

The above example defines 500 rb (or m^3) as the minimum pore volume for a cell to be active in the model.

6.3.110 MINPV – SET A MINIMUM GRID BLOCK PORE VOLUME THRESHOLD FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MINPV defines a minimum threshold pore volume that makes all grid blocks whose pore volume is below this value inactive in the model (inactive cells are not used in OPM Flow calculations). Note this keyword is different to the MINPVV keyword in the GRID section that sets a minimum threshold pore volume for individual cells in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	MINPV	MINPV is a real positive number that defines the minimum pore volume for a cell to be active in the model.			
		rb 1.0e-6	rm^3 1.0e-6	rcc 1.0e-6	Defined
Notes: 1) The keyword is terminated by "/".					

Table 6.59: MINPV Keyword Description

See also the PINCH keyword for the treatment of inactive grid cells and pinch-outs.

Example

```
--
--        MINIMUM PORE VOLUME FOR ACTIVE CELLS
--
MINPV
          500.0                                                                    /
```

The above example defines 500 rb (or m^3) as the minimum pore volume for a cell to be active in the model.

6.3.111 MINPVV – SET A MINIMUM GRID BLOCK PORE VOLUME THRESHOLD FOR INDIVIDUAL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MINPVV is an array that defines the minimum threshold pore volume for each cell, that makes grid blocks whose pore volume is below this value inactive in the model (inactive cells are not used in OPM Flow calculations).

Note this keyword is different to the MINPV keyword in the GRID section that sets a constant minimum threshold pore volume for all cells in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	MINPVV	MINPVV is an array of real positive numbers that defines the minimum pore volumes for each cell in the model in order for the cells to be active.			
		rb	rm^3	rcc	
		1.0e-6	1.0e-6	1.0e-6	Defined

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.60: MINPVV Keyword Description

See also the PINCH keyword for the treatment of inactive grid cells and pinch-outs.

Example

```
--
--        DEFINE A BOX GRID FOR THE BOTTOM TWO LAYERS OF A 100 X 100 X 20 MODEL
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   19  20 / SELECT THE BOTTOM LAYER
--
--        MINIMUM PORE VOLUME FOR INDIVIDUAL CELLS TO BE ACTIVE
--
MINPVV
          10000*500.0   10000*750.0
/
--
--        RESET THE INPUT BOX TO BE THE FULL MODEL
--
ENDBOX
```

The above example defines 500 rb (or m^3) as the minimum pore volume for all cells in layer 19 to be active in the model, and 750 rb (or m^3) as the minimum pore volume for all cells in layer 20.

6.3.112 MINVALUE – SET A MINIMUM VALUE FOR AN ARRAY ELEMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MINVALUE keyword sets a minimum value for the specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the MINVALUE keyword is being used.

No.	Name	Description	Default
1	ARRAY	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	CONSTANT	CONSTANT is a positive integer or positive real value that an ARRAY element will be reset to if an element in the defined input BOX, as defined by items (3) to (8), is less than CONSTANT. CONSTANT has in the same units as the ARRAY property.	None
3	I1	A positive integer that defines the lower bound of the array in the I-direction to be modified must be greater than or equal to one and less than or equal to I2 and NX.	1
4	I2	A positive integer that defines the upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
5	J1	A positive integer that defines the lower bound of the array in the J-direction to be modified must be greater than or equal to one and less than or equal to J2 and NY.	1
6	J2	A positive integer that defines the upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
7	K1	A positive integer that defines the lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
8	K2	A positive integer that defines the upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.61: MINVALUE Keyword Description

The applicable arrays for each section are defined in Table 6.62 on the following page.

EQUALS Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL				
DY	PORV	SWCR				
DZ	TRANX	SWU				
PERMX	TRANY	SGL				
PERMY	TRANZ	SGCR				
PERMZ	DIFFX	SGU				
MULTX	DIFFY	KRW				
MULTY	DIFFZ	KRO				
MULTZ	TRANR	KRG				
DR	TRANTHT	PCG				
THETA	DIFFR	PCW				
PERMR	DIFFTHT					
PERMTHT						
DZNET						
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.62: MINVALUE Keyword Applicable Arrays by Section

Example

```
--
--        ARRAY     CONSTANT         ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
MINVALUE
          PERMX     1.0E1            1*  1*   1*  1*   1*  1* / MINIMUM PERMX
          PERMY     1.0E1            1*  1*   1*  1*   1*  1* / MINIMUM PERMY
          PERMZ     1.0E-1           1*  1*   1*  1*   1*  1* / MINIMUM PERMZ
/
```

The above example resets the minimum values for the PERMX, PERMY and PERMZ, arrays to 1.0, 1.0 and 0.1, respectively, for all cells in layer five.

6.3.113 MPFANUM – Define Multi-Point Flux Discretization Regions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MPFANUM keyword defines regions in the model where the multi-point flux discretization should be applied.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.114 MPFNNC – Define Multi-Point Flux Non-Neighbor Connections

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MPFNNC keyword defines multi-point flux non-neighbor connections explicitly.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.115 MULTFLT – MULTIPLY THE TRANSMISSIBILITY OF A DEFINED FAULT BY A CONSTANT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTFLT enables the transmissibilities across defined faults, as declared by the FAULTS keyword, to be modified. They keyword allows for the re-scaling of the existing fault transmissibilities calculated by OPM Flow, for example setting a fault to be completely sealing by setting the multiplier to zero.

No.	Name	Description	Default
1	FLTNAME	FLTNAME is a character string enclosed in quotes with a maximum length of eight characters, that defines the name of the fault that FLTMULT will be applied to. FLTNAME must have previously been defined using the FAULTS keyword in GRID section	None
2	FLT-TRS	A positive real number that sets the transmissible multiplier to be applied to the FLTNAME transmissibilities positive real number that sets the transmissible multiplier to be applied to the FLTNAME transmissibilities.	1.0
3	FLT-DIF	A positive real number that sets the diffusivity multiplier to be applied to the FLTNAME diffusivities. This option should only be used if the Diffusion option has been made activate by the DIFFUSE keyword in the RUNSPEC section. OPM Flow does not support the Diffusion option.	1.0

Notes:

1) Repeated entries of the same FLTNAME will result in all but the last entry being overwritten.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.63: MULTFLT Keyword Description

Example

```
--
--       MODIFY THE TRANSMISSIBILITES ACROSS DEFINED FAULTS
--
--       FAULT            TRANS            DIFUSS
--       NAME             MULTIPLIER       MULTIPLIER
MULTFLT
         'FAULT01'        0.0                                  / FAULT MULTIPLIERS
         'FAULT02'        0.0                                  / FAULT MULTIPLIERS
         'FAULT03'        0.0                                  / FAULT MULTIPLIERS
/
```

The above example sets the fault transmissibility multiplier for defined faults named FAULT01, FAULT02, and FAULT03 to zero making the faults sealing in the model.

6.3.116 MULTIPLY – MULTIPLY A SPECIFIED ARRAY BY A CONSTANT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MULTIPLY keyword multiplies a specified array or part of an array by a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

No.	Name	Description	Default
1	ARRAY	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	CONSTANT	An integer or real value that the ARRAY will be set to in the same units as the ARRAY property.	None
3	I1	A positive integer that defines the lower bound of the array in the I-direction to be modified must be greater than or equal to one and less than or equal to I2 and NX.	1
4	I2	A positive integer that defines the upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
5	J1	A positive integer that defines the lower bound of the array in the J-direction to be modified must be greater than or equal to one and less than or equal to J2 and NY.	1
6	J2	A positive integer that defines the upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
7	K1	A positive integer that defines the lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
8	K2	A positive integer that defines the upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.64: MULTIPLY Keyword Description

The applicable arrays for each section are defined in Table 6.65 as shown on the next page.

MULTIPLY Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.65: MULTIPLY Keyword Applicable Arrays by Section

Example

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
MULTIPLY
          PERMZ        0.50000       1*  1*   1*  1*   1*  1* / PERMZ * 0.5
/
```

The above example multiples the PERMZ property array by 0.5 throughout the model.

6.3.117 MULTIREG – MULTIPLY AN ARRAY BY A CONSTANT BASED ON A REGION NUMBER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MULTIREG keyword multiplies an array or part of an array by a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTIREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the MULTIREG keyword is being used.

No.	Name	Description	Default
1	ARRAY	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and enclosed in quotes.	None
2	CONSTANT	An integer or real value to multiply the ARRAY by in the same units as the ARRAY property for a given REGION.	0
3	REGION	REGION is a positive integer representing the region for which the CONSTANT in (2) should be applied	None
4	ARRAY	The ARRAY to use for applying the CONSTANT in (2) based on the REGION in (3). ARRAY can have the following values: 1) F for the FLUXNUM array 2) M for the MULTNUM array 3) O for the OPERNUM array	M

Notes:

1) Where the REGION should be less than or equal to the maximum number of regions as defined on the REGDIMS keyword for the FIPNUM and OPERNUM arrays or the GRIDOPTS keyword for the MULTNUM array in the RUNSPEC section.

2) Each record must be terminated by a "/" and the keyword is terminated by "/" .

Table 6.66: MULTIREG Keyword Description

The applicable arrays for each section are defined in Table 6.67 as shown on the following page.

MULTREG Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		

MULTREG Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.67: MULTIREG Keyword Applicable Arrays by Section

Example

```
--
-- FIRST DEFINE THE PROPERTY ARRAYS AND MULTNUM ARRAYS FOR 10 X 10 X 20 MODEL
--
--  ARRAY     CONSTANT     ---------- BOX ---------
--                          I1  I2   J1  J2   K1  K2
EQUALS
    PORO       0.2000       1*  1*   1*  1*   1*  1*  / PORO  TO 0.20 IN MODEL
    PERMX      100.00       1*  1*   1*  1*   1*  1*  / PERMX TO 0.10 IN MODEL
    MULTNUM    1            1*  1*   1*  1*   1*  1*  / MULTNUM IN MODEL
    MULTNUM    2            1*  5    1   5    6   6   / MULTNUM IN MODEL
    MULTNUM    3            1*  1*   1*  1*   10  10  / MULTNUM IN MODEL
/
--
-- NOW RESET PORO AND PERMX BASED ON THE MULTNUM REGION NUMBER
--
-- MULTIPLY AN ARRAY BY A CONSTANT BASED ON A REGION NUMBER
--
--    ARRAY     CONSTANT  REGION   REGION ARRAY
--              VALUE     NUMBER    M / F / O
MULTIREG
      PORO      1.050     1         M               /
      PORO      1.100     2         M               /
      PORO      0.950     3         M               /
      PERMX      1.25     1         M               /
      PERMX      1.30     2         M               /
      PERMX      0.90     3         M               /
/
```

The example first defines the PORO and PERMX property arrays for the model and then sets the MULTNUM array to 1 for all cells in the model, after which selected areas of model are assigned various MULTNUM integer values. The MULTIREG can then be invoked to multiple the PORO and PERMX arrays by a constant for the various MULTNUM regions.

6.3.118 MULTNUM – DEFINE THE MULTIPLE TRANSMISSIBILITY REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MULTNUM keyword defines the inter-region transmissibility region numbers for each grid block, as such there must be one entry for each cell in the model. The array can be used with the EQUALREG, ADDREG, COPYREG, MULTIREG, MULTREGP and MULTREGT keywords in calculating various grid properties in the GRID section.

No.	Name	Description	Default
1	MULTNUM	MULTNUM defines an array of positive integers assigning a grid cell to a particular inter-region transmissibility region. The maximum number of MULTNUM regions is set by the NRMULT variable on the GRIDOPTS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.68: MULTNUM Keyword Description

Examples

The example below sets three MULTNUM regions for a 4 x 5 x 2 model.

```
--
--        DEFINE MULTNUM REGIONS FOR ALL CELLS
--
MULTNUM
          2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          MULTNUM     1            1*  1*   1*  1*   1*  1* / SET REGION 1
          MULTNUM     2            1   2    1   2    1   1  / SET REGION 2
          MULTNUM     3            1   2    1   2    2   2  / SET REGION 3
/
```

One can then increase PERMX by 25% in region three only.

```
--
--        MULTIPLY AN ARRAY BY A CONSTANT BASED ON A REGION NUMBER
--
--        ARRAY     CONSTANT  REGION   REGION ARRAY
--                  VALUE     NUMBER    M / F / O
MULTIREG
          PERMX     1.25      3        M                    /
/
```

6.3.119 MULTPV – MULTIPLY CELL PORE VOLUMES BY A CONSTANT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTPV multiples the pore volumes of a cell by a real positive constant for all the cells in the model via an array. An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTPV keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description	Default
1	MULTPV	MULTPV is an array of real positive numbers assigning the pore volume multipliers for each cell in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.69: MULTPV Keyword Description

See also the MULTREGP for scaling the cell pore volumes by region numbers.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   3                          / DEFINE BOX AREA
--
--        SET MULTX+ TRANSMISSIBILITY MULTIPLIERS
--
MULTPV
          18*0.0500                                        /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.05 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.120 MULTR - MULTIPLY CELL TRANSMISSIBILITY IN THE +R DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTR multiples the transmissibility between two cell faces in the +R direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I+1, J, K). An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTR keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MULTR+	MULTR+ is an array of real positive numbers assigning the transmissibility multipliers in the +R direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.70: MULTR Keyword Description

See also the MULTR-, MULTTHT, MULTTHT-, MULTZ and MULTZ- keywords for scaling transmissible between radial grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   3                          / DEFINE BOX AREA
--
--        SET MULTR+ TRANSMISSIBILITY MULTIPLIERS
--
MULTR
          18*0.300                                          /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.3 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.121 MULTR- - MULTIPLY CELL TRANSMISSIBILITY IN THE -R DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTR- multiples the transmissibility between two cell faces in the -R direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I-1, J, K) and (I, J, K). An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTR- keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MULTR-	MULTR- is an array of real positive numbers assigning the transmissibility multipliers in the -R direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.71: MULTR- Keyword Description

See also the MULTR, MULTTHT, MULTTHT-, MULTZ and MULTZ- keywords for scaling transmissible between radial grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--        SET MULTX TRANSMISSIBILITY MULTIPLIERS CELLS
--
MULTR-
          6*0.500                                           /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.5 scaling multiplier for the six cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.122 MULTREGD – MULTIPLY DIFFUSIVITIES BETWEEN REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MULTREGT keyword multiplies the diffusivity between two regions by a constant. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGT keyword is read by the simulator. The constant should be a real number.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	REGION1	A positive integer value that defines the from REGION number for which the CONSTANT in (2) should be applied.	None
2	REGION2	A positive integer value that defines the to REGION number for which the CONSTANT in (2) should be applied.	None
3	CONSTANT	A real value to multiply the diffusivity between REGION1 and REGION2.	1
4	DIR	A character string that defines the direction to apply the diffusivity multiplier between the two regions, should be set to one of the following X, Y, Z, XY, YX, XZ, or XYZ.	XYZ
5	TYPE	A character string that defines the type of connections the diffusivity multiplier should be applied to, should be one of the following: 1) NNC – Only apply the diffusivity multiplier between REGION1 and REGION2 to non-neighbor connections. 2) NONNC – Do not apply the diffusivity multiplier between REGION1 and REGION2 to non-neighbor connections. 3) ALL - Apply the diffusivity multiplier between REGION1 and REGION2 to all connections.	ALL
6	ARRAY	The ARRAY to use for applying the CONSTANT in (2) based on the ARRAY in (1). ARRAY can have the following values: 1) F for the FLUXNUM array 2) M for the MULTNUM array 3) O for the OPERNUM array	M

Notes:

1) Where REGION1 and REGION2 should be less than or equal to the maximum number of regions as defined on the REGDIMS keyword for the FIPNUM and OPERNUM arrays or the GRIDOPTS keyword for the MULTNUM array in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.72: MULTREGD Keyword Description

Example

```
--
--    MULTIPLY DIFFUSIVITIES BETWEEN RESERVOIRS
--
--    REGION   REGION   DIFFS   DIREC   NNC    REGION ARRAY
--    FROM     TO       MULT    OPT     OPTS   M / F / O
MULTREGD
      1*       1*       1.05    1*     'ALL'   M           / ALL REGIONS
/
```

The above example multiplies the thermal conductivities between all the MULTNUM regions by 1.05 in all directions and for all connections types.

6.3.123 MULTREGH – MULTIPLY THERMAL CONDUCTIVITIES BETWEEN REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MULTREGH keyword multiplies the thermal conductivity between two regions by a constant. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGT keyword is read by the simulator. The constant should be a real number.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	REGION1	A positive integer value that defines the from REGION number for which the CONSTANT in (2) should be applied.	None
2	REGION2	A positive integer value that defines the to REGION number for which the CONSTANT in (2) should be applied.	None
3	CONSTANT	A real value to multiply the thermal conductivity between REGION1 and REGION2.	1
4	DIR	A character string that defines the direction to apply the thermal conductivity multiplier between the two regions, should be set to one of the following X, Y, Z, XY, YX, XZ, or XYZ.	XYZ
5	TYPE	A character string that defines the type of connections the thermal conductivity multiplier should be applied to, should be one of the following: 4) NNC – Only apply the thermal conductivity multiplier between REGION1 and REGION2 to non-neighbor connections. 5) NONNC – Do not apply the thermal conductivity multiplier between REGION1 and REGION2 to non-neighbor connections. 6) ALL - Apply the thermal conductivity multiplier between REGION1 and REGION2 to all connections.	ALL
6	ARRAY	The ARRAY to use for applying the CONSTANT in (2) based on the ARRAY in (1). ARRAY can have the following values: 1) F for the FLUXNUM array 2) M for the MULTNUM array 3) O for the OPERNUM array	M

Notes:

1) Where REGION1 and REGION2 should be less than or equal to the maximum number of regions as defined on the REGDIMS keyword for the FIPNUM and OPERNUM arrays or the GRIDOPTS keyword for the MULTNUM array in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.73: MULTREGH Keyword Description

Example

```
--
--    MULTIPLY THERMAL CONDUCTIVITIES BETWEEN RESERVOIRS
--
--    REGION   REGION   CONDS   DIREC   NNC    REGION ARRAY
--    FROM     TO       MULT    OPT     OPTS   M / F / O
MULTREGH
      1*       1*       1.05    1*     'ALL'   M           / ALL REGIONS
/
```

The above example multiplies the diffusivities between all the MULTNUM regions by 1.05 in all directions and for all connections types.

6.3.124 MULTREGP – MULTIPLY PORE VOLUMES BASED ON REGION NUMBER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MULTREGP keyword multiplies the pore volume of a cell by a constant for all cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGP keyword is read by the simulator. The constant should be a real number.

No.	Name	Description	Default
1	REGION	REGION is a positive integer representing the region for which the CONSTANT in (2) should be applied.	None
2	CONSTANT	A real value to multiply the pore volume by for a given REGION.	1
3	ARRAY	The ARRAY to use for applying the CONSTANT in (2) based on the REGION in (1). ARRAY can have the following values: 1) F for the FLUXNUM array 2) M for the MULTNUM array 3) O for the OPERNUM array	M

Notes:

1) Where the REGION should be less than or equal to the maximum number of regions as defined on the REGDIMS keyword for the FIPNUM and OPERNUM arrays or the GRIDOPTS keyword for the MULTNUM array in the RUNSPEC section.

2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.74: MULTREGP Keyword Description

Example

```
--
-- RESET PORE VOLUME FOR DIFFERENT REGIONS
--
--    REGION    PORV          REGION ARRAY
--    NUMBER    MULT          M / F / O
MULTREGP
         1       1.0456573    M             /  Fault Block 1
         2       0            M             /  Fault Block 2
         3       0.9756715    M             /  Fault Block 3
         4       0            M             /  Inactive Blocks
/
```

The above example re-scales the pore volumes for MULTNUM regions one and three and makes regions two and four inactive by setting their pore volumes to zero.

6.3.125 MULTREGT – MULTIPLY TRANSMISSIBILITIES BETWEEN REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MULTREGT keyword multiplies the transmissibility between two regions by a constant. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGT keyword is read by the simulator. The constant should be a real number.

No.	Name	Description	Default
1	REGION1	A positive integer value that defines the from REGION number for which the CONSTANT in (2) should be applied.	None
2	REGION2	A positive integer value that defines the to REGION number for which the CONSTANT in (2) should be applied.	None
3	CONSTANT	A real value to multiply the transmissibility between REGION1 and REGION2.	1
4	DIR	A character string that defines the direction to apply the transmissibility multiplier between the two regions, should be set to one of the following X, Y, Z, XY, YX, XZ, or XYZ.	XYZ
5	TYPE	A character string that defines the type of connections the transmissibility multiplier should be applied to, should be one of the following: 7) NNC – Only apply the transmissibility multiplier between REGION1 and REGION2 to non-neighbor connections. 8) NONNC – Do not apply the transmissibility multiplier between REGION1 and REGION2 to non-neighbor connections. 9) ALL - Apply the transmissibility multiplier between REGION1 and REGION2 to all connections.	ALL
6	ARRAY	The ARRAY to use for applying the CONSTANT in (2) based on the ARRAY in (1). ARRAY can have the following values: 1) F for the FLUXNUM array 2) M for the MULTNUM array 3) O for the OPERNUM array	M

Notes:

1) Where REGION1 and REGION2 should be less than or equal to the maximum number of regions as defined on the REGDIMS keyword for the FIPNUM and OPERNUM arrays or the GRIDOPTS keyword for the MULTNUM array in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.75: MULTREGT Keyword Description

Note

Note if the MULTREGT keyword is used in the EDIT section, OPM Flow will always apply the changes irrespective, of if the TRANX, TRANY and TRANZ transmissibility arrays have been entered or not in the EDIT section.

This behavior is different to the commercial simulator that only applies the keyword if the transmissibility arrays have been entered in the EDIT section.

Example

```
--
--    SET TRANSMISSIBILITES ACROSS DIFFERENT RESERVOIRS TO ZERO
--
--    REGION   REGION   TRANS   DIREC   NNC    REGION ARRAY
--    FROM     TO       MULT    OPT     OPTS   M / F / O
MULTREGT
      1*       1*       0.0     1*     'ALL'   M           / ALL REGIONS SEALED
/
```

The above example isolates all regions from one another by setting the transmissibility for the MULTNUM regions to zero in all directions and for all connections types.

6.3.126 MULTTHT - MULTIPLY CELL TRANSMISSIBILITY IN THE +THETA DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTTHT multiples the transmissibility between two cell faces in the +Theta direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J+1, K). An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTTHT keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MULTTHT+	MULTTHT+ is an array of real positive numbers assigning the transmissibility multipliers in the +Theta direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.76: MULTTHT Keyword Description

See also the MULTTHT-, MULTR, MULTR-, MULTZ and MULTZ- keywords for scaling transmissible between radial grid cells.

Example

```
--
--       DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--       ---------- BOX ---------
--       I1  I2   J1  J2   K1  K2
BOX
         10  10   1   6    1   3                          / DEFINE BOX AREA
--
--       SET MULTTHT+ TRANSMISSIBILITY MULTIPLIERS
--
MULTTHT
         18*0.300                                          /
--
--       DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.3 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.127 MULTTHT- - MULTIPLY CELL TRANSMISSIBILITY IN THE -THETA DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTTHT- multiples the transmissibility between two cell faces in the -Theta direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J-1, K) and (I, J, K). An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTTHT- keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	MULTTHT-	MULTTHT- is an array of real positive numbers assigning the transmissibility multipliers in the -Theta direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.77: MULTTHT- Keyword Description

See also the MULTTHT, MULTR, MULTR-, MULTZ and MULTZ- keywords for scaling transmissible between radial grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--        SET MULTX TRANSMISSIBILITY MULTIPLIERS CELLS
--
MULTTHT-
          6*0.500                                          /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.5 scaling multiplier for the six cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.128 MULTX - MULTIPLY CELL TRANSMISSIBILITY IN THE +X DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTX multiples the transmissibility between two cell faces in the +X direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I+I, J, K).

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTX keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description	Default
1	MULTX+	MULTX+ is an array of real positive numbers assigning the transmissibility multipliers in the +X direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.78: MULTX Keyword Description

See also the MULTX-, MULTY, MULTY-, MULTZ and MULTZ- keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   3                          / DEFINE BOX AREA
--
--        SET MULTX+ TRANSMISSIBILITY MULTIPLIERS
--
MULTX
          18*0.300                                          /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.3 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.129 MULTX- - MULTIPLY CELL TRANSMISSIBILITY IN THE -X DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTX- multiples the transmissibility between two cell faces in the -X direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I-1, J, K) and (I, J, K).

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTX- keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description	Default
1	MULTX-	MULTX- is an array of real positive numbers assigning the transmissibility multipliers in the -X direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.79: MULTX- Keyword Description

See also the MULTX, MULTY, MULTY-, MULTZ and MULTZ- keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--        SET MULTX TRANSMISSIBILITY MULTIPLIERS CELLS
--
MULTX-
          6*0.500                                           /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.5 scaling multiplier for the six cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.130 MULTY - MULTIPLY CELL TRANSMISSIBILITY IN THE +Y DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTY multiples the transmissibility between two cell faces in the +Y direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J+1, K).

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTY keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description	Default
1	MULTY+	MULTY+ is an array of real positive numbers assigning the transmissibility multipliers in the +Y direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.80: MULTY Keyword Description

See also the MULTY-, MULTX, MULTX-, MULTZ and MULTZ- keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   3                          / DEFINE BOX AREA
--
--        SET MULTX+ TRANSMISSIBILITY MULTIPLIERS
--
MULTY
          18*0.300                                          /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.3 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.131 MULTY- - MULTIPLY CELL TRANSMISSIBILITY IN THE -Y DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTY- multiples the transmissibility between two cell faces in the -Y direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J-1, K) and (I, J, K).

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTY- keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description	Default
1	MULTY-	MULTY- is an array of real positive numbers assigning the transmissibility multipliers in the -Y direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.81: MULTY- Keyword Description

See also the MULTY, MULTX, MULTX-, MULTZ and MULTZ- keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--        SET MULTX TRANSMISSIBILITY MULTIPLIERS CELLS
--
MULTY-
          6*0.500                                           /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.5 scaling multiplier for the six cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.132 MULTZ - MULTIPLY CELL TRANSMISSIBILITY IN THE +Z DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTZ multiples the transmissibility between two cell faces in the +Z direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J, K+1).

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTZ keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description	Default
1	MULTZ+	MULTZ+ is an array of real positive numbers assigning the transmissibility multipliers in the +Z direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.82: MULTZ Keyword Description

See also the MULTZ-, MULTX, MULTX-, MULTY and MULTY- keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   18   1   1                          / DEFINE BOX AREA
--
--        SET MULTX+ TRANSMISSIBILITY MULTIPLIERS
--
MULTZ
          18*0.300                                         /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.3 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.133 MULTZ- - MULTIPLY CELL TRANSMISSIBILITY IN THE -Z DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MULTZ- multiples the transmissibility between two cell faces in the -Z direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K-1) and (I, J, K).

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTZ- keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description	Default
1	MULTZ-	MULTZ- is an array of real positive numbers assigning the transmissibility multipliers in the -X direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.83: MULTZ- Keyword Description

See also the MULTZ, MULTX, MULTX-, MULTY and MULTY- keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   1                          / DEFINE BOX AREA
--
--        SET MULTX TRANSMISSIBILITY MULTIPLIERS CELLS
--
MULTZ-
          6*0.500                                           /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.5 scaling multiplier for the six cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.134 NEWTRAN – ACTIVATE IRREGULAR CORNER-POINT GRID TRANSMISSIBILITIES

Description

This keyword switches on Irregular Corner-Point Grid geometry transmissibility calculation, which is the default option for this type of grid. Grids defined with the COORD and ZCORN keywords will always invoke this option by default.

For Cartesian Regular Grids defined by the DX, DY, and DZ series of keywords the block center geometry transmissibility calculations should be activated via the OLDTRAN keyword. Again this is automatically invoked if this type of grid is being employed.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        ACTIVATE IRREGULAR CORNER-POINT GRID TRANSMISSIBILITIES
--
NEWTRAN
```

The above example manually activates Irregular Corner-Point Grid transmissibility calculations.

6.3.135 NINENUM – DEFINE THE NINE-POINT DISCRETIZATION REGION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NINENUM keyword defines areas in the grid that should use the Nine-Point Discretization formulation by setting a grid block's NINENUM value to one, or zero for the conventional standard five-point discretization formulation, for when the Nine-Point Discretization formulation has been activated by the NINEPOIN keyword in the RUNSPEC section. There should be a NINENUM value for each grid block in the model. Note that if the if the NINEPOIN keyword in the RUNSPEC section has been invoked and the NINENUM keyword has not been used in the input deck, then all the grid will use the nine-point scheme.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	NINENUM	NINENUM defines an integer array of zeros and ones assigning a grid cell to a particular discretization region, a value of zero for five-point or a value of one for nine-point discretization. Note that the default value of one implies a cell is included in the Nine-Point Discretization region; thus, if a cell is to use the conventional standard five-point finite difference discretization formulation, then NINENUM must be explicitly set to zero.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.84: NINENUM Keyword Description

The NINENUM keyword cannot be used in models with Local Grid Refinements ("LGR") to set different discretization regions within the model, that is if LGRs are present in the model either all the grid users nine-point discretization, if NINEPOIN is present in the RUNSPEC section, or five-point if NINEPOIN is absent.

Example

The example below sets a portion of the model to us the Nine-Point Discretization formulation.

```
--
--        DEFINE NINE-POINT DISCRETIZATION REGION FOR ALL CELLS
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          NINENUM'    0            1*  1*   1*  1*   1*  1* / FIVE-POINT
          NINENUM'    1            1*  1*   1*  1*   1   5  / NINE-POINT
/
```

Here the first line sets all the grid to us the five-point discretization formulation, all values set to zero, and then the second line sets all the cells in the layers one to five to use the nine-point discretization formulation.

6.3.136 NMATOPTS – DEFINE THE DISCRETIZED MATRIX DUAL POROSITY PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NMATOPTS keyword defines the Discretized Matrix Dual Porosity parameters for when the Discretized Matrix Dual Porosity option has been activated by NMATRIX keyword in the RUNSPEC section. The option allows the matrix grid blocks to be subdivided into smaller cells for more accurate flow calculations, in particular the modeling of transient flow within the matrix grid blocks.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.137 NNC – DEFINE NON-NEIGHBOR CONNECTIONS BETWEEN CELLS MANUALLY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

NNC enables Non-Neighbor Connections ("NNC") to be manually defined. This keyword is normally generated by static modeling software as opposed to be manually entered in the OPM Flow input deck due to the verbosity and complexity of calculating the required parameters for this keyword.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	I1	A positive integer that defines the first grid block in the I-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NX on the DIMENS keyword in the RUNSPEC section.			None
2	J1	A positive integer that defines the first grid block in the J-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NY on the DIMENS keyword in the RUNSPEC section.			None
3	K1	A positive integer that defines the first grid block in the K-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NZ on the DIMENS keyword in the RUNSPEC section.			None
4	I2	A positive integer that defines the second grid block in the I-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NX on the DIMENS keyword in the RUNSPEC section.			None
5	J2	A positive integer that defines the second grid block in the J-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NY on the DIMENS keyword in the RUNSPEC section.			None
6	K2	A positive integer that defines the second grid block in the K-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NZ on the DIMENS keyword in the RUNSPEC section.			None
7	TRANSNNC	TRANSNNC is a positive real number greater than or equal to zero that defines the transmissibility between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2). The default value of zero sets the transmissibility between the two cells to zero.			
		cP.rb/day/psia	cP.rm^3/day/bars	cP.rcc/hr/atm	0.0
8	ISATNUM1	ISATNUM1 is a positive integer defining which saturation table number (relative permeability table) to be used for flow from the first grid block to the second grid block. The default value of zero means the existing saturation table allocated to the upstream cell (I1,J1,K1).			0

No.	Name	Description			Default
		Field	Metric	Laboratory	
9	ISATNUM2	ISATNUM2 is a positive integer defining which saturation table number (relative permeability table) to be used for flow from the second grid block to the first grid block. The default value of zero means the existing saturation table allocated to the downstream cell (I2,J2,K2).			0
10	IPRSNUM1	IPRSNUM1 is a positive integer defining which pressure table number (PVT table) to be used for flow from the first grid block to the second grid block. The default value of zero means the existing PVT table allocated to the upstream cell (I1,J1,K1).			0
11	IPRSNUM2	IPRSNUM2 is a positive integer defining which pressure table number (PVT table) to be used for flow from the second grid block to the first grid block. The default value of zero means the existing PVT table allocated to the downstream cell (I2,J2,K2).			0
12	FACE1	FACE1 is a character string that defines the face associated with flow from the first grid block to the second grid block, where FACE1 can have values of: X+, X-, Y+, Y-, Z+, or Z-.			None
13	FACE2	FACE2 is a character string that defines the face associated with flow from the second grid block to the first grid block, where FACE2 can have vaules of: X+, X-, Y+, Y-, Z+, or Z-.			None
14	DIFFNNC	DIFFNNC is a positive real number that defines the diffusivity between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2).			
		feet	meters	cm	0.0
15	DISPNNC	DISPNNC s a positive real number that defines the dispersion coefficient $\frac{1}{(Area\ x\ Porosity)}$ between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2), used with the DISPERSE option.			
		ft^{-2}	m^{-2}	cm^{-2}	0.0
16	AREANNC	AREANNC is a positive real number that defines the area associated with the connection between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2).			
		ft^2	m^2	cm^2	None
17	PERMNNC	AREANNC is a positive real number that defines the permeability associated with the connection between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2). This used by the non-Darcy option.			
		mD	mD	mD	None

Notes:

1) Only functionality defined by items (1) to (7) are activated in OPM Flow.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.85: NNC Keyword Description

Note that although items (8) to (17) for this keyword are not available in OPM Flow, even if they were, it is strongly recommended that these items are defaulted if the data is being entered manually, as opposed to being generated by a pre-processing software.

Care should be taken that cells in different PVTNUM regions (see the PVTNUM keyword in the REGIONS section) are not connected, since the fluid properties are associated with a cell. If for example, a rbbl or a rm3 of oil flows from PVTNUM region 1 to PVTNUM region 2, then the oil properties of that oil will change from the PVT 1 data set to the PVT data set 2. This will result in material balance errors, that may or may not cause numerical issues.

If the transmissibility across a fault needs to be modified see the FAULTS and MULTFLT keywords in the GRID section for an alternative and less complicated method to modifying fault transmissibilities. Transmissibility between reservoir regions can be modified by using MULTREGT keyword, provided MULTNUM has been used to define the inter-region transmissibility region numbers for each grid block. Finally, the MULTX, MULTY and MULTZ series of keywords can be used to modify transmissibility between various cells. All the aforementioned keywords are described in the GRID section.

Example

```
--
--       MANUALLY DEFINE NON-NEIGHBOR CONNECTIONS
--
--       ------------ BOX -----------    -- TRANSNCC --
--       I1   J1   K1    I2   J2   K2
NCC
         1    1    1     1    1    2        0.2500     / SET NNC FOR FAULT
         1    1    2     1    1    3        0.2500     / SET NNC FOR FAULT
         1    1    3     1    1    4        0.2500     / SET NNC FOR FAULT
/
```

The above example defines the transmissibility between cells (1, 1, 1) and (1, 1, 2), (1, 1, 2) and (1, 1, 3) and finally between (1, 1, 3) and (1, 1, 4) to be 0.2500.

6.3.138 NODPPM – DEACTIVATE FRACTURE POROSITY-PERMEABILITY CALCULATION

The NODPPM keyword deactivates the default behavior of multiplying the fracture porosity by the fracture permeability to calculate the effective fracture permeability in dual porosity and dual permeability runs. Either the DUALPORO or DUALPERM keywords in the RUNSPEC section must be declared in the input file in order to use this keyword. If the default calculation is switched off by this keyword, then the effective fracture permeability is taken to be those entered for the fracture using the PERMX, PERMY and PERMZ keywords in the GRID section. If the keyword is absent from the input deck, then the entered PERMX, PERMY and PERMZ arrays for the fractures are multiplied by fracture PORO array values in order to obtain the effective fracture permeability.

See *NODPPM – Deactivate Fracture Porosity-Permeability Calculation* in the RUNSPEC section for a full description.

6.3.139 NOGGF – DEACTIVATE OUTPUT OF GRID GEOMETRY FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword deactivates the output of a standard GRID or extended GRID file, as well as the extensible EGRID file for post-processing applications.

This keyword is ignored by OPM Flow and has no effect on the simulation.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        DEACTIVATE GRID GEOMETRY OUTPUT
--
NOGGF
```

The above example switches off the default behavior of writing out the grid geometry files.

6.3.140 NTG – DEFINE THE NET-TO-GROSS RATIO FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

NTG defines the Net-to-Gross Ratio ("NTG") for all the cells in the model via an array. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NTG	NTG is an array of real numbers greater than or equal to zero and less than or equal to one, that are assigned the net-to-gross ratio values for each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 200*0.850.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) Setting a cells NTG value to zero will make the cell inactive, similar to setting the cells ACTNUM property to zero.
2) The keyword is terminated by "/".

Table 6.86: NTG Keyword Description

See also the PORO, PERMX, PERMY and PERMZ keywords to fully define a grid's properties.

Example

```
--
--        DEFINE GRID BLOCK NTG DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
NTG
          100*1.000   100*0.850   100*0.500                                    /
```

The above example defines a constant NTG of 1.00 for the first 100 cells, then 0.85 for the second 100 hundred cells, and finally 0.500 for the last 100 cell, for the 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.141 NXFIN – DEFINE THE NUMBER OF LGR GRID BLOCKS IN THE X-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

NXFIN defines the number of Local Grid Refinement ("LGR") cells within a global or host cell in the x-direction via a vector, as opposed to defining the size for each cell for a Cartesian LGR Grid. The LGR keyword in the RUNSPEC section should be activated to indicate an LGR is being used, and the keyword NXFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NXFIN	NXFIN is a vector of integer numbers describing the number of LGR cells within each defined global or host grid block in the x-direction in a Cartesian LGR grid. Repeat counts may be used, for example 2*2.0.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX parameter on the CARFIN keyword in the GRID section.
2) The keyword is terminated by "/".

Table 6.87: NXFIN Keyword Description

See also the CARFIN, ENDFIN, NYFIN, and NZFIN keywords in the GRID section to fully define a Cartesian LGR grid model.

Example

```
--
--       CARFIN LGR GRID COMMANDS
--
--       LGR        ----- HOST GRID ------    -- CARFIN GRID --  MAX     HOST
--       NAME       I1  I2  J1  J2  K1  K2     NX    NY    NZ   WELLS   NAME
CARFIN
         LGR-OP01   24  25  87  87   1  50      8     1    50     1     GLOBAL /
--
--       DEFINE LGR GRID BLOCK IN THE X-DIRECTION
--
NXFIN
         4  4                                                            /

ENDFIN
```

The above example splits the global cells (24-25,87, 1-50) into four and four LGR grid blocks in the x-direction, and since the HXFIN keyword has not been supplied, then the host cells will split into equal proportions.

6.3.142 NYFIN – DEFINE THE NUMBER OF LGR GRID BLOCKS IN THE Y-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

NYFIN defines the number of Local Grid Refinement ("LGR") cells within a global or host cell in the x-direction via a vector, as opposed to defining the size for each cell for a Cartesian LGR Grid. The LGR keyword in the RUNSPEC section should be activated to indicate an LGR is being used, and the keyword NYFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NYFIN	NYFIN is a vector of integer numbers describing the number of LGR cells within each defined global or host grid block in the y-direction in a Cartesian LGR grid. Repeat counts may be used, for example 2*2.0.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NY parameter on the CARFIN keyword in the GRID section.

2) The keyword is terminated by "/".

Table 6.88: NYFIN Keyword Description

See also the CARFIN, ENDFIN, NXFIN, and NZFIN keywords in the GRID section to fully define a Cartesian LGR grid model.

Example

```
--
--       CARFIN LGR GRID COMMANDS
--
--       LGR        ----- HOST GRID ------    -- CARFIN GRID --  MAX     HOST
--       NAME       I1  I2  J1  J2  K1  K2     NX    NY    NZ   WELLS   NAME
CARFIN
         LGR-OP01   24  24  86  87   1  50      1     8    50     1     GLOBAL /
--
--       DEFINE LGR GRID BLOCK IN THE Y-DIRECTION
--
NYFIN
         4  4                                                                /

ENDFIN
```

The above example splits the global cells (24, 86-87,1-50) into four and four LGR grid blocks in the y-direction and since the HYFIN keyword has not been supplied, then the host cells will split into equal proportions.

6.3.143 NZFIN – DEFINE THE NUMBER OF LGR GRID BLOCKS IN THE Z-DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

NZFIN defines the number of Local Grid Refinement ("LGR") cells within a global or host cell in the z-direction via a vector, as opposed to defining the size for each cell for a Cartesian LGR Grid. The LGR keyword in the RUNSPEC section should be activated to indicate an LGR is being used, and the keyword NXFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NZFIN	NZFIN is a vector of integer numbers describing the number of LGR cells within each defined global or host grid block in the x-direction in a Cartesian LGR grid. Repeat counts may be used, for example 2*2.0.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX parameter on the CARFIN keyword in the GRID section.

2) The keyword is terminated by "/".

Table 6.89: NZFIN Keyword Description

See also the CARFIN, ENDFIN, NXFIN, and NYFIN keywords in the GRID section to fully define a Cartesian LGR grid model.

Example

```
--
--        CARFIN LGR GRID COMMANDS
--
--        LGR         ----- HOST GRID ------    -- CARFIN GRID --   MAX      HOST
--        NAME        I1   I2   J1   J2   K1   K2      NX     NY     NZ    WELLS    NAME
CARFIN
          LGR-OP01    24   24   86   86    1   50       8      1    100     1      GLOBAL /
--
--        DEFINE LGR GRID BLOCK IN THE Z-DIRECTION
--
NZFIN
          50*2                                                                      /

ENDFIN
```

The above example splits the global cells (24, 86, 1-50) into two LGR grid blocks per host cell in the z-direction, and since the HZFIN keyword has not been supplied, then the host cells will split into equal proportions.

6.3.144 OLDTRAN – ACTIVATE CARTESIAN REGULAR GRID TRANSMISSIBILITIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on Cartesian Regular Grids geometry transmissibility calculation (or block centered transmissibility calculations), which is the default option for this type of grid. Grids defined by the DX, DY, and DZ series of keywords will always invoke this option by default.

For Irregular Corner-Point Grids defined by the COORD and ZCORN keywords Irregular Corner-Point Grid geometry transmissibility calculations should be activated via the NEWTRAN keyword. Again this is automatically invoked if this type of grid is being employed.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        ACTIVATE CARTESIAN REGULAR GRID TRANSMISSIBILITIES
--
OLDTRAN
```

The above example manually activates Cartesian Regular Grid transmissibility calculations.

6.3.145 OLDTRANR – ACTIVATE RADIAL REGULAR GRID TRANSMISSIBILITIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on Radial Regular Grids geometry transmissibility calculation (or block centered transmissibility calculations), which is the default option for this type of grid. Grids defined by the DR, DTHETA, and DZ series of keywords will always invoke this option by default.

For Irregular Corner-Point Grids defined by the COORD and ZCORN keywords Irregular Corner-Point Grid geometry transmissibility calculations should be activated via the NEWTRAN keyword. Again this is automatically invoked if this type of grid is being employed.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--        ACTIVATE RADIAL REGULAR GRID TRANSMISSIBILITIES
--
OLDTRANR
```

The above example manually activates Radial Regular Grid transmissibility calculations.

6.3.146 OPERATE – DEFINE MATHEMATICAL OPERATIONS ON ARRAYS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, OPERATE, defines mathematical operations on property arrays (NTG, PORO etc.) and optionally using another property array as input to the function. The keyword allows for various mathematical functions and their associated variables to be defined and applied to the selected array data. Input constants can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

No.	Name	Description	Default
1	Y	The name of the array to be modified. This is the keyword name identifying the property and is up to eight characters in length and optionally enclosed in quotes.	None
2	I1	A positive integer that defines the lower bound of the array in the I-direction to be modified must be greater than or equal to one and less than or equal to I2 and NX.	1
3	I2	A positive integer that defines the upper bound of the array in the I-direction to be modified must be greater than or equal to I1 and less than or equal to NX	NX
4	J1	A positive integer that defines the lower bound of the array in the J-direction to be modified must be greater than or equal to one and less than or equal to J2 and NY.	1
5	J2	A positive integer that defines the upper bound of the array in the J-direction to be modified must be greater than or equal to J1 and less than or equal to NY.	NY
6	K1	A positive integer that defines the lower bound of the array in the K-direction to be modified must be greater than or equal to one and less than or equal to K2 and NZ.	1
7	K2	A positive integer that defines the upper bound of the array in the K-direction to be modified must be greater than or equal to K1 and less than or equal to NZ.	NZ
8	EQUATION	A defined character string enclosed in quotes that selects the mathematical function to be applied, using the X array and the ALPHA and BETA constants declared on this keyword. EQUATION should be set to one of the following character strings: 'MULTA' - $Y = \alpha X + \beta$ 'POLY' - $Y = Y + \alpha X^{\beta}$ 'SLOG' - $Y = 10^{\alpha X + \beta}$ 'LOG10' - $Y = \log(X)$ 'LOGE' - $Y = \ln(X)$ 'INV' - $Y = \frac{1}{X}$ 'MULTX' - $Y = \alpha X$ 'ADDX' - $Y = \alpha + X$ 'COPY' - $Y = X$ 'MAXLIM' - $Y = max(\alpha, X)$ 'MINLIM' - $Y = min(\alpha, X)$ 'MULTP' - $Y = \alpha X^{\beta}$ 'ABS' - $Y = \lvert(X)\rvert$ 'MULTIPLY' - $Y = XY$	None

No.	Name	Description	Default
9	X	The name of the array to be used as an input parameter. This is the keyword name identifying the property and is up to eight characters in length and optionally enclosed in quotes.	None
10	ALPHA	An integer or real value that is the α variable in the EQUATION function.	None
11	BETA	An integer or real value that is the β variable in the EQUATION function.	None

Notes:

1) Where NX, NY and NZ are the dimensions of the model as defined on the DIMENS keyword in the RUNSPEC section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.90: OPERATE Keyword Description

The applicable arrays for each section are defined in Table 6.91 as shown below.

OPERATE Keyword And Variable Options By Section						
GRID	**EDIT**	**PROPS**	**REGIONS**	**SOLUTION**	**SUMMARY**	**SCHEDULE**
DX	DEPTH	SWL	ENDNUM	PRESSURE		
DY	PORV	SWCR	EQLNUM	SWAT		
DZ	TRANX	SWU	FIPNUM	SGAS		
PERMX	TRANY	SGL	IMBNUM	RV		
PERMY	TRANZ	SGCR	MISCNUM	RS		
PERMZ	DIFFX	SGU	PVTNUM	TBLK		
MULTX	DIFFY	KRW	ROCKNUM	GI		
MULTY	DIFFZ	KRO	SATNUM	OILAPI		
MULTZ	TRANR	KRG	WH2NUM	SALT		
DR	TRANTHT	PCG		GASCONC		
THETA	DIFFR	PCW		SOLVCONC		
PERMR	DIFFTHT			SOLVFRAC		
PERMTHT				SFOAM		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.91: OPERATE Keyword Applicable Arrays by Section

Note that care should be exercised when performing operations on integer array data as all transforms are performed using floating point arithmetic operations. In addition, operations on any of the transmissibility arrays (TRANX, TRANX-, TRANY, TRANY-, TRANZ, and TRANZ-) may result in untended consequences as these arrays have zero values on the boundary of the grid. In this use OPM ResInsight to verify and visually inspect the results.

Example

The first example uses the MULTP function combined with the Net-to-Gross (NTG) array to re-scale the MULTX, MULTY and MULTZ arrays to reduce the transmissibility in three separation reservoirs based on the reservoir quality (NTG).

```
--
--        MATHEMATICAL OPERATIONS ON ARRAYS
--
--        OUTPUT   ---------- BOX ---------   OPERATION  INPUT   ALPHA   BETA
--        ARRAY    I1  I2   J1  J2   K1  K2   ---------  ARRAY   -----   ----
OPERATE
          MULTX    1*  1*   1*  1*     1 32   'MULTP'    NTG     1.00    0.75 / RES1
          MULTY    1*  1*   1*  1*     1 32   'MULTP'    NTG     1.00    0.75 / RES1
          MULTZ    1*  1*   1*  1*     1 32   'MULTP'    NTG     1.00    0.75 / RES1

          MULTX    1*  1*   1*  1*    34 64   'MULTP'    NTG     1.00    0.85 / RES2
          MULTY    1*  1*   1*  1*    34 64   'MULTP'    NTG     1.00    0.85 / RES2
          MULTZ    1*  1*   1*  1*    34 64   'MULTP'    NTG     1.00    0.85 / RES2

          MULTX    1*  1*   1*  1*    67 96   'MULTP'    NTG     1.00    0.50 / RES3
          MULTY    1*  1*   1*  1*    67 96   'MULTP'    NTG     1.00    0.50 / RES3
          MULTZ    1*  1*   1*  1*    67 96   'MULTP'    NTG     1.00    0.50 / RES3
/
```

The next example shows how to set the maximum gas saturation (SGU) based on the minimum (lowest) water saturation (SWL) when using the End-Point Scaling option.

```
--
--        MATHEMATICAL OPERATIONS ON ARRAYS
--
--        OUTPUT   ---------- BOX ---------   OPERATION  INPUT   ALPHA   BETA
--        ARRAY    I1  I2   J1  J2   K1  K2   ---------  ARRAY   -----   ----
OPERATE
          SGU      1*  1*   1*  1*   1*  1*   'MULTA'     SWL    -1.0    1.0      /
/
```

The above example set the maximum gas saturation to be one minus the minimum water saturation.

6.3.147 OPERATER – Define Mathematical Operations on Arrays by Region

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the mathematical operations on arrays for specific regions in the commercial simulator and is currently not supported by OPM Flow. However, similar functionality is provided by the ADD and MULTIPLY keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.148 OPERNUM – Define Regions for Mathematical Operations on Arrays

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the OPERATE region numbers for each grid block. The OPERATE keyword defines mathematical operations on arrays in the commercial simulator and is currently not supported by OPM Flow. However, similar functionality is provided by the ADD and MULTIPLY keywords combined with the MULTNUM region array.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.149 OUTRAD - DEFINE THE OUTER RADIUS OF A RADIAL GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

OUTRAD[48] defines the OUTER radius of the reservoir model for a radial grid geometry. The RADIAL keyword in the RUNSPEC should be activated to indicate that radial geometry is being used.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	OUTRAD	A single real positive number greater than INRAD defining the outer radius of a radial grid.			
		feet	m	cm	None
Notes: 1) The keyword is terminated by "/".					

Table 6.92: OUTRAD Keyword Description

The keyword allows for an alternative method of entering the size of the R direction grid cells instead of entering the data using the DR or DRV keywords in the GRID section. Given the internal radius set by the INRAD keyword, the external radius set by the OUTRAD keyword and the number of grid cells in the R direction set by the NX variable on the DIMENS keyword in the RUNSPEC section, the R direction cells sizes are computed automatically on a geometric spacing, as defined by:

$$\frac{R_i}{R_{i-1}} = \left(\frac{OUTRAD}{R_{i_j-1}}\right)^{\frac{1}{(NX - i_j + 1)}} \tag{6.12}$$

or

$$R_i = \left(R_{i_j-1}\right)\left(\frac{OUTRAD}{R_{i_j-1}}\right)^{\frac{(i - i_j + 1)}{(NX - i_j + 1)}} \tag{6.13}$$

and the DR value for the ith cell, that is the value that can also be manually entered on the DR keyword in the GRID section, is given by:

$$DR_i = R_i - R_{i-1} \tag{6.14}$$

Where:

DR_i	=	DR value for the ith cell
R_i	=	current total radius for the i radii.
R_{i-1}	=	total radius for the i – 1 radii.
NX (NR)	=	number of radial grid cells excluding the inner radius
OUTRAD	=	the outer radius of the radial grid, the value includes the inner radius.

For example, given an inner radius set to 0.25, an outer radius of 2,050 and the number of cells in the R direction set to ten, then Table 6.93 shows the grid size calculations.

[48] *Radial grids are not currently implemented in this version of OPM Flow, but is expected to be incorporated in the next release.*

OUTRAD Radial Grid Example			
INRAD	0.25		
OUTRAD	2050.0		
NX	10		
NX	**Ri**	**DR**	**Ratio**
0	0.250	0.250	
1	0.616	0.366	1.463
2	1.516	0.900	2.463
3	3.733	2.217	2.463
4	9.193	5.460	2.463
5	22.638	13.445	2.463
6	55.748	33.109	2.463
7	137.281	81.533	2.463
8	338.058	200.777	2.463
9	832.477	494.420	2.463
10	2050.000	1217.523	2.463
Total		**2050.000**	

Table 6.93: OUTRAD Radial Grid Example

See also the DR, DRV, DTHETA, DTHETAV and TOPS keywords to fully define a Radial Grid.

Example

```
--
--        INNER RADIUS OF FIRST GRID BLOCK IN THE RADIAL DIRECTION
--
INRAD
         0.25                                                                  /
--
--        OUTER RADIUS OF FIRST GRID BLOCK IN THE RADIAL DIRECTION
--
OUTRAD
         2050.0                                                                /
```

The above example defines the inner radius to be 0.25 and the outer radius to be 2,050 feet. Note that the outer radius includes the inner radius.

6.3.150 PARAOPTS – DEFINE PARALLEL RUN OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PARAOPTS keyword defines various options for parallel runs, for when the Parallel option has been invoked by the PARALLEL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to run OPM Flow in parallel mode.

6.3.151 PEBI – ACTIVATE AND DEFINED PEBI GRID OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PEBI activates the unstructured Perpendicular Bisector ("PEBI")[49] and [50] loading of grid data generated by an external pre-processing program for generating simulation grids.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	OPTION1	A defined character string that activates or deactivates the checking of negative transmissibility values. OPTION1 should be set to YES to check for negative values, or NO switches off this option.	NO
2	OPTION2	A defined character string that activates or deactivates the calculation of pore volumes and transmissibilities. OPTION2 should be set to YES if the pore volumes and transmissibilities are provided, or NO for the values to calculated by the simulator.	NO

Table 6.94: PEBI Keyword Description

Example

```
--
--      OPTION1  OPTION2
--      CHECK    CALCULATE
GRIDOPTS
        NO       YES                                                    /
```

The above example switches off the negative transmissibility check and requests that the simulator calculates pore volumes and transmissibilities as they are not provided by the input data.

[49] *Heinemann, Z.E. and Brand, C.W. 1988. Gridding Techniques in Reservoir Simulation. Proc., First Intl. Forum on Reservoir Simulation, Alpbach, Austria, 339.*

[50] *Heinemann, Z.E., Brand, C.W., Munka, M. et al. 1991. Modeling Reservoir Geometry With Irregular Grids. SPE Res Eng 6 (2): 225–232. SPE-18412-PA. http://dx.doi.org/10.2118/18412-PA*

6.3.152 PERMAVE – DEFINE AVERAGE TRANSMISSIBILITY COEFFICIENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PERMAVE keyword defines the three directional exponent coefficients used to average the grid block permeabilities between two neighboring cells when calculating the transmissibility between the two blocks. The keyword can be used to change from the default weighted harmonic averaging (coefficient set equal to -1), to geometric (coefficient equal to zero), or to arithmetic averaging (coefficient equal to 1). The three coefficients represent the averaging in the x-, y- and z-directions.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.153 PERMJFUN – DEFINE LEVERETT J-FUNCTION PERMEABILITY FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PERMJFUN defines the permeability to be used in de-normalizing the Leverett J-Functions[51] for when the PERM variable on the JFUNC or the JFUNCR keyword in the GRID section has been set to "U", as oppose to using PERMX, PERMY, PERMZ arrays etc.

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PERMJFUN	PERMJFUN is an array of real positive numbers assigning the permeability to be used in de-normalizing the Leverett J-Function to each cell in the model. Repeat counts may be used, for example 20*100.0.			
		mD	mD	mD	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.95: PERMJFUN Keyword Description

For grid blocks that have not been assigned a PERMJFUN value the default directional permeability will be used, that is the average of PERMX and PERMY.

See also the PERMX, PERMY and PERMZ keywords to fully define the permeability for the model.

Example

```
--
--       DEFINE GRID BLOCK PERMJFUN FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PERMJFUN
         100*500.0   100*50.0   100*200.0                                    /
```

The above example defines the PERMJFUN to be 500.0, 50.0, and 200.0 for the first, second and third layers in the model for all 300 cells, as defined by the DIMENS keyword in the RUNSPEC section.

[51] *Leverett, M. C.; "Capillary Behaviour in Porous Solids", Trans. AIME (1941) 142, 152-168.*

6.3.154 PERMR – DEFINE THE PERMEABILITY FOR EACH CELL IN THE R DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PERMR[52] sets the permeability for each cell in the R direction in a radial geometry grid. The RADIAL keyword in the RUNSPEC should be activated to indicate that radial geometry is being used.

Although this keyword is read by OPM Flow, radial grids have not been fully implemented and therefore this type of grid should not be used.

[52] *Radial grids are not currently implemented in this version of OPM Flow but are expected to be incorporated in a future release.*

6.3.155 PERMTHT – DEFINE THE PERMEABILITY FOR EACH CELL IN THE THETA DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PERMTHT[53] sets the permeability for each cell in the THETA direction in a radial geometry grid. The RADIAL keyword in the RUNSPEC should be activated to indicate that radial geometry is being used.

Although this keyword is read by OPM Flow, radial grids have not been fully implemented and therefore this type of grid should not be used.

[53] *Radial grids are not currently implemented in this version of OPM Flow but are expected to be incorporated in a future release.*

6.3.156 PERMX - DEFINE THE PERMEABILITY IN THE X DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PERMX defines the permeability in the X direction for all the cells in the model via an array. The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PERMX	PERMX is an array of real positive numbers assigning the permeability in the X direction to each cell in the model. Repeat counts may be used, for example 20*100.0.			
		mD	mD	mD	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.96: PERMX Keyword Description

See also the PERMY and PERMZ keywords to fully define the permeability for the model.

Example

```
--
--        DEFINE GRID BLOCK PERMX DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PERMX
          100*500.0   100*50.0   100*200.0                                        /
```

The above example defines the PERMX to be 500.0, 50.0, and 200.0 for the first, second and third layers in the model for all 300 cells, as defined by the DIMENS keyword in the RUNSPEC section.

6.3.157 PERMY - DEFINE THE PERMEABILITY IN THE Y DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PERMY defines the permeability in the Y direction for all the cells in the model via an array. The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PERMY	PERMY is an array of real positive numbers assigning the permeability in the Y direction to each cell in the model. Repeat counts may be used, for example 20*100.0.			
		mD	mD	mD	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.97: PERMY Keyword Description

See also the PERMX and PERMZ keywords to fully define the permeability for the model.

Example

```
--
--        DEFINE GRID BLOCK PERMY DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PERMY
          100*500.0   100*50.0   100*200.0                                        /
```

The above example defines the PERMY to be 500.0, 50.0, and 200.0 for the first, second and third layers in the model for all 300 cells, as defined by the DIMENS keyword in the RUNSPEC section.

6.3.158 PERMZ - DEFINE THE PERMEABILITY IN THE Z DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PERMZ defines the permeability in the Z direction for all the cells in the model via an array. The keyword can be used for all grid types, except for the Radial Grid geometry.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PERMZ	PERMZ is an array of real positive numbers assigning the permeability in the Z direction to each cell in the model. Repeat counts may be used, for example 200*50.0.			
		mD	mD	mD	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.98: PERMZ Keyword Description

Note

Although PERMX and PERMZ are commonly set to be equal, PERMZ is typically not equal to either PERMX or PERMY. Normally PERMZ is set as a fraction of PERMX with typical values ranging from 0.1 to 0.5 times PERMX.

See also the PERMX and PERMY keywords to fully define the permeability for the model.

Example

```
--
--       DEFINE GRID BLOCK PERMZ DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PERMZ
         100*50.0    100*5.0   100*20.0                                          /
```

The above example defines the PERMZ to be 50.0, 5.0, and 20.0 for the first, second and third layers in the model for all 300 cells, as defined by the DIMENS keyword in the RUNSPEC section.

6.3.159 PETGRID – Load a Generic Simulation Grid File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PETGRID keyword instructs the simulator to load a Generic Simulation Grid (*.GSG) file that contains grid geometry data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.160 PINCH – DEFINE PINCH-OUT LAYER OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PINCH keyword defines the parameters used to control the generation of Non-Neighbor Connections ("NNCs") in the vertical (K) direction due to layers pinching out. This keyword is applied to all layers in the model as opposed to the PINCHREG keyword that offers more flexibility by applying the pinch-out controls to various regions in the model defined by the PINCHNUM keyword.

OPM Flow will automatically generate connections between non neighbor cells in the vertical direction based on the parameters on this keyword.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PINCHTHK	A real number defining the pinch-out threshold thickness for any cell. NNCs are generated across inactive cells having a vertical thickness less than PINCHTHK.			
		ft. 0.001	m 0.001	cm 0.001	Defined
2	PINCHOPT	A character string controlling the generation of pinch-outs when the MINPV keyword has been used to deactive cells with small pore volumes. PINCHOPT can either be set to: 1) GAP to allow the generation of NNCs across cells that have been made inactive with the MINPV keyword when the thickness is greater than PINCHTHK threshold. 2) NOGAP to enforce the strict adherence to the PINCHTHK threshold whether or not cells have been made inactive due to the MINPV keyword.			GAP
3	PINCHGAP	A real number defining the maximum "empty" thickness allowed between grid blocks in adjacent grid layers for a non-zero transmissibility to exist between them.			
		ft. 1.0E20	m 1.0E20	cm 1.0E20	Defined
4	PINCHCAL	A character string controlling the calculation of the pinch-out transmissibilities. PINCHCAL can either be set to: 1) TOPBOT results in the pinch-out transmissibility being calculated from the half-cell Z-direction transmissibilities of the active cells on either side of the pinched-out layers. 2) ALL results in the pinch-out transmissibility being calculated from the Z-direction transmissibilities harmonic average of all the cells between the active cells on either side of the pinched-out layers.			TOPBOT

No.	Name	Description			Default
		Field	Metric	Laboratory	
5	PINCHMUL	A character string controlling the calculation of the pinch-out transmissibilities when adjustments have been made by the MULTZ keyword. PINCHMUL can either be set to: 1) TOP results in the pinch-out transmissibility being calculated from the active cell at the top of the pinch-out. 2) ALL results in the pinch-out transmissibility being calculated from the minimum value of the MULTZ of the active cell at the top of the pinch-out and all the inactive cells in the pinch-out vertical column. Note if PINCHCAL has been set equal to ALL then PINCHMUL is reset to TOP, irrespective of the entered value for PINCHMUL.			TOP
Notes: 1) The keyword is terminated by "/".					

Table 6.99: PINCH Keyword Description

Examples

The first example below will create NNCs between the cells above and below any cell having vertical thickness less than 0.01 in either feet or metres.

```
--
--        SET PINCH-OUT PARAMETERS FOR CALCULATING PINCH-OUT PROPERTIES
--
PINCH
--        THRESHOLD   GAP      EMPTY   TRANS
--        THICKNESS   NO GAP   GAP     CALC
          0.01        1*       1*      1*                                  /
```

For the second example, the MINPV keyword is used to set the minimum pore volume to 500 m^3 (metric units) and then the PINCH keyword is invoked with PINCHGAP set equal to GAP, as follows:

```
--
--        MINIMUM PORE VOLUME FOR ACTIVE CELLS
--
MINPV
          1000.0                                                          /
--
--        SET PINCH-OUT CRITERIA FOR THE MODEL
--
PINCH
--        THRESHOLD   GAP      EMPTY   TRANS
--        THICKNESS   NO GAP   GAP     CALC
          0.1         GAP       1*     1*                                  /
```

In the above example the MINPV keyword will deactivate all cells with pore volumes less than 500 m^3. These deactivated cells are inactive in the model and therefore are not included in the flow calculations; however, by default they will result in no-flow barriers but may not be thin enough for PINCH to create NNCs across them. By setting PINCHGAP equal to GAP on the PINCH keyword (the default setting), then OPM Flow generates NNCs across the cells that have been deactivated by the MINPV keyword. However, in this case there may be grid blocks in the model with a pore volume greater than MINPV but a thickness less than the pinch-out threshold. These cells will not be deactivated by the PINCH keyword.

6.3.161 PINCHNUM – DEFINE PINCH-OUT REGIONS FOR THE PINCHREG KEYWORD

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PINCHNUM keyword defines the pinch-out region numbers for each grid block, as such there must be one entry for each cell in the model. The array is used with the PINCHREG keyword to set the pinch-out options and threshold thickness for each region.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	PINCHNUM	PINCHNUM defines an array of positive integers assigning a grid cell to a particular PINCHNUM region. The maximum number of PINCHNUM regions is set by the NRPINC variable on the GRIDOPTS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.100: PINCHNUM Keyword Description

Example

The example below sets defines three PINCHNUM regions for various layers in a model based on the model's layering.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          MULTNUM     1            1*  1*   1*  1*   1*  1* / SET REGION 1
          MULTNUM     2            1   2    1   2    10  50 / SET REGION 2
          MULTNUM     3            1   2    1   2    51 100 / SET REGION 3
/
```

One can then set the pinch-out criteria for each region.

```
--
--        SET PINCH-OUT CRITERA VIA THE PINCHNUM REGION
--
PINCHREG
--        THRESHOLD   GAP      EMPTY   TRANS
--        THICKNESS   NO GAP   GAP     CALC
          0.1         1*       1*      1*                  / PINCHNUM 01
          1.0         1*       10      1*                  / PINCHNUM 02
          1.0         NOGAP    20      1*                  / PINCHNUM 03
```

The above example sets the default pinch-out criteria for grid blocks defined as region one via the PINCHNUM array and different criteria for regions two and three.

6.3.162 PINCHOUT - DEFINE PINCH-OUT LAYERS OPTION (FIXED)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PINCHOUT keyword activates the generation of Non-Neighbor Connections ("NNCs") in the vertical (K) direction due to layers pinching out, using a constant threshold thickness of 0.001 for all unit systems. See also the PINCH keyword in the GRID section that allows for specifying the threshold thickness and other parameters on a layer basis, and the PINCHREG keyword that applies the pinch-out controls to various regions in the model defined by the PINCHNUM keyword.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

The example will create NNCs between the cells above and below any cell having vertical thickness less than 0.001 in either feet or metres.

```
--
--        SET PINCH-OUT CRITERA WITH CONSTANT THRESHOLD THICKNESS OF 0.001
--
PINCHOUT
```

6.3.163 PINCHREG - DEFINE PINCH-OUT REGION OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PINCHREG keyword defines the parameters used to control the generation of Non-Neighbor Connections ("NNCs") in the vertical (K) direction due to layers pinching out in combination with the PINCHNUM keyword. This allows different regions in the model to use different criteria in controlling the how pinch-outs are generated. The keyword should contain NRPINC records defining the criteria for each pinch-out region defined with the PINCHNUM keyword. NRPINC is the maximum number of PINCHNUM regions defined via the GRIDOPTS keyword in the RUNSPEC section.

An alternative method to set the pinch-out criteria is to use the PINCH keyword, that applies the criteria to the whole model.

OPM Flow will automatically generate connections between non neighbor cells in the vertical direction based on the parameters on this keyword.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PINCHTHK	A real number defining the pinch-out threshold thickness for any cell. NNCs are generated across inactive cells having a vertical thickness less than PINCHTHK.			
		ft. 0.001	m 0.001	cm 0.001	Defined
2	PINCHOPT	A character string controlling the generation of pinch-outs when the MINPV keyword has been used to deactivate cells with small pore volumes. PINCHOPT can either be set to: 1) GAP to allow the generation of NNCs across cells that have been made inactive with the MINPV keyword when the thickness is greater than PINCHTHK threshold. 2) NOGAP to enforce the strict adherence to the PINCHTHK threshold whether or not cells have been made inactive due to the MINPV keyword.			GAP
3	PINCHGAP	A real number defining the maximum "empty" thickness allowed between grid blocks in adjacent grid layers for a non-zero transmissibility to exist between them.			
		ft. 1.0E20	m 1.0E20	cm 1.0E20	Defined
4	PINCHCAL	A character string controlling the calculation of the pinch-out transmissibilities. PINCHCAL can either be set to: 1) TOPBOT results in the pinch-out transmissibility being calculated from the half-cell Z-direction transmissibilities of the active cells on either side of the pinched-out layers. 2) ALL results in the pinch-out transmissibility being calculated from the Z-direction transmissibilities harmonic average of all the cells between the active cells on either side of the pinched-out layers.			TOPBOT

No.	Name	Description			Default
		Field	Metric	Laboratory	
5	PINCHMUL	A character string controlling the calculation of the pinch-out transmissibilities when adjustments have been made by the MULTZ keyword. PINCHMUL can either be set to: 1) TOP results in the pinch-out transmissibility being calculated from the active cell at the top of the pinch-out. 2) ALL results in the pinch-out transmissibility being calculated from the minimum value of the MULTZ of the active cell at the top of the pinch-out and all the inactive cells in the pinch-out vertical column. Note if PINCHCAL has been set equal to ALL then PINCHMUL is reset to TOP, irrespective of the entered value for PINCHMUL.			TOP

Notes:

1) The keyword should contain NRPINC records defining the criteria for each pinch-out region defined with the PINCHNUM keyword. NRPINC is the maximum number of PINCHNUM regions defined via the GRIDOPTS keyword in the RUNSPEC section.

2) Each record must be terminated by a "/" there is no keyword terminating "/".

Table 6.101: PINCHREG Keyword Description

Example

```
--
--        SET PINCH-OUT CRITERA VIA THE PINCHNUM REGION
--
PINCHREG
--        THRESHOLD   GAP      EMPTY   TRANS
--        THICKNESS   NO GAP   GAP     CALC
          0.1         1*       1*      1*                  / PINCHNUM 01
          1.0         1*       10      1*                  / PINCHNUM 02
          1.0         NOGAP    20      1*                  / PINCHNUM 03
```

The above example sets the default pinch-out criteria for grid blocks defined as region one via the PINCHNUM array and different values for regions two and three.

6.3.164 PINCHXY – DEFINE PINCH-OUT AREAL OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PINCHXY keyword defines the x-direction and y-direction threshold thickness used to control the generation of Non-Neighbor Connections ("NNCs") in the x- and y- directions for missing cells in the areal plane.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PINCHTHX	A real number defining the pinch-out threshold width for any cell in the x-direction. NNCs are generated across inactive cells having a width less than PINCHTHX in the x-direction.			
		ft. 0.001	m 0.001	cm 0.001	Defined
2	PINCHTHY	A real number defining the pinch-out threshold width for any cell in the y-direction. NNCs are generated across inactive cells having a width less than PINCHTHY in the y-direction.			
		ft. 0.001	m 0.001	cm 0.001	Defined

Notes:

1) The keyword is terminated by "/".

Table 6.102: PINCHXY Keyword Description

Example

The example below will create NNCs between the cells in the areal plane having cell widths less than 0.01 in either feet or metres in both the x- and y-directions.

```
--
--        SET PINCH-OUT PARAMETERS FOR AREAL PLANE
--
PINCHXY
--        X-DIRC       Y-DIRC
--        THRESHOLD    THRESHOLD
--
          0.01         0.01                                          /
```

6.3.165 PORO - DEFINE THE POROSITY VALUES FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PORO defines the porosity for all the cells in the model via an array. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PORO	PORO is an array of real positive numbers that are greater than or equal to zero and less than or equal to one that are the porosity values for each cell in the model. Repeat counts may be used, for example 3000*0.15			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.103: PORO Keyword Description

See also the NTG, PERMX, PERMY and PERMX keywords to fully define a grid's properties

Example

```
--
--    DEFINE GRID BLOCK POROSITY DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PORO
      300*0.300                                                                  /
```

The above example defines a constant porosity of 0.300 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.166 PYEND – END THE DEFINITION OF A PYINPUT SECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords.

PYINPUT declares the start of a PYINPUT Definition Section on a single separate line, which is then followed by various standard Python commands, with one command per line. A PYINPUT Definition Section is terminated by a PYEND keyword (this keyword) on a separate single line.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Although this keyword is read by OPM Flow and the script processing has been implemented, one should use caution when using this facility as it may result in OPM Flow aborting. This is because the PYINPUT facility allows the user to implement complex functionality and the implementation is new for the 2020-04 release. Users should therefore use caution when using this facility.

Note

This is an OPM Flow specific keyword for the simulator's scripting facility using the standard Python interpreter, as such it gives more flexibility than the commercial simulator's data editing keywords (ADD, EQUAL, MULTIPLY, etc.), although OPM Flow also supports these keywords as well.

The PYINPUT facility should be considered experimental as details of the OPM Flow - Python interface might change for future releases. In particular, the current implementation is quite minimal; however, future releases are expected to add more entry points in the simulator's deck class which can be used to manipulate the input deck as the data is loaded. As a user you are encouraged to come with wishes in this regard.

The PYINPUT facility is very powerful and allows for any piece of Python code to be included and run, including potentially malicious code. The important point is to scrutinize the Python code in between PYINPUT and PYEND in a deck you receive from other parties.

See also the PYACTION keyword in the SCHEDULE section which is also part of OPM Flow's Python scripting facility, that loads a standard Python script file that can be used to define a series of conditions and actions as the simulation proceeds through time.

Example

The example shows how to construct the DX variable in the GRID section and to add the resulting DX array as part of the input deck.

```
--
--       START OF PYINPUT SECTION
--
PYINPUT
#
# Import Numpy Model
#
import numpy as np
#
# Define DX and Get the Input Decks Unit Systems
#
dx = np.array([100.0, 100.0, 100.0, 100.0])
active_unit_system  = context.deck.active_unit_system()
default_unit_system = context.deck.default_unit_system()
#
# Set DX in the Input Deck
#
kw = context.DeckKeyword( context.parser['DX'], dx, active_unit_system,
default_unit_system )
context.deck.add(kw)

PYEND
```

The active Parser objects are accessible as context.parser and the active Deck object is available as context.deck.

6.3.167 PYINPUT – DEFINE THE START OF A PYINPUT SECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords used by the simulator.

PYINPUT declares the start of a PYINPUT Definition Section on a single separate line, which is then followed by various standard Python commands, with one command per line. A PYINPUT Definition Section is terminated by a PYEND keyword on a separate single line.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Although this keyword is read by OPM Flow and the script processing has been implemented, one should use caution when using this facility as it may result in OPM Flow aborting. This is because the PYINPUT facility allows the user to implement complex functionality and the implementation is new for the 2020-04 release. Users should therefore use caution when using this facility.

Note

This is an OPM Flow specific keyword for the simulator's scripting facility using the standard Python interpreter, as such it gives more flexibility than the commercial simulator's data editing keywords (ADD, EQUAL, MULTIPLY, etc.), although OPM Flow also supports these keywords as well.

The PYINPUT facility should be considered experimental as details of the OPM Flow - Python interface might change for future releases. In particular, the current implementation is quite minimal; however, future releases are expected to add more entry points in the simulator's deck class which can be used to manipulate the input deck as the data is loaded. As a user you are encouraged to come with wishes in this regard.

The PYINPUT facility is very powerful and allows for any piece of Python code to be included and run, including potentially malicious code. The important point is to scrutinize the Python code in between PYINPUT and PYEND in a deck you receive from other parties.

No.	Name	Description	Default
PYINPUT		PYINPUT declares the start of a PYINPUT Definition Section. This is then followed by any number Python commands.	Not Applicable
1-1	PYTHON	A series of standard Python commands with one line per command. The active Parser objects are accessible as context.parser and the active Deck object is available as context.deck.	
PYEND		PYEND declares the end of a PYINPUT Definition Section. The Python code between PYINPUT and PYEND is read and executed, and the simulator thenreturns to reading the normal simulation input deck.	

Notes:

1) There is no terminating "/" for this keyword, instead the PYEND keyword terminates the keyword.

Table 6.104: PYINPUT Keyword Description

The PYINPUT/PYEND set of keywords is a result of combining two programming languages, the interactive Python interpreter and OPM Flow's source code language C++. When combing two languages one extends and embeds one into the other. When extending Python with C++ the functionality implemented in C++ is

made available to Python applications, when embedding Python in C++ one can call Python functions from within C++. The PYINPUT/PYEND set of keywords is based on embedding a Python interpreter in the C++ OPM Flow simulator, but the Python code actually runs as part of the PYINPUT keyword is based on wrapping C++ objects in Python, that is extending Python.

The Python code in between the PYINPUT and PYEND keywords are imported during processing of the input deck and as such this implies that basic Python syntax checking is performed during reading the Python script.

See also the PYACTION keyword in the SCHEDULE section which is also part of OPM Flow's Python scripting facility, that loads a standard Python script file that can be used to define a series of conditions and actions as the simulation proceeds through time.

Example

The example shows how to construct the DX variable in the GRID section and to add the resulting DX array as part of the input deck.

```
--
--       START OF PYINPUT SECTION
--
PYINPUT
#
# Import Numpy Model
#
import numpy as np
#
# Define DX and Get the Input Decks Unit Systems
#
dx = np.array([100.0, 100.0, 100.0, 100.0])
active_unit_system  = context.deck.active_unit_system()
default_unit_system = context.deck.default_unit_system()
#
# Set DX in the Input Deck
#
kw = context.DeckKeyword( context.parser['DX'], dx, active_unit_system,
default_unit_system )
context.deck.add(kw)

PYEND
```

The active Parser objects is accessible as context.parser and the active Deck object is available as context.deck.

6.3.168 QMOBIL ACTIVATE OR DEACTIVATE LGR END-POINT MOBILITY CORRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The QMOBIL keyword activates or deactivates the end-point mobility correction for Local Grid Refinements ("LGR"), for when LGRs have been activated for the input deck using the LGR keyword in the RUNSPEC section. QMOBIL should be placed in between the LGR definition keywords CARFIN, or RADIN (or RAFDIN4) and the ENDFIN keyword in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.169 RADFIN – Define a Radial Local Grid Refinement with One Column

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines a radial local grid refinement using one columns Local grid refinement is currently not supported by OFM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.170 RADFIN4 – Define a Radial Local Grid Refinement with Four Columns

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines a radial local grid refinement using four columns. Local grid refinement is currently not supported by OFM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

6.3.171 REFINE – START THE DEFINITION OF A LOCAL GRID REFINEMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The REFINE keyword defines the start of a Cartesian or radial Local Grid Refinement ("LGR") definition that sets the properties of the selected LGR. The keyword is then followed by the property keywords associated with the section where the keyword is being invoked. For example, if the REFINE keyword is used in the GRID section then most of the keywords in that section can be used to set the grid properties for the LGR.

The ENDFIN keyword is used to terminate the LGR definition.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.172 RESVNUM – DEFINE RESERVOIR COORDINATE DATA SET

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RESVNUM keyword is used to define the start of a reservoir coordinate data set and stipulates the reservoir number for the data set. The keyword is used in conjunction with the COORD keyword in the GRID section, that specifies a set of coordinate lines or pillars for a reservoir grid via an array. Note that the COORD keyword should immediately follow the RESVNUM keyword.

See the NUMRES keyword in the RUNSPEC section that defines he number of reservoir grids (COORD data sets) that the simulator should process.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	RESVNUM	A positive integer values that defines the reservoir coordinate data set, or the independent reservoir, for which the subsequent COORD data is to be associated with. RESVNUM should be less than or equal to NUMRES on the NUMRES keyword in the RUNSPEC section. OPM Flow currently only accepts a single data set, that is the default value of one.	1

Notes:

1) The keyword is terminated by "/".

Table 6.105: RESVNUM Keyword Description

The facility is useful to combine two separate reservoir grids into one model in the simulator.

Example

```
--
--        NUMRES
--        NUMBER
RESVNUM
          1                                                                    /
--
-- SPECIFY VERTICAL COORDINATE LINES FOR A REGULAR 3 x 2 GRID
--(DX = 100 and DY = 200)
--
-- X1      Y1     Z1       X2      Y2     Z2
-- ---     ---    ----     ---     ---    ----
COORD
     0       0   1000       0       0   5000
   100       0   1000     100       0   5000
   200       0   1000     200       0   5000
   300       0   1000     300       0   5000
     0     200   1000       0     200   5000
   100     200   1000     100     200   5000
   200     200   1000     200     200   5000
   300     200   1000     300     200   5000
     0     400   1000       0     400   5000
   100     400   1000     100     400   5000
   200     400   1000     200     400   5000
   300     400   1000     300     400   5000
/
--
--        NUMRES
--        NUMBER
RESVNUM
          2                                                                    /
--
-- SPECIFY VERTICAL COORDINATE LINES FOR A REGULAR 3 x 2 GRID
--(DX = 100 and DY = 200)
--
-- X1      Y1     Z1       X2      Y2     Z2
-- ---     ---    ----     ---     ---    ----
COORD
     0       0   1000       0       0   5000
   100       0   1000     100       0   5000
   200       0   1000     200       0   5000
   300       0   1000     300       0   5000
     0     200   1000       0     200   5000
   100     200   1000     100     200   5000
   200     200   1000     200     200   5000
   300     200   1000     300     200   5000
     0     400   1000       0     400   5000
   100     400   1000     100     400   5000
   200     400   1000     200     400   5000
   300     400   1000     300     400   5000
/
```

6.3.173 ROCKFRAC - DEFINE THE ROCK VOLUME TO BULK VOLUME FRACTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ROCKFRAC defines the rock volume to bulk volume fraction for all the cells, The keyword can be used with all grid types. Rock volume of a grid block is calculated by multiply a cell's bulk volume by it's ROCKFRAC volume. A cell's rock volume is used in the Coal option to calculate the adsorbed gas in the rock (coal), as well as the Thermal and Temp options to calculate the energy is stored in the rock.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ROCKFRAC	ROCKFRAC is an array of real numbers greater than or equal to zero and less than or equal to one, that are assigned the rock volume to bulk volume fraction values for each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 200*0.850.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) Setting a cells ROCKFRAC value to zero will make the cell inactive, similar to setting the cells ACTNUM property to zero.
2) The keyword is terminated by "/".

Table 6.106: NTG Keyword Description

See also the PORO, PERMX, PERMY, PERMZ and NTG keywords to fully define a grid's properties.

Example

```
--
--       DEFINE GRID ROCKFRAC DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
ROCKFRAC
         100*1.000   100*0.850   100*0.500                                    /
```

The above example defines a constant ROCKFRAC of 1.00 for the first 100 cells, then 0.85 for the second 100 hundred cells, and finally 0.500 for the last 100 cell, for the 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.174 RPTGRID – DEFINE GRID SECTION REPORTING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data in the GRID section that is to be printed to the output print file in human readable format. The keyword has two distinct forms, the first of which consists of the keyword followed by a series of integers on the next line indicating the data to be printed (see the first example). This is the original formal in the commercial simulator and was subsequently superseded by the second format. The second format consists of the keyword followed by a series of character strings that indicate the data to be printed. In most cases the character string is the keyword used to load the data in the OPM Flow input deck, for example PORO for the porosity array. Its is anticipated that OPM Flow will eventually support the functionality of the second format only, the first format although recognized will be completely ignored.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	ALLNCC	Print all the non-neighbor connections.	N/A
2	COORD	Print the coordinate lines.	N/A
3	COORDYS	Print the coordinate systems.	N/A
4	DEPTH	Print grid cells center depths.	N/A
….		….	N/A

Notes:

1) The keyword is terminated by "/".

Table 6.107: RPTGRID Keyword Description

Note

This keyword has the potential to produce very large print files that some text editors may have difficulty loading, coupled with the fact that reviewing the data in this format is very cumbersome.

A more efficient solution is to load the *.INIT file into OPM ResInsight to view the data graphically, this also has the benefit of being able to filter the grid based on I, J, K ranges and grid properties.

Examples

The first example shows the original format of this keyword; although the keyword and format are recognized by OPM Flow, the format is ignored and is unlikely to be implemented in in the simulator.

```
--
--       DEFINE GRID SECTION REPORT OPTION (ORIGINAL FORMAT)
-
RPTGRID
         1        2*0      1        3*1                                        /
```

The next example shows the second format of the keyword which may be supported in a future release of OPM Flow.

```
--       DEFINE GRID SECTION REPORT OPTIONS
--
RPTGRID
         DX       DY       DZ       DEPTH    PORO     PERMX                    /
```

6.3.175 RPTGRIDL – DEFINE GRID SECTION REPORTING FOR LGRS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data in the GRID section that is to be printed to the output print file in human readable format for Local Grid Refinements ("LGRs"), for when LGRs have been activated for the input deck using the LGR keyword in the RUNSPEC section.

The keyword has two distinct forms, the first of which consists of the keyword followed by a series of integers on the next line indicating the data to be printed (see the first example). This is the original formal in the commercial simulator and was subsequently superseded by the second format. The second format consists of the keyword followed by a series of character strings that indicate the data to be printed. In most cases the character string is the keyword used to load the data in the OPM Flow input deck, for example PORO for the porosity array. Its is anticipated that OPM Flow will eventually support the functionality of the second format only, the first format although recognized will be completely ignored.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	ALLNCC	Print all the non-neighbor connections.	N/A
2	COORD	Print the coordinate lines.	N/A
3	COORDYS	Print the coordinate systems.	N/A
4	DEPTH	Print grid cells center depths.	N/A
….		….	N/A
24	ALLNNC	ALLNNC is a defined positive integer that specifies the type of Non-Neighbor Connections ("NNC") to be printed, and should be set to one of the follow: 1) To print the NNCs within the LGRs, and the connections between the local and host cells to the print file (*.PRT). 2) To print the NNCs within the LGRs, and the connections between the local and host cells to the print (*.PRT) and debug files (*.DBG). 3) Same as (2) but the data in the debug file (*.DBG) is written out in an alternative format.	N/A
….		….	N/A
57	EXTHOST	EXTHOSTS outputs host cells for Perpendicular Bisector ("PEBI")[54 and 55] LGRs.	
….		….	N/A

Notes:

1) The keyword is terminated by "/".

Table 6.108: RPTGRIDL Keyword Description

[54] *Heinemann, Z.E. and Brand, C.W. 1988. Gridding Techniques in Reservoir Simulation. Proc., First Intl. Forum on Reservoir Simulation, Alpbach, Austria, 339.*

[55] *Heinemann, Z.E., Brand, C.W., Munka, M. et al. 1991. Modeling Reservoir Geometry With Irregular Grids. SPE Res Eng 6 (2): 225–232. SPE-18412-PA. http://dx.doi.org/10.2118/18412-PA*

Note

This keyword has the potential to produce very large print files that some text editors may have difficulty loading, coupled with the fact that reviewing the data in this format is very cumbersome.

A more efficient solution is to load the *.INIT file into OPM ResInsight to view the data graphically, this also has the benefit of being able to filter the grid based on I, J, K ranges and grid properties.

Examples

The first example shows the original format of this keyword; although the keyword and format are recognized by OPM Flow, the format is ignored and is unlikely to be implemented in in the simulator.

```
--
--        DEFINE LGR GRID SECTION REPORT OPTION (ORIGINAL FORMAT)
-
RPTGRIDL
          1        2*0      1        3*1                                    /
```

The next example shows the second format of the keyword which may be supported in a future release of OPM Flow.

```
--        DEFINE LGR GRID SECTION REPORT OPTIONS
--
RPTGRIDL
          DX       DY       DZ       DEPTH    PORO     PERMX                 /
```

6.3.176 RPTINIT – DEFINE OUTPUT TO THE INIT FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data in the GRID and EDIT sections that is to be written out to the INIT file (*.INIT or *.FINIT). The format consists of the keyword followed by a series of character strings that indicate the data to be written. In most cases the character string is the keyword used to load the data into the OPM Flow input deck, for example PORO for the porosity array in the GRID section. In addition, values either read or calculated by the simulator in the EDIT section can also be written to the INIT file. Again the keyword or property name is used as the mnemonic for the character string, for example the PORV, TRANX keywords etc. If the RPTINIT keyword is not used in the input deck then a default set of data array are written to the file, in this case the actual data written is dependent on the model's configuration and the options being used.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.177 RPTISOL – ACTIVATE ISOLATED RESERVOIR NUMBER REPORTING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RPTISOL keyword activates the isolated reservoir report that generates an array of isolated region numbers that is printed in the debug file (*.DBG). The main purpose of this facility is to use the generated array as input to the ISOLNUM keyword in the GRID section in conjunction with the Independent Reservoir Regions option. If the model can be divided into isolated reservoirs then the individual reservoirs may be solved independently, resulting in increased computational efficient, compared with solving the model as a whole.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       ACTIVATE ISOLATED RESERVOIR NUMBER REPORTING
--
RPTISOL
```

The above example activates the isolated reservoir report that generates an array of isolated region numbers to the debug file (*.DBG).

6.3.178 SIGMA – DUAL POROSITY MATRIX TO FRACTURE SIGMA (ALL CELLS)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SIGMA keyword defines the dual porosity matrix to fracture transmissibility multiplier, sigma, that is applied to all cells, for when the Dual Porosity model has been activated by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section. Sigma (σ) takes into account the matrix-fracture interface area per unit volume and was defined by Kazemi et al[56] to be:

$$\sigma = 4\left(\frac{1}{l_x^2} + \frac{1}{l_y^2} + \frac{1}{l_z^2}\right) \tag{6.15}$$

Where l_x, l_y and l_z are not the grid block dimensions in the model in the respective directions, but the dimensions of the blocks of the matrix material. In practice, σ is used as a tuning parameter in dual porosity runs to match reservoir and well performance.

See also the SIGMAV keyword in the GRID section that supplies the sigma values on an individual cells basis.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

[56] *Kazemi, H., Merrill JR., L. S., Porterfield, K. L., and Zeman, P. R. "Numerical Simulation of Water-Oil Flow in Naturally Fractured Reservoirs," paper SPE 5719, Society of Petroleum Engineers Journal (1976) 16, No. 6, 317-326.*

6.3.179 SIGMAGD – DUAL POROSITY MATRIX TO FRACTURE SIGMA FOR GRAVITY DRAINAGE (ALL CELLS)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SIGMAGD keyword defines the dual porosity matrix to fracture transmissibility multiplier, sigma, that is applied to all cells, for when the Dual Porosity model has been activated by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section. In addition, the GRAVDR keyword in the RUNSPEC section should be used to enable the Gravity Drainage model for the run. Sigma (σ) takes into account the matrix-fracture interface area per unit volume and was defined by Kazemi et al[57] to be:

$$\sigma = 4\left(\frac{1}{l_x^2} + \frac{1}{l_y^2} + \frac{1}{l_z^2}\right) \tag{6.16}$$

Where l_x, l_y and l_z are not the grid block dimensions in the model in the respective directions, but the dimensions of the blocks of the matrix material. In practice, σ is used as a tuning parameter in dual porosity runs to match reservoir and well performance.

Note that SIGMAGD keyword data is used for areas being swept by gas and the SIGMA keyword data is used when the area is being invaded by water. See also the SIGMAGDV keyword in the GRID section that supplies the sigma values on an individual cells basis

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

[57] *Kazemi, H., Merrill JR., L. S., Porterfield, K. L., and Zeman, P. R. "Numerical Simulation of Water-Oil Flow in Naturally Fractured Reservoirs," paper SPE 5719, Society of Petroleum Engineers Journal (1976) 16, No. 6, 317-326.*

6.3.180 SIGMAGDV – DUAL POROSITY MATRIX TO FRACTURE SIGMA GRAVITY DRAINAGE (INDIVIDUAL CELLS)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SIGMAGD keyword defines the dual porosity matrix to fracture transmissibility multiplier, sigma, that is applied to individual cells, for when the Dual Porosity model has been activated by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section. In addition, the GRAVDR keyword in the RUNSPEC section should be used to enable the Gravity Drainage model for the run. Sigma (σ) takes into account the matrix-fracture interface area per unit volume and was defined by Kazemi et al[58] to be:

$$\sigma = 4\left(\frac{1}{l_x^2} + \frac{1}{l_y^2} + \frac{1}{l_z^2}\right) \tag{6.17}$$

Where l_x, l_y and l_z are not the grid block dimensions in the model in the respective directions, but the dimensions of the blocks of the matrix material. In practice, σ is used as a tuning parameter in dual porosity runs to match reservoir and well performance.

Note that SIGMAGDV keyword data is used for areas being swept by gas and the SIGMA keyword data is used when the area is being invaded by water. See also the SIGMAGD keyword in the GRID section that supplies a constant sigma value for all cells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

[58] *Kazemi, H., Merrill JR., L. S., Porterfield, K. L., and Zeman, P. R. "Numerical Simulation of Water-Oil Flow in Naturally Fractured Reservoirs," paper SPE 5719, Society of Petroleum Engineers Journal (1976) 16, No. 6, 317-326.*

6.3.181 SIGMAV – DUAL POROSITY MATRIX TO FRACTURE SIGMA (INDIVIDUAL CELLS)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SIGMAV keyword defines a dual porosity matrix to fracture multiplier, sigma, that is applied to individual cells, for when the Dual Porosity model has been invoked by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section. Sigma (σ) takes into account the matrix-fracture interface area per unit volume and was defined by Kazemi et al[59] to be:

$$\sigma = 4\left(\frac{1}{l_x^2} + \frac{1}{l_y^2} + \frac{1}{l_z^2}\right) \tag{6.18}$$

Where l_x, l_y and l_z are not the grid block dimensions in the model in the respective directions, but the dimensions of the blocks of the matrix material. In practice, σ is used as a tuning parameter in dual porosity runs to match reservoir and well performance.

See also the SIGMA keyword in the GRID section that supplies a constant sigma to all cells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

[59] *Kazemi, H., Merrill JR., L. S., Porterfield, K. L., and Zeman, P. R. "Numerical Simulation of Water-Oil Flow in Naturally Fractured Reservoirs," paper SPE 5719, Society of Petroleum Engineers Journal (1976) 16, No. 6, 317-326.*

6.3.182 SMULTX - MULTIPLY CELL TRANSMISSIBILITY IN THE +X DIRECTION (AUTO-REFINEMENT)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SMULTX multiples the transmissibility between two cell faces in the +X direction between cells in a host base grid and the connecting auto-refined grid cells, via an array, that is the keyword sets the transmissibility multiplier of block (I_{host}, J_{host}, K_{host}) in the host base grid, multiplies the transmissibility all the cells (I_{auto}, J_{auto}, K_{auto}) and ($I+I_{auto}$, J_{auto}, K_{auto}) in the auto-refinement grid. The Auto Refinement option must be enabled to use this keyword via the AUTOREF keyword in the RUNSPEC section.

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the SMULTX keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	SMULTX+	SMULTX+ is an array of real positive numbers assigning the transmissibility multipliers in the +X direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.109: SMULTX Keyword Description

See also the MULTX, MULTY and MULTZ keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   3                          / DEFINE BOX AREA
--
--        SET SMULTX+ TRANSMISSIBILITY MULTIPLIERS
--
SMULTX
          18*0.300                                          /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.3 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.183 SMULTY - MULTIPLY CELL TRANSMISSIBILITY IN THE +Y DIRECTION (AUTO-REFINEMENT)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SMULTY multiples the transmissibility between two cell faces in the +Y direction between cells in a host base grid and the connecting auto-refined grid cells, via an array, that is the keyword sets the transmissibility multiplier of block (I_{host}, J_{host}, K_{host}) in the host base grid, multiplies the transmissibility all the cells (I_{auto}, J_{auto}, K_{auto}) and (I_{auto}, $J+1_{auto}$, K_{auto}) in the auto-refinement grid. The Auto Refinement option must be enabled to use this keyword via the AUTOREF keyword in the RUNSPEC section.

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the SMULTY keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	SMULTY+	SMULTY+ is an array of real positive numbers assigning the transmissibility multipliers in the +X direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".

Table 6.110: SMULTY Keyword Description

See also the MULTX, MULTY and MULTZ keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   3                          / DEFINE BOX AREA
--
--        SET SMULTY+ TRANSMISSIBILITY MULTIPLIERS
--
SMULTY
          18*0.300                                          /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.3 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.184 SMULTZ - MULTIPLY CELL TRANSMISSIBILITY IN THE +Z DIRECTION (AUTO-REFINEMENT)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SMULTZ multiples the transmissibility between two cell faces in the +Z direction between cells in a host base grid and the connecting auto-refined grid cells, via an array, that is the keyword sets the transmissibility multiplier of block (I_{host}, J_{host}, K_{host}) in the host base grid, multiplies the transmissibility all the cells (I_{auto}, J_{auto}, K_{auto}) and (I_{auto}, J_{auto}, $K+1_{auto}$) in the auto-refinement grid. The Auto Refinement option must be enabled to use this keyword via the AUTOREF keyword in the RUNSPEC section.

An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the SMULTZ keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	SMULTZ+	SMULTZ+ is an array of real positive numbers assigning the transmissibility multipliers in the +X direction to each cell face in the model. Repeat counts may be used, for example 20*100.0.	1.0

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.111: SMULTX Keyword Description

See also the MULTX, MULTY and MULTZ keywords for scaling transmissible between grid cells.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          10  10   1   6    1   3                          / DEFINE BOX AREA
--
--        SET SMULTZ+ TRANSMISSIBILITY MULTIPLIERS
--
SMULTZ
          18*0.300                                          /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The above example defines a 0.3 scaling multiplier for the 18 cells defined by the preceding BOX statement. The ENDBOX keyword resets the input box to the full grid.

6.3.185 SOLVDIRS – DEFINE LINEAR SOLVER PRINCIPAL DIRECTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOLVDIRS keyword defines the linear solver principal directions, which should be set to XY, XZ, YX, YX, ZX, or ZY. The default direction is based on the direction of the highest transmissibility and SOLVDIRS allows for over writing the default direction for when linear convergence of the equations are problematic.

This keyword is ignored by OPM Flow and has no effect on the simulation.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

6.3.186 SOLVNUM – DEFINE PEBI GRID CORRESPONDENCE TO SOLVER ORDER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOLVNUM defines the unstructured Perpendicular Bisector ("PEBI")[60] and [61] grid correspondence to the nested factorization solver order, for when the grid has been entered as a PEBI list. This keyword is generated by an external pre-processing program for generating simulation grids.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[60] *Heinemann, Z.E. and Brand, C.W. 1988. Gridding Techniques in Reservoir Simulation. Proc., First Intl. Forum on Reservoir Simulation, Alpbach, Austria, 339.*

[61] *Heinemann, Z.E., Brand, C.W., Munka, M. et al. 1991. Modeling Reservoir Geometry With Irregular Grids. SPE Res Eng 6 (2): 225–232. SPE-18412-PA. http://dx.doi.org/10.2118/18412-PA*

6.3.187 SPECGRID- DEFINE THE DIMENSIONS OF A CORNER-POINT GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SPECGRID defines the dimensions of a corner-point grid in the x, y, and z planes as well as the number of reservoirs, where each reservoir has it's own set of corner-point geometry data.

The keyword can only be used with Irregular Corner-Point Grids.

No.	Name	Description	Default
1	NDIVIX	A positive integer value that defines the number of cells in the X or R direction	1
2	NDIVIY	A positive integer value that defines the number of cells in the Y or THETA direction	1
3	NDIVZ	A positive integer value that defines the number of cells in the Z direction	1
4	NUMRES	A positive integer values that defines number of coordinate data sets, or independent reservoirs in the model. OPM Flow currently only accepts a single data set, that is the default value of one.	1
5	TYPE	A character string set to either T of F that defines the type of grid to be defined by subsequent keywords: 1) T = Radial grid with radial coordinates 2) F = Cartesian grid	F
Notes: 1) The keyword is terminated by "/". 2) The dimensions are also entered on the DIMENS section in the RUNSPEC section and the two sets of numbers should be consistent.			

Table 6.112: SPECGRID Keyword Description

See also the COORD, COORDSYS and ZCORN keywords to fully define an Irregular Corner-Point Grid.

Example

```
--
--        MAX      MAX      MAX      MAX      GRID
--        NDIVIX   NDIVIY   NDIVIZ   NUMRES   TYPE
SPECGRID
          46       112      22       1        F                                    /
```

The above example defines a 46 x 112 x 22 grid with one set of irregular corner-point data.

6.3.188 SWATINIT – DEFINE THE INITIAL WATER SATURATION ARRAY FOR CAPILLARY PRESSURE SCALING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SWATINIT defines the initial water saturation for all the cells in the model via an array. The keyword can be used with all grid types. SWATINIT is used to initialize the model by setting each grid block's initial water saturation ("Sw"). If the array is present in the input deck, then OPM Flow will re-scale the water-oil capillary pressure curves entered via the SWFN saturation functions in the PROPS section, so that the resulting initialized Sw matches the values in the SWATINIT array.

Normally the SWATINIT array is generated in the static earth model when calculating the hydrocarbons in-place. volumes using Saturation Height Functions ("SHF") derived from capillary pressure functions. Static earth models do not directly use capillary pressure in these type of calculations as individual cell pressures are not required. There is therefore some potential for inconsistencies to arise between the two sets of formulations. This is normally manifested by extreme scaling in the scaled capillary pressure values calculated by the simulator. If this is the case then the PPCMAX keyword can be used to set a maximum scaled capillary pressure value. Note that as large values of scaled capillary pressures can result in numerical issues, a more technically sound approach would be to resolve these inconsistencies before continuing with the model build.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWATINIT	SWATINIT is an array of real positive numbers that are greater than or equal to zero and less than or equal to one, that define the initial water saturation values to each cell in the model. Repeat counts may be used, for example 3000*0.15			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.113: SWATINIT Keyword Description

See also the PPCMAX to control the re-scaling of the capillary pressure entries on the SWFN saturation function keyword in the PROPS section.

Example

```
--
--        DEFINE GRID BLOCK INITIAL SW DATA FOR ALL CELLS
--        (BASED ON NX x NY x NZ = 300)
--
SWATINIT
          300*0.300                                                    /
```

The above example defines a constant initial water saturation of 0.300 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.189 THCGAS – DEFINE GAS PHASE THERMAL CONDUCTIVITY FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THCGAS keyword defines the gas phase thermal conductivity for when the thermal calculation is activated by the THERMAL keyword in the RUNSPEC section, and should be used in conjunction with THCROCK keyword in the GRID section.

This keyword can only be used if the thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	THCGAS	THCGAS is an array of real positive numbers that define the thermal conductivity of the gas phase in each grid block. Repeat counts may be used, for example 3000*20.0			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.114:THCGAS Keyword Description

The THCGAS data is used in conjunction with the other thermal conductivity arrays to calculate the porosity weighted thermal conductivity of a grid block using:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - PORO) \times THCROCK \quad \textbf{(6.19)}$$

See also the THCOIL, THCWATER, THROCK and THCSOLID keywords in the GRID section

Example

```
--
--        DEFINE GRID BLOCK GAS PHASE THERMAL CONDUCTIVITY
–         FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
THCGAS
          300*20.0                                                    /
```

The above example defines the gas phase thermal conductivity of 20.0 for each cell in the 300 grid block model as defined by the DIMENS keyword in the RUNSPEC section.

6.3.190 THCOIL – DEFINE OIL PHASE THERMAL CONDUCTIVITY FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THCOIL keyword defines the oil phase thermal conductivity for when the thermal calculation is activated by the THERMAL keyword in the RUNSPEC section, and should be used in conjunction with THCROCK keyword in the GRID section.

This keyword can only be used if the thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	THCOIL	THCOIL is an array of real positive numbers that define the thermal conductivity of the oil phase in each grid block. Repeat counts may be used, for example 3000*20.0			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.115:THCOIL Keyword Description

The THCOIL data is used in conjunction with the other thermal conductivity arrays to calculate the porosity weighted thermal conductivity of a grid block using:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - \text{PORO}) \times \text{THCROCK} \quad \textbf{(6.20)}$$

See also the THCGAS, THCWATER, THROCK and THCSOLID keywords in the GRID section

Example

```
--
--        DEFINE GRID BLOCK OIL PHASE THERMAL CONDUCTIVITY
–         FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
THCOIL
          300*20.0                                                    /
```

The above example defines the oil phase thermal conductivity of 20.0 for each cell in the 300 grid block model, as defined by the DIMENS keyword in the RUNSPEC section.

6.3.191 THCONR – DEFINE ROCK AND FLUID THERMAL CONDUCTIVITY FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THCONR keyword defines the reservoir rock plus fluid thermal conductivity for all cells for when the thermal calculation is activated by the THERMAL keywords in the RUNSPEC section.

Note that the THCROCK and THCONR keywords are mutually exclusive.

This keyword can only be used if the thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	THCONR	THCONR is an array of real positive numbers that define the combined rock and fluid conductivity of a grid block. Repeat counts may be used, for example 3000*25.0			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.116:THCONR Keyword Description

Example

```
--
--        DEFINE GRID BLOCK ROCK-FLUID THERMAL CONDUCTIVITY
–         FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
THCONR
          300*25.0                                                    /
```

The above example defines the combined rock and fluid thermal conductivity of 25.0 for each cell in the 300 grid block model, as defined by the DIMENS keyword in the RUNSPEC section.

6.3.192 THCONSF – DEFINE GAS SATURATION DEPENDENT THERMAL CONDUCTIVITY SCALING FACTOR FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THCONSF keyword defines a gas saturation dependent scaling factor to the fluid and reservoir rock thermal conductivities entered via the THCONR keyword in the GRID section, for when the thermal calculation is activated by the THERMAL keyword in the RUNSPEC.

Note that the THCROCK and THCONR keywords are mutually exclusive.

This keyword can only be used if the thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	THCONSF	THCONSF is an array of real positive numbers, greater than zero and less than or equal to one, that define the gas saturation dependent scaling factor that is applied to the THCONR data, entered via the THCONR keyword, to adjust the thermal conductivity of the reservoir cells in each grid block. Repeat counts may be used, for example 3000*0.15			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.117:THCROCK Keyword Description

The THCONSF keyword defines a scaling factor which is a function of the gas saturation that scales a cells total thermal conductivity (reservoir fluids plus reservoir rock) entered via the THCONR keyword in the GRID section. This combination of keywords, THCONSF and THCONR implies that the oil and water phase thermal conductivities are saturation independent with respect to the liquid phase, and that only the gas saturation influences a cell's thermal conductivity as entered via the THCONR keyword. Thus, THCONSF scales the THCORNR values via a multiplier Ω, by:

$$\Omega_{i,j,k} = \left(1 - \text{THCONSF x Gas Saturation}\right)_{i,j,k} \tag{6.21}$$

See also the THCGAS, THCOIL, THCWATER and THCSOLID keywords in the GRID section, for an alternative way to enter the thermal conductivity properties. However, the THCONSF keyword cannot be used with the THCGAS, THCOIL, THCWATER and THCSOLID keywords. Secondly, the solid phase is not supported by OPM Flow and therefore neither is the THCSOLID keyword.

Example

```
--
--       DEFINE GRID SGAS DEPENDENT SCALING FACTOR FOR THE THCONR ARRAY
--       FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--       (OPM FLOW THERMAL OPTION ONLY)
--
THCONSF
         300*0.12                                                        /
```

The above example defines the gas saturation thermal conductivity scaling factor to be applied to the THCONR to be 0.12 for all 300 cells in the model, as defined by the DIMENS keyword in the RUNSPEC section.

6.3.193 THCROCK – DEFINE RESERVOIR ROCK THERMAL CONDUCTIVITY FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THCROCK keyword defines the reservoir rock thermal conductivity for when the thermal calculation is activated by the THERMAL keyword in the RUNSPEC section.

Note that the THCROCK and THCONR keywords are mutually exclusive.

This keyword can only be used if the thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	THCROCK	THCROCK is an array of real positive numbers that define the thermal conductivity of the reservoir rock in each grid block. Repeat counts may be used, for example 3000*20.0			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.118: THCROCK Keyword Description

The THCROCK data is used in conjunction with the other thermal conductivity arrays to calculate the porosity weighted thermal conductivity of a grid block using:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - PORO) \times THCROCK \qquad \textbf{(6.22)}$$

See also the THCGAS, THCOIL, THCWATER and THCSOLID keywords in the GRID section

Example

```
--
--        DEFINE GRID BLOCK RESERVOIR ROCK THERMAL CONDUCTIVITY
–         FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
THCROCK
          300*20.0                                                    /
```

The above example defines the reservoir rock thermal conductivity of 20.0 for each cell in the 300 grid block model, as defined by the DIMENS keyword in the RUNSPEC section.

6.3.194 THCWATER – DEFINE WATER PHASE THERMAL CONDUCTIVITY FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THCWATER keyword defines the water phase thermal conductivity for when the thermal calculation is activated by the THERMAL keyword in the RUNSPEC section, and should be used in conjunction with THCROCK keyword in the GRID section.

This keyword can only be used if the thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	THCWATER	THCWATER is an array of real positive numbers that define the thermal conductivity of the water phase in each grid block. Repeat counts may be used, for example 3000*20.0			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 6.119: THCWATER Keyword Description

The THCWATER data is used in conjunction with the other thermal conductivity arrays to calculate the porosity weighted thermal conductivity of a grid block using:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - PORO) \times THCROCK \quad \textbf{(6.23)}$$

See also the THCGAS, THCOIL, THROCK and THCSOLID keywords in the GRID section

Example

```
--
--        DEFINE GRID BLOCK WATER PHASE THERMAL CONDUCTIVITY
–         FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
THCWATER
          300*20.0                                                    /
```

The above example defines the water phase thermal conductivity of 20.0 for each cell in the 300 grid block model, as defined by the DIMENS keyword in the RUNSPEC section.

6.3.195 THPRESFT - DEFINE FAULT THRESHOLD PRESSURES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THPRESFT keyword defines a fault threshold pressures that prevents fluid flow from occurring across the fault plane until the threshold pressure is exceeded, for when the threshold pressure option has been activated via the THRPRES variable on the EQLOPTS keyword in the RUNSPEC section.

Each row entry in the THPRESFT keyword defines a fault threshold pressure.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	FLTNAME	FLTNAME is a character string enclosed in quotes with a maximum length of eight characters, that defines the name of the fault. FLTNAME must have been previously defined using the FAULTS keyword in the GROD section, otherwise an error will occur.			None
2	PRESS	PRESS is a single positive real value that defines the threshold pressure for the fault (FLTNAME). If PRESS is defaulted then the simulator will set the threshold pressure to zero, that is the fault is open to flow along the fault plane.			
		psia	barsa	atma	0

Notes:

1) If there are multiple entries for FLTNAME only the last entry is applied.
2) Each record is terminated by a "/" and the keyword should be terminated by a "/".

Table 6.120:THPRESFT Keyword Description

Sea also the FAULTS keyword in the GRID section that is used to created named faults. Normally this fault data is automatically generated by pre-processing software that generates static model.

Example

The example below defines two fault traces, 'M_WEST' and 'BC' fault having threshold pressures of 1000.0 and 2000 psis respectively.

```
--
--        DEFINE FAULTS IN THE GRID GEOMETRY
--
--        FAULT       ------------ FAULT TRACE -------------
--        NAME         I1   I2    J1   J2    K1   K2    FACE
FAULTS
          'M_WEST'      5    5     3    3    1    22   'X'   /
          'M_WEST'      5    5     4    4    1    22   'X'   /
          'M_WEST'      5    5     5    5    1    22   'X'   /
……………………………………..

          'BC'         43   43     8    8    1    22   'Y'   /
          'BC'         42   42     9    9    1    22   'X'   /
          'BC'         44   44     8    8    1    22   'Y'   /
……………………………………..
/
--
--        DEFINE FAULT THRESHOLD PRESSURES
--
--        FAULT        THRESHOLD
--        NAME         PRESSURE
THPRESFT
          'M_WEST'     1000.0                                /
          'BC'         1200.0                                /
/
```

6.3.196 TOPS - DEFINE THE DEPTH AT THE CENTER OF THE TOP FACE FOR EACH CELL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TOPS defines the depth of the top face of each cell in the model.

It can only be used with the Cartesian Regular Grid or Radial Grid models.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TOPS	TOPS is an array of real numbers defining the depth at the top face of each cell in the model. One can either just enter the TOPS for the first layer only based on NX x NY entries and OPM Flow will calculate the remaining TOPS based on either DZ or DZV. Alternatively NX x NY x NZ TOPS may be entered for each cell in the model. See the DIMENS keyword in the RUNSPEC section for the definition of NX, NY and NZ. Repeat counts may be used, for example 10*5201.0.			
		feet	m	cm	None
Notes: 1) The keyword is terminated by "/".					

Table 6.121:TOPS Keyword Description

See also the DEPTHS keyword to define the structural depth for the cells.

Examples

The example below defines the TOPS of the cells for each cell for NX = 5, NY = 5 and NZ = 3 model, as well as the X and Y direction cells sizes.

```
--
--        DEFINE GRID BLOCK TOPS FOR THE TOP LAYER (NX=5, NY=5, and NZ=)
--
TOPS
          25*3100  25*3105  25*3110                                        /
--
--        DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NX = 5)
--
DXV
          5*100                                                            /
--
--        DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NY = 5)
--
DYV
          5*100                                                            /
```

A second example is shown on the following page.

This example defines the same grid as before but with the TOPS keyword only defining the top layer and DZV keyword defining the cells thickness.

```
--
--      DEFINE GRID BLOCK TOPS FOR THE TOP LAYER (NX = 5, NY = 5, NZ = 3)
--
TOPS
        25*3100                                                         /
--
--      DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NX = 5)
--
DZV
        3*5.0                                                           /
--
--      DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NX = 5)
--
DXV
        5*100                                                           /
--
--      DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NY = 5)
--
DYV
        5*100                                                           /
```

6.3.197 TRANGL – DEFINE NON-NEIGHBOR CONNECTIONS BETWEEN GLOBAL AND LGR CELLS MANUALLY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TRANGL enables Non-Neighbor Connections ("NNC") between the global cells and the Local Grid Refinement ("LGR") cells to be manually specified, as oppose to the simulator calculating the transmissibilities. The LGR keyword in the RUNSPEC section should be utilized to define the presence of LGRs in the model and to define various LGR dimension parameters.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	I1	A positive integer that defines the LGR grid block in the I-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NX on the CARFIN keyword in the GRID section.			None
2	J1	A positive integer that defines the LGR grid block in the J-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NY on the CARFIN keyword in the GRID section.			None
3	K1	A positive integer that defines the LGR grid block in the K-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NZ on the CARFIN keyword in the GRID section.			None
4	I2	A positive integer that defines the GLOBAL grid block in the I-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NX on the DIMENS keyword in the RUNSPEC section.			None
5	J2	A positive integer that defines the GLOBAL grid block in the J-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NY on the DIMENS keyword in the RUNSPEC section.			None
6	K2	A positive integer that defines the GLOBAL grid block in the K-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NZ on the DIMENS keyword in the RUNSPEC section.			None
7	TRANSNNC	TRANSNNC is a positive real number greater than or equal to zero that defines the transmissibility between the GLOBAL grid block (I1, J1, K1) and the LGR grid block (I2, J2, K2). The default value of zero sets the transmissibility between the two cells to zero.			
		cP.rb/day/psia	cP.rm^3/day/bars	cP.rcc/hr/atm	0.0

Notes:

1) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 6.122: TRANGL Keyword Description

Example

```
--
--       MANUALLY DEFINE LGR-GLOBAL GRID NON-NEIGHBOR CONNECTIONS
--
--       ----LGR-----   ---GLOBAL----   -- TRANSNCC --
--       I1   J1   K1    I2   J2   K2
TANGL
         1    1    1     1    1    2        0.2500     /
         1    1    2     1    1    3        0.2500     /
         1    1    3     1    1    4        0.2500     /
/
```

The above example defines the transmissibility between LGR cell (1, 1, 1) and global cell (1, 1, 2), LGR cell (1, 1, 2) and global cell (1, 1, 3) and finally between LGR cell (1, 1, 3) and global cell (1, 1, 4) to be 0.2500.

6.3.198 USEFLUX – ACTIVATE FLUX BOUNDARY MODEL AND DEFINE FLUX FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The USEFLUX keyword activates the Flux Boundary model and defines the name of the FLUX file. Only grid blocks that have been declared by the FLUXREG keyword in the GRID section to be in an active flux region, are active for the run.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.199 USENOFLO – ACTIVATE FLUX BOUNDARY MODEL WITHOUT A FLUX FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The USENOFLUX keyword activates the Flux Boundary model without a FLUX file. The USEFLUX keyword should still be in the input deck, but in this case the FLUX filename is ignored. The option is useful when the no-flow boundary condition is a reasonable assumption and avoids the pre-cursor run used to generate the FLUX file via the DUMPFLUX keyword in the GRID section. Only grid blocks that have been declared by the FLUXREG keyword in the GRID section to be in an active flux region, are active for the run.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ACTIVATE FLUX BOUNDARY MODEL WITHOUT A FLUX FILE
--
USEFLUX
/

USENOFLO
```

The above example activates the Flux Boundary model without a FLUX file.

6.3.200 VEDEBUG – Vertical Equilibrium Debug Data Output

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the debug Vertical Equilibrium ("VE") data to be written to the debug file (*.DBG), for when the VE model has been activated by the VE keyword in the RUNSPEC section.

The keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.201 VEFIN – ACTIVATE VERTICAL EQUILIBRIUM MODEL (LGR)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

If the VE keyword in the RUNSPEC section has been used to activate the Vertical Equilibrium ("VE") model for the global grid, then the VEFIN keyword may used to set various options for the Local Grid Refinements ("LGR"). The LGR keyword in the RUNSPEC section should be activated to indicate the presence of LGRs and the keyword VEFIN should be placed in between the CARFIN and ENDFIN keywords in the GRID section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

6.3.202 ZCORN – DEFINE THE DEPTH OF EACH CORNER-POINT OF A GRID BLOCK

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ZCORN defines the depth of each corner point of a grid block on the pillars defining the reservoir grid. A total of 8 x NX x NY x NZ values are needed to fully define all the depths in the model. The depths specifying the top of the first layer are entered first with one point for each pillar for each grid block. The points are entered with the X axis cycling fastest. Next come the depths of the bottom of the first layer. The top of layer two follows etc.

The keyword can be only used be used with Irregular Corner-Point Grids.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ZCORN	An array of depths with 8 depths for each cell, for a total of 8 x Nx x NY x NZ entries			
		feet	metres	cm	None

Notes:

1) Regular Cartesian and Radial grid keywords cannot be used with this keyword, that is: DR, DRV, DTHETA, DTHETAV, DX, DXV, DY, DYV, DZ, INRAD, and TOPS.

2) The keyword is terminated by "/".

Table 6.123: ZCORN Keyword Description

See also the SPECGRID, COORD and COORDSYS keywords to fully define an Irregular Corner-Point Grid.

Example

```
--
--        SPECIFY CORNER-POINT DEPTHS FOR A 3 x 2 x 2 GRID,
--        WITH CONSTANT SLOPE IN THE X AND Y DIRECTIONS
--        SUCH THAT ALL CORNER POINTS OF NEIGHBOURING BLOCKS ALIGN

ZCORN
          1450   1500   1500   1550   1550   1600 # top of layer 1
          1500   1550   1550   1600   1600   1650
          1500   1550   1550   1600   1600   1650
          1550   1600   1600   1650   1650   1700
          1460   1510   1510   1560   1560   1610 # bottom of layer 1
          1510   1560   1560   1610   1610   1660
          1510   1560   1560   1610   1610   1660
          1560   1610   1610   1660   1660   1710
          1460   1510   1510   1560   1560   1610 # top of layer 2
          1510   1560   1560   1610   1610   1660
          1510   1560   1560   1610   1610   1660
          1560   1610   1610   1660   1660   1710
          1470   1520   1520   1570   1570   1620 # bottom of layer 2
          1520   1570   1570   1620   1620   1670
          1520   1570   1570   1620   1620   1670
          1570   1620   1620   1670   1670   1720
/
```

The above example defines depths of the vertical coordinate lines for a regular 3 by 2 by 2 grid with a constant slope in the x and y directions such that all the corner points of neighboring blocks are aligned.

CHAPTER 7: EDIT SECTION

7.1 INTRODUCTION

This section enables user defined changes to be applied after OPM Flow has processed the data in the GRID section, that is the resulting pore volume (PORV) and transmissibility arrays (TRANX, TRANY and TRANX). The entered primary static arrays (PORO, PERMX etc.) in the GRID section are no longer available and all modifications are applied to the pore volume and transmissibility arrays.

Historically the intention of this section was allow for the editing of the processed data; however, the features available in this section have, through time, migrated to the GRID section. For example the array operator keywords like ADD, COPY, MULTIPLY, etc. are available in the GRID section and thus enabling editing of the primary static arrays (PORO, PERMX etc.). This increased in capability in the GRID section has therefore made the EDIT section some what redundant.

Nevertheless the section is sometimes used by users to incorporate history matching parameter changes and by static earth modeling software packages to import directly the pore volumes and transmissibilities calculated in the static model directly into the numerical model via the EDIT section. Although the latter work flow is not very common.

7.2 DATA REQUIREMENTS

As the primary purpose of this section is to modify the simulator's calculated pore volumes and transmissibilities, then the properties used to define these arrays must have been fully defined in the GRID section. The arrays available for modification in the EDIT section are listed in Table 7.1 together with the associated GRID arrays used to generate the EDIT property array.

Cartesian And Irregular Corner-Point Grids Keywords		**Radial Grid Keywords**	
GRID	**EDIT**	**GRID**	**EDIT**
TOPS	DEPTH	TOPS	DEPTH
DX	PORV	DR	PORV
DY		THETA	
DZ		DZ	
DZNET		DZNET	
PORO		PORO	
NTG		NTG	
PERMX	TRANX	PERMR	TRANR
MULTX		MULTR	
PERMY	TRANY	PERMTHT	TRANTHT
MULTY		MULTTHT	
PERMZ	TRANZ	PERMZ	TRANZ
MULTZ		MULTZ	

Notes:

1) Currently Radial Grids have not been implemented in OPM Flow.
2) The GRID property association to the EDIT property is only indicative as several variables, DZNET and NTG for example, are also used in the transmissibility calculations.

Table 7.1: EDIT Section Arrays Available for Modification

An example pore volume array (PORV property) from the Volve[62] field is shown in Figure 7.1 and Figure 7.2 illustrates the model's transmissibility in the x-direction (TRANX).

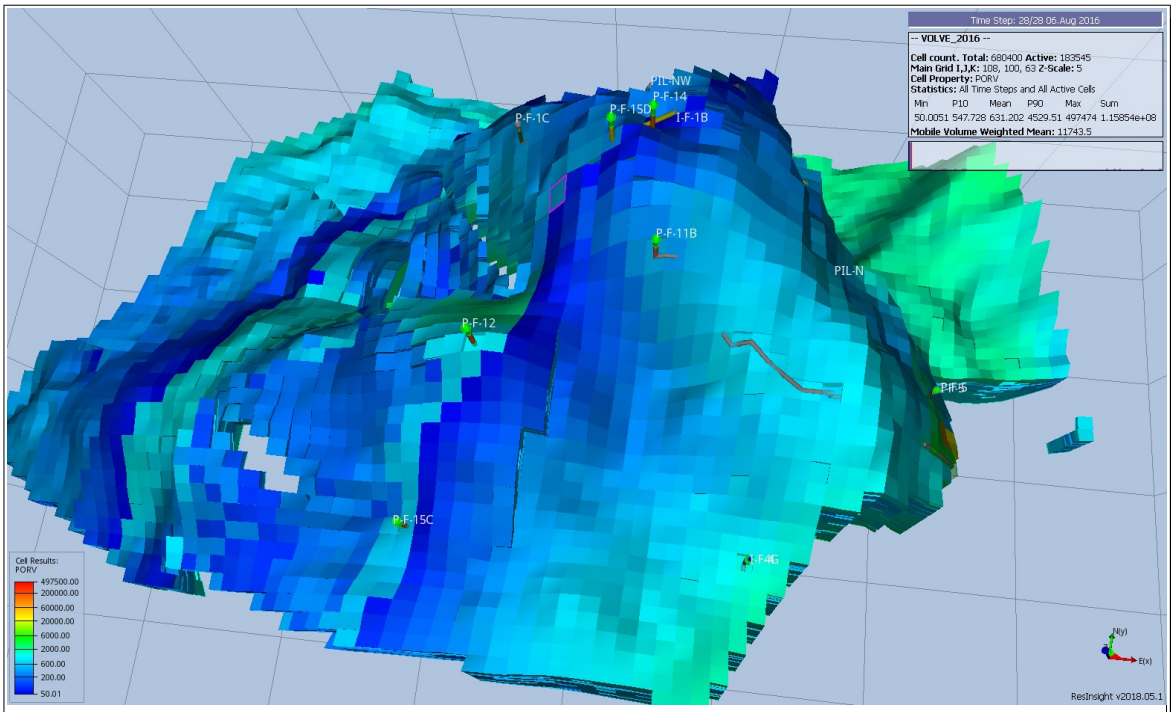


Figure 7.1: Volve Full Field Model PORV Array

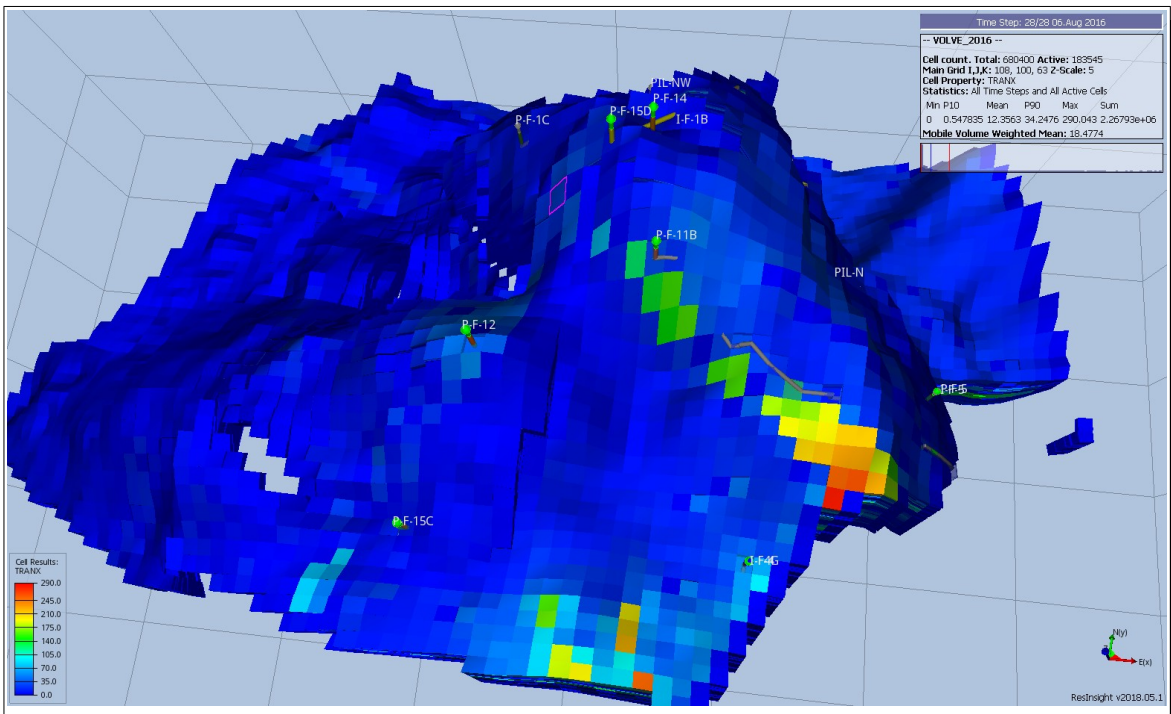


Figure 7.2: Volve Full Field Model TRANX Array

[62] *The Volve Data was approved for data sharing in 2018 by the initiative of the last Operating company, Equinor and approved by the license partners ExxonMobil E&P Norway AS and Bayerngas Norge AS in the end of 2017.*

7.3 KEYWORD DEFINITIONS

7.3.1 ADD – ADD A CONSTANT TO A SPECIFIED ARRAY

The ADD keyword adds a constant to a specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the ADD keyword is being applied.

See *ADD – Add a Constant to a Specified Array* in the GRID section for a full description.

7.3.2 ADDREG – ADD A CONSTANT TO AN ARRAY BASED ON A REGION NUMBER

The ADDREG keyword adds a constant to a specified array or part of an array based on cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the ADDREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the ADDREG keyword is being used.

See *ADDREG – Add a Constant to an Array based on a Region Number* in the GRID section for a full description.

7.3.3 BOUNDARY – DEFINE A BOUNDARY BOX FOR PRINTING

The BOUNDARY keyword defines a a rectangular grid for printing various arrays to the output print file (*.PRT); thus, avoiding printing all the elements in the selected array.

See *BOUNDARY – Define a Boundary Box for Printing* in the GRID section for a full description.

7.3.4 BOX - DEFINE A RANGE OF GRID BLOCKS TO ENTER PROPERTY DATA

BOX defines a range of grid blocks for which subsequent data is assigned for all the cells in the defined BOX. Note that the BOX grid is reset by the keyword ENDBOX by resetting the current defined BOX to be the whole grid. The keyword can be used for any array and for all grid types.

See *BOX - Define a Range of Grid Blocks to Enter Property Data* in the GRID section for a full description.

7.3.5 COPY – COPY ARRAY DATA TO ANOTHER ARRAY

The COPY keyword copies an array (or part of an array) to another array or part of an array. The arrays can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the COPY keyword is being used.

See *COPY – Copy Array Data to Another Array* in the GRID section for a full description.

7.3.6 COPYREG – COPY AN ARRAY TO ANOTHER ARRAY BASED ON A REGION NUMBER

The COPYREG keyword copies a specified array or part of an array based on cells with a specific region number to another array. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the COPYREG keyword is read by the simulator. The property arrays can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the COPYREG keyword is being used.

See *COPYREG – Copy an Array to Another Array based on a Region Number* in the GRID section for a full description.

7.3.7 DEPTH - EDITS THE DEPTH AT THE CENTER OF EACH CELL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DEPTH keywords modifies the depth at the center of selected cells in the model. The cells DEPTH are calculated by OPM Flow at the end of the GRID section and this keyword allows the user to adjust the calculated depths in the EDIT section. The area to be modified can be defined via the various grid selection keywords, ADD, BOX, EQUALS, etc., and areas that are not selected remain unchanged.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	DEPTH is an array of real numbers defining the depth at the center of each cell in the model. Only the values in the currently defined input BOX needed be entered. Repeat counts may be used, for example 30*5201.0.			
		feet	m	cm	None
Notes: 1) The keyword is terminated by "/".					

Table 7.2: Depth Keyword Description

See also the TOPS keyword to define the top structural depth for the cells.

Examples

The example below defines the DEPTH of the cells for each cell for NX = 5, NY = 5 and NZ = 3 model, as well as the X and Y direction cells sizes.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
           1  10   11  11   20  20 / SET BOX AREA TO BE MODIFIED
/
--
--        SET GRID BLOCK CENTER DEPTH FOR THE GRID BLOCKS
--
DEPTH     10*3500.0                                                    /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

Alternatively the EQUALS keyword can be used to perform the same edit.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          DEPTH       3500.0        1  10   11  11   20  20 / RESET DEPTH
/
```

7.3.8 DIFFR – DEFINE GRID BLOCK RADIAL DIRECTION DIFFUSIVITY VALUES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFR keyword defines the radial direction diffusivity values for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

7.3.9 DIFFTHT – Define Grid Block Theta Direction Diffusivity Values

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFTHT keyword defines the theta direction diffusivity values for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

7.3.10 DIFFX – Define Grid Block X-Direction Diffusivity Values

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFX keyword defines the x-direction diffusivity values for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

7.3.11 DIFFY – Define Grid Block Y-Direction Diffusivity Values

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFY keyword defines they y-direction diffusivity values for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

7.3.12 DIFFZ – DEFINE GRID BLOCK Z-DIRECTION DIFFUSIVITY VALUES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFZ keyword defines the z-direction diffusivity values for cells in the current input box for when the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

7.3.13 EDIT - DEFINE THE START OF THE EDIT SECTION OF KEYWORDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EDIT activation keyword marks the end of the GRID section and the start of the EDIT section that enables modifications to the OPM Flow calculated properties derived from the data entered in the GRID section, for example grid block pore volumes via the PORV array and the transmissibilities via the TRANX, TRANY and TRANZ family of keywords.

There is no data required for this keyword.

Example

```
-- ==============================================================================
--
-- EDIT SECTION
--
-- ==============================================================================
EDIT
```

The above example marks the end of the GRID section and the start of the EDIT section in the OPM Flow data input file.

7.3.14 EDITNNC – SCALE NON-NEIGHBOR CONNECTIONS BETWEEN CELLS MANUALLY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

EDITNNC enables Non-Neighbor Connections ("NNC"), entered via the NNC keyword or calculated by the simulator, to be multiplied (re-scaled) by a constant. For example, if the existing transmissibility between non-neighbor connections is T_{old} and the multiplier is C, then the resulting transmissibility, T_{new}, will be $T_{new} = C \ x \ T_{old}$. Only previously defined NNC's entered via the NNC keyword or calculated by the simulator can be edited, otherwise an error will occur.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	I1	A positive integer that defines the first grid block in the I-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NX on the DIMENS in the RUNSPEC section.			None
2	J1	A positive integer that defines the first grid block in the J-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NY on the DIMENS in the RUNSPEC section.			None
3	K1	A positive integer that defines the first grid block in the K-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NZ on the DIMENS in the RUNSPEC section.			None
4	I2	A positive integer that defines the second grid block in the I-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NX on the DIMENS in the RUNSPEC section.			None
5	J2	A positive integer that defines the second grid block in the J-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NY on the DIMENS in the RUNSPEC section.			None
6	K2	A positive integer that defines the second grid block in the K-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NZ on the DIMENS in the RUNSPEC section.			None
7	TRANSMUL	TRANSMUL is a positive real number greater than or equal to zero that defines a constant that scales the transmissibility between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2). The default vale of one means no scaling will be applied.			
		dimensionless	dimensionless	dimensionless	1
8	ISATNUM1	The default value of zero means the existing saturation table allocated to the upstream cell (I1,J1,K1).			0
9	ISATNUM2	ISATNUM2 is a positive integer defining which saturation table number (relative permeability table) to be used for flow from the second grid block to the first grid block. The default value of zero means the existing saturation table allocated to the downstream cell (I2,J2,K2).			0

No.	Name	Description			Default
		Field	Metric	Laboratory	
10	IPRSNUM1	IPRSNUM1 is a positive integer defining which pressure table number (PVT table) to be used for flow from the first grid block to the second grid block. The default value of zero means the existing PVT table allocated to the upstream cell (I1,J1,K1).			0
11	IPRSNUM2	IPRSNUM2 is a positive integer defining which pressure table number (PVT table) to be used for flow from the second grid block to the first grid block. The default value of zero means the existing PVT table allocated to the downstream cell (I2,J2,K2).			0
12	FACE1	FACE1 is a character string that defines the face associated with flow from the first grid block to the second grid block, where FACE1 can have vales of: X+, X-, Y+, Y-, Z+, or Z-.			None
13	FACE2	FACE2 is a character string that defines the face associated with flow from the second grid block to the first grid block, where FACE2 can have vales of: X+, X-, Y+, Y-, Z+, or Z-.			None
14	DIFFNNC	DIFFNNC is a positive real number greater than or equal to zero that scales the diffusivity between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2).			
		dimensionless	dimensionless	dimensionless	0.0

Notes:

1) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 7.3: EDITNNC Keyword Description

Note that although items (8) to (14) for this keyword are not available in OPM Flow, even if they were, it is strongly recommended that these items are defaulted if the data is being entered manually, as opposed to being generated by pre-processing software.

Care should be taken that cells in different PVTNUM regions (see the PVTNUM keyword in the REGIONS section) are not connected, since the fluid properties are associated with a cell. If for example, a rbbl or a rm^3 of oil flows from PVTNUM region 1 to PVTNUM region 2, then the oil properties of that oil will change from the PVT 1 data set to the PVT data set 2. This will result in material balance errors, that may or may not cause numerical issues.

If the transmissibility across a fault needs to be modified see the FAULTS and MULTFLT keywords in the GRID section for an alternative and less complicated method to modifying fault transmissibilities. Transmissibility between reservoir regions can be modified by using MULTREGT keyword, provided MULTNUM has been used to define the inter-region transmissibility region numbers for each grid block. Finally, the MULTX, MULTY and MULTZ series of keywords can be used to modify transmissibility between various cells. All the aforementioned keywords are described in the GRID section.

See also the EDITNNCR keyword in the EDIT section that resets an existing NNC to a user defined value.

Example

```
--
--       MANUALLY RESCALE NON-NEIGHBOR CONNECTIONS
--
--       ------------ BOX -----------    -- TRANSMUL --
--       I1   J1   K1    I2   J2   K2
EDITNCC
         1    1    1     1    1    2        0.2000     / SET NNC FOR FAULT
         1    1    2     1    1    3        0.2000     / SET NNC FOR FAULT
         1    1    3     1    1    4        0.2000     / SET NNC FOR FAULT
/
```

The above example multipliers the transmissibility between cells (1, 1, 1) and (1, 1, 2), (1, 1, 2) and (1, 1, 3) and finally between (1, 1, 3) and (1, 1, 4) by 0.200.

7.3.15 EDITNNCR – RESET NON-NEIGHBOR CONNECTIONS BETWEEN CELLS MANUALLY

Description

EDITNNCR enables Non-Neighbor Connections ("NNC"), entered via the NNC keyword or calculated by the simulator, to be reset to a user defined value. Only previously defined NNC's entered via the NNC keyword or calculated by the simulator can be edited, otherwise an error will occur. See also the EDITNNC keyword in the EDIT section that scales an existing NNC.

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	I1	A positive integer that defines the first grid block in the I-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NX on the DIMENS in the RUNSPEC section.			None
2	J1	A positive integer that defines the first grid block in the J-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NY on the DIMENS in the RUNSPEC section.			None
3	K1	A positive integer that defines the first grid block in the K-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NZ on the DIMENS in the RUNSPEC section.			None
4	I2	A positive integer that defines the second grid block in the I-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NX on the DIMENS in the RUNSPEC section.			None
5	J2	A positive integer that defines the second grid block in the J-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NY on the DIMENS in the RUNSPEC section.			None
6	K2	A positive integer that defines the second grid block in the K-direction to be joined in a non-neighbor connection, must be greater than or equal to one and less than or equal to NZ on the DIMENS in the RUNSPEC section.			None
7	TRANSNNC	TRANSNNC is a positive real number greater than or equal to zero that defines the transmissibility between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2). This value cannot be defaulted and must be defined.			
		cP.rb/day/psia	cP.rm^3/day/bars	cP.rcc/hr/atm	None
8	ISATNUM1	ISATNUM1 is a positive integer defining which saturation table number (relative permeability table) to be used for flow from the first grid block to the second grid block. The default value of zero means the existing saturation table allocated to the upstream cell (I1,J1,K1).			0
9	ISATNUM2	ISATNUM2 is a positive integer defining which saturation table number (relative permeability table) to be used for flow from the second grid block to the first grid block. The default value of zero means the existing saturation table allocated to the downstream cell (I2,J2,K2).			0

No.	Name	Description			Default
		Field	Metric	Laboratory	
10	IPRSNUM1	IPRSNUM1 is a positive integer defining which pressure table number (PVT table) to be used for flow from the first grid block to the second grid block. The default value of zero means the existing PVT table allocated to the upstream cell (I1,J1,K1).			0
11	IPRSNUM2	IPRSNUM2 is a positive integer defining which pressure table number (PVT table) to be used for flow from the second grid block to the first grid block. The default value of zero means the existing PVT table allocated to the downstream cell (I2,J2,K2).			0
12	FACE1	FACE1 is a character string that defines the face associated with flow from the first grid block to the second grid block, where FACE1 can have vales of: X+, X-, Y+, Y-, Z+, or Z-.			None
13	FACE2	FACE2 is a character string that defines the face associated with flow from the second grid block to the first grid block, where FACE2 can have vales of: X+, X-, Y+, Y-, Z+, or Z-.			None
14	DIFFNNC	DIFFNNC is a positive real number greater than or equal to zero that scales the diffusivity between the first grid block (I1, J1, K1) and the second grid block (I2, J2, K2). The default value is the value calculated in the GRID section.			
		feet	meters	cm	1*

Notes:

1) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 7.4: EDITNNCR Keyword Description

Note that although items (8) to (14) for this keyword are not available in OPM Flow, even if they were, it is strongly recommended that these items are defaulted if the data is being entered manually, as opposed to being generated by pre-processing software.

If the transmissibility across a fault needs to be modified see the FAULTS and MULTFLT keywords in the GRID section for an alternative and less complicated method to modifying fault transmissibilities. Transmissibility between reservoir regions can be modified by using MULTREGT keyword, provided MULTNUM has been used to define the inter-region transmissibility region numbers for each grid block. Finally, the MULTX, MULTY and MULTZ series of keywords can be used to modify transmissibility between various cells. All the aforementioned keywords are described in the GRID section.

Example

```
--
--       MANUALLY RESET NON-NEIGHBOR CONNECTIONS
--
--       ------------ BOX -----------    -- TRANSNNC --
--       I1   J1   K1    I2   J2   K2
EDITNCCR
         1    1    1     1    1    2        0.2500     / SET NNC FOR FAULT
         1    1    2     1    1    3        0.2500     / SET NNC FOR FAULT
         1    1    3     1    1    4        0.2500     / SET NNC FOR FAULT
/
```

The above example res-sets the transmissibility between cells (1, 1, 1) and (1, 1, 2), (1, 1, 2) and (1, 1, 3) and (1, 1, 3) and (1, 1, 4) to be 0.2500.

7.3.16 ENDBOX – Define the End of the BOX Defined Grid

This keyword marks the end of a previously defined BOX sub-grid as defined by a previously entered BOX keyword. The keyword resets the input grid to be the full grid as defined by the NX, NY, and NZ variables on the DIMENS keyword in the RUNSPEC section.

See *ENDBOX – Define the End of the BOX Defined Grid* in the GRID section for a full description.

7.3.17 ENDFIN – End the Definition of a Local Grid Refinement

NDFIN defines the end of a Cartesian or radial local grid refinement ("LGR") definition and a LGR property definition data set.

See *ENDFIN – End the Definition of a Local Grid Refinement* in the GRID section for a full description.

7.3.18 EQUALREG – Sets an Array to a Constant by Region Number

The EQUALREG keyword sets a specified array to a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the EQUALREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the EQUALREG keyword is being used.

See *EQUALREG – Sets an Array to a Constant by Region Number* in the GRID section for a full description.

7.3.19 EQUALS – Sets a Specified Array to a Constant

The EQUALS keyword sets a specified array or part of an array to a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the EQUALS keyword is being used.

See *EQUALS – Sets a Specified Array to a Constant* in the GRID section for a full description.

7.3.20 FILEUNIT – Activate Unit Consistency Verification

The FILEUNIT keyword defines the units of the of the data set, and is used to verify that the units in the input deck and any associated include files are consistent grid data. The keyword does not provide for the conversion between different sets of units.

See *FILEUNIT – Activate Unit Consistency Checking* in the GRID section for a full description.

7.3.21 GETDATA – Load and Assign Data Array from INIT or RESTART File

The GETDATA keyword loads a data array from a previously generated INIT or RESTART file and assigns the loaded array to either same array in the run or another array name.

See *GETDATA – Load and Assign Data Array from INIT or RESTART Files* in the GRID section for a full description

7.3.22 HMMULT – HISTORY MATCH GRID TRANSMISSIBILITY & PORE VOLUME GRADIENT CUMULATIVE MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMUMLT series of keywords defines the history match gradient cumulative permeability multipliers, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The keyword consists of the first five characters of "HMMULT" followed by a one or two character string shown in Table 7.5, that determines the transmissibility direction, for example, HMMULTX.

This keyword is ignored by OPM Flow and has no effect on the simulation.

Mnemonic	Cartesian Grid		Radial Grid	
	Grid Keyword	HMMULT Keyword	Grid Keyword	HMMULT Keyword
X/R	MULTX	HMMULTX	MULTR	HMMULTR
XY	MULTXY	HMMULTXY		
Y/HT	MULTY	HMMULTY	MULTTHT	HMMULTTH
Z	MULTZ	HMMULTZ	MULTZ	HMUMLTZ
PV	MULTPV	HMULTPV	MULTPV	HMULTPV

Table 7.5: HMMULT Keyword List

See also the HMMULT keyword in the GRID section.

7.3.23 IMPORT – Import Grid File Data at the Current Position

The IMPORT keyword informs the simulator to continue reading input data from the specified IMPORT file. When the end of the IMPORT file is reached, input data is read from the next keyword in the current file. Normally IMPORT files are generated by grid pre-processoring software and the keyword allows for both formatted and unformatted (binary) files to be loaded.

See *IMPORT – Import Grid File Data at the Current Position* in the GRID section for a full description.

7.3.24 LGRCOPY – Activate Local Grid Refinement Inheritance

The LGRCOPY keyword actives Local Grid Refinement ("LGR") Inheritance option that allows the LGR to inherit the properties of the global or host cell containing a LGR grid block at the start of the GRID section, as oppose to the normal process of applying this transform at the end of the GRID section. LGRCOPY can be used in the RUNSPEC, GRID and EDIT sections. If used in the RUNSPEC section then the option is applied to all LGRs defined in the input file, whereas if used in the GRID and EDIT sections the keyword must be placed inside a LGR definition section, that is between a CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) and the ENDFIN keyword. In the latter case inheritance is applied on an individual LGR basis.

See *LGRCOPY – Activate Local Grid Refinement Inheritance* in the RUNSPEC section for a full description.

7.3.25 MAXVALUE – Sets a Maximum Value for an Array Element

The MAXVALUE keyword sets a maximum value for the specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the MAXVALUE keyword is being used.

See *MAXVALUE – Sets a Maximum Value for an Array Element* in the GRID section for a full description.

7.3.26 MINVALUE – Set a Minimum Value for an Array Element

The MINVALUE keyword sets a minimum value for the specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the MINVALUE keyword is being used.

See *MINVALUE – Set a Minimum Value for an Array Element* in the GRID section for a full description.

7.3.27 MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant

MULTFLT enables the transmissibilities across defined faults, as declared by the FAULTS keyword, to be modified. They keyword allows for the re-scaling of the existing fault transmissibilities calculated by OPM Flow, for example setting a fault to be completely sealing by setting the multiplier to zero..

See *MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant* in the GRID section for a full description.

7.3.28 MULTIPLY – Multiply a Specified Array by a Constant

The MULTIPLY keyword multiplies a specified array or part of an array by a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

See *MULTIPLY – Multiply a Specified Array by a Constant* in the GRID section for a full description.

7.3.29 MULTIREG – Multiply an Array by a Constant based on a Region Number

The MULTIREG keyword multiplies an array or part of an array by a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTIREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the MULTIREG keyword is being used.

See *MULTIREG – Multiply an Array by a Constant based on a Region Number* in the GRID section for a full description.

7.3.30 MULTPV – Multiply Cell Pore Volumes by a Constant

MULTPV multiples the pore volumes of a cell by a real positive constant for all the cells in the model via an array. An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTPV keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

See *MULTPV – Multiply Cell Pore Volumes by a Constant*in the GRID section for a full description.

7.3.31 MULTR - Multiply Cell Transmissibility in the +R Direction

MULTR multiples the transmissibility between two cell faces in the +R direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I+I, J, K). The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

See *MULTR - Multiply Cell Transmissibility in the +R Direction* in the GRID section for a full description.

7.3.32 MULTR- - Multiply Cell Transmissibility in the -R Direction

MULTX- multiples the transmissibility between two cell faces in the -X direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I-1, J, K) and (I, J, K). The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

See *MULTR- - Multiply Cell Transmissibility in the -R Direction* in the GRID section for a full description.

7.3.33 MULTREGD – Multiply Diffusivities Between Regions

The MULTREGT keyword multiplies the diffusivity between two regions by a constant. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGT keyword is read by the simulator. The constant should be a real number.

See *MULTREGD – Multiply Diffusivities Between Regions* in the GRID section for a full description.

7.3.34 MULTREGH – Multiply Thermal Conductivities Between Regions

The MULTREGH keyword multiplies the thermal conductivity between two regions by a constant. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGT keyword is read by the simulator. The constant should be a real number.

See *MULTREGH – Multiply Thermal Conductivities Between Regions* in the GRID section for a full description.

7.3.35 MULTREGP– Multiply Pore Volumes Based On Region Number

The MULTREGP keyword multiplies the pore volume of a cell by a constant for all cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGP keyword is read by the simulator. The constant should be a real number.

See *MULTREGP – Multiply Pore Volumes Based On Region Number* in the GRID section for a full description.

7.3.36 MULTREGT– Multiply Transmissibilities Between Regions

The MULTREGT keyword multiplies the transmissibility between two regions by a constant. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTREGT keyword is read by the simulator. The constant should be a real number.

See *MULTREGT – Multiply Transmissibilities Between Regions*in the GRID section for a full description.

7.3.37 MULTTHT - Multiply Cell Transmissibility in the +Theta Direction

MULTTHT multiples the transmissibility between two cell faces in the +Theta direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J+1, K). The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

See *MULTTHT - Multiply Cell Transmissibility in the +Theta Direction* in the GRID section for a full description.

7.3.38 MULTTHT- - Multiply Cell Transmissibility in the -Theta Direction

MULTTHT- multiples the transmissibility between two cell faces in the -Theta direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J-1, K) and (I, J, K). The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

See *MULTTHT- - Multiply Cell Transmissibility in the -Theta Direction* in the GRID section for a full description.

7.3.39 MULTX - Multiply Cell Transmissibility in the +X Direction

MULTX multiples the transmissibility between two cell faces in the +X direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I+I, J, K).

See *MULTX - Multiply Cell Transmissibility in the +X Direction* in the GRID section for a full description.

7.3.40 MULTX- - Multiply Cell Transmissibility in the -X Direction

MULTX- multiples the transmissibility between two cell faces in the -X direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I-1, J, K) and (I, J, K).

See *MULTX- - Multiply Cell Transmissibility in the -X Direction* in the GRID section for a full description.

7.3.41 MULTY - Multiply Cell Transmissibility in the +Y Direction

MULTY multiples the transmissibility between two cell faces in the +Y direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J+1, K).

See *MULTY - Multiply Cell Transmissibility in the +Y Direction* in the GRID section for a full description.

7.3.42 MULTY- - Multiply Cell Transmissibility in the -Y Direction

MULTY- multiples the transmissibility between two cell faces in the -Y direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J-1, K) and (I, J, K).

See *MULTY- - Multiply Cell Transmissibility in the -Y Direction* in the GRID section for a full description.

7.3.43 MULTZ - Multiply Cell Transmissibility in the +Z Direction

MULTZ multiples the transmissibility between two cell faces in the +Z direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J, K+1).

See *MULTZ - Multiply Cell Transmissibility in the +Z Direction* in the GRID section for a full description.

7.3.44 MULTZ- - Multiply Cell Transmissibility in the -Z Direction

MULTZ- multiples the transmissibility between two cell faces in the -Z direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (1, J, K-1) and (I, J, K).

See *MULTZ- - Multiply Cell Transmissibility in the -Z Direction* in the GRID section for a full description.

7.3.45 OPERATE – Define Mathematical Operations on Arrays

This keyword, OPERATE, defines mathematical operations on property arrays (NTG, PORO etc.) and optionally using another property array as input to the function. The keyword allows for various mathematical functions and their associated variables to be defined and applied to the selected array data. Input constants can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

See *OPERATE – Define Mathematical Operations on Arrays* in the GRID section for a full description.

7.3.46 OPERATER – Define Mathematical Operations on Arrays by Region

This keyword defines the mathematical operations on arrays for specific regions in the commercial simulator and is currently not supported by OPM Flow. However, similar functionality is provided by the ADD and MULTIPLY keywords.

See *OPERATER – Define Mathematical Operations on Arrays by Region* in the GRID section for a full description.

7.3.47 PORV - DEFINE THE PORE VOLUMES FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PORV defines the pore volumes for all the cells in the model via an array. The keyword can be used for all grid types, except for the Radial Grid geometry. The keyword effectively overwrites previously entered and calculated data. The area to be modified can be defined via the various grid selection keywords, ADD, BOX, EQUALS, etc., and areas that are not selected remain unchanged.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PORV	PORV is an array of real positive numbers assigning a pore volume to each cell in the model. Only the values in the currently defined input BOX needed be entered. Repeat counts may be used, for example 20*100.0.			
		rb	rm^3	rcc	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) Values not reset by this keyword remain unaltered.
3) The keyword is terminated by "/".

Table 7.6: PORV Keyword Description

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1* 100   1* 100   20  20                        / DEFINE BOX AREA
--
--        SET PORV FOR THE GRID BLOCKS
--
PORV
          1000*0.00                                       /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

Here the BOX statement is used to define the input grid for the PORV keyword, which overwrites the pore volume previously calculated with pore volume values of zero, resulting in a no-flow boundary in that part of the field between layers 19 and 21, since layer 20 is deactivated. The ENDBOX keyword resets the input box to the full grid.

7.3.48 PYEND – END THE DEFINITION OF A PYINPUT SECTION

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords. A PYINPUT Definition Section is terminated by a PYEND keyword on a separate single line.

See *PYEND – End the Definition of a PYINPUT Section* in the GRID section for a full description.

7.3.49 PYINPUT – DEFINE THE START OF A PYINPUT SECTION

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords used by the simulator. PYINPUT declares the start of a PYINPUT Definition Section on a single separate line, which is then followed by various standard Python commands, with one command per line.

See *PYINPUT – Define the Start of a PYINPUT Section* in the GRID section for a full description.

7.3.50 REFINE – START THE DEFINITION OF A LOCAL GRID REFINEMENT

The REFINE keyword defines the start of a Cartesian or radial local grid refinement ("LGR") definition that sets the properties of the selected LGR. The keyword is then followed by the property keywords associated with the section where the keyword is being invoked. For example, if the REFINE keyword is used in the GRID section then most of the keywords in that section can be used to set the grid properties for the LGR.

See *REFINE – Start the Definition of a Local Grid Refinement* in the GRID section for a full description.

7.3.51 TRANR - DEFINE THE TRANSMISSIBILITY IN THE +R DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TRANR defines the transmissibility in the +R direction for all the cells in the model via an array. The keyword can only be used with Radial Grid geometry grids. The keyword effectively overwrites previously entered and calculated data. The transmissibility overwritten is the +R face transmissibility of each grid block, that is for cell (I, J, K) the transmissibility between cells (I, J, K) and (I+1, J, K).

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TRANR	TRANR is an array of real positive numbers assigning the transmissibility in the R direction to each cell in the model. Repeat counts may be used, for example 20*100.0.			
		cP.rb/day/psia	cP.rm^3/day/bars	cP.rcc/hr/atm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) Values not reset by this keyword remain unaltered.
3) The keyword is terminated by "/".

Table 7.7: TRANR Keyword Description

See also the TRANTHT and TRANYZ keywords to modify the transmissibilities in the other directions.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1   1    10  10   1  120                        / DEFINE BOX AREA
--
--        SET TRANR+ TRANSMISSIBILITY
--
TRANR
          120*0.00                                        /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

Here the BOX statement is used to define the input grid for the TRANR keyword, which overwrites the transmissibility previously calculated with transmissibility values of zero, resulting in a no-flow boundary in that part of the grid. The ENDBOX keyword resets the input box to the full grid.

7.3.52 TRANTHT - DEFINE THE TRANSMISSIBILITY IN THE +THETA DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TRANTHT defines the transmissibility in the +Theta direction for all the cells in the model via an array. The keyword can only be used with Radial Grid geometry grids. The keyword effectively overwrites previously entered and calculated data. The transmissibility overwritten is the +Theta face transmissibility of each grid block, that is for cell (I, J, K) the transmissibility between cells (I, J, K) and (I, J+1, K).

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TRANTHT	TRANTHT is an array of real positive numbers assigning the transmissibility in the +Theta direction to each cell in the model. Repeat counts may be used, for example 20*100.0.			
		cP.rb/day/psia	cP.rm^3/day/bars	cP.rcc/hr/atm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) Values not reset by this keyword remain unaltered.
3) The keyword is terminated by "/".

Table 7.8: TRANR Keyword Description

See also the TRANR and TRANYZ keywords to modify the transmissibilities in the other directions.

Example

```
--
--       DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--       ---------- BOX ---------
--       I1  I2   J1  J2   K1  K2
BOX
         10  10   1   6    1   3                          / DEFINE BOX AREA
--
--       SET TRANR+ TRANSMISSIBILITY
--
TRANR
         18*0.00                                           /
--
--       DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

Here the BOX statement is used to define the input grid for the TRANTHT keyword, which overwrites the transmissibility previously calculated with transmissibility values of zero, resulting in a no-flow boundary in that part of the grid. The ENDBOX keyword resets the input box to the full grid.

7.3.53 TRANX - DEFINE THE TRANSMISSIBILITY IN THE X DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TRANX defines the transmissibility in the X direction for all the cells in the model via an array. The keyword can be used for all grid types, except for the Radial Grid geometry. The keyword effectively overwrites previously entered and calculated data. The transmissibility overwritten is the +X face transmissibility of each grid block, that is for cell (I, J, K) the transmissibility between cells (I, J, K) and (I+1, J, K).

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TRANX	TRANX is an array of real positive numbers assigning the transmissibility in the X direction to each cell in the model. Repeat counts may be used, for example 20*100.0.			
		cP.rb/day/psia	cP.rm^3/day/bars	cP.rcc/hr/atm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) Values not reset by this keyword remain unaltered.
3) The keyword is terminated by "/".

Table 7.9: TRANX Keyword Description

See also the TRANY and TRANYZ keywords to modify the transmissibilities in the other directions.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1   1    10  10   1  120                        / DEFINE BOX AREA
--
--        SET TRANX+ TRANSMISSIBILITY
--
TRANX
          120*0.00                                        /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

Here the BOX statement is used to define the input grid for the TRANX keyword, which overwrites the transmissibility previously calculated with transmissibility values of zero, resulting in a no-flow boundary in that part of the field. The ENDBOX keyword resets the input box to the full grid.

7.3.54 TRANY - DEFINE THE TRANSMISSIBILITY IN THE Y DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TRANY defines the transmissibility in the Y direction for all the cells in the model via an array. The keyword can be used for all grid types, except for the Radial Grid geometry. The keyword effectively overwrites previously entered and calculated data. The transmissibility overwritten is the +Y face transmissibility of each grid block, that is for cell (I, J, K) the transmissibility between cells (I, J, K) and (I, J+1, K).

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TRANY	TRANY is an array of real positive numbers assigning the transmissibility in the Y direction to each cell in the model. Repeat counts may be used, for example 20*100.0.			None
		cP.rb/day/psia	cP.rm^3/day/bars	cP.rcc/hr/atm	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) Values not reset by this keyword remain unaltered.
3) The keyword is terminated by "/".

Table 7.10: TRANY Keyword Description

See also the TRANX and TRANZ keywords to modify the transmissibilities in the other directions.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1   1    10  10   1  120                        / DEFINE BOX AREA
--
--        SET TRANY+ TRANSMISSIBILITY
--
TRANY
          120*0.00                                        /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

Here the BOX statement is used to define the input grid for the TRANY keyword, which overwrites the transmissibility previously calculated with transmissibility values of zero, resulting in a no-flow boundary in that part of the field. The ENDBOX keyword resets the input box to the full grid.

7.3.55 TRANZ - DEFINE THE TRANSMISSIBILITY IN THE Z DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TRANX defines the transmissibility in the z direction for all the cells in the model via an array. The keyword can be used for all grid types, except for the Radial Grid geometry. The keyword effectively overwrites previously entered and calculated data. The transmissibility overwritten is the +Z face transmissibility of each grid block, that is for cell (I, J, K) the transmissibility between cells (I, J, K) and (I, J, K+1).

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TRANZ	TRANZ is an array of real positive numbers assigning the transmissibility in the Z direction to each cell in the model. Repeat counts may be used, for example 20*100.0.			
		cP.rb/day/psia	cP.rm^3/day/bars	cP.rcc/hr/atm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) Values not reset by this keyword remain unaltered.
3) The keyword is terminated by "/".

Table 7.11: TRANZ Keyword Description

See also the TRANX and TRANY keywords to modify the transmissibilities in the other directions.

Example

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1* 100   1* 100   20  20                          / DEFINE BOX AREA
--
--        SET TRANZ+ TRANSMISSIBILITY
--
TRANZ
          1000*0.00                                         /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

Here the BOX statement is used to define the input grid for the TRANZ keyword, which overwrites the transmissibility previously calculated with transmissibility values of zero, resulting in a no-flow boundary in that part of the field between layers 20 and 21. The ENDBOX keyword resets the input box to the full grid.

CHAPTER 8: PROPS SECTION

8.1 INTRODUCTION

The PROPS section is the section that contains the fluid property keywords used to define the PVT behavior of the fluids in the model and therefore the data is fluid type dependent. For example, if the oil phase has been activated in the RUNSPEC section via the OIL keyword then one of the oil PVT keywords needs to be defined in this section. The other main type of data required for the PROPS section is the saturation tables that govern how the various fluids flow in the model relative to the other phases. Again, the saturation tables are fluid type dependent.

Various other fluid and rock property data are also entered in this section including rock compressibility via the ROCK keyword for the standard rock compressibility model, and rather unusual the Carter-Tracy influence function entered via the AQUTAB keyword.

8.2 DATA REQUIREMENTS

For all phases activated in the model a complete description of the PVT behavior (PVT tables) and fluid flow behavior (saturations tables) is required. As the data is fluid type dependent, the next two sections attempt to define the appropriate keywords for the various activated fluid types. The first section outlines the fluid PVT property requirements and the second section summarizes the keywords associated with fluid flow property data, namely the relative permeability and capillary pressure data.

8.2.1 FLUID PROPERTY TABLES

Table 8.1 outlines the oil, gas and water fluid types that can be active in the model, together with the related RUNSPEC section keywords that activate the phases, versus the PVT keywords that can be used to define the PVT behavior. The table also includes several water types, the standard water phase used in most simulations models, the Brine water phase used in the Brine Tracking model to track the flow of brine through the simulation grid and the effect of brine on reservoir performance, and finally OPM Flow's Vaporized Water phase that is is used in the simulator's Salt Precipitation model. The latter water phase is not available in the commercial simulator.

Fluid Property Keywords Versus Oil, Gas & Water Fluid Types							
Item	**Oil**		**Gas**			**Water**	
Fluid Type	Dead Oil	Live Oil	Dry Gas	Wet Gas	Dry / Wet Gas with Vaporized Water	Water	Brine
RUNSPEC Keywords	OIL	OIL	GAS	GAS	GAS	WATER	WATER
		DISGAS		VAPOIL	None/VAPOIL		
					VAPWAT		
					WATER		
					BRINE		BRINE
Pressure Dependent PVT	PVCDO	PVCO	PVDG	PVTG	PVTWSALT	PVTW	PVTWSALT
	PVDO	PVTO	PVZG		PVTGW		
					PVTGWO		
Miscellaneous	RSCONST		RVCONST		RWGSALT		
	RSCONSTT		RVCONSTT				
Surface Density	DENSITY					BDENSITY	BDENSITY
	GRAVITY						

Notes:

1) Cells colored in gray with no mnemonic indicate that there is no keyword for this combination.
2) Cells colored orange show keywords that have not been implemented in OPM Flow.
3) When two or more keywords are stated for the RUNSPEC keyword for a given fluid type, then all are required to define the given phase.
4) When two keywords are stated for the Pressure Dependent PVT and Miscellaneous data for a given fluid type, then either one can be used to define the PVT behavior for the given phase.
5) For the Dead Oil phases the RSCONST and RSCONSTT keywords are used to set a constant gas-oil ratio (Rs). In this case the Rs is independent of the reservoir pressure and Rs is also negligible, as in for example heavy oil type fluids.
6) Similarly for the Dry Gas phase, where the RVCONST and RVCONSTT keywords are used to set a condensate-gas ratio (Rv) which is independent of the reservoir pressure and is also negligible, as in for example dry gas type fluids.
7) In addition for the Brine phase, then either the SALT or SALTVD keywords in the SOLUTION section should be used to define the initial equilibration salt concentration for the model.

Table 8.1: Fluid Property Keywords versus Oil, Gas and Water Fluid Type

In addition to the above the ROCK keyword should be used to define the rock compressibility.

Similarly, Table 8.2 outlines the fluid property data keywords for the foam, polymer and solvent phases. Note that for these phases multiple keywords can be used to define the desired property behavior.

Fluid Property Keywords Versus Foam, Polymer & Solvent Fluid Types			
Fluid Type	**Foam**	**Polymer**	**Solvent**
RUNSPEC Keywords	FOAM	POLYMER	SOLVENT
Pressure Dependent PVT			PVDS
Surface Density			SDENSITY
Miscellaneous	FOAMADS	PLMIXPAR	
	FOAMDCYO	PLYADS	
	FOAMDCYW	PLYADSS	
	FOAMFCN	PLYATEMP	
	FOAMFRM	PLYCAMAX	
	FOAMFSC	PLYDHFLF	
	FOAMFSO	PLYESAL	
	FOAMFST	PLYKRRF	
	FOAMFSW	PLYMAX	
	FOAMMOB	PLYRMDEN	
	FOAMMOBP	PLYROCK	
	FOAMMOBS	PLYSHEAR	
	FOAMOPTS	PLYSHLOG	
	FOAMROCK	PLYTRRF	
		PLYTRRFA	
		PLYVISC	

Fluid Property Keywords Versus Foam, Polymer & Solvent Fluid Types			
Fluid Type	**Foam**	**Polymer**	**Solvent**
		PLYVISCS	
		PLYVISCT	
		PLYVSCST	

Notes:

1) Cells colored in gray with no mnemonic indicate that there is no keyword for this combination.
2) Cells colored orange show keywords that have not been implemented in OPM Flow.
3) When multiple keywords are stated for the Miscellaneous data for a given fluid type, then several keywords can be used to defined the fluid property behavior.

Table 8.2: Fluid Property Keywords versus Foam, Polymer and Solvent Fluid Types

Typical live oil and dry gas PVT data is from the Volve[63] field is shown in Figure 8.1 and Figure 8.2, respectively.

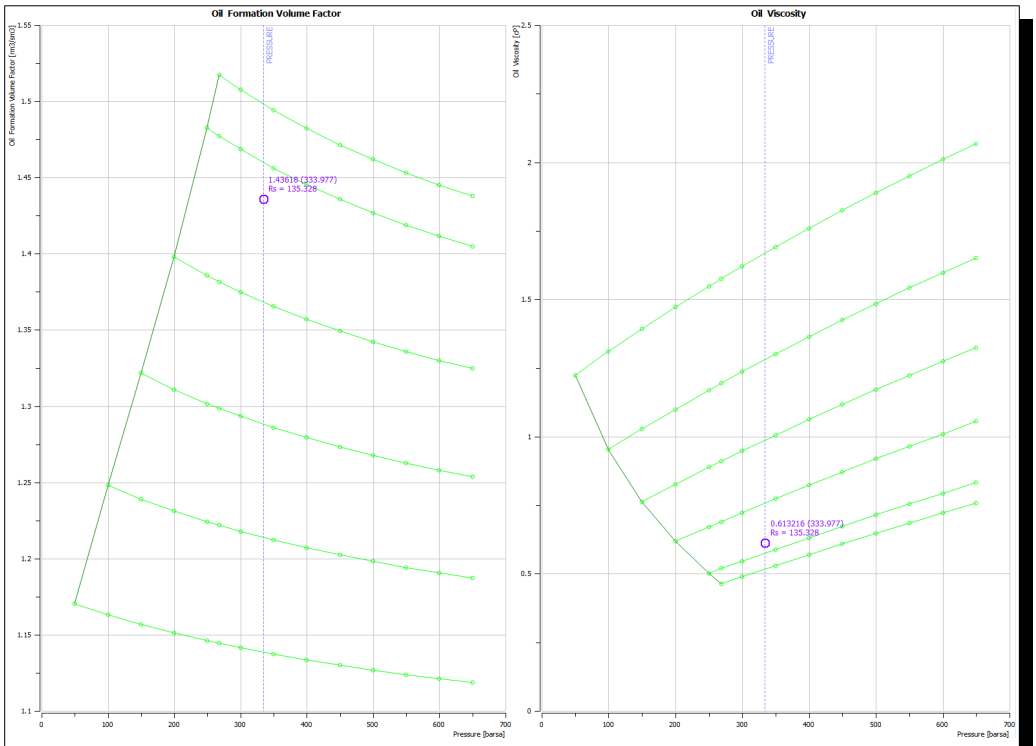


Figure 8.1:Volve Field Live Oil PVT Data

[63] *The Volve Data was approved for data sharing in 2018 by the initiative of the last Operating company, Equinor and approved by the license partners ExxonMobil E&P Norway AS and Bayerngas Norge AS in the end of 2017.*

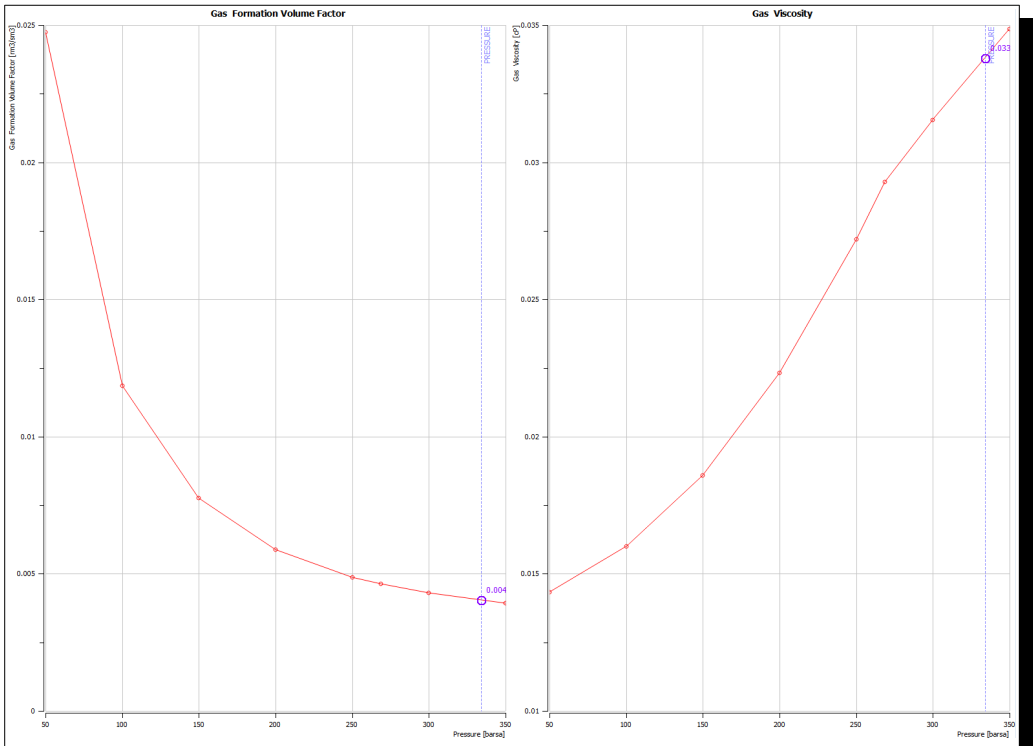


Figure 8.2: Volve Field Gas Dry PVT Data

8.2.2 SATURATION TABLES (RELATIVE PERMEABILITY AND CAPILLARY PRESSURE TABLES)

Saturation tables contain the relative permeability and capillary pressure data as a function of fluid saturation and are used to both initialize the model and to describe multi-phase flow in the reservoir. Multiple saturation tables can be entered and allocated to various areas in the model, based on rock typing. Alternatively, a limited number of saturation tables may be entered and allocated by region and combined with end-point scaling option to enable a more robust reservoir rock characterization.

A typical oil-water relative permeability set of curves is shown in Figure 8.3 indicating the oil end-point data (KRO, KRORW and (1 – SOWCR)) and the water end-point data (KRWR, KRW. SWL and SWCR).

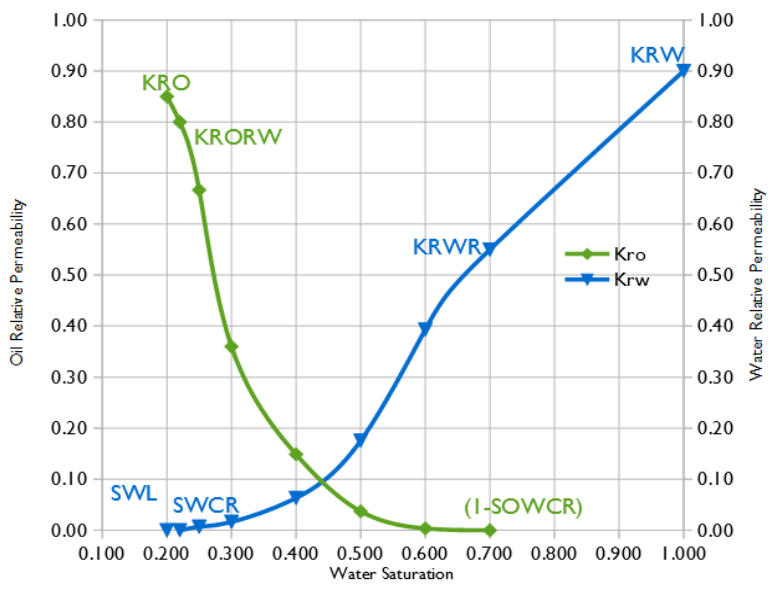


Figure 8.3: Example Oil-Water Relative Permeability Curves

The associated oil-water end-point definitions are outlined in the following table:

Type	End-Point Keyword	Oil-Water End-Point Definitions
Saturation	SWL	Connate water saturation, that is the smallest water saturation in a water saturation function table.
	SWCR	Critical water saturation, that is the largest water saturation for which the water relative permeability is zero.
	SOWCR	Critical oil-in-water saturation, that is the largest oil saturation for which the oil relative permeability is zero in an oil-water system.
Relative Permeability	KRW	Relative permeability of water at the maximum water saturation (normally the maximum water saturation is one).
	KRO	Relative permeability of oil at the maximum oil saturation.
	KRWR	Relative permeability of water at the residual oil saturation or the residual gas saturation in a gas-water run.
	KRORW	Relative permeability of oil at the critical water saturation
Capillary Pressure	SWLPC	Capillary pressure connate water saturation, that is the smallest water saturation in a water saturation function table.

Table 8.3: Oil-Water Relative Permeability End-Point Data Definitions

Similarly for gas-oil systems, Figure 8.4 illustrates a typical gas-oil relative permeability set of curves indicating the oil end-point data (KRORG and (1 – SOGCR)) and the gas end-point data (KRGR, KRG and SGCR).

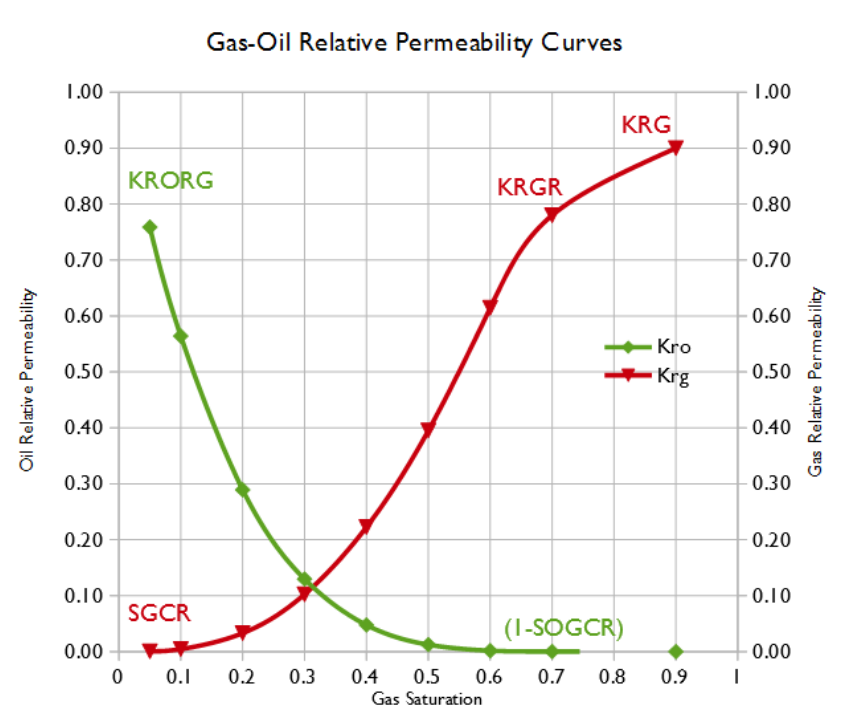


Figure 8.4: Example Gas-Oil Relative Permeability Curves

The gas-oil end-point definitions are outlined in the following table:

Type	End-Point Keyword	Gas-Oil End-Point Definitions
Saturation	SGL	Connate gas saturation, that is the smallest gas saturation in a gas saturation function table.
	SGCR	Critical gas saturation, that is the largest gas saturation for which the gas relative permeability is zero.
	SOGCR	Critical oil-in-gas saturation, that is the largest oil saturation for which the oil relative permeability is zero in an oil-gas-connate water system.
Relative Permeability	KRG	Relative permeability of gas at the maximum gas saturation.
	KRGR	Relative permeability of gas at the residual oil saturation or the critical water saturation in a gas-water run.
	KRORG	Relative permeability of oil at the critical gas saturation.
Capillary Pressure	SGLPC	Capillary pressure connate gas saturation, that is the smallest gas saturation in a gas saturation function table.

Table 8.4: Gas-Oil Relative Permeability End-Point Data Definitions

End-point scaling is activated in the RUNSPEC section with the ENDSCALE keyword and the data used to apply end-point scaling is entered in the PROPS section using the end-point keywords defined in Table 8.3 and Table 8.4 to define each grid block's end-point data. There is also direction dependent versions of the keywords for when directional end-point scaling has been activated. For example for critical water saturation, SWCR is used with non-direction end-point scaling and the SWCRX± , SWCRX± and SWCRX± series of keyword is used for when directional end-point scaling has been activated. In addition, there is also the facility to incorporate end-point scaling based on the drainage and / or imbibition process which again can be either non-directional or directional.

Saturation functions can be entered via several keywords consisting of two format types as depicted in the following table:

Format Type One				Format Type Two			
Keyword	**Oil**	**Gas**	**Water**	**Keyword**	**Oil**	**Gas**	**Water**
SGOF	Pcog			SGFN[1]		Pcog	
SLGOF	Pcog			SGWFN		Pcgw	
SWOF	Pcwo		Pcwo	SOF2[2]	No P_c		
				SOF3[3]	No P_c		
				SOF32D	No P_c		
				SWFN			Pcwo

Notes:

1) Cells colored in gray with no mnemonic indicate that there is no keyword for this combination.
2) Cells colored orange show keywords that have not been implemented in OPM Flow.
3) In gas-water systems, the gas-water Pcgw data should be entered on the SWFN keyword and the Pcog on the SGFN keyword should be set to zero.
4) The SOF2 defines the relative permeability in oil-gas and oil-water runs only, and the miscible hydrocarbon in SOVENT runs. This keyword should not be used to define the oil relative permeability when oil, gas and water are present.
5) Defines oil in relative with respect to water and oil relative permeability with respect gas.

Table 8.5: Saturation Table Formats and Phases

Note that only format type can be used in a run, that is one must either use format type one relative permeability keywords to define the required saturation functions, or format two. One cannot combine the keywords from the different format types in the same input deck.

8.3 Keyword Definitions

8.3.1 ADD – Add a Constant to a Specified Array

The ADD keyword adds a constant to a specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the ADD keyword is being applied.

See *ADD – Add a Constant to a Specified Array* in the GRID section for a full description.

8.3.2 ADDREG – Add a Constant to an Array based on a Region Number

The ADDREG keyword adds a constant to a specified array or part of an array based on cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the ADDREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the ADDREG keyword is being used.

See *ADDREG – Add a Constant to an Array based on a Region Number* in the GRID section for a full description.

8.3.3 ADSALNOD – SALT CONCENTRATION BASED ON SATNUM ARRAY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ADSALNOD defines the salt concentration value based on a cells SATNUM number. The ADSALNOD property is used in the calculation of a polymer viscosity when the polymer and the salt options has been activated by the POLYMER and BRINE keywords in the RUNSPEC section. In the RUNSPEC section the number of SATNUM functions is declared by the NTSFUN variable on the TABDIMS keyword and allocated to individual cells by the SATNUM property array in the REGIONS section. NSSFUN on the TABDIMS keyword in the RUNSPEC section defines the maximum number of rows (or saturation values) in the relative permeability saturation tables and also sets the maximum number of entries for each ADSALNOD data set. The number of values for each data set must correspond to the number of polymer solution adsorption entries on the PLYADSS keyword. For example, if there are three sets of relative permeability tables and four values on the PLYADSS keyword, then three ADSALNOD data sets with four values of salt concentrations need to be entered.

The salt concentrations within each data set should be positive and monotonically increasing and each ADSALNOD data set is delimited by "/" including the last data set.

No.	Name	Description			Default
1	SALTCON	**Field**	**Metric**	**Laboratory**	
		A real positive columnar vector that sets the salt concentrations for the given relative permeability saturation tables.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) Each data set must be terminated by a "/" including the last data set.

Table 8.6: ADSALNOD Keyword Description

An alternative manner of entering the salt concentrations is by utilizing the PVTNUM region array by using the SALTNODE keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

Given three sets of relative permeability tables and four values on the PLYADSS keyword, then the data salt concentration should be entered as follows:

```
--
--    SETS SALT CONCENTRATION FOR POLYMER SOLUTION ADSORPTION
--    VIA SATNUM ARRAY ALLOCATION
--
--    SALT
--
ADSALNOD
      1.0
      5.0
      10.5
      25.0      / SATNUM TABLE NO. 01
      1.0
      3.0
      7.5
      15.0      / SATNUM TABLE NO. 02
      1.0
      7.5
      20.5
      35.0      / SATNUM TABLE NO. 03
```

See also the SALTNODE keyword.

8.3.4 ADSORP – DEFINE GENERALIZED LANGMUIR ADSORPTION FUNCTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ADSORP keyword defines the parameters for the generalized Langmuir Adsorption[64] function for when the polymer, surfact, alkaline, foam and tracers phases have been activated in the RUNSPEC section by the POLYMER, SURFACT, ALKALINE, FOAM and TRACER keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[64] *Langmuir, Irving (June 1918). "The Adsorption of Gases on Plane Surface of Glass, Mica and Platinum". The Research Laboratory of the General Electric Company. 40 (9): 1361–1402. doi:10.1021/ja02242a004*

8.3.5 ALKADS – DEFINE ALKALINE ADSORPTION FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ALKADS defines the alkaline adsorption functions for when the alkaline model has been activated via the ALKALINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

8.3.6 ALKROCK – DEFINE ROCK ALKALINE PROPERTIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ALKROCK keyword defines the rock alkaline properties for when the alkaline model has been activated via the ALKALINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

8.3.7 ALPOLADS – POLYMER ADSORPTION VERSUS ALKALINE CONCENTRATION MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ALPOLDS defines the polymer adsorption versus alkaline concentration multipliers for when the alkaline model has been activated via the ALKALINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

8.3.8 ALSURFAD – SURFACTANT ADSORPTION VERSUS ALKALINE CONCENTRATION MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ALSURAD defines the surfactant adsorption versus alkaline concentration multipliers for when the alkaline model has been activated via the ALKALINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

8.3.9 ALSURFST – Water-Oil Surface Tension versus Alkaline Concentration Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ALSURFST keyword defines the water-oil surface tension versus alkaline concentration multipliers for when the alkaline model has been activated via the ALKALINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

8.3.10 APIGROUP – Define API Tracking Number of Grouped Oil PVT Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

The APIGROUP keyword defines the maximum number of groups of oil PVT tables when the API tracking option has been activated via the API keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation

8.3.11 AQUCT – DEFINE CARTER-TRACY ANALYTICAL AQUIFERS

The AQUCT keyword defines a Carter Tracy aquifer, the properties of the aquifer, including the Carter-Tracy aquifer influence function associated with the aquifer, defined by the AQUTAB keyword in the PROPS section.

See *AQUCT – Define Carter-Tracy Analytical Aquifers* in the GRID section for a full description

8.3.12 AQUTAB – DEFINE CARTER-TRACY AQUIFER INFLUENCE FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUTAB keyword defines additional Carter-Tracy[65] aquifer functions to be used in the model. Carter-Tracy representation of the aquifer influx is via a q_w term in the nonlinear aquifer influence function Q(t). It allows the water influx from the aquifer to be represented in the simulator by assuming that there is a constant water influx rate over finite time periods. It is derived from the superposition methods of van Everdingen and Hurst[66], whose superposition methods are not suitable for implementation in reservoir simulation software, although they are very useful in interpreting aquifer response. The storage requirements and calculation complexity of handling the resulting superposition formulas can be largely eliminated by use of the Carter-Tracy approximate water influx method.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TD	Dimensionless Time			
		dimensionless	dimensionless	dimensionless	None
2	PD	Dimensionless Pressure			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NIFTBL tables as declared on the AQUDIMS keyword in the RUNSPEC section.
2) Each table must contain at least two complete rows with a maximum of NRIFTB rows as declared on the AQUDIMS keyword in the RUNSPEC section. Note that NRIFTB must not be less than 36 in order to accommodate the default infinite acting Carter-Tracy aquifer influence function.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.7: AQUTAB Keyword Description

Note

OPM Flow includes the infinite acting Carter-Tracy aquifer influence table as a default for table number one; thus data entered on this keyword starts from table number two.

Table 8.8 to Table 8.11 outline the standard finite tables derived by van Everdingen and Hurst that are used for the Carter-Tracy analytical aquifers and are taken from Bradely[67] table 38-6 on page 38-12. In the tables r_D is defined as the ratio of the aquifer external radius divided by hydrocarbon radius, that is: $r_D = \frac{r_e}{r_o}$.

[65] *Carter, R. D., and Tracy, G. W. "An Improved Method for Calculating Water Influx." Transactions of AIME, Vol. 219 (1060), pp 415-417.*

[66] *Van Everdingen, A. F., and Hurst, W. "The Application of the Laplace Transform to Flow Problems in Reservoirs." Transactions of AIME, Vol. 186 (1949), pp. 305-324.*

[67] *Bradley Howard B., et. al,, Petroleum Engineering Handbook, Society of Petroleum Engineers (June 1989), ISBN:9781555630102.*

Carter-Tracy Aquifer Influence Functions								
No.	r_D = 1.5 Dimensionless		r_D = 2.0 Dimensionless		r_D = 2.5 Dimensionless		r_D = 3.0 Dimensionless	
	t_D	p_D	t_D	p_D	t_D	p_D	t_D	p_D
1	0.0600	0.2510	0.2200	0.4430	0.4000	0.5650	0.5200	0.6270
2	0.0800	0.2880	0.2400	0.4590	0.4200	0.5760	0.5400	0.6360
3	0.1000	0.3220	0.2600	0.4760	0.4400	0.5870	0.5600	0.6450
4	0.1200	0.3550	0.2800	0.4920	0.4600	0.5980	0.6000	0.6620
5	0.1400	0.3870	0.3000	0.5070	0.4800	0.6080	0.6500	0.6830
6	0.1600	0.4200	0.3200	0.5220	0.5000	0.6180	0.7000	0.7030
7	0.1800	0.4520	0.3400	0.5360	0.5200	0.6280	0.7500	0.7210
8	0.2000	0.4840	0.3600	0.5510	0.5400	0.6380	0.8000	0.7400
9	0.2200	0.5160	0.3800	0.5650	0.5600	0.6470	0.8500	0.7580
10	0.2400	0.5480	0.4000	0.5790	0.5800	0.6570	0.9000	0.7760
11	0.2600	0.5800	0.4200	0.5930	0.6000	0.6660	0.9500	0.7910
12	0.2800	0.6120	0.4400	0.6070	0.6500	0.6880	1.0000	0.8060
13	0.3000	0.6440	0.4600	0.6210	0.7000	0.7100	1.2000	0.8650
14	0.3500	0.7240	0.4800	0.6340	0.7500	0.7310	1.4000	0.9200
15	0.4000	0.8040	0.5000	0.6480	0.8000	0.7520	1.6000	0.9730
16	0.4500	0.8840	0.6000	0.7150	0.8500	0.7720	2.0000	1.0760
17	0.5000	0.9640	0.7000	0.7820	0.9000	0.7920	3.0000	1.3280
18	0.5500	1.0440	0.8000	0.8490	0.9500	0.8120	4.0000	1.5780
19	0.6000	1.1240	0.9000	0.9150	1.0000	0.8320	5.0000	1.8280
20			1.0000	0.9820	2.0000	1.2150		
21			2.0000	1.6490	3.0000	1.5960		
22			3.0000	2.3160	4.0000	1.9770		
23			5.0000	3.6490	5.0000	2.3580		

Table 8.8: Carter-Tracy Aquifer Influence Functions (R_D =1.5, 2.0, 2.5 and 3.0)

Carter-Tracy Aquifer Influence Functions								
No.	r_D = 3.5 Dimensionless		r_D = 4.0 Dimensionless		r_D = 4.5 Dimensionless		r_D = 5.0 Dimensionless	
	t_D	p_D	t_D	p_D	t_D	p_D	t_D	p_D
1	1.0000	0.8020	1.5000	0.9270	2.0000	1.0230	3.0000	1.1670
2	1.1000	0.8300	1.6000	0.9480	2.1000	1.0400	3.1000	1.1800
3	1.2000	0.8570	1.7000	0.9680	2.2000	1.0560	3.2000	1.1920
4	1.3000	0.8820	1.8000	0.9880	2.3000	1.0720	3.3000	1.2040
5	1.4000	0.9060	1.9000	1.0070	2.4000	1.0870	3.4000	1.2150
6	1.5000	0.9290	2.0000	1.0250	2.5000	1.1020	3.5000	1.2270
7	1.6000	0.9510	2.2000	1.0590	2.6000	1.1160	3.6000	1.2380
8	1.7000	0.9730	2.4000	1.0920	2.7000	1.1300	3.7000	1.2490
9	1.8000	0.9940	2.6000	1.1230	2.8000	1.1440	3.8000	1.2590
10	1.9000	1.0140	2.8000	1.1540	2.9000	1.1580	3.9000	1.2700
11	2.0000	1.0340	3.0000	1.1840	3.0000	1.1710	4.0000	1.2810
12	2.2500	1.0830	3.5000	1.2550	3.2000	1.1970	4.2000	1.3010
13	2.5000	1.1300	4.0000	1.3240	3.4000	1.2220	4.4000	1.3210
14	2.7500	1.1760	4.5000	1.3920	3.6000	1.2460	4.6000	1.3400
15	3.0000	1.2210	5.0000	1.4600	3.8000	1.2690	4.8000	1.3600
16	4.0000	1.4010	5.5000	1.5270	4.0000	1.2920	5.0000	1.3780
17	5.0000	1.5790	6.0000	1.5940	4.5000	1.3490	5.5000	1.4240
18	6.0000	1.7570	6.5000	1.6600	5.0000	1.4030	6.0000	1.4690
19			7.0000	1.7270	5.5000	1.4570	6.5000	1.5130
20			8.0000	1.8610	6.0000	1.5100	7.0000	1.5560
21			9.0000	1.9940	7.0000	1.6150	7.5000	1.5980
22			10.0000	2.1270	8.0000	1.7190	8.0000	1.6410
23					9.0000	1.8230	9.0000	1.7250
24					10.0000	1.9270	10.0000	1.8080
25					11.0000	2.0310	11.0000	1.8920
26					12.0000	2.1350	12.0000	1.9750
27					13.0000	2.2390	13.0000	2.0590
28					14.0000	2.3430	14.0000	2.1420
29					15.0000	2.4470	15.0000	2.2250

Table 8.9: Carter-Tracy Aquifer Influence Functions (R_D =3.5, 4.0, 4.5 and 5.0)

Carter-Tracy Aquifer Influence Functions								
No.	r_D = 6.0 Dimensionless		r_D = 7.0 Dimensionless		r_D = 8.0 Dimensionless		r_D = 9.0 Dimensionless	
	t_D	p_D	t_D	p_D	t_D	p_D	t_D	p_D
1	4.0000	1.2750	6.0000	1.4360	8.0000	1.5560	10.0000	1.6510
2	4.5000	1.3220	6.5000	1.4700	8.5000	1.5820	10.5000	1.6730
3	5.0000	1.3640	7.0000	1.5010	9.0000	1.6070	11.0000	1.6930
4	5.5000	1.4040	7.5000	1.5310	9.5000	1.6310	11.5000	1.7130
5	6.0000	1.4410	8.0000	1.5590	10.0000	1.6530	12.0000	1.7320
6	6.5000	1.4770	8.5000	1.5860	10.5000	1.6750	12.5000	1.7500
7	7.0000	1.5110	9.0000	1.6130	11.0000	1.6970	13.0000	1.7680
8	7.5000	1.5440	9.5000	1.6380	11.5000	1.7170	13.5000	1.7860
9	8.0000	1.5760	10.0000	1.6630	12.0000	1.7370	14.0000	1.8030
10	8.5000	1.6070	11.0000	1.7110	12.5000	1.7570	14.5000	1.8190
11	9.0000	1.6380	12.0000	1.7570	13.0000	1.7760	15.0000	1.8350
12	9.5000	1.6680	13.0000	1.8010	13.5000	1.7950	15.5000	1.8510
13	10.0000	1.6980	14.0000	1.8450	14.0000	1.8130	16.0000	1.8670
14	11.0000	1.7570	15.0000	1.8880	14.5000	1.8310	17.0000	1.8970
15	12.0000	1.8150	16.0000	1.9310	15.0000	1.8490	18.0000	1.9260
16	13.0000	1.8730	17.0000	1.9740	17.0000	1.9190	19.0000	1.9550
17	14.0000	1.9310	18.0000	2.0160	19.0000	1.9860	20.0000	1.9830
18	15.0000	1.9880	19.0000	2.0580	21.0000	2.0510	22.0000	2.0370
19	16.0000	2.0450	20.0000	2.1000	23.0000	2.1160	24.0000	2.0900
20	17.0000	2.1030	22.0000	2.1840	25.0000	2.1800	26.0000	2.1420
21	18.0000	2.1600	24.0000	2.2670	30.0000	2.3400	28.0000	2.1930
22	19.0000	2.2170	26.0000	2.3510	35.0000	2.4990	30.0000	2.2440
23	20.0000	2.2740	28.0000	2.4340	40.0000	2.6580	34.0000	2.3450
24	25.0000	2.5600	30.0000	2.5170	45.0000	2.8170	38.0000	2.4460
25	30.0000	2.8460					40.0000	2.4960
26							45.0000	2.6210
27							50.0000	2.7460

Table 8.10: Carter-Tracy Aquifer Influence Functions (R_D =6.0, 7.0, 8.0 and 9.0)

Carter-Tracy Aquifer Influence Functions				
No.	r_D = 10.0 Dimensionless		Finite Linear Dimensionless	
	t_D	p_D	t_D	p_D
1	12.0000	1.7320	0.0050	0.0798
2	12.5000	1.7500	0.0100	0.1130
3	13.0000	1.7680	0.0200	0.1596
4	13.5000	1.7840	0.0600	0.2764
5	14.0000	1.8010	0.0800	0.3192
6	14.5000	1.8170	0.1000	0.3568
7	15.0000	1.8320	0.1200	0.3909
8	15.5000	1.8470	0.1600	0.4515
9	16.0000	1.8620	0.2000	0.5052
10	17.0000	1.8900	0.2400	0.5544
11	18.0000	1.9170	0.3000	0.6228
12	19.0000	1.9430	0.4000	0.7294
13	20.0000	1.9680	0.6000	0.9328
14	22.0000	2.0170	0.8000	1.1333
15	24.0000	2.0630	1.0000	1.3333
16	26.0000	2.1080		
17	28.0000	2.1510		
18	30.0000	2.1940		
19	32.0000	2.2360		
20	34.0000	2.2780		
21	36.0000	2.3190		
22	38.0000	2.3600		
23	40.0000	2.4010		
24	50.0000	2.6040		
25	60.0000	2.8060		
26	70.0000	3.0080		

Table 8.11: Carter-Tracy Aquifer Influence Functions (R_D =10 and Finite Linear)

For the finite linear Carter-Tracy influence function in Table 8.11 set the inner radius of the aquifer to the length of linear aquifer and the angle of influence to $= \frac{360 \times Width}{(2 \times \pi \times Length)}$ on the AQUCT keyword in the grid section.

For reference Table 8.12 outlines the content terminal rate case for an infinite aquifer derived by van Everdingen and Hurst that is the default table number one used for the Carter-Tracy analytical aquifers and is taken from Bradely[68] table 38-3 on page 38-6.

Carter-Tracy Infinite Radial Aquifer Influence Function (Default)					
No.	**Infinite Dimensionless**		**No.**	**Infinite Dimensionless**	
	t_D	p_D		t_D	p_D
1	1.0×10^{-2}	0.112	19	4.0	1.275
2	5.0×10^{-2}	0.229	20	5.0	1.362
3	1.0×10^{-1}	0.315	21	6.0	1.436
4	1.5×10^{-1}	0.376	22	7.0	1.500
5	2.0×10^{-1}	0.424	23	8.0	1.556
6	2.5×10^{-1}	0.469	24	9.0	1.604
7	3.0×10^{-1}	0.503	25	10.0	1.651
8	4.0×10^{-1}	0.564	26	15.0	1.829
9	5.0×10^{-1}	0.616	27	20.0	1.960
10	6.0×10^{-1}	0.659	28	25.0	2.067
11	7.0×10^{-1}	0.702	29	30.0	2.147
12	8.0×10^{-1}	0.735	30	40.0	2.282
13	9.0×10^{-1}	0.772	31	50.0	2.388
14	1.0	0.802	32	60.0	2.476
15	1.5	0.927	33	70.0	2.550
16	2.0	1.020	34	80.0	2.615
17	2.5	1.101	35	90.0	2.672
18	3.0	1.169	36	100.0	2.723

Table 8.12: Carter-Tracy Infinite Radial Aquifer Influence Function (Default)

For an overview of analytical aquifers see Dake[69].

[68] *Bradley Howard B., et. al,, Petroleum Engineering Handbook, Society of Petroleum Engineers (June 1989), ISBN:9781555630102.*

[69] *Dake, L.P. Fundamentals of Reservoir Engineering, Amsterdam, The Netherlands, Elsevier Science BV (1978) Chapter 9.*

Example

```
--
--       CARTER-TRACY AQUIFER INFLUENCE TABLES
--       (STARTS FROM TABLE NO. 2, AS DEFAULT IS TABLE NO. 1)
--
AQUTAB
--
--         TD          PD
--       -------    ---------
          0.06        0.251
          0.08        0.288
          0.10        0.322
          0.12        0.355
          0.14        0.387
          0.16        0.420
          0.18        0.452
          0.20        0.484
          0.22        0.516
          0.24        0.548
          0.26        0.580
          0.28        0.612
          0.30        0.644
          0.35        0.724
          0.40        0.804
          0.45        0.884
          0.50        0.964
          0.55        1.044
          0.60        1.124                                / RD=1.5 TABLE NO. 02
--
--         TD          PD
--       -------    ---------
          0.22        0.443
          0.24        0.459
          0.26        0.476
          0.28        0.492
          0.30        0.507
          0.32        0.522
          0.34        0.536
          0.36        0.551
          0.38        0.565
          0.40        0.579
          0.42        0.593
          0.44        0.607
          0.46        0.621
          0.48        0.634
          0.50        0.648
          0.6         0.715
          0.7         0.782
          0.8         0.849
          0.9         0.915
          1.0         0.982
          2.0         1.649
          3.0         2.316
          5.0         3.649                                / RD=2.0 TABLE NO. 03
```

The above example defines tables two and three Carter-Tracy aquifer influence tables.

8.3.13 BDENSITY – DEFINE THE SURFACE BRINE DENSITY FOR THE FLUID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

BDENSITY defines the brine surface density for when the brine phase has been activated in the model by the BRINE keyword in the RUNSPEC section. The number of BDENSITY vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section. Each record consists of a maximum of NPPVT values, as declared on the TABDIMS keyword in the RUNSPEC section, with each value representing a brine surface density.

The keyword is used in conjunction with the PVTWSALT keyword in the PROPS section, with each brine density value matching with the salt concentration values in column 1 of each table in the PVTWSALT keyword. Note that the BDENSITY keyword is optional, and if absent from the input file, then the brine surface densities will be set to the water density values declared via the DENSITY keyword in the PROPS section. In this case there is no variation in brine surface density with respect to salt concentration.

No.	Name	Description			Default
1	WATDEN	**Field**	**Metric**	**Laboratory**	
		WATDEN is a real monotonically increasing positive row vector that defines the brine density at surface conditions for the given salt concentrations on the corresponding PVTWSALT keyword in the PROPS section. There should be one row element for each salt concentration columnar element (SALTCON) on the PVTWSALT keyword.			
		lb/ft^3	kg/m	gm/cc	None

Notes:

1) Each row vector data set must be terminated by a "/" including the last data set.

Table 8.13: BDENSITY Keyword Description

Note

In OPM Flow the tracer equations are solved decoupled from the reservoir equations at the end of a time step. For each tracer an implicit system is solved, however, the tracer equations are linear, resulting in converge in two iterations. However, the Brine phase is solved fully implicitly and is fully coupled with the other flow equations.

This is different to the commercial simulator, where the tracer equations are solved explicitly after the flow equations have converged at the end of a time step. This can lead to numerical instabilities if there are large variations in brine densities.

Example

The following shows the BDENSITY and PVTWSALT keywords for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set equal to two and NPPVT is set to greater than four on the TABDIMS keyword.

```
--
--       BRINE WATER DENSITY DATA FOR PVTWSALT KEYWORD
--
--       SALTCON  SALTCON  SALTCON  SALTCON  SALTCON
--       DENSITY  DENSITY  DENSITY  DENSITY  DENSITY
--       -------  -------  -------  -------  -------
BDENSITY
         62.20    63.50    64.75    65.90              / FOR PVTWSALT TABLE 1
         64.00    65.50    67.00                       / FOR PVTWSALT TABLE 2
--
--       WATER SALT PVT TABLE
--
PVTWSALT
--       REF PRES  REF SALT
--       PSIA      LB/STB
--       --------  --------
         4500.0    0.000                               / TABLE NO. REF. DATA
--
--       SALTCONC  BW        CW        VISC     VISC
--       LB/STB    RB/STB    1/PSIA    CPOISE   GRAD
--       --------  --------  -------   ------   ------
            0.0    1.020     2.7E-6    0.370    0.0
            2.0    1.010     2.7E-6    0.370    0.0
            4.0    1.000     2.7E-6    0.370    0.0
           10.0    0.950     2.7E-6    0.370    0.0     / TABLE NO. 01 SALT DATA
--
--       REF PRES  REF SALT
--       PSIA      LB/STB
--       --------  --------
         4000.0    0.000                               / TABLE NO. 02 REF. DATA
--
--       SALTCONC  BW        CW        VISC     VISC
--       LB/STB    RB/STB    1/PSIA    CPOISE   GRAD
--       --------  --------  -------   ------   ------
            0.0    1.005     2.5E-6    0.320    0.0
            6.0    0.985     2.5E-6    0.320    0.0
           12.0    0.930     2.5E-6    0.320    0.0     / TABLE NO. 02 SALT DATA
```

8.3.14 BGGI - DEFINE GI GAS FORMATION VOLUME FACTOR PRESSURE TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The BGGI keyword defines Gi gas formation volume factor as a function of Gi and pressure for when the Gi option has been invoked via the GIMODEL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

The accuracy of gas condensate and volatile oil modeling using a "black-oil" reservoir simulator is now firmly accepted in the industry; both depletion and gas cycling above the saturation point can be modeled and yield an acceptable match compared with compositional simulators. The main deficiency with the existing "black-oil" formulation is the treatment of gas injection below the saturation point, where the compositional effect of the stripping of liquid components is inversely proportional to their molecular weights, is not considered. This is because the "black-oil" model assumes that the saturated hydrocarbon fluid properties are only functions of pressure. Thus, when dry gas is injected into a condensate reservoir below the saturation pressure the injected gas continues to re-vaporize liquid at a rate governed only by the cell pressures. Compositional modeling indicate that this not the case.

The GI option attempts to overcome the limitation of the standard "black-oil" approach by extending the "black-oil" model using the method of Cook et al.[70] to take into account the fluid property changes occurring during gas injection. This is done by extending the fluid property treatment so that the saturated fluid properties depend on pressure (as per the standard "black-oil" formulation) and also on an additional parameter which characterizes the compositional changes in the reservoir liquid and vapor phases at constant pressure.

See also the PVTG and GINODE keywords in the PROPS section.

[70] *Cook, R. E., Jacoby, R. H., and Ramesh, A. B. "A Beta-type Reservoir Simulator for Approximating Compositional Effects During Gas Injection" paper SPE 4272, Society of Petroleum Engineers Journal (1974) 14, No. 5, 471-481.*

8.3.15 BOGI - DEFINE GI OIL FORMATION VOLUME FACTOR PRESSURE TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The BOGI keyword defines Gi oil formation volume factor as a function of Gi and pressure for when the Gi option has been invoked via the GIMODEL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

The accuracy of gas condensate and volatile oil modeling using a "black-oil" reservoir simulator is now firmly accepted in the industry; both depletion and gas cycling above the saturation point can be modeled and yield an acceptable match compared with compositional simulators. The main deficiency with the existing "black-oil" formulation is the treatment of gas injection below the saturation point, where the compositional effect of the stripping of liquid components is inversely proportional to their molecular weights, is not considered. This is because the "black-oil" model assumes that the saturated hydrocarbon fluid properties are only functions of pressure. Thus, when dry gas is injected into a condensate reservoir below the saturation pressure the injected gas continues to re-vaporize liquid at a rate governed only by the cell pressures. Compositional modeling indicate that this not the case.

The GI option attempts to overcome the limitation of the standard "black-oil" approach by extending the "black-oil" model using the method of Cook et al.[71] to take into account the fluid property changes occurring during gas injection. This is done by extending the fluid property treatment so that the saturated fluid properties depend on pressure (as per the standard "black-oil" formulation) and also on an additional parameter which characterizes the compositional changes in the reservoir liquid and vapor phases at constant pressure.

See also the PVTG and GINODE keywords in the PROPS section.

[71] *Cook, R. E., Jacoby, R. H., and Ramesh, A. B. "A Beta-type Reservoir Simulator for Approximating Compositional Effects During Gas Injection" paper SPE 4272, Society of Petroleum Engineers Journal (1974) 14, No. 5, 471-481.*

8.3.16 BOX - Define a Range of Grid Blocks to Enter Property Data

BOX defines a range of grid blocks for which subsequent data is assigned for all the cells in the defined BOX. Note that the BOX grid is reset by the keyword ENDBOX by resetting the current defined BOX to be the whole grid. The keyword can be used for any array and for all grid types.

See *BOX - Define a Range of Grid Blocks to Enter Property Data* in the GRID section for a full description.

8.3.17 COALADS – Define Gas and Solvent Relative Adsorption Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COALADS keyword defines the gas and solvent relative adsorption tables for when the coal phase has been activated via the COAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation

8.3.18 COALPP – Define Gas and Solvent Partial Pressure Adsorption Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COALPP keyword defines the gas and solvent partial pressure adsorption tables for when the coal phase has been activated via the COAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation

8.3.19 COPY – Copy Array Data to Another Array

The COPY keyword copies an array (or part of an array) to another array or part of an array. The arrays can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the COPY keyword is being used.

See *COPY – Copy Array Data to Another Array* in the GRID section for a full description.

8.3.20 COPYBOX – Copy Array Data Defined by a Box

The COPYBOX keyword copies an array (or part of an array) to part of the same array. The array can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the COPYBOX keyword is being used.

See *COPYBOX – Copy Array Data Defined by a Box* in the GRID section for a full description.

8.3.21 COPYREG – Copy an Array to Another Array based on a Region Number

The COPYREG keyword copies a specified array or part of an array based on cells with a specific region number to another array. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the COPYREG keyword is read by the simulator. The property arrays can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the COPYREG keyword is being used.

See *COPYREG – Copy an Array to Another Array based on a Region Number* in the GRID section for a full description.

8.3.22 DENSITY – DEFINE THE SURFACE OIL, WATER GAS DENSITIES FOR THE FLUIDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DENSITY defines the oil, water and gas surface densities for the fluids for various regions in the model. The number of DENSITY vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the DENSITY data sets to different grid blocks in the model is done via the PVTNUM keyword in the REGION section. One data set consists of one record or line which is terminated by a "/". This surface density or gravity must be entered using either the DENSITY or GRAVITY keywords irrespective of which phases are active in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	OILDEN	OILDEN is a real number defining the density of oil at surface conditions.			
		lb/ft^3	kg/m^3	gm/cc	
		600	600	600	Defined
2	WATDEN	WATDEN is a real number defining the density of water at surface conditions.			
		lb/ft^3	kg/m^3	gm/cc	
		999.014	999.014	999.014	Defined
3	GASDEN	GASDEN is a real number defining the density of gas at surface conditions.			
		lb/ft^3	kg/m^3	gm/cc	
		1.000	1.000	1.000	Defined

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.14: DENSITY Keyword Description

According to the SPE SI standard[72], ***Relative Density*** (γ) replaces ***Specific Gravity*** as the term used to define the ratio of the density of a known material to the density of reference material, at standard conditions of pressure and temperature. Standard conditions vary throughout the world, but for oil field units one normally uses14.7 psia and 60 °F, whereas for SI units some areas use 101.325 kPa and 15 °C.

See also the GRAVITY keyword in the PROPS section.

[72] *The SI Metric System of Units and SPE Metric Standard, Adopted for Use as a Voluntary Standard by the SPE Board of Directors, June 1983, Society of Petroleum Engineers.*

Examples

The following shows the DENSITY keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to one.

```
--
--        OIL       WAT        GAS
--        DENSITY   DENSITY    DENSITY
--        -------   -------    -------
DENSITY
          39.0      62.37      0.04520                        / PVT DATA REGION 1
```

The next example shows the DENSITY keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to three.

```
--
--        OIL       WAT        GAS
--        DENSITY   DENSITY    DENSITY
--        -------   -------    -------
DENSITY
          38.0      62.30      0.04500                        / PVT DATA REGION 1
          39.0      62.37      0.04520                        / PVT DATA REGION 2
          40.0      62.40      0.04800                        / PVT DATA REGION 3
```

There is no terminating "/" for this keyword.

8.3.23 DEPTHTAB – RIVER TIME AND DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DEPTHTAB, defines the river time and depth tables, for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.24 DIAGDISP – Activate Alternate Form of Tracer Dispersion

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DIAGDISP, activates the alternate form of tracer dispersion matrix for when the Tracer facility has been activated by the TRACERS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.25 DIFFC – DEFINE PVT REGION MOLECULAR DIFFUSION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFFC keyword defines the molecular diffusion tables for each PVT region for when the Diffusion option has been activated by the DIFFUSE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.26 DIFFCOAL – Define Coal Bed Methane Gas Diffusion Data

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DIFF keyword defines the coal bed methane diffusion data for when the Coal Bed Methane option has been activated via the COAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.27 DIFFDP – Activate Dual Porosity Molecular Diffusion for Matrix-Fracture Flow Only

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DIFFDP, activates the dual porosity molecular diffusion for matrix-fracture flow only option for when the Dual Porosity option has be activated by either the DUALPORO or DUALPERM keywords, and the Diffusivity option has been activated by the DIFFUSE keywords; three keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.28 DIFFMMF – Define Diffusivity Multipliers for Matrix-Fractures

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DIFFMMF, defines the diffusivity multipliers for matrix-fractures for when the Dual Porosity option has be activated by either the DUALPORO or DUALPERM keywords, or the Coal Bed Methane option is selected by the COAL keyword, and the Diffusivity option has been activated by the DIFFUSE keywords; all four keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.29 DISPERSE– DEFINE DISPERSION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DISPERSE, defines the dispersion tables for when the Dispersion option has been activated via declaring the dimensions of the DISPERSE tables using the DISPDIMS keyword and activating the Tracer option via the TRACERS keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.30 DPKRMOD – Modify Matrix Oil Relative Permeability Data

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DPKRMOD keyword can be used to modify the matrix oil relative permeability data (oil-water, oil-gas) and the scaling of the fracture to matrix relative permeabilities, for dual porosity runs for when a Dual Porosity model has been activated by either the DUALPORO or DUALPERM keywords in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.31 DSPDEINT – Activate Brine Tracer Dispersion Interpolation by Water Density

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DSPDEINT, activates the brine tracer dispersion interpolation by water density option for when the Brine phase is activated in the model by the BRINE keyword in the RUNSPEC section and the DISPERSE keyword in the PROPS section is in the input file. They keyword cause the lookup and interpolation of the DISPERSE tracer concentration to water density, that is the tracer concentration data on the DISPERSE keyword has been replaced by the water density data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.32 EHYSTR – DEFINE HYSTERESIS MODEL AND PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EHYSTR keyword defines the hysteresis model and associated parameters when the hysteresis option has been activated by the HYSTER variable on the SATOPTS keyword in the RUNSPEC section. Both the Carlson[73] and Killough[74] models are available.

No.	Name	Description	Default
1	HYSTRCP	HYSTRCP is a positive real value that defines the Killough curvature parameter for capillary pressure hysteresis model. The value should range from 0.05 to 0.10. This option is ignored by OPM Flow.	0.1
2	HYSTMOD	An integer value that determines the relative permeability hysteresis model to be used depending on the phase and the wettability of the system. HYSTMOD should be set to one of the following values:	0

HYSMOD	Non-Wetting Phases	Wetting Phase
Water Wet Hysteresis Models		
-1	Equilibration option for equilibrating the model with the SATNUM (drainage curves) and running the model with imbibition curves (IMBNUM). This option implies no hysteresis.	
0	Carlson Hysteresis Model	SATNUM
1	Carlson Hysteresis Model	IMBNUM
2	Killough Hysteresis Model	SATNUM
3	Killough Hysteresis Model	IMBNUM
4	Killough Hysteresis Model	Killough Hysteresis Model
Oil Wet to Water Wet Water Wet		
5	Carlson Non-Wetting Modeling for Gas and Water	SATNUM
6	Killough Non-Wetting Modeling for Gas and Water	SATNUM
7	Killough Non-Wetting Modeling for Gas and Water	Killough Non-Wetting Modeling for the Wetting Oil Phase
Note only the default value of zero is supported by OPM Flow.		

[73] *Carlson, F. M. "Simulation of Relative Permeability Hysteresis to the Non-Wetting Phase," paper SPE 10157, presented at the SPE Annual Technical Conference & Exhibition, San Antonio, Texas, USA (October 5-7, 1981).*

[74] *Killough, J. E. "Reservoir Simulation with History-dependent Saturation Functions," paper SPE 5106, Society of Petroleum Engineers Journal (1976) 16, No. 1, 37-48.*

No.	Name	Description	Default
3	HYSTREL	HYSTREL is a positive real number that defines the Killough's wetting phase relative permeability curvature parameter. This parameter is only applicable if HYSMOD is set to either 4 or 7. This option is ignored by OPM Flow.	1.0
4	HYSTSGR	HYSTSGR is a positive real number that sets a scaling parameter for the trapped non-wetting phase saturation in the Killough model. This option is ignored by OPM Flow.	0.1
5	HYSTOPT	A character string that determines if the hysteresis model should be activated for relative permeability, capillary pressure curves, or both, and should be set to one of the following: 1) BOTH: apply hysteresis modeling to both relative permeability, and capillary pressure curves. 2) PC: apply hysteresis modeling to capillary pressure curves only. 3) KR: apply hysteresis modeling to relative permeability curves only. For all cases HYSTMOD defines the model to be used for relative permeability hysteresis modeling (if applicable). Capillary pressure hysteresis always users the Killough capillary pressure model. Note only the default value of BOTH is supported by OPM Flow.	BOTH
6	HYSTSCAN	A character string that determines the shape of Killough capillary pressure scanning curves when secondary reversal curves, that is for a drainage, imbibition, drainage cycle. 1) RETR: Secondary drainage curves re-traverses the same scanning curve. 2) NEW: Secondary drainage curves follows a new scanning curve and further reversals also generate a new scanning curve. This option is ignored by OPM Flow.	RETR
7	HYSTMOB	A character string that determines how to apply the mobility control correction invoked by the MOBILE variable on the EQLOPTS keyword in the RUNSPEC section. HYSTMOB should be set to one of the following: 1) DRAIN: Only the drainage curve end-points are modified. 2) BOTH: Both the drainage and imbibition curve end-points are modified. The Mobility Control option is not supported in OPM Flow so this parameter has no effect.	DRAIN
8	HYSTWET	A character string that sets the wetting phase in three phase systems to either oil or gas and should be set to one of the following: 1) OIL: Oil is set as the wetting phase and the oil-gas relative permeability curves are determined by HYSTMOD for the wetting phase. 2) GAS: Oil is set as the non-wetting phase and the oil-gas relative permeability curves are determined by HYSTMOD for the non-wetting phase. Note for all the above cases the gas relative permeability curves are always treated as as a non-wetting phase. This option is ignored by OPM Flow.	None
9		Not used	
10		Not used	

No.	Name	Description	Default
11		Not used	
12		Not used	
13		Not used	

Notes:

1) The keyword is terminated by "/".

Table 8.15: EHYSTR Keyword Description

Example

```
--
--        HYSTERESIS MODEL AND PARAMETERS
--
--        PC-CUR  MODEL   RELPERM TRAPPED OPTION  SHAPE    MOBILIT  WET
--        HYSTRCP HYSTMOD HYSTREL HYSTSGR HYSTOPT HYSTSCAN HYSTMOB  HYSTWET
EHYSTR
          0.1     0       0.1     1*      KR      1*       1*       1*          /
```

The above example defines the hysteresis model and parameters used in the Norne model. Here the default value is used for the Killough curvature parameter for capillary pressure hysteresis mode, the Carlson hysteresis model is used for the non-wetting phase and SATNUM for the wetting phase, 0.1 is used for Killough's wetting phase relative permeability curvature parameter (this parameter is ignored because the Carlson model has been selected), the default values for the trapped non-wetting phase saturation in the Killough mode (again, this parameter is ignored because the Carlson model has been selected, and the hysteresis modeling is only applied to relative permeability curves.

8.3.33 EHYSTRR – DEFINE HYSTERESIS MODEL AND PARAMETERS VIA SATNUM

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EHYSTRR keyword defines the hysteresis model and associated parameters via the drainage SATNUM allocation region array, for when the hysteresis option has been activated by the HYSTER variable on the SATOPTS keyword in the RUNSPEC section. Only the Killough[75] model is available for this keyword and the keyword is optional.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness. See also the EHYSTR keyword in the RUNSPEC for an alternative keyword to enter the hysteresis model and associated parameters that is supported by OPM Flow

No.	Name	Description	Default
1	HYSTRCP	HYSTRCP is a positive real value that defines the Killough curvature parameter for capillary pressure hysteresis model. The value should range from 0.05 to 0.10.	0.1
2	HYSTREL	HYSTREL is a positive real number that defines the Killough's wetting phase relative permeability curvature parameter. This parameter is ignored if HYSMOD on the EHYSTR keyword is not set to 4.	1.0
3	HYSTSGR	HYSTSGR is a positive real number that sets a scaling parameter for the trapped non-wetting phase saturation in the Killough model.	0.1

Notes:

1) The keyword is followed by NTSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
2) There is no "/" terminator for the keyword.

Table 8.16: EHYSTRR Keyword Description

Example

```
--
--        HYSTERESIS MODEL AND PARAMETERS VIA SATNUM
--
--        PC-CUR  RELPERM TRAPPED
--        HYSTRCP HYSTREL HYSTSGR
EHYSTRR
          0.04    1.0     1*                                  / SATNUM REGION 1
          0.06    1.0     1*                                  / SATNUM REGION 2
          0.08    1.0     1*                                  / SATNUM REGION 3
          0.10    1.0     1*                                  / SATNUM REGION 4
          0.10    1.0     1*                                  / SATNUM REGION 5
```

The above example defines the hysteresis model and parameters for when NTSFUN equals five on the TABDIMS keyword in the RUNSPEC section, that is for five SATNUM regions.

[75] *Killough, J. E. "Reservoir Simulation with History-dependent Saturation Functions," paper SPE 5106, Society of Petroleum Engineers Journal (1976) 16, No. 1, 37-48.*

8.3.34 ENDBOX – DEFINE THE END OF THE BOX DEFINED GRID

This keyword marks the end of a previously defined BOX sub-grid as defined by a previously entered BOX keyword. The keyword resets the input grid to be the full grid as defined by the NX, NY, and NZ variables on the DIMENS keyword in the RUNSPEC section.

See *ENDBOX – Define the End of the BOX Defined Grid* in the GRID section for a full description.

8.3.35 ENDFIN – END THE DEFINITION OF A LOCAL GRID REFINEMENT

ENDFIN defines the end of a Cartesian or radial local grid refinement ("LGR") definition and a LGR property definition data set.

See *ENDFIN – End the Definition of a Local Grid Refinement* in the GRID section for a full description.

8.3.36 ENKRVD – Define Relative Permeability End-Points versus Depth Functions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the maximum oil, gas, and water relative permeability values versus depth for the three phases and for when the end-point scaling option has been invoked by the ENDSCALE keyword in the RUNSPEC section. This functionality is not supported in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.37 ENPCVD – Define Maximum Capillary Pressure versus Depth Functions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the maximum gas-oil and water-oil capillary pressure values versus depth for when the end-point scaling option has been invoked by the ENDSCALE keyword in the RUNSPEC section

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.38 ENPTVD – Define Relative Permeability Saturation End-Points versus Depth

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the variation of the relative permeability saturation end-points (SWL, SWCR, etc.) for all three phases versus depth for when the end-point scaling option has been invoked by the ENDSCALE keyword in the RUNSPEC section. This functionality is not supported in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.39 ENSPCVD – Define Capillary Pressure End-Points versus Depth

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the variation of the capillary pressure saturation end-points, connate gas (SGL) and connate water (SWL), versus depth for when the end-point scaling option has been invoked by the ENDSCALE keyword in the RUNSPEC section. This functionality is not supported in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.40 EPSDBGS - Write End-Point Debug Data to the DEBUG File (Multiple)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, EPSDBGS, defines the end-point debug data for multiple grid blocks that should be written to the DEBUG file (*.DBG) for when the End-Point Scaling option has been activated by the ENDSCALE keyword in the RONSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.41 EPSDEBUG - Write End-Point Debug Data to the DEBUG File (Individual)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, EPSDEBUG, defines the end-point debug data for individual grid blocks that should be written to the DEBUG file (*.DBG) for when the End-Point Scaling option has been activated by the ENDSCALE keyword in the RONSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.42 EQUALREG – Sets an Array to a Constant by Region Number

The EQUALREG keyword sets a specified array to a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the EQUALREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the EQUALREG keyword is being used.

See *EQUALREG – Sets an Array to a Constant by Region Number* in the GRID section for a full description.

8.3.43 EQUALS – Sets a Specified Array to a Constant

The EQUALS keyword sets a specified array or part of an array to a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the EQUALS keyword is being used.

See *EQUALS – Sets a Specified Array to a Constant* in the GRID section for a full description.

8.3.44 ESSNODE – Define Salt Concentration Data for Water-Oil Surface Tension

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, ESSNODE, defines the salt concentration data that is used in calculating the water-oil surface tension for when the Brine option has been activated by the BRINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.45 FHERCHBL – DEFINE HERSCHEL-BULKLEY DATA VERSUS POLYMER CONCENTRATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FHERCHBL keyword defines Herschel-Bulkley rheological property data for Non-Newtonian fluids versus polymer concentration, for when the Polymer option has been invoked via the POLYMER keyword in the RUNSPEC section and Non-Newtonian Fluid phase has been declared active by the NNEWTF keyword, also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.46 FILEUNIT – ACTIVATE UNIT CONSISTENCY VERIFICATION

The FILEUNIT keyword defines the units of the of the data set, and is used to verify that the units in the input deck and any associated include files are consistent grid data. The keyword does not provide for the conversion between different sets of units.

See *FILEUNIT – Activate Unit Consistency Checking* in the GRID section for a full description.

8.3.47 FILLEPS – ACTIVATE SATURATION END-POINT EXPORT TO THE INIT FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword switches on the export of the saturation end-point data (SWL, SWCR, SOWCR array etc.) to the *.INIT file so that the data can be viewed in post-processing software like OPM ResInsight.

There is no data required for this keyword.

Example

```
--
--       ACTIVATE SATURATION END-POINT EXPORT TO THE INIT FILE
--
FILLEPS
```

The above example switches on the export of the end-point saturation data to the *.INIT file.

8.3.48 FOAMADS - DEFINE FOAM ROCK ADSORPTION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMADS keyword defines the foam rock adsorption tables for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	FOAMCON	A columnar vector of real monotonically increasing down the column values that defines the foam concentration in the solution surrounding the rock. The first entry should be zero to define a no foam concentration data set. Units are dependent on the transport phase specified via the FOAMOPT1 variable on the FOAMOPTS keywod in the PROPS section. FOAMOPT1 should be set to either GAS or WATER.			
		Gas: lb/Mscf Water: lb/stb	Gas: kg/sm^3 Water: kg/sm^3	Gas: gm/scc Water: gm/scc	None
2	FOAMRATI	A columnar vector of real increasing down the column values that defines the mass of adsorbed foam per unit mass of rock of the saturated concentration of foam adsorbed by the rock for a given FOAMCON. The first table data set entry should be zero to define a no foam concentration data set. Each FOAMCON/FOAMRATI data set should be terminated by a "/"			
		lb/lb	kg/kg	gm/gm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.17: FOAMADS Keyword Description

Example

```
--
--       FOAM ROCK ADSORPTION TABLE
--
FOAMADS
--       FOAM       FOAM
--       FOAMCON    FOAMRATI
--       -------    --------
             0.0     0.00000
             2.0     0.00003
             4.0     0.00005
             6.0     0.00007
             8.0     0.00009
            10.0     0.00011
            12.0     0.00012
            14.0     0.00015                                / TABLE NO. 01
--       FOAM       FOAM
--       FOAMCON    FOAMRATI
--       -------    --------
             0.0     0.00000
             3.0     0.00004
             5.0     0.00006
             7.0     0.00008
             8.0     0.00009
            10.0     0.00011                                / TABLE NO. 02
```

The above example defines two foam rock adsorption tables assuming NTSFUN equals two and NSSFUN is greater than or equal to eight on the TABDIMS keyword in the RUNSPEC section.

8.3.49 FOAMDCYO – Define Foam Decay versus Oil Saturation Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMDCYO keyword defines the foam decay half-life versus oil saturation for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.50 FOAMDCYW – Define Foam Decay versus Water Saturation Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMDCYW keyword defines the foam decay half-life versus water saturation for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.51 FOAMFCN – Define Foam Gas Mobility Reduction versus Capillary Number

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMFCN keyword defines the reduction in gas mobility versus capillary number, for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section, and the FOAMOPT2 parameter on the FOAMOPTS keyword in the PROPS section has been set to the character string FUNC.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.52 FOAMFRM – DEFINE FOAM GAS MOBILITY REDUCTION VERSUS REFERENCE MOBILITY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMFRM keyword defines the reduction in gas mobility versus the reference mobility reduction factor, for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section, and the FOAMOPT2 parameter on the FOAMOPTS keyword in the PROPS section has been set to the character string FUNC.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.53 FOAMFSC – DEFINE FOAM GAS MOBILITY VERSUS SURFACTANT CONCENTRATION FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMFSC keyword defines the reduction in gas mobility as a function of the foam surfactant concentration within a grid block. The Foam option must be activated by the FOAM keyword in the RUNSPEC section in order to use this keyword. In addition, the FOAMOPT2 parameter on the FOAMOPTS keyword in the PROPS section must be set to the character string FUNC, in order to activate the functional form of the gas mobility reduction calculations.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	FOAMCON	A real positive value that defines the foam surfactant concentration at which foam modeling becomes active in the model and a strong foam is formed. FOAMCON cannot be defaulted and must be specified for the first table. Subsequent tables can be defaulted and will in this case use the previous tables' entries as the default value.			
		lb/stb	kg/sm^3	gm/scc	None
2	FOAMEXP	A real positive value that defines an exponent that determines the gradient in the change of the reduction in gas mobility due to foam (e_s in equation (8.1). Note if e_s is less than one then the slope of F_s in equation (8.1) will be infinite at C_s equal to zero. In this case, small surfactant concentrations have a significant effect on the mobility, especially if the reference concentration C_s^r is also small. If this is the case use MINSURF one this keyword to set a minimum surfactant concentration to avoid small-scale numerical errors from affecting the simulation.			
		dimensionless 1.0	dimensionless 1.0	dimensionless 1.0	Defined
3	MINSURF	MINSURF is a real positive value that defines the minimum surfactant concentration for which the reduction in gas mobility will be calculated. The default value of 1×10^{-20} implies that there is no minimum			
		lb/stb 1×10^{-20}	kg/sm^3 1×10^{-20}	gm/scc 1×10^{-20}	Defined
4	MINSWAT	MINSWAT is a real positive value less than 1.0 that sets the minimum water saturation for which foam has no effect. The default value of 1×10^{-6} implies that there is no minimum. Note that this parameter is only used in the commercial simulator's compositional simulator and is therefore not used by OPM Flow or the commercial simulators "black-oil" simulator.			
		dimensionless 1×10^{-6}	dimensionless 1×10^{-6}	dimensionless 1×10^{-6}	Defined

No.	Name	Description			Default
		Field	Metric	Laboratory	

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain just one row and one row only.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.18: FOAMFSC Keyword Description

The gas mobility reduction as a function of surfactant concentration is of the form:

$$F_s = \left(\frac{C_s}{C_s^r}\right)^{e_s} \tag{8.1}$$

Where:

F_s = the resulting gas mobility reduction factor as a function of surfactant concentration,
C_s = surfactant concentration,
C^r_s = reference surfactant concentration, that is $C_s < C_s^r$ defines a weak foam and $C_s > C_s^r$ defines a strong foam (FOAMCON), and
e_s = exponent that determines the gradient in the change of the reduction in gas mobility due to foam (FAOAMEXP).

The functional form of the reduction in gas mobility factor (M_{rf}) is:

$$M_{rf} = \frac{1}{1 + \left(M_r \times F_s \times F_w \times F_o \times F_c\right)} \tag{8.2}$$

Where:

M_{rf} = the reference mobility reduction factor, see the FOAMFRM keyword in the PROPS section,
F_s = gas mobility reduction factor as a function of surfactant concentration, see the FOAMFSC keyword in the PROPS section,
F_w = gas mobility reduction factor as a function of water saturation, see the FOAMFSW keyword in the PROPS section,
F_o = gas mobility reduction factor as a function of oil saturation, see the FOAMFSO keyword in the PROPS section, and
F_c = gas mobility reduction factor as a function of capillary number, see the FOAMFCN keyword in the PROPS section.

See also the FOAM keyword in the RUNSPEC section, the FOAMADS, FOAMMOB, FOAMOPTS and FOAMROCK keywords in the PROPS section.

Example

```
--
--       FOAM GAS MOBILITY VERSUS SURFACTANT CONCENTRATION FUNCTIONS
--
FOAMFSC
--       FOAM       FOAM      FOAM      FOAM
--       FOAMCON    FOAMEXP   MINSURF   MINSWAT
--       -------    -------   -------   -------
           0.001      1.010                          / TABLE NO. 01
           0.002      1.000                          / TABLE NO. 02
                                                     / TABLE NO. 03 (DEFAULTED)
           0.001      0.850  1.0E-10                 / TABLE NO. 04
           0.002      1.030                          / TABLE NO. 05
           0.002      1.000                          / TABLE NO. 06
```

Here, NTSFUN equals six on the TABDIMS keyword in the RUNSPEC section and therefore six entries are required for the FOAMFSC keyword. Table number three is completed defaulted and will therefore use all the properties from the previous table, that is table number two.

8.3.54 FOAMFSO – DEFINE FOAM GAS MOBILITY REDUCTION VERSUS OIL SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMFSO keyword defines the reduction in gas mobility versus oil saturation, for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section, and the FOAMOPT2 parameter on the FOAMOPTS keyword in the PROPS section has been set to the character string FUNC.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.55 FOAMFST – DEFINE FOAM GAS-WATER SURFACE TENSION VERSUS SURFACTANT CONCENTRATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMFST keyword defines the gas-water surface tension versus the foam surfactant concentration, for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section, and the FOAMOPT2 parameter on the FOAMOPTS keyword in the PROPS section has been set to the character string FUNC.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.56 FOAMFSW – Define Foam Gas Mobility Reduction versus Water Saturation

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMFRM keyword defines the reduction in gas mobility versus water saturation, for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section, and the FOAMOPT2 parameter on the FOAMOPTS keyword in the PROPS section has been set to the character string FUNC.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.57 FOAMMOB - DEFINE FOAM GAS MOBILITY VERSUS FOAM CONCENTRATION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMMOB keyword defines the reduction in gas mobility as a function of the foam concentration within a grid block. The Foam option must be activated by the FOAM keyword in the RUNSPEC section in order to use this keyword. In addition, this keyword must be supplied if the foam model is activated.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	FOAMCON	A columnar vector of real monotonically increasing down the column values that defines the foam concentration for the corresponding gas mobility reduction factor (FOAMRATI). The first entry should be zero to define a no foam concentration data set. Units are dependent on the transport phase specified via the FOAMOPT1 variable on the FOAMOPTS keyword in the PROPS section. FOAMOPT1 should be set to either GAS or WATER.			
		Gas: lb/Mscf Water: lb/stb	Gas: kg/sm^3 Water: kg/sm^3	Gas: gm/scc Water: gm/scc	None
2	FOAMRATI	A columnar vector of real decreasing down the column values that defines the corresponding gas mobility reduction factor for a given FOAMCON. The first table data set entry should be one to define a no foam concentration data set. Each FOAMCON/FOAMRATI data set should be terminated by a "/"			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.19: FOAMMOB Keyword Description

See also the FOAM keyword in the RUNSPEC section, the FOAMADS, FOAMOPTS and FOAMROCK keywords in the PROPS section.

Example

```
--
--        FOAM GAS MOBILITY VERSUS FOAM CONCENTRATION TABLES
--
FOAMMOB
--        FOAM       FOAM
--        FOAMCON    FOAMRATI
--        -------    --------
            0.000     1.00000
            0.005     0.50000
            0.010     0.20000
            0.015     0.10000
            0.020     0.07500
            0.025     0.07000
            0.030     0.06500
            0.035     0.06500                                / TABLE NO. 01
--        FOAM       FOAM
--        FOAMCON    FOAMRATI
--        -------    --------
            0.000     0.00000
            0.010     0.50000
            0.015     0.25000
            0.020     0.07500
            0.025     0.07000
            0.030     0.07000                                / TABLE NO. 02
```

Given NTPVT equals two and NPPVT is greater and or equal to eight on the TABDIMS keyword in the RUNSPEC section, the example defines the foam gas mobility versus foam concentration tables for two tables.

There is no terminating "/" for this keyword.

8.3.58 FOAMMOBP – Define Foam Mobility Reduction versus Oil Pressure

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMMOBP keyword defines the reduction in foam mobility reduction versus oil pressure, for when the Foam option has been activated by the FOAM keyword in the RUNSPEC.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.59 FOAMMOBS – Define Foam Mobility Reduction versus Shear

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMMOBS keyword defines the reduction in foam mobility reduction versus shear, for when the Foam option has been activated by the FOAM keyword in the RUNSPEC.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.60 FOAMOPTS - DEFINE FOAM MODEL OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMOPTS keyword defines the transport phase for the foam (gas or water) and how gas mobility reduction should be calculated for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section.

The keyword is recognized by the input deck parser and simulator support is available in the experimental "ebos" simulator.

No.	Name	Description	Default
1	FOAMOPT1	A defined character that defines the transport phase for the foam, and should be set to one of the following character strings: 1) GAS: for the foam to be transport in the gas phase., or 2) WATER: for the foam to be transported in the water phase. Only the default value of GAS is currently supported by OPM Flow.	GAS
2	FOAMOPT2	A defined character that defines the method to be used to calculated the reduction in gas mobility, and should be set to one of the following character strings: 1) TAB: Sets the reduction in gas mobility to be calculated based on tables using the FOAMMOD keyword as a function of foam concentration, the FOAMMOBS as a function for shear, or as a function of pressure using the FOAMMOBP keyword. All keywords are in the PROPS section. 2) FUNC: Sets the reduction in gas mobility to be calculated based on a function defined via the FOAMFRM, FOAMFSC, FOAMFSW, FOAMFSO, FOAMFCN, or FOAMFST keywords in the PROPS section. Note this option is not supported by OPM Flow. Only the default value of TAB is currently supported by OPM Flow.	TAB
Notes: 1) The keyword is terminated by "/".			

Table 8.20: FOAMOPTS Keyword Description

Example

```
--
--        FOAMOPT1  FOAMOPT2
--        PHASE     MOBILITY
--        --------  --------
FOAMOPTS
          GAS       TAB                                    / FOAM MODEL OPTIONS
```

The above example defines the transport phase to be gas and the gas mobility reduction to be use a table as defined by FOAMMOD keyword as a function of foam concentration, the FOAMMOBS as a function for shear, or as a function of pressure using the FOAMMOBP keyword.

8.3.61 FOAMROCK - DEFINE FOAM ROCK PROPERTIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FOAMROCK keyword defines the foam rock properties for when the Foam option has been activated by the FOAM keyword in the RUNSPEC section.

The keyword is recognized by the input deck parser and simulator support is available in the experimental "ebos" simulator.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ADINDX	A positive integer of 1 or 2 that defines foam desorption option, as per: 1) then foam desorption may occur by retracing the foam adsorption isotherm when the local foam concentration in the solution decreases. 2) then no foam desorption may occur. Only the default value of 1 is supported by OPM Flow.			
		dimensionless 1	dimensionless 1	dimensionless 1	Defined
2	DENSITY	A real value that defines the rock in-situ density, that is at reservoir conditions.			
		lb/rtb	kg/rm^3	gm/rcc	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain just one row and one row only.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.21: FOAMROCK Keyword Description

Note

In the commercial simulator if the POLYMER and SURFACT phases have been activated in conjunction with the FOAM phase then the mass density of rock will be set by the PLYROCK, SURFROCK, or the FOAMROCK keywords depending on the order entered in the run deck. This is not the case for OPM Flow.

OPM Flow's FOAM phase is a standalone implementation and cannot be used in conjunction with the either the POLYMER or SURFACT phases.

Example

```
--
--       FOAM-ROCK PROPERTIES
--
FOAMROCK
--       DESORP   INSITU
--       OPTN     DENSITY
--       ------   -------
           1      1800.0                                  / TABLE NO. 01
           2      1980.0                                  / TABLE NO. 02
           1      2005.0                                  / TABLE NO. 03
```

The above example defines three foam-rock tables, based on the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section being equal to three.

There is no terminating "/" for this keyword.

8.3.62 GASDENT – DEFINE GAS DENSITY TEMPERATURE COEFFICIENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

GASDENT defines the gas density as a function of temperature coefficients for when OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC. The reference pressure for this table is given by the VISCREF keyword in the PROPS section. Note this is an OPM Flow keyword used with OPM Flow's "black-oil" thermal model that is not available in the commercial simulator's "black-oil" thermal formulation.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	TEMP is a real positive value greater than zero that defines the absolute reference temperature used with TEXP1 and TEXP2 to estimate the change in gas density with respect to temperature.			
		°R 527.67	°K 293.15	°K 293.15	Defined
2	TEXP1	TEXP1 is a real positive value greater than zero that defines the gas thermal expansion coefficient of the first order.			
		1/°R 1.67×10^{-4}	1/°K 3.0×10^{-4}	1/°K 3.0×10^{-4}	Defined
3	TEXP2	TEXP2 is a real positive value greater than zero that defines the gas thermal expansion coefficient of the second order.			
		$1/°R^2$ 9.26×10^{-7}	$1/°K^2$ 3.0×10^{-6}	$1/°K^2$ 3.0×10^{-6}	Defined

Notes:

1) The keyword is followed by NTPVT records as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each data set is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.22: GASDENT Keyword Description

Example

The following example shows the GASDENT keyword using the default values, for when the thermal option has been activated by the THERMAL keyword in the RUNSPEC section and for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to two.

```
--
--        GAS DENSITY TEMPERATURE COEFFICIENTS (OPM FLOW THERMAL KEYWORD)
--
--        GAS         DENSITY   DENSITY
--        TEMP        COEFF1    COEFF2
--        --------    -------   -------
GASDENT
          1*          1*        1*                          / TABLE NO. 01
          1*          1*        1*                          / TABLE NO. 02
```

There is no terminating "/" for this keyword.

8.3.63 GASVISCT – DEFINE GAS VISCOSITY VERSUS TEMPERATURE FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

GASVISCT defines the gas viscosity as a function of temperature for when OPM Flow's thermal option has been activated by the THERMAL keywords in the RUNSPEC. The reference pressure for this table is given by the VISCREF keyword in the PROPS section. Note this is an OPM Flow keyword used with OPM Flow's "black-oil" thermal model that is not available in the commercial simulator's "black-oil" thermal formulation.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	A columnar vector of real monotonically increasing down the column values that defines the temperature values.			
		°F	°C	°C	None
2	VIS	A columnar vector of real increasing down the column values that defines the gas viscosity for the corresponding temperature values (TEMP). VIS should be given at the reference pressure defined by the PRESS variable on the VISCREF keyword.			
		cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.23: GASVISCT Keyword Description

Example

The following example shows the GASVISCT keyword for when the thermal option has been activated by the THERMAL keyword in the RUNSPEC section and for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set equal to one.

```
--
--       GAS VISCOSITY VERSUS TEMPERATURE TABLES (OPM FLOW EXTENSION KEYWORD)
--
--       GAS         GAS
--       TEMP        VISC
--       --------    -------
GASVISCT
           100.0     0.0500
           110.0     0.0550
           120.0     0.0580
           150.0     0.0620
           165.0     0.0625                                  / TABLE NO. 01
```

There is no terminating "/" for this keyword.

8.3.64 GETDATA – Load and Assign Data Array from INIT or RESTART File

The GETDATA keyword loads a data array from a previously generated INIT or RESTART file and assigns the loaded array to either same array in the run or another array name.

See *GETDATA – Load and Assign Data Array from INIT or RESTART Files* in the GRID section for a full description.

8.3.65 GIALL – DEFINE GI VALUES AND PVT PROPERTIES VERSUS PRESSURE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GIALL keyword defines the GI values and the associated RVGI, RSGI, BGGI and BOGI values as a function of pressure, for when the GI Pseudo Compositional option has been activated in the model via the GIMODEL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.66 GINODE – DEFINE GI NODE VALUES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GINODE keyword defines the Gi node values used when the GIMODEL keyword in the RUNSPEC section has been used to activate the GI Pseudo Compositional option for the run. The keyword is used in conjunction with the RSGI, RVGI, BGGI and BOGI keywords in the PROPS section to describe the fluid properties for the GI Pseudo Compositional option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.67 GRAVCONS – RE-DEFINE GRAVITY CONSTANT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRAVCONS keyword re-defines the gravity constant used in various calculations from the default value used by the simulator. Normally this keyword should not be used.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRAVCONS	GRAVCONS is a positive real number number that defines the gravity constant used in various calculations.			
		ft^2psi/lb 0.00694	m^2bars/kg 0.0000981	cm^2atm/gm 0.000968	Defined

Notes:

1) The keyword is terminated by "/".

Table 8.24: GRAVCONS Keyword Description

Example

```
--
--        RE-DEFINE GRAVITY CONSTANT
--
GRAVITY
          0.0000980665                                    /
```

The above example re-defines the gravity constant to be 0.0000980665 ft^2psi/lb from the default value of 0.00694 ft^2psi/lb.

8.3.68 GRAVITY– DEFINE THE SURFACE OIL, WATER GAS GRAVITIES FOR THE FLUIDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

GRAVITY defines the oil API gravity and water and gas surface specific gravities for the fluids for various regions in the model. The number of GRAVITY vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the GRAVITY data sets to different grid blocks in the model is done via the PVTNUM keyword in the REGION section. One data set consists of one record or line which is terminated by a "/".

This surface density or gravity must be entered using either the DENSITY or GRAVITY keywords irrespective of which phases are active in the model.

This keyword is not supported by OPM Flow but is documented here for completeness; however, the density data can be entered using the DENSITY keyword.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	OILAPI	OILAPI is a real number defining the density of oil at surface conditions. The American Petroleum Institute ("API") classifies oils based on an API gravity (γ_{API}), or degrees API (°API), the relationship between relative density (γ_o) of oil and API gravity (γ_{API}) is given by: $\gamma_{API} = \frac{141.5}{\gamma_o} - 131.5$			
		°API	°API	°API	None
2	WATGRAV	WATGRAV is a real number defining the density of water at surface conditions.			
		(water =1.0) 0.7773	(water =1.0) 0.7773	(water =1.0) 0.7773	Defined
3	GRAVGAS	GRAVGAS is a real number defining the density of gas at surface conditions.			
		(air =1.0) 1.000	(air =1.0) 1.000	(air =1.0) 1.000	Defined

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) The each data set terminated by terminated by "/" at the end of the line, there is no "/" terminator for the keyword.

Table 8.25: GRAVITY Keyword Description

According to the SPE SI standard[76], ***Relative Density*** (γ) replaces ***Specific Gravity*** as the term used to define the ratio of the density of a known material to the density of reference material, at standard conditions of pressure and temperature. Standard conditions vary throughout the world, but for oil field units one normally uses14.7 psia and 60 °F, while for SI units some areas use 101.325 kPa and 15 °C.

[76] *The SI Metric System of Units and SPE Metric Standard, Adopted for Use as a Voluntary Standard by the SPE Board of Directors, June 1983, Society of Petroleum Engineers.*

Examples

The following shows the GRAVITY keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to one.

```
--
--        OIL       WAT        GAS
--        GRAVITY   GRAVITY    GRAVITY
--        -------   -------    -------
GRAVITY
           39.0      1.012      0.650                / GRAVITY PVT DATA REGION 1
```

The next example shows the DENSITY keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to three.

```
--
--        OIL       WAT        GAS
--        GRAVITY   GRAVITY    GRAVITY
--        -------   -------    -------
GRAVITY
           37.0      1.012      0.650                / GRAVITY PVT DATA REGION 1
           38.0      1.012      0.646                / GRAVITY PVT DATA REGION 2
           39.0      1.012      0.640                / GRAVITY PVT DATA REGION 3
```

There is not terminating "/" for this keyword.

8.3.69 HA – HISTORY MATCH END-POINT GRADIENT ADDITIVE MODIFIER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HA series of keywords defines the history match end-point gradient parameters used to set the additive cumulative end point data, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. In addition, the End-Point Scaling option must also be activated by the ENDSCALE keyword which is also in the RUNSPEC section. The keyword consists of the first two characters of "HA" followed by the end-point keyword shown in Table 8.26, for example, HASWL.

This keyword is ignored by OPM Flow and has no effect on the simulation.

Type	End-Point Keyword	Oil-Water End-Point Definitions
Saturation	SWL	Connate water saturation, that is the smallest water saturation in a water saturation function table.
	SWCR	Critical water saturation, that is the largest water saturation for which the water relative permeability is zero.
	SOWCR	Critical oil-in-water saturation, that is the largest oil saturation for which the oil relative permeability is zero in an oil-water system.
Relative Permeability	KRW	Relative permeability of water at the maximum water saturation (normally the maximum water saturation is one).
	KRO	Relative permeability of oil at the maximum oil saturation.
	KRWR	Relative permeability of water at the residual oil saturation or the residual gas saturation in a gas-water run.
	KRORW	Relative permeability of oil at the critical water saturation.
Capillary Pressure	SWLPC	Capillary pressure connate water saturation, that is the smallest water saturation in a water saturation function table.
Type	**End-Point Keyword**	**Gas-Oil End-Point Definitions**
Saturation	SGL	Connate gas saturation, that is the smallest gas saturation in a gas saturation function table.
	SGCR	Critical gas saturation, that is the largest gas saturation for which the gas relative permeability is zero.
	SOGCR	Critical oil-in-gas saturation, that is the largest oil saturation for which the oil relative permeability is zero in an oil-gas-connate water system.
Relative Permeability	KRG	Relative permeability of gas at the maximum gas saturation.
	KRGR	Relative permeability of gas at the residual oil saturation or the critical water saturation in a gas-water run.
	KRORG	Relative permeability of oil at the critical gas saturation.
Capillary Pressure	SGLPC	Capillary pressure connate gas saturation, that is the smallest gas saturation in a gas saturation function table.

Table 8.26: HA Keyword List

See also the HMPROPS keyword in the PROPS section that allows the use of the ADD, BOX, EQUALS, COPY, MINVALUE, and MAXVALUE keywords to be used with the HA and HM series of keywords.

8.3.70 HDISP – Define Tracer Mechanical Dispersivity Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HDISP keyword is combined with three character tracer name, specified by the TRACER keyword in the PROPS section, to define the tracer's mechanical dispersivity parameters.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.71 HM – HISTORY MATCH END-POINT GRADIENT MULTIPLICATIVE MODIFIER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HM series of keywords defines the history match end-point gradient parameters used to set the multiplicative cumulative end point data, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. In addition, the End-Point Scaling option must also be activated by the ENDSCALE keyword which is also in the RUNSPEC section. The keyword consists of the first two characters of "HM" followed by the end-point keyword shown in Table 8.27, for example, HMSWL.

This keyword is ignored by OPM Flow and has no effect on the simulation.

Type	End-Point Keyword	Oil-Water End-Point Definitions
Saturation	SWL	Connate water saturation, that is the smallest water saturation in a water saturation function table.
	SWCR	Critical water saturation, that is the largest water saturation for which the water relative permeability is zero.
	SOWCR	Critical oil-in-water saturation, that is the largest oil saturation for which the oil relative permeability is zero in an oil-water system.
Relative Permeability	KRW	Relative permeability of water at the maximum water saturation (normally the maximum water saturation is one).
	KRO	Relative permeability of oil at the maximum oil saturation.
	KRWR	Relative permeability of water at the residual oil saturation or the residual gas saturation in a gas-water run.
	KRORW	Relative permeability of oil at the critical water saturation.
Capillary Pressure	SWLPC	Capillary pressure connate water saturation, that is the smallest water saturation in a water saturation function table.
Type	**End-Point Keyword**	**Gas-Oil End-Point Definitions**
Saturation	SGL	Connate gas saturation, that is the smallest gas saturation in a gas saturation function table.
	SGCR	Critical gas saturation, that is the largest gas saturation for which the gas relative permeability is zero.
	SOGCR	Critical oil-in-gas saturation, that is the largest oil saturation for which the oil relative permeability is zero in an oil-gas-connate water system.
Relative Permeability	KRG	Relative permeability of gas at the maximum gas saturation.
	KRGR	Relative permeability of gas at the residual oil saturation or the critical water saturation in a gas-water run.
	KRORG	Relative permeability of oil at the critical gas saturation.
Capillary Pressure	SGLPC	Capillary pressure connate gas saturation, that is the smallest gas saturation in a gas saturation function table.

Table 8.27: HM Keyword List

See also the HMPROPS keyword in the PROPS section that allows the use of the ADD, BOX, EQUALS, COPY, MINVALUE, and MAXVALUE keywords to be used with the HA and HM series of keywords.

8.3.72 HMMROCK – History Match Rock Compressibility Gradient Cumulative Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HMMROCK defines the rock compressibility gradient cumulative multipliers to be applied to the rock compressibility as defined by the ROCK keyword in the PROPS section, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The constant should be a real number.

The allocation of the ROCK tables to different grid blocks in the model is done via the PVTNUM or the SATNUM keywords in the REGION section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.73 HMMROCKT – HISTORY MATCH ROCK COMPACTION GRADIENT CUMULATIVE MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HMMROCKT defines the rock compaction gradient cumulative multipliers to be applied to the compaction data entered by the ROCTAB or ROCKTABH keywords in the PRROPS section, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section

The ROCKTAB keyword defines the rock compaction attributes to be applied for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section. ROCKTAB defines pore volume and transmissibility multipliers versus pressure that are used in the compaction calculations. If the RKTRMDIR has been activated in the PROPS section, then the transmissibility multiplier is directional dependent

This keyword should only be used if compaction option has been enabled.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.74 HMPROPS – HISTORY MATCH END-POINT SECTION START

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HMPROPS defines the start of a history match end-points section, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. In addition, the End-Point Scaling option must also be activated by the ENDSCALE keyword which is also in the RUNSPEC section. The keyword allows for the BOX, EQUALS, COPY, MINVALUE, MAXVALUE and ADD keywords to be used with the HA and HM series of keywords that reference the end-point scaling arrays, that is: HMKRG, HMKRGR, HMKRO, HMKRORG, HMKRORW, HMKRW, HMKRWR, HMPCW, HMPCG, HMSGCR, HMSOWCR, HMSOGCR, HMSWCR, and HMSWL keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.75 HMROCK – History Match Rock Compressibility Gradient Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMROCK keyword defines the history match rock compressibility gradient parameters for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of rock gradient parameters that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.76 HMROCKT – HISTORY MATCH ROCK COMPACTION GRADIENT PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMROCKT keyword defines the history match rock compaction gradient parameters for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section, and the history match rock compaction data has been entered via the HMMROCKT, ROCKTAB and ROCKTABH keywords in the PROPS section.

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of rock gradient parameters that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.77 HMRREF – History Match Rock Table Reference Pressure Values

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMRREF keyword defines the history match rock compaction reference pressure gradient values to be used in conjunction with HMMROCKT, ROCKTAB and ROCKTABH keywords in the PROPS section, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The history match rock compaction data is entered via the HMMROCKT, ROCKTAB and ROCKTABH keywords in the PROPS section.

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of rock gradient parameters that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.78 HWKRO – End-Point Scaling of Grid Cell Kro(Swl) (High Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWKRO defines the scaling parameter for the oil relative permeability value at the connate water saturation (SWL), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil relative permeability in the high salinity water wet oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.79 HWKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (High Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWKRORG defines the scaling parameter for the relative permeability of oil at the critical gas saturation (SGCR), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil relative permeability in the high salinity water wet oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.80 HWKRORW – END-POINT SCALING OF GRID CELL KRO(SWCR) (HIGH SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWKRORW defines the scaling parameter for the relative permeability of oil at the critical water saturation (SWCR), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil relative permeability in the high salinity water wet oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.81 HWKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (High Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWKRW defines the scaling parameter at the maximum oil relative permeability value (SWU), that is for S_w = 1.0, for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water relative permeability in the high salinity water wet water relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.82 HWKRWR – End-Point Scaling of Grid Cell KRWR(Sw=1.0) (High Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWKRWR defines the scaling parameter at the maximum oil relative permeability value (SWU), that is for S_w = 1.0, for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water relative permeability in the high salinity water wet water relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.83 HWPCW – END-POINT SCALING OF GRID CELL WATER CAPILLARY PRESSURE (HIGH SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWPCW defines the maximum water-oil pressure values for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section. The keyword re-scales the oil-water capillary pressure in the high salinity water wet capillary saturation tables from a cell's assigned saturation function by the grid block's HWPCW value.

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{HWPCW}{P_{c_{TABLE-MAX}}} \right) \tag{8.3}$$

Where:

P_c = the resulting high salinity water wet water capillary pressure for a grid cell.

HWPCW = the maximum capillary pressure from the HWPCW array for a given cell.

$P_{c_{TABLE}}$ = the capillary pressure in the high salinity water wet water capillary pressure table allocated to the grid block.

$P_{c_{TABLE-MAX}}$ = the maximum capillary pressure in the high salinity water wet water capillary pressure table allocated to the grid block (that is at the connate water saturation).

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.84 HWSOGCR – END-POINT SCALING GRID CELL SOGCR (HIGH SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWSOGCR defines the critical oil saturation with respect to gas ("SOGCR"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil saturation in the high salinity water wet oil-gas relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.85 HWSOWCR – End-Point Scaling Grid Cell SOWCR (High Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWSOWCR defines the critical oil saturation with respect to water ("SOWCR"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil saturation in the high salinity water wet water-oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.86 HWSWCR – End-Point Scaling Grid Cell SWCR (High Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWSWCR defines the critical water saturation ("SWCR"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water saturation in the high salinity water wet water-oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.87 HWSWL – End-Point Scaling Grid Cell SWL (High Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWSWL defines the connate water saturation ("SWL"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water saturation in the high salinity water wet water-oil relative permeability saturation tables, as well as the associated capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.88 HWSWLPC – END-POINT SCALING GRID CELL SWLPC (HIGH SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWSWLPC defines the capillary pressure connate water saturation ("SWLPC"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water saturation in the high salinity water wet water-oil capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

Note the keyword only applies the scaling to the capillary pressures tables, unlike the HWSWL keyword that applies the scaling to both the capillary pressure and relative permeability tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.89 HWSWU – END-POINT SCALING GRID CELL SWU (HIGH SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

HWSWU defines the maximum water saturation("SWU"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water saturation in the high salinity water wet water-oil relative permeability saturation tables, as well as the associated capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.90 HYDRHEAD – Define Hydraulic Head Output Reference Data

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HYDRHEAD keyword defines the hydraulic head reference data for when the hydraulic head information is requested to be written out via one on the SUMMARY keywords (BHD, BHDF, etc.) in the SUMMARY section, or to the RESTART file via the HYDH or HYDHFW variables on the RESTART keyword

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.91 HYMOBGDR – ACTIVATE CARLSON AND KILLOUGH ALTERNATIVE DRAINAGE HYSTERESIS OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, HYMOBGDR, activates the Carlson and Killough alternative secondary drainage hysteresis option for when the hysteresis option has been activated by the HYSTER variable on the SATOPTS keyword in the RUNSPEC section, and either the Carlson[77] or Killough[78] models have been selected via the EHYSTR keyword in the PROPS section. Due to numerical accuracy, the gas saturation may fall below the critical gas saturation (SGCR), that is the largest gas saturation for which the gas relative permeability is zero, and gas would therefore be immobile until the gas saturation increases above SGCR. This option overcomes this situation by letting the gas become mobile once it starts increasing, effectively setting the SGCR to the current gas saturation.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ACTIVATE CARLSON AND KILLOUGH ALTERNATIVE DRAINAGE HYSTERESIS OPTION
--
HYMOBGDR
```

[77] *Carlson, F. M. "Simulation of Relative Permeability Hysteresis to the Non-Wetting Phase," paper SPE 10157, presented at the SPE Annual Technical Conference & Exhibition, San Antonio, Texas, USA (October 5-7, 1981).*

[78] *Killough, J. E. "Reservoir Simulation with History-dependent Saturation Functions," paper SPE 5106, Society of Petroleum Engineers Journal (1976) 16, No. 1, 37-48.*

8.3.92 HYSTCHCK - Activate Hysteresis Inhibition and Drainage End-Point Validation

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HYSTCHCK keyword activate the hysteresis imbibition and drainage end-point check to validate that the two sets of end-points are consistent, for when the Hysteresis option has been activated by the HYSTER variable on the SATOPTS keyword in the RUNSPEC section, and the ENDSCALE keyword in the RUNSPEC section has been activated to enable end-point scaling.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.93 IKRG – END-POINT SCALING OF GRID CELL KRG(SGU) (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IKRG defines the imbibition scaling parameter at the maximum gas relative permeability value (ISGU), normally ISGU is equal to 1.0 - S_{wc}, for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the Hysteresis option. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IKRG	IKRG is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling IKRG imbibition values for each cell in the model. Repeat counts may be used, for example 50*0.400. dimensionless			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the IKRGX±, IKRGY± and IKRGZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.28: IKRG Keyword Description

For the two point scaling option and for the IKRGR gas relative permeability array NOT present in the input deck the k_{rg} value for a grid block is scaled by:

$$k_{rg} = k_{rg_{TABLE}} \left(\frac{IKRG}{k_{rg_{TABLE-MAX}}} \right) \quad (8.4)$$

Where:

k_{rg} = the resulting k_{rg} value for a grid cell.

IKRG = the scaling gas relative permeability value from the IKRG array for a given cell.

$k_{rg_{TABLE}}$ = the gas relative permeability from a grid block's gas-oil table at the grid blocks gas saturation.

$k_{rg_{TABLE-MAX}}$ = the maximum gas relative permeability from a grid block's gas-oil table, that is at the connate water saturation (S_{wc}).

If the IKRGR keyword is present in the input deck then the scaling matches the imbibition relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Phases Present	Critical Saturation
1	Gas-Oil	$S_{critical}$ = 1.0 – ISOGCR - ISWL
2	Gas-Oil-Water	$S_{critical}$ = 1.0 – ISOGCR - ISWL
3	Gas-Water	$S_{critical}$ = 1.0 – ISWCR

Table 8.29: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWUX, ISWUY and ISWUZ instead of ISWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWUX, ISWUX-, ISWUY, ISWUY-, ISWUZ and ISWUZ-, instead of the ISWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the IKRG, IKRGR, IKRO, IKRORG, IKRORW, IKRW and IKRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is IKRGX, IKRGY and IKRGZ instead of IKRG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is IKRGX, IKRGX-, IKRGY, IKRGY-,I KRGZ and IKRGZ-, instead of the IKRG keyword.

Example

The example below defines an input box for the whole grid and for layers one to three, for layer one IKRG is set equal to 0.550, for layer two IKRG equals 0.575, and for layer three IKRG equals 0.600.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET IKRG VALUES FOR THREE LAYERS IN THE MODEL
--
IKRG
          1000*0.555  1000*0.575  1000.0.600               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

8.3.94 IKRGR – END-POINT SCALING OF GRID CELL KRGR(1-SOGCR) (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IKRGR defines the imbibition scaling parameter at the relative permeability of gas at residual oil saturation (1 – ISOGCR), or critical water saturation in a gas-water run (S_{wc}), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the Hysteresis option. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IKRGR	IKRGR is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned imbibition scaling IKRGR values for each cell in the model. In addition, for a given grid block IKGRGT should be less than IKRG. Repeat counts may be used, for example 50*0.400.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the IKRGRX± , IKRGRY± and IKRGRZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.30: IKRGR Keyword Description

When the IKRGR keyword is present in the input deck then the scaling matches the imbibition relative permeability at the critical saturation of the displacing phase (oil or water).

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Phases Present	Critical Saturation
1	Gas-Oil	$S_{critical}$ = 1.0 – ISOGCR - ISWL
2	Gas-Oil-Water	$S_{critical}$ = 1.0 – ISOGCR - ISWL
3	Gas-Water	$S_{critical}$ = 1.0 – ISWCR

Table 8.31: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWUX, ISWUY and ISWUZ instead of ISWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible

versions of the aforementioned arrays should be used, that is ISWUX, ISWUX-, ISWUY, ISWUY-, ISWUZ and ISWUZ-, instead of the ISWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the IKRG, IKRGR, IKRO, IKRORG, IKRORW, IKRW and IKRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is IKRGX, IKRGY and IKRGZ instead of IKRG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is IKRGX, IKRGX-, IKRGY, IKRGY-,I KRGZ and IKRGZ-, instead of the IKRG keyword.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one IKRRG is set equal to 0.500, for layer two IKRGR equals 0.570, and for layer three IKRGR equals 0.580.

```
--
--       DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--       ---------- BOX ---------
--       I1  I2   J1  J2   K1  K2
BOX
         1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--       SET IKRGR VALUES FOR THREE LAYERS IN THE MODEL
--
IKRGR
         1000*0.500  1000*0.570  1000.0.580               /
--
--       DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--       ARRAY       CONSTANT     ---------- BOX ---------
--                                I1  I2   J1  J2   K1  K2
EQUALS
         IKRGR'      0.5500       1*  1*   1*  1*    1   1  / IKRGR FOR LAYER 1
         IKRGR'      0.5700       1*  1*   1*  1*    2   2  / IKRGR FOR LAYER 2
         IKRGR'      0.5800       1*  1*   1*  1*    3   3  / IKRGR FOR LAYER 3
/
```

8.3.95 IKRO – END-POINT SCALING OF GRID CELL KRO(SWL) (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IKRO defines the scaling parameter for the imbibition oil relative permeability value at the connate water saturation (ISWL), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the Hysteresis option. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IKRO	IKRO is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned imbibition scaling IKRO values for each cell in the model. Repeat counts may be used, for example 50*0.500.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the IKROX±, IKROY± and IKROZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.32: IKRO Keyword Description

For the two point scaling option and for the IKRORW or IKRORG oil imbibition relative permeability arrays NOT being present in the input deck the k_{ro} value for a grid block is scaled by:

$$k_{ro} = k_{ro_{TABLE}} \left(\frac{IKRO}{k_{ro_{TABLE-MAX}}} \right) \quad (8.5)$$

Where:

k_{ro} = the resulting k_{ro} value for a grid cell.

IKRO = the scaling oil relative permeability value from the IKRO array for a given cell.

$k_{ro_{TABLE}}$ = the oil relative permeability from a grid block's oil relative permeability table at the grid blocks oil saturation.

$k_{ro_{TABLE-MAX}}$ = the maximum oil relative permeability from a grid block's oil relative table, that is at the critical water saturation (S_{wcr}).

If the IKRORW or IKRORG keywords are present in the input deck then the scaling matches the relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Keywords Present	Critical Saturation
1	KRORW	$S_{critical}$ = 1.0 – SWCR - SGL
2	KRORG	$S_{critical}$ = 1.0 – SGCR - SWL

Table 8.33: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWUX, ISWUY and ISWUZ instead of ISWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWUX, ISWUX-, ISWUY, ISWUY-, ISWUZ and ISWUZ-, instead of the ISWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the IKRG, IKRGR, IKRO, IKRORG, IKRORW, IKRW and IKRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is IKRGX, IKRGY and IKRGZ instead of IKRG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is IKRGX, IKRGX-, IKRGY, IKRGY-,I KRGZ and IKRGZ-, instead of the IKRG keyword.

Example

The example below defines an input box for the whole grid and for layers one to three, for layer one IKRO is set equal to 0.850, for layer two IKRO equals 0.875, and for layer three IKRO equals 0.900.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          IKRO         0.8550        1*  1*   1*  1*    1   1  / IKRO FOR LAYER 1
          IKOG         0.8750        1*  1*   1*  1*    2   2  / IKRO FOR LAYER 2
          IKRO         0.9000        1*  1*   1*  1*    3   3  / IKRO FOR LAYER 3
/
```

8.3.96 IKRORG – END-POINT SCALING OF GRID CELL KRO(SGCR) (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IKRORG defines the scaling parameter for the imbibition relative permeability of oil at the critical gas saturation (ISGCR), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the Hysteresis option. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IKRORG	IKRORG is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned imbibition scaling IKRORG values for each cell in the model. Repeat counts may be used, for example 50*0.850.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the IKRORGX±, IKRORGY± and IKRORGZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.34: IKRORG Keyword Description

When the IKRORG keyword is present in the input deck then the scaling matches the imbibition relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Keywords Present	Critical Saturation
1	IKRORW	$S_{critical}$ = 1.0 – ISWCR - ISGL
2	IKRORG	$S_{critical}$ = 1.0 – ISGCR - SWL

Table 8.35: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWUX, ISWUY and ISWUZ instead of ISWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWUX, ISWUX-, ISWUY, ISWUY-, ISWUZ and ISWUZ-, instead of the ISWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the IKRG, IKRGR, IKRO, IKRORG, IKRORW, IKRW and IKRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is IKRGX, IKRGY and IKRGZ instead of IKRG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is IKRGX, IKRGX-, IKRGY, IKRGY-,I KRGZ and IKRGZ-, instead of the IKRG keyword.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one IKRORG is set equal to 0.750, for layer two IKRORG equals 0.775, and for layer three IKRORG equals 0.800.

```
--
--       DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--       ---------- BOX ---------
--       I1  I2   J1  J2   K1  K2
BOX
         1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--       SET IKRORG VALUES FOR THREE LAYERS IN THE MODEL
--
IKRORG
         1000*0.755  1000*0.775  1000.0.800               /
--
--       DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--       ARRAY       CONSTANT     ---------- BOX ---------
--                                I1  I2   J1  J2   K1  K2
EQUALS
         IKRORG      0.7550       1*  1*   1*  1*    1   1  / IKRORG FOR LAYER 1
         IKRORG      0.7750       1*  1*   1*  1*    2   2  / IKRORG FOR LAYER 2
         IKRORG      0.8000       1*  1*   1*  1*    3   3  / IKRORG FOR LAYER 3
/
```

8.3.97 IKRORW – END-POINT SCALING OF GRID CELL KRO(SWCR) (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IKRORW defines the scaling parameter for the imbibition relative permeability of oil at the critical water saturation (ISWCR), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the Hysteresis option. The SCALECRS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IKRORW	IKRORW is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned imbibition scaling IKRORW values for each cell in the model. Repeat counts may be used, for example 50*0.850			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the IKRORWX±, IKRORWY± and IKRORWZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.36: IKRORW Keyword Description

When the IKRORW keyword is present in the input deck then the scaling matches the imbibition relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Keywords Present	Critical Saturation
1	IKRORW	$S_{critical}$ = 1.0 – ISWCR - ISGL
2	IKRORG	$S_{critical}$ = 1.0 – ISGCR - ISWL

Table 8.37: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWUX, ISWUY and ISWUZ instead of ISWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWUX, ISWUX-, ISWUY, ISWUY-, ISWUZ and ISWUZ-, instead of the ISWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the IKRG, IKRGR, IKRO, IKRORG, IKRORW, IKRW and IKRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is IKRGX, IKRGY and IKRGZ instead of IKRG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is IKRGX, IKRGX-, IKRGY, IKRGY-,I KRGZ and IKRGZ-, instead of the IKRG keyword.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one IKRORW is set equal to 0.750, for layer two IKRORW equals 0.775, and for layer three IKRORW equals 0.800.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET IKRORW VALUES FOR THREE LAYERS IN THE MODEL
--
IKRORW
          1000*0.755  1000*0.775  1000.0.800               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          IKRORW      0.7550       1*  1*   1*  1*    1   1  / IKRORW FOR LAYER 1
          IKRORW      0.7750       1*  1*   1*  1*    2   2  / IKRORW FOR LAYER 2
          IKRORW      0.8000       1*  1*   1*  1*    3   3  / IKRORW FOR LAYER 3
/
```

8.3.98 IKRW – END-POINT SCALING OF GRID CELL KRW(SW =1.0) (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IKRW defines the scaling parameter at the maximum imbibition oil relative permeability value (ISWU), that is for S_w = 1.0, for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the Hysteresis option. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IKRW	IKRW is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned imbibition scaling IKRW values for each cell in the model. Repeat counts may be used, for example 50*1.000.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the IKRWX±, IKRWY± and IKRWZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.38: IKRW Keyword Description

For the two point scaling option and for the IKRWR water relative permeability array NOT present in the input deck the k_{rw} value for a grid block is scaled by:

$$k_{rw} = k_{rw_{TABLE}} \left(\frac{IKRW}{k_{rw_{TABLE-MAX}}} \right) \quad (8.6)$$

Where:

k_{rw} = the resulting IKRW value for a grid cell.

IKRW = the scaling water relative permeability value from the IKRW array for a given cell.

$k_{rw_{TABLE}}$ = the water relative permeability from a grid block's oil relative permeability table at the grid blocks water saturation.

$k_{rw_{TABLE-MAX}}$ = the maximum water relative permeability from a grid block's water relative table, that is at the maximum water saturation.

If the IKRWR keyword is present in the input deck then the scaling matches the imbibition relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Phases Present	Critical Saturation
1	Gas-Oil	$S_{critical}$ = 1.0 – ISOWCR - ISGL
2	Gas-Oil-Water	$S_{critical}$ = 1.0 – ISOWCR - ISGL
3	Gas-Water	$S_{critical}$ = 1.0 – ISGCR

Table 8.39: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWUX, ISWUY and ISWUZ instead of ISWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWUX, ISWUX-, ISWUY, ISWUY-, ISWUZ and ISWUZ-, instead of the ISWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the IKRG, IKRGR, IKRO, IKRORG, IKRORW, IKRW and IKRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is IKRGX, IKRGY and IKRGZ instead of IKRG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is IKRGX, IKRGX-, IKRGY, IKRGY-,I KRGZ and IKRGZ-, instead of the IKRG keyword.

Example

The example below defines an input box for the whole grid and for layers one to three, for layer one IKRW is set equal to 0.850, for layer two IKRW equals 0.875, and for layer three IKRW equals 0.900.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET IKRW VALUES FOR THREE LAYERS IN THE MODEL
--
IKRW
          1000*0.855  1000*0.875  1000.0.900               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

8.3.99 IKRWR – END-POINT SCALING OF GRID CELL KRWR(SOWCR) (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IKRWR defines the scaling parameter at the imbibition critical oil to water saturation value (SOWCR), for the imbibition water relative permeability curve, for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the Hysteresis option. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IKRWR	IKRWR is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned imbibition scaling IKRWR values for each cell in the model. Repeat counts may be used, for example 50*1.000.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the IKRWRX±, IKRWRY± and IKRWRZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.40: IKRWR Keyword Description

When the IKRWR keyword is present in the input deck then the scaling matches the imbibition relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Phases Present	Critical Saturation
1	Gas-Oil	$S_{critical}$ = 1.0 – ISOWCR - ISGL
2	Gas-Oil-Water	$S_{critical}$ = 1.0 – ISOWCR - ISGL
3	Gas-Water	$S_{critical}$ = 1.0 – ISGCR

Table 8.41: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWUX, ISWUY and ISWUZ instead of ISWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible

versions of the aforementioned arrays should be used, that is ISWUX, ISWUX-, ISWUY, ISWUY-, ISWUZ and ISWUZ-, instead of the ISWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the IKRG, IKRGR, IKRO, IKRORG, IKRORW, IKRW and IKRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is IKRGX, IKRGY and IKRGZ instead of IKRG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is IKRGX, IKRGX-, IKRGY, IKRGY-,I KRGZ and IKRGZ-, instead of the IKRG keyword.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one IKRWR is set equal to 0.750, for layer two IKRWR equals 0.775, and for layer three IKRWR equals 0.800.

```
--
--       DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--       ---------- BOX ---------
--       I1  I2   J1  J2   K1  K2
BOX
         1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--       SET IKRWR VALUES FOR THREE LAYERS IN THE MODEL
--
IKRWR
         1000*0.755  1000*0.775  1000.0.800               /
--
--       DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--       ARRAY       CONSTANT     ---------- BOX ---------
--                                I1  I2   J1  J2   K1  K2
EQUALS
         IKRWR       0.7550       1*  1*   1*  1*    1   1  / IKRWR FOR LAYER 1
         IKRWR       0.7750       1*  1*   1*  1*    2   2  / IKRWR FOR LAYER 2
         IKRWR       0.8000       1*  1*   1*  1*    3   3  / IKRWR FOR LAYER 3
/
```

8.3.100 IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the maximum imbibition oil, gas, and water relative permeability versus depth for the three phases. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the Hysteresis option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.101 IMPCVD – Imbibition Maximum Capillary Pressure versus Depth Functions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the maximum imbibition gas-oil and water-oil capillary pressure values versus depth for when the end-point scaling option has been invoked by the ENDSCALE keyword in the RUNSPEC section and the HYSTER option on the SATOPTS keyword in the RUNSPEC section has been activated to invoke the Hysteresis option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.102 IMPORT – Import Grid File Data at the Current Position

The IMPORT keyword informs the simulator to continue reading input data from the specified IMPORT file. When the end of the IMPORT file is reached, input data is read from the next keyword in the current file. Normally IMPORT files are generated by grid pre-processoring software and the keyword allows for both formatted and unformatted (binary) files to be loaded.

See *IMPORT – Import Grid File Data at the Current Position* in the GRID section for a full description.

8.3.103 IMPTVD – IMBIBITION RELATIVE PERMEABILITY SATURATION END-POINTS VERSUS DEPTH

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the variation of the imbibition relative permeability saturation end-points (SWL, SWCR, etc.) for all three phases versus depth., for when the end-point scaling option has been invoked by the ENDSCALE keyword in the RUNSPEC section, and the HYSTER option on the SATOPTS keyword in the RUNSPEC section has been activated to invoke the Hysteresis option. This functionality is not supported in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.104 IMSPCVD – Imbibition Capillary Pressure Connate Saturations versus Depth

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the imbibition capillary pressure gas and water connate saturations values versus depth for when the end-point scaling option has been invoked by the ENDSCALE keyword in the RUNSPEC section, and the HYSTER option on the SATOPTS keyword in the RUNSPEC section has been activated to invoke the Hysteresis option. This functionality is not supported in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.105 INTPC – ACTIVATE DUAL POROSITY INTEGRATED CAPILLARY PRESSURE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The INTPC keyword activates the integrated capillary pressure option for the oil, gas or both phases, for when a Dual Porosity model has been activated by either the DUALPORO or DUALPERM keywords in the RUNSPEC section. In addition, the keyword can only be used if the Gravity Drainage option has been specified by either the GRAVDR or GRAVDRM in the RUNSPEC section. Basically, activating this feature results in the simulator adjusting the capillary pressure curves by integrating the matrix capillary pressure curves over the matrix block height to calculate the average saturation.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.106 IONXROCK - Define Ion Exchange Constant by Saturation Table Regions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IONXROCK keyword activates ion exchange and defines the ion exchange constant by saturation table regions, for when the brine phase has been activated by the BRINE keyword and the Multi-Component Brine model, that allows for the water phase to have multiple water salinities, has been activated by the ECLMC keyword. Both keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.107 IONXSURF - Define Surfactant Ion Exchange Constant by Saturation Table Regions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IONXROCK keyword activates ion exchange on surfactant micellae[79] and defines the ion exchange constant by surfactant equivalent molecular weight for saturation table regions, for when the brine and surfactant phases has been activated by the BRINE and SURFACT keywords, and the Multi-Component Brine model, that allows for the water phase to have multiple water salinities, has been activated by the ECLMC keyword. All three keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[79] *Particle of colloidal dimensions that exists in equilibrium with the molecules or ions in solution from which it is formed. A micella or micelle (plural micellae or micelles, respectively) is an aggregate (or supramolecular assembly) of surfactant molecules dispersed in a liquid colloid. A typical micella in aqueous solution forms an aggregate with the hydrophilic "head" regions in contact with surrounding solvent, sequestering the hydrophobic single-tail regions in the micella centre (https://en.wikipedia.org/wiki/Micelle).*

8.3.108 IPCG – END-POINT SCALING OF GRID CELL GAS CAPILLARY PRESSURE (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IPCG defines the maximum imbibition gas-oil capillary pressure values for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the hysteresis option. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IPCG	IPCG is an array of positive real numbers assigning the maximum imbibition gas capillary pressure values for each cell in the model. Repeat counts may be used, for example 30*100.0.			
		psia	bars	atm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 8.42: IPCG Keyword Description

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{IPCG}{P_{c_{TABLE-MAX}}} \right) \quad \textbf{(8.7)}$$

Where:

P_c = the resulting imbibition gas-oil capillary pressure for a grid cell.

IPCG = the maximum capillary pressure from the IPCG array for a given cell.

$P_{c_{TABLE}}$ = the capillary pressure in the inhibition capillary pressure table allocated to the grid block.

$P_{c_{TABLE-MAX}}$ = the maximum capillary pressure in the inhibition capillary pressure table allocated to the grid block at $S_g = 1 - S_{wco}$.

See also the PCG keyword for the equivalent drainage functionality.

Example

```
--
--        DEFINE GRID BLOCK IPCG DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
IPCG
          100*50.0  100*75.0  100*125.0                                          /
```

The above example defines the IPCG for 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.109 IPCW – END-POINT SCALING OF GRID CELL WATER CAPILLARY PRESSURE (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IPCW defines the maximum imbibition water-oil or water-gas capillary pressure values for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the HYSTER option on the SATOPTS keyword in the RUNSPEC section has to be activated to invoke the hysteresis option. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	IPCW	IPCW is an array of positive real numbers assigning the maximum imbibition water capillary pressure values for each cell in the model. Repeat counts may be used, for example 30*100.0.			
		psia	bars	atm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 8.43: IPCW Keyword Description

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{IPCW}{P_{c_{TABLE-MAX}}} \right) \tag{8.8}$$

Where:

P_c = the resulting imbibition water capillary pressure for a grid cell.

IPCW = the maximum capillary pressure from the IPCW array for a given cell.

$P_{c_{TABLE}}$ = the capillary pressure in the inhibition capillary pressure table allocated to the grid block.

$P_{c_{TABLE-MAX}}$ = the maximum capillary pressure in the inhibition capillary pressure table allocated to the grid block (that is at the connate water saturation).

See also the PCW keyword for the equivalent drainage functionality.

Example

```
--
--        DEFINE GRID BLOCK IPCW DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
IPCW
          100*50.0  100*75.0   100*125.0                                        /
```

The above example defines the IPCW for 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.110 ISGCR – END-POINT SCALING OF GRID CELL CRITICAL GAS SATURATION (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISGCR defines the imbibition critical gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The critical gas saturation is defined as the maximum gas saturation for which the gas relative permeability is zero in a two-phase relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISGCR	ISGCR is an array of real numbers assigning the critical gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.03			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

3) Note this the directional independent version of the critical gas saturation used with the end-point scaling option. If directional end-point scaling has been activated then the ISGCRX± , ISGCRX± and ISGCRX± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.44: ISGCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISGCRX, ISGCRY and ISGCRZ instead of ISGCR. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISGCRX, ISGCRX-, ISGCRY, ISGCRY-, ISGCRZ and ISGCRZ-, instead of the ISGCR keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT ISGCR DATA FOR CELLS (NX x NY x NZ = 300)
ISGCR
          300*0.050                                                          /
```

The above example defines a constant critical gas saturation of 0.05 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.111 ISGL – END-POINT SCALING OF GRID CELL CONNATE GAS SATURATION (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISGL defines the imbibition connate gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The connate gas saturation is defined as the minimum gas saturation in a two-phase gas relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISGL	ISGL is an array of real numbers assigning the connate gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.03 dimensionless			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

3) Note this the directional independent version of the connate gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the ISGLX± , ISGLY± and ISGZ± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.45: ISGL Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISGLX, ISGLY and ISGLZ instead of ISGL. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISGLX, ISGLX-, ISGLY, ISGLY-, ISGLZ and ISGLZ-, instead of the ISGL keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT ISGL DATA FOR ALL CELLS (NX x NY x NZ = 300)
ISGL
          300*0.030                                                            /
```

The above example defines a constant connate gas saturation of 0.03 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.112 ISGLPC – END-POINT SCALING OF GRID CELL CAPILLARY PRESSURE CONNATE GAS SATURATION (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISGLPC defines the imbibition connate gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The connate gas saturation is defined as the minimum gas saturation in a two-phase gas relative permeability table. The keyword only applies the scaling to the imbibition capillary pressures tables, unlike the ISGL keyword that applies the scaling to both the capillary pressure and relative permeability tables. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISGLPC	IGLPC is an array of real numbers assigning the connate gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. If IGLPC is omitted from the input deck the values will be defaulted to those on the ISGL series of keywords. If the ISGL series of keywords are missing from the input deck then the values are taken from the cell allocated capillary pressure table. Repeat counts may be used, for example 30*0.03			Taken from SGL or from the cell allocated capillary pressure table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the connate gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the ISGLX± , ISGLY± and ISGZ± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.46: ISGLPC Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISGLX, ISGLY and ISGLZ instead of ISGL or ISGLPC. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISGLX, ISGLX-, ISGLY, ISGLY-, ISGLZ and ISGLZ-, instead of the ISGL or ISGLPC keywords.

Missing Some Functionality - Use with Caution.

Example

```
--
--       DEFINE GRID BLOCK END-POINT ISGLPC DATA FOR ALL CELLS
–       (NX x NY x NZ = 300)
ISGLPC
         300*0.030                                                    /
```

The above example defines a constant connate gas saturation of 0.03 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.113 ISGU – END-POINT SCALING OF GRID CELL MAXIMUM GAS SATURATION (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISGU defines the imbibition maximum gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The maximum gas saturation is defined as the maximum gas saturation in a two-phase gas relative permeability table. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISGU	ISGU is an array of real numbers assigning the maximum gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.70			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the maximum gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the ISGUX± , ISGUX± and ISGU± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.47: ISGU Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISGUX, ISGUY and ISGUZ instead of ISGU. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISGUX, ISGUX-, ISGUY, ISGUY-, ISGUZ and ISGUZ-, instead of the ISGU keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT ISGU DATA FOR ALL CELLS (NX x NY x NZ = 300)
ISGU
          300*0.700                                                            /
```

The above example defines a constant connate gas saturation of 0.70 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.114 ISOGCR – END-POINT SCALING OF GRID CELL CRITICAL OIL SATURATION TO GAS (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISOGCR defines the imbibition critical oil saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The critical oil saturation with respect to gas is defined as the maximum oil saturation for which the oil relative permeability is zero in a two-phase gas-oil relative permeability table. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISOGCR	ISOGCR is an array of real numbers assigning the critical oil saturation with respect to gas values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.30			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the critical gas saturation used with the end-point scaling option. If directional end-point scaling has been activated then the ISOGCRX± , ISOGCRX± and ISOGCRX± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.48: ISOGCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISOGCRX, ISOGCRY and ISOGCRZ instead of ISOGCR. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISOGCRX, ISOGCRX-, ISOGCRY, ISOGCRY-, ISOGCRZ and ISOGCRZ-, instead of the ISOGCR keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT ISOGCR DATA FOR ALL CELLS
--        (NX x NY x NZ = 300)
--
ISOGCR
          300*0.200                                                    /
```

The above example defines a constant critical gas saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.115 ISOWCR – END-POINT SCALING OF GRID CELL CRITICAL OIL SATURATION TO WATER (IMBIB.)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISOWCR defines the imbibition critical oil saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The critical oil saturation with respect to water is defined as the maximum oil saturation for which the oil relative permeability is zero in a two-phase oil-water relative permeability table. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISOWCR	ISOWCR is an array of real numbers assigning the critical oil saturation with respect to water values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.30			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the critical gas saturation used with the end-point scaling option. If directional end-point scaling has been activated then the ISOWCRX± , ISOWCRX± and ISOWCRX± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.49: ISOWCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISOWCRX, ISOWCRY and ISOWCRZ instead of ISOWCR. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISOWCRX, ISOWCRX-, ISOWCRY, ISOWCRY-, ISOWCRZ and ISOWCRZ-, instead of the ISOWCR keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT ISOWCR DATA FOR ALL CELLS
--        (NX x NY x NZ = 300)
--
ISOWCR
          300*0.200                                                    /
```

The above example defines a constant critical gas saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section

8.3.116 ISWCR – END-POINT SCALING OF GRID CELL CRITICAL WATER SATURATION (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISWCR defines the imbibition critical water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The critical water saturation is defined as the maximum water saturation for which the water relative permeability is zero in a two-phase relative permeability table. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISWCR	ISWCR is an array of real numbers assigning the critical water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.20			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

3) Note this the directional independent version of the critical water saturation used with the end-point scaling option. If directional end-point scaling has been activated then the ISWCRX± , ISWCRX± and ISWCRX± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.50: ISWCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWCRX, ISWCRY and ISWCRZ instead of ISWCR. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWCRX, ISWCRX-, ISWCRY, ISWCRY-, ISWCRZ and ISWCRZ-, instead of the ISWCR keyword.

Example

```
--
--       DEFINE GRID BLOCK END-POINT ISWCR DATA FOR ALL CELLS
--       (NX x NY x NZ = 300)
--
ISWCR
  300*0.200                                                                  /
```

The above example defines a constant critical water saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.117 ISWL – END-POINT SCALING OF GRID CELL CONNATE WATER SATURATION (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISWL defines the imbibition connate water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The connate water saturation is defined as the minimum water saturation in a two-phase water relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISWL	ISWL is an array of real numbers assigning the connate water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.15			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

3) Note this the directional independent version of the connate gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the ISWLX± , ISWLY± and ISWZ± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.51: ISWL Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWLX, ISWLY and ISWLZ instead of ISWL. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWLX, ISWLX-, ISWLY, ISWLY-, ISWLZ and ISWLZ-, instead of the ISWL keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT ISWL DATA FOR ALL CELLS (NX x NY x NZ = 300)
--
ISWL
          300*0.150                                                          /
```

The above example defines a constant connate water saturation of 0.15 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.118 ISWLPC – END-POINT SCALING GRID CELL CAPILLARY PRESSURE CONNATE WATER SATURATIONS (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISWLPC defines the imbibition connate water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The connate water saturation is defined as the minimum water saturation in a two-phase water relative permeability table. The keyword only applies the scaling to the imbibition capillary pressures tables, unlike the ISWL keyword that applies the scaling to both the capillary pressure and relative permeability tables. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISWLPC	ISWLPC is an array of real numbers assigning the connate water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. If ISWLPC is omitted from the input deck the values will be defaulted to those on the ISGL series of keywords. If the ISWL series of keywords are missing from the input deck then the values are taken from the cell allocated capillary pressure table. Repeat counts may be used, for example 30*0.15			Taken from SWL or from the cell allocated capillary pressure table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the connate gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the ISWLX± , ISWLY± and ISWZ± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.52: ISWLPC Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWLX, ISWLY and ISWLZ instead of ISWL or ISWLPC. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWLX, ISWLX-, ISWLY, ISWLY-, ISWLZ and ISWLZ-, instead of the ISWL or ISWLPC keywords.

Missing Some Functionality - Use with Caution.

Example

```
--
--      DEFINE GRID BLOCK END-POINT ISWLPC DATA FOR ALL CELLS (
--      NX x NY x NZ = 300)
--
ISWLPC
         300*0.150                                                    /
```

The above example defines a constant connate water saturation of 0.15 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.119 ISWU – END-POINT SCALING OF GRID CELL MAXIMUM WATER SATURATION (IMBIBITION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ISWU defines the imbibition maximum water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE in the RUNSPEC section and the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section. The maximum water saturation is defined as the maximum water saturation in a two-phase water relative permeability table. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ISWU	ISWU is an array of real numbers assigning the maximum water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.70			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the maximum water saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the ISWUX± , ISWUX± and ISWU± series of keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.53: ISWU Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, ISOWCR, and ISOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is ISWUX, ISWUY and ISWUZ instead of ISWU. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is ISWUX, ISWUX-, ISWUY, ISWUY-, ISWUZ and ISWUZ-, instead of the ISWU keyword.

Example

```
--
--       DEFINE GRID BLOCK END-POINT ISWU DATA FOR ALL CELLS (NX x NY x NZ = 300)
--
ISWU
         300*0.700                                                          /
```

The above example defines a constant connate gas saturation of 0.70 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.120 KRG – END-POINT SCALING OF GRID CELL KRG(SGU) (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

KRG defines the scaling parameter at the maximum drainage gas relative permeability value (SGU), normally SGU is equal to 1.0 - S_{wc}, for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	KRG	KRG is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling KRG values for each cell in the model. Repeat counts may be used, for example 50*0.400. dimensionless			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the KRGX±, KRGY± and KRGZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.54: KRG Keyword Description

For the two point scaling option and for the KRGR gas relative permeability array NOT present in the input deck the k_{rg} value for a grid block is scaled by:

$$k_{rg} = k_{rg_{TABLE}} \left(\frac{KRG}{k_{rg_{TABLE-MAX}}} \right) \tag{8.9}$$

Where:

k_{rg} = the resulting k_{rg} value for a grid cell.

KRG = the scaling gas relative permeability value from the KRG array for a given cell.

$k_{rg_{TABLE}}$ = the gas relative permeability from a grid block's gas-oil table at the grid blocks gas saturation.

$k_{rg_{TABLE-MAX}}$ = the maximum gas relative permeability from a grid block's gas-oil table, that is at the connate water saturation (S_{wc}).

If the KRGR keyword is present in the input deck then the scaling matches the relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Phases Present	Critical Saturation
1	Gas-Oil	$S_{critical}$ = 1.0 – SOGCR - SWL
2	Gas-Oil-Water	$S_{critical}$ = 1.0 – SOGCR - SWL
3	Gas-Water	$S_{critical}$ = 1.0 – SWCR

Table 8.55: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWUX, SWUY and SWUZ instead of SWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWUX, SWUX-, SWUY, SWUY-, SWUZ and SWUZ-, instead of the SWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the KRG, KRGR, KRO, KRORG, KRORW, KRW and KRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is KRGX, KRGY and KRGZ instead of KRG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is KRGX, KRGX-, KRGY, KRGY-, KRGZ and KRGZ-, instead of the KRG keyword.

If the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section, then the equivalent imbibition arrays suffixed with the letter I, for example IKRG, can be used to define the KRG for the relative permeability imbibition tables.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one KRG is set equal to 0.550, for layer two KRG equals 0.575, and for layer three KRG equals 0.600.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET KRG VALUES FOR THREE LAYERS IN THE MODEL
--
KRG
          1000*0.555  1000*0.575  1000.0.600               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--       ARRAY       CONSTANT     ---------- BOX ---------
--                                I1  I2   J1  J2   K1  K2
EQUALS
         KRG         0.5550       1*  1*   1*  1*   1   1  / KRG FOR LAYER 1
         KRG         0.5750       1*  1*   1*  1*   2   2  / KRG FOR LAYER 2
         KRG         0.6000       1*  1*   1*  1*   3   3  / KRG FOR LAYER 3
/
```

8.3.121 KRGR – END-POINT SCALING OF GRID CELL KRGR(1-SOGCR) (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

KRGR defines the scaling parameter at the relative permeability of gas at residual oil saturation (1 – SOGCR), or critical water saturation in a gas-water run (S_{wc}), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	KRGR	KRGR is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling KRGR values for each cell in the model. In addition, for a given grid block KGRG should be less than KRG. Repeat counts may be used, for example 50*0.400.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the KRGRX± , KRGRY± and KRGRZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.56: KRGR Keyword Description

When the KRGR keyword is present in the input deck then the scaling matches the relative permeability at the critical saturation of the displacing phase (oil or water).

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Phases Present	Critical Saturation
1	Gas-Oil	$S_{critical}$ = 1.0 – SOGCR - SWL
2	Gas-Oil-Water	$S_{critical}$ = 1.0 – SOGCR - SWL
3	Gas-Water	$S_{critical}$ = 1.0 – SWCR

Table 8.57: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWUX, SWUY and SWUZ instead of SWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWUX, SWUX-, SWUY, SWUY-, SWUZ and SWUZ-, instead of the SWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the KRG, KRGR, KRO, KRORG, KRORW, KRW and KRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is KRGRX, KRGRY and KRGRZ instead of KRGR, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is KRGRX, KRGRX-, KRGRY, KRGRY-, KRGRZ and KRGRZ-, instead of the KRGR keyword.

If the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section, then the equivalent imbibition arrays suffixed with the letter I, for example IKRGR, can be used to define the KRG for the relative permeability imbibition tables.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one KRRG is set equal to 0.500, for layer two KRGR equals 0.570, and for layer three KRGR equals 0.580.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET KRGR VALUES FOR THREE LAYERS IN THE MODEL
--
KRGR
          1000*0.500  1000*0.570  1000.0.580               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          KRGR        0.5500       1*  1*   1*  1*    1   1  / KRGR FOR LAYER 1
          KRGR        0.5700       1*  1*   1*  1*    2   2  / KRGR FOR LAYER 2
          KRGR        0.5800       1*  1*   1*  1*    3   3  / KRGR FOR LAYER 3
/
```

8.3.122 KRO – END-POINT SCALING OF GRID CELL KRO(SWL) (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

KRO defines the scaling parameter for the drainage oil relative permeability value at the connate water saturation (SWL), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	KRO	KRO is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling KRO values for each cell in the model. Repeat counts may be used, for example 50*0.500.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the KROX±, KROY± and KROZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.58: KRO Keyword Description

For the two point scaling option and for the KRORW or KRORG oil relative permeability arrays NOT being present in the input deck the k_{ro} value for a grid block is scaled by:

$$k_{ro} = k_{ro_{TABLE}} \left(\frac{KRO}{k_{ro_{TABLE-MAX}}} \right) \tag{8.10}$$

Where:

k_{ro} = the resulting k_{ro} value for a grid cell.

KRO = the scaling oil relative permeability value from the KRO array for a given cell.

$k_{ro_{TABLE}}$ = the oil relative permeability from a grid block's oil relative permeability table at the grid blocks oil saturation.

$k_{ro_{TABLE-MAX}}$ = the maximum oil relative permeability from a grid block's oil relative table, that is at the critical water saturation (S_{wcr}).

If the KRORW or KRORG keywords are present in the input deck then the scaling matches the relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Keywords Present	Critical Saturation
1	KRORW	$S_{critical}$ = 1.0 – SWCR - SGL
2	KRORG	$S_{critical}$ = 1.0 – SGCR - SWL

Table 8.59: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWUX, SWUY and SWUZ instead of SWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWUX, SWUX-, SWUY, SWUY-, SWUZ and SWUZ-, instead of the SWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the KRG, KRGR, KRO, KRORG, KRORW, KRW and KRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is KROX, KROY and KROZ instead of KRO, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is KROX, KROX-, KROY, KROY-, KROZ and KROZ-, instead of the KRO keyword.

If the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section, then the equivalent imbibition arrays suffixed with the letter I, for example IKRO, can be used to define the KRO for the relative permeability imbibition tables.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one KRO is set equal to 0.850, for layer two KRO equals 0.875, and for layer three KRO equals 0.900.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET KRO VALUES FOR THREE LAYERS IN THE MODEL
--
KRO
          1000*0.855  1000*0.875  1000.0.900               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--        ARRAY        CONSTANT     ---------- BOX ---------
--                                  I1  I2   J1  J2   K1  K2
EQUALS
          KRO          0.8550       1*  1*   1*  1*    1   1  / KRO FOR LAYER 1
          KOG          0.8750       1*  1*   1*  1*    2   2  / KRO FOR LAYER 2
          KRO          0.9000       1*  1*   1*  1*    3   3  / KRO FOR LAYER 3
/
```

8.3.123 KRORG – END-POINT SCALING OF GRID CELL KRO(SGCR) (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

KRORG defines the scaling parameter for the drainage relative permeability of oil at the critical gas saturation (SGCR), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	KRORG	KRORG is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling KRORG values for each cell in the model. Repeat counts may be used, for example 50*0.850.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the KRORGX±, KRORGY± and KRORGZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.60: KRORG Keyword Description

When the KRORG keyword is present in the input deck then the scaling matches the relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Keywords Present	Critical Saturation
1	KRORW	$S_{critical}$ = 1.0 – SWCR - SGL
2	KRORG	$S_{critical}$ = 1.0 – SGCR - SWL

Table 8.61: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWUX, SWUY and SWUZ instead of SWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWUX, SWUX-, SWUY, SWUY-, SWUZ and SWUZ-, instead of the SWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the KRG, KRGR, KRORG, KRORGRG, KRORGRW, KRW and KRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is KRORGX, KRORGY and KRORGZ instead of KRORG, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is KRORGX, KRORGX-, KRORGY, KRORGY-, KRORGZ and KRORGZ-, instead of the KRORG keyword.

If the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section, then the equivalent imbibition arrays suffixed with the letter I, for example IKRORG, can be used to define the KRORG for the relative permeability imbibition tables.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one KRORG is set equal to 0.750, for layer two KRORG equals 0.775, and for layer three KRORG equals 0.800.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET KRORG VALUES FOR THREE LAYERS IN THE MODEL
--
KRORG
          1000*0.755  1000*0.775  1000.0.800               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          KRORG       0.7550       1*  1*   1*  1*    1   1  / KRORG FOR LAYER 1
          KRORG       0.7750       1*  1*   1*  1*    2   2  / KRORG FOR LAYER 2
          KRORG       0.8000       1*  1*   1*  1*    3   3  / KRORG FOR LAYER 3
/
```

8.3.124 KRORW – END-POINT SCALING OF GRID CELL KRO(SWCR) (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

KRORW defines the scaling parameter for the drainage relative permeability of oil at the critical water saturation (SWCR), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The SCALECRS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	KRORW	KRORW is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling KRORW values for each cell in the model. Repeat counts may be used, for example 50*0.850			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the KRORWX±, KRORWY± and KRORWZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.62: KRORW Keyword Description

When the KRORW keyword is present in the input deck then the scaling matches the relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Keywords Present	Critical Saturation
1	KRORW	$S_{critical}$ = 1.0 – SWCR - SGL
2	KRORG	$S_{critical}$ = 1.0 – SGCR - SWL

Table 8.63: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWUX, SWUY and SWUZ instead of SWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWUX, SWUX-, SWUY, SWUY-, SWUZ and SWUZ-, instead of the SWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the KRG, KRGR, KRORW, KRORWRG, KRORWRW, KRW and KRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is KRORWX, KRORWY and KRORWZ instead of KRORW, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is KRORWX, KRORWX-, KRORWY, KRORWY-, KRORWZ and KRORWZ-, instead of the KRORW keyword.

If the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section, then the equivalent imbibition arrays suffixed with the letter I, for example IKRORW, can be used to define the KRORW for the relative permeability imbibition tables.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one KRORW is set equal to 0.750, for layer two KRORW equals 0.775, and for layer three KRORW equals 0.800.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET KRORW VALUES FOR THREE LAYERS IN THE MODEL
--
KRORW
          1000*0.755  1000*0.775  1000.0.800              /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          KRORW       0.7550       1*  1*   1*  1*    1   1  / KRORW FOR LAYER 1
          KRORW       0.7750       1*  1*   1*  1*    2   2  / KRORW FOR LAYER 2
          KRORW       0.8000       1*  1*   1*  1*    3   3  / KRORW FOR LAYER 3
/
```

8.3.125 KRW – END-POINT SCALING OF GRID CELL KRW(SW =1.0) (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

KRW defines the scaling parameter at the maximum drainage water relative permeability value (SWU), that is for S_w = 1.0, for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	KRW	KRW is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling KRW values for each cell in the model. Repeat counts may be used, for example 50*1.000.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the KRWX±, KRWY± and KRWZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.64: KRW Keyword Description

For the two point scaling option and for the KRWR water relative permeability array NOT present in the input deck the k_{rw} value for a grid block is scaled by:

$$k_{rw} = k_{rw_{TABLE}} \left(\frac{KRW}{k_{rw_{TABLE-MAX}}} \right) \tag{8.11}$$

Where:

k_{rw} = the resulting KRW value for a grid cell.

KRW = the scaling water relative permeability value from the KRW array for a given cell.

$k_{rw_{TABLE}}$ = the water relative permeability from a grid block's oil relative permeability table at the grid blocks water saturation.

$k_{rw_{TABLE-MAX}}$ = the maximum water relative permeability from a grid block's water relative table, that is at the maximum water saturation.

If the KRWR keyword is present in the input deck then the scaling matches the relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Phases Present	Critical Saturation
1	Gas-Oil	$S_{critical}$ = 1.0 – SOWCR - SGL
2	Gas-Oil-Water	$S_{critical}$ = 1.0 – SOWCR - SGL
3	Gas-Water	$S_{critical}$ = 1.0 – SGCR

Table 8.65: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWUX, SWUY and SWUZ instead of SWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWUX, SWUX-, SWUY, SWUY-, SWUZ and SWUZ-, instead of the SWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the KRG, KRGR, KRW, KRORG, KRORW, KRW and KRWR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is KRWX, KRWY and KRWZ instead of KRW, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is KRWX, KRWX-, KRWY, KRWY-, KRWZ and KRWZ-, instead of the KRW keyword.

If the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section, then the equivalent imbibition arrays suffixed with the letter I, for example IKRW, can be used to define the KRW for the relative permeability imbibition tables.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one KRW is set equal to 0.850, for layer two KRW equals 0.875, and for layer three KRW equals 0.900.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET KRW VALUES FOR THREE LAYERS IN THE MODEL
--
KRW
          1000*0.855  1000*0.875  1000.0.900               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          KRW         0.8550       1*  1*   1*  1*    1   1  / KRW FOR LAYER 1
          KRW         0.8750       1*  1*   1*  1*    2   2  / KRW FOR LAYER 2
          KRW         0.9000       1*  1*   1*  1*    3   3  / KRW FOR LAYER 3
/
```

8.3.126 KRWR – END-POINT SCALING OF GRID CELL KRWR(SOWCR) (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

KRWR defines the scaling parameter at the drainage critical oil to water saturation value (SOWCR), for the drainage water relative permeability curve, for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The SCALCERS keyword in the PROPS section defines the options used in the re-scaling process, the options are two point scaling and three point scaling.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	KRWR	KRWR is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling KRWR values for each cell in the model. Repeat counts may be used, for example 50*1.000.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

3) Note this the directional independent version of the keyword used with the end-point scaling option. If directional end-point scaling has been activated then the KRWRX±, KRWRY± and KRWRZ± series of the keywords should be used. The directional form of the keyword is recognized, but is not supported by OPM Flow.

Table 8.66: KRWR Keyword Description

When the KRWR keyword is present in the input deck then the scaling matches the relative permeability at the critical saturation of the displacing phase.

If three point scaling option has been selected via the SCALECRS keyword in the PROPS section the critical displacing phase is defined as:

No	Phases Present	Critical Saturation
1	Gas-Oil	$S_{critical}$ = 1.0 – SOWCR - SGL
2	Gas-Oil-Water	$S_{critical}$ = 1.0 – SOWCR - SGL
3	Gas-Water	$S_{critical}$ = 1.0 – SGCR

Table 8.67: Critical Displacement Relationships

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWUX, SWUY and SWUZ instead of SWU, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWUX, SWUX-, SWUY, SWUY-, SWUZ and SWUZ-, instead of the SWU keyword.

End-point scaling also allows the entered relative permeability functions to be scale on the relative permeability values using the KRG, KRGR, KRWR, KRORG, KRORW, KRWR and KRWRR relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is KRWRX, KRWRY and KRWRZ instead of KRWR, There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is KRWRX, KRWRX-, KRWRY, KRWRY-, KRWRZ and KRWRZ-, instead of the KRWR keyword.

If the hysteresis model option has been activated on the SATOPTS keyword in the RUNSPEC section, then the equivalent imbibition arrays suffixed with the letter I, for example IKRWR, can be used to define the KRWR for the relative permeability imbibition tables.

Examples

The first example defines an input box for the whole grid and for layers one to three, for layer one KRWR is set equal to 0.750, for layer two KRWR equals 0.775, and for layer three KRWR equals 0.800.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET KRWR VALUES FOR THREE LAYERS IN THE MODEL
--
KRWR
          1000*0.755  1000*0.775  1000.0.800               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

The next example does exactly the same thing using the EQUALS keyword instead.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          KRWR        0.7550       1*  1*   1*  1*    1   1  / KRWR FOR LAYER 1
          KRWR        0.7750       1*  1*   1*  1*    2   2  / KRWR FOR LAYER 2
          KRWR        0.8000       1*  1*   1*  1*    3   3  / KRWR FOR LAYER 3
/
```

8.3.127 LANGMPL – DEFINE LANGMUIR PRESSURE GRID CELL MULTIPLIER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, LANGMPL, defines the coal bed methane Langmuir Adsorption[80] pressure multiplier for each grid block, for when the Coal Bed Methane option has been activated via the COAL keyword in the RUNSPEC section. The keyword applies the multiplier to the pressure values in a cell's allocated Langmuir table when calculating a cell's adsorption capacity. See the LANGMUIR keyword in the PROPS section for specifying the Langmuir tables for the model.

Note that if he Dual Porosity model has been activated by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section, then LANGMPL applies to only the matrix grid block.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[80] *Langmuir, Irving (June 1918). "The Adsorption of Gases on Plane Surface of Glass, Mica and Platinum". The Research Laboratory of the General Electric Company. 40 (9): 1361–1402. doi:10.1021/ja02242a004*

8.3.128 LANGMUIR – LANGMUIR ADSORPTION ISOTHERM TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LANGMUIR keyword defines the coal bed methane Langmuir Adsorption Isotherms[81] tables, for when the Coal Bed Methane option has been activated via the COAL keyword in the RUNSPEC section. See the COALNUM keyword in the GRID section for allocating the Langmuir tables to the grid blocks and also the LANGMPL keyword in the PROPS section for re-scaling the pressure values in the tables that are allocated to a cell.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[81] *Langmuir, Irving (June 1918). "The Adsorption of Gases on Plane Surface of Glass, Mica and Platinum". The Research Laboratory of the General Electric Company. 40 (9): 1361–1402. doi:10.1021/ja02242a004*

8.3.129 LANGSOLV – LANGMUIR ADSORPTION ISOTHERM SOLVENT TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LANGMUIR keyword defines the coal bed methane Langmuir Adsorption Isotherms[82] Solvent tables, for when the Coal Bed Methane option has been activated via the COAL keyword and the Solvent phase has been declared by the SOLVENT keyword in the RUNSPEC section. See the COALNUM keyword in the GRID section for allocating the Langmuir solvent tables to the grid blocks, and also the LANGMUIR keyword in the PROPS section for defining the Langmuir Adsorption Isotherm tables. Keywords COALADS and COALPP, also in the PROPS section, are used to specify the relative adsorption data in runs containing the solvent phase.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[82] *Langmuir, Irving (June 1918). "The Adsorption of Gases on Plane Surface of Glass, Mica and Platinum". The Research Laboratory of the General Electric Company. 40 (9): 1361–1402. doi:10.1021/ja02242a004*

8.3.130 LCUNIT – DEFINE LINEAR COMBINATION RATE AND VOLUME UNITS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LCUNIT keyword defines the units for the Linear Combination facility which allows for a linear combination of oil, gas and water rates and volumes to be used as combination targets and constraints in controlling group and well production and injection data. See also the LINCOM in the SCHEDULE section that defines the actual linear combination equation.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.131 LKRO – End-Point Scaling of Grid Cell Kro(Swl) (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LKRO defines the scaling parameter for the oil relative permeability value at the connate water saturation (SWL), for all the cells in the model via an array, for when the Low Salt option and the End-point Scaling options has been activated by the LOWSALT and the ENDSCALE keywords in the RUNSPEC section. The data is used to scale the oil relative permeability in the low salinity oil wet oil relative permeability saturation tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.132 LKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LKRORG defines the scaling parameter for the relative permeability of oil at the critical gas saturation (SGCR), for all the cells in the model via an array, for when the Low Salt option and the End-point Scaling options has been activated by the LOWSALT and the ENDSCALE keywords in the RUNSPEC section. The data is used to scale the oil relative permeability in the low salinity oil wet oil relative permeability saturation tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.133 LKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LKRORW defines the scaling parameter for the relative permeability of oil at the critical water saturation (SWCR), for all the cells in the model via an array, for when the Low Salt option and the End-point Scaling options has been activated by the LOWSALT and the ENDSCALE keywords in the RUNSPEC section. The data is used to scale the oil relative permeability in the low salinity oil wet oil relative permeability saturation tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.134 LKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LKRW defines the scaling parameter at the maximum oil relative permeability value (SWU), that is for S_w = 1.0, for all the cells in the model via an array, for when the Low Salt option and the End-point Scaling options has been activated by the LOWSALT and the ENDSCALE keywords in the RUNSPEC section. The data is used to scale the water relative permeability in the low salinity oil wet water relative permeability saturation tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.135 LKRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LKRWR defines the scaling parameter at the maximum oil relative permeability value (SWU), that is for S_w = 1.0, for all the cells in the model via an array, for when the Low Salt option and the End-point Scaling options has been activated by the LOWSALT and the ENDSCALE keywords in the RUNSPEC section. The data is used to scale the water relative permeability in the low salinity oil wet water relative permeability saturation tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.136 LPCW – END-POINT SCALING OF GRID CELL WATER CAPILLARY PRESSURE (LOW SALINITY AND OIL WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LPCW defines the maximum oil-water pressure values for all the cells in the model via an array, for when the Low Salt option and the End-point Scaling options has been activated by the LOWSALT and the ENDSCALE keywords in the RUNSPEC section. The keyword re-scales the oil-water capillary pressure in the low salinity oil wet capillary saturation tables from a cell's assigned saturation function by the grid block's LPCW value.

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{LPCW}{P_{c_{TABLE-MAX}}} \right) \tag{8.12}$$

Where:

P_c	=	the resulting low salt oil wet water capillary pressure for a grid cell.
LPCW	=	the maximum capillary pressure from the LPCW array for a given cell.
$P_{c_{TABLE}}$	=	the capillary pressure in the low salt oil wet capillary pressure table allocated to the grid block.
$P_{c_{TABLE-MAX}}$	=	the maximum capillary pressure in the low salt oil capillary pressure table allocated to the grid block (that is at the connate water saturation).

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.137 LSALTFNC - Define Low Salt Weighting Factors versus Salt Concentration Functions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LSALTFNC keyword defines the low salt weighting factors versus salt concentration functions for when the Low Salt option has been activated by the LOWSALT keyword in the RUNSPEC section. The tables are used to modify the oil and water relative permeability saturation end-points, as well as the water-oil capillary pressure end-points, for different salt concentrations within a grid cell.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.138 LSOGCR – End-Point Scaling Grid Cell SOGCR (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LSOGCR defines the critical oil saturation with respect to gas ("SOGCR"), for all the cells in the model via an array, for when the Low Salt option has been selected. The data is used to scale the oil saturation in the low salinity oil wet oil-gas relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.139 LSOWCR – End-Point Scaling Grid Cell SOWCR (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LSOWCR defines the critical oil saturation with respect to water ("SOWCR"), for all the cells in the model via an array, for when the Low Salt option has been selected. The data is used to scale the oil saturation in the low salinity oil wet water-oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.140 LSWCR – End-Point Scaling Grid Cell SWCR (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LSWCR defines the critical water saturation ("SWCR"), for all the cells in the model via an array, for when the Low Salt option has been selected. The data is used to scale the water saturation in the low salinity oil wet water-oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.141 LSWL – End-Point Scaling Grid Cell SWL (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LSWL defines the connate water saturation ("SWL"), for all the cells in the model via an array, for when the Low Salt option has been selected. The data is used to scale the water saturation in the low salinity oil wet water-oil relative permeability saturation tables, as well as the associated capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.142 LSWLPC – End-Point Scaling Grid Cell SWLPC (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LSWLPC defines the capillary pressure connate water saturation ("SWLPC"), for all the cells in the model via an array, for when the Low Salt option has been selected. The data is used to scale the water saturation in the low salinity oil wet water-oil capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section.

Note the keyword only applies the scaling to the capillary pressures tables, unlike the LSWL keyword that applies the scaling to both the capillary pressure and relative permeability tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.143 LSWU – End-Point Scaling Grid Cell SWU (Low Salinity and Oil Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LSWU defines the maximum water saturation("SWU"), for all the cells in the model via an array, for when the Low Salt option has been selected. The data is used to scale the water saturation in the low salinity oil wet water-oil relative permeability saturation tables, as well as the associated capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.144 LWKRO – End-Point Scaling of Grid Cell Kro(Swl) (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWKRO defines the scaling parameter for the oil relative permeability value at the connate water saturation (SWL), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil relative permeability in the low salinity water wet oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.145 LWKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWKRORG defines the scaling parameter for the relative permeability of oil at the critical gas saturation (SGCR), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil relative permeability in the low salinity water wet oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.146 LWKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWKRORW defines the scaling parameter for the relative permeability of oil at the critical water saturation (SWCR), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil relative permeability in the low salinity water wet oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.147 LWKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWKRW defines the scaling parameter at the maximum water relative permeability value (SWU), that is for S_w = 1.0, for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water relative permeability in the low salinity water wet water relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.148 LWKRWR – End-Point Scaling of Grid Cell KRWR(Sw=1.0) (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWKRWR defines the scaling parameter at the critical oil to water saturation value (SOWCR), for the water relative permeability curve, for all the cells in the model via an array, and for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water relative permeability in the low salinity water wet water relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.149 LWPCW – END-POINT SCALING OF GRID CELL WATER CAPILLARY PRESSURE (LOW SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWPCW defines the maximum water-oil pressure values for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section. The keyword re-scales the oil-water capillary pressure in the low salinity water wet capillary saturation tables from the cell's assigned saturation function by the grid block's LWPCW value.

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{HWPCW}{P_{c_{TABLE-MAX}}} \right) \tag{8.13}$$

Where:

P_c	=	the resulting high salinity water wet water capillary pressure for a grid cell.
LWPCW	=	the maximum capillary pressure from the HWPCW array for a given cell.
$P_{c_{TABLE}}$	=	the capillary pressure in the high salinity water wet water capillary pressure table allocated to the grid block.
$P_{c_{TABLE-MAX}}$	=	the maximum capillary pressure in the high salinity water wet water capillary pressure table allocated to the grid block (that is at the connate water saturation).

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.150 LWSOGCR – END-POINT SCALING GRID CELL SOGCR (LOW SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWSOGCR defines the critical oil saturation with respect to gas ("SOGCR"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil saturation in the low salinity water wet oil-gas relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.151 LWSOWCR – End-Point Scaling Grid Cell SOWCR (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWSOWCR defines the critical oil saturation with respect to water ("SOWCR"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the oil saturation in the low salinity water wet water-oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.152 LWSWCR – End-Point Scaling Grid Cell SWCR (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWSWCR defines the critical water saturation ("SWCR"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water saturation in the low salinity water wet water-oil relative permeability saturation tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.153 LWSWL – End-Point Scaling Grid Cell SWL (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWSWL defines the connate water saturation ("SWL"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water saturation in the low salinity water wet water-oil relative permeability saturation tables, as well as the associated capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.154 LWSWLPC – END-POINT SCALING GRID CELL SWLPC (LOW SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWSWLPC defines the capillary pressure connate water saturation ("SWLPC"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water saturation in the low salinity water wet water-oil capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

Note the keyword only applies the scaling to the capillary pressures tables, unlike the LWSWL keyword that applies the scaling to both the capillary pressure and relative permeability tables.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.155 LWSWU – End-Point Scaling Grid Cell SWU (Low Salinity and Water Wet)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

LWSWU defines the maximum water saturation("SWU"), for all the cells in the model via an array, for when the Low Salt and Surfactant Wettability options have been selected. The data is used to scale the water saturation in the low salinity water wet water-oil relative permeability saturation tables, as well as the associated capillary pressure tables. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Low Salt option should be activated by the LOWSALT keyword in the RUNSPEC section and the Surfactant Wettability option activated by the SURFACT or SURFACTW keywords, which are also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.156 MASSFLOW – Define River Mass Flow versus Time Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MASSFLOW keyword defines the upstream river mass flow versus time tables for rivers, for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.157 MAXVALUE – Sets a Maximum Value for an Array Element

The MAXVALUE keyword sets a maximum value for the specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the MAXVALUE keyword is being used.

See *MAXVALUE – Sets a Maximum Value for an Array Element* in the GRID section for a full description.

8.3.158 MINVALUE – Set a Minimum Value for an Array Element

The MINVALUE keyword sets a minimum value for the specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the MINVALUE keyword is being used.

See *MINVALUE – Set a Minimum Value for an Array Element* in the GRID section for a full description.

8.3.159 MISC – DEFINE SOLVENT MISCIBILITY-IMMISCIBILITY TRANSFORM FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

MISC defines the transformation between the miscible and immiscible relative permeability models, for when the MISCIBLE and SOLVENT keywords in the RUNSPEC section has been activated. The keyword can only be used with the MISCIBLE option and for when the oil, water, gas and solvent phases are active in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSOL	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the solvent fraction with respect to the solvent and gas saturation, and is defined by: $\frac{S_s}{(S_g + S_s)}$ Where Sg is the gas saturation and Ss is the solvent saturation. Note that the first entry in the columnar vector should be zero and the last entry should be one to fully define the solvent fraction range.			
		dimensionless	dimensionless	dimensionless	None
2	MISC	A columnar vector of real equal or increasing down the column values that are greater than or equal to zero and less then one, that define the corresponding miscibility for the corresponding solvent fraction SSOL. The first entry in the columnar vector should be zero and the last entry should be one to fully define the miscible-immiscible relationship.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTMISC tables as declared on the MISCIBLE keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSMISC rows as declared on the MISCIBLE keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.68: MISC Keyword Description

Example

```
--
--       SOLVENT MISCIBILITY-IMMISCIBLITY TRANSFORM TABLE
--
SGCWMIS
--       SSOL       MISC
--       FRAC       FRAC
--       -------    --------
          0.0000     0.0000
          0.2000     0.2500
          0.5000     0.7500
          1.0000     1.0000                                / TABLE NO. 01

--       SSOL       MISC
--       FRAC       FRAC
--       -------    --------
          0.0000     0.0000
          0.3000     0.2500
          0.6000     1.0000
          1.0000     1.0000                                / TABLE NO. 02
```

The above example defines two solvent miscible-immiscible transform tables assuming NTMISC equals two and NSMISC is greater than or equal to four on the MISCIBLE keyword in the RUNSPEC section.

8.3.160 MLANG – Define Langmuir Maximum Gas Concentration for All Grid Cells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, MLANG, defines the coal bed methane Langmuir Adsorption[83] maximum gas concentration for each grid cell used to scale the Langmuir isotherm table allocated to the cell, for when the Coal Bed Methane option has been activated via the COAL keyword in the RUNSPEC section. See the LANGMUIR keyword in the PROPS section for specifying the Langmuir tables for the model.

Note that if he Dual Porosity model has been activated by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section, then MLANG applies to only the matrix grid block.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[83] *Langmuir, Irving (June 1918). "The Adsorption of Gases on Plane Surface of Glass, Mica and Platinum". The Research Laboratory of the General Electric Company. 40 (9): 1361–1402. doi:10.1021/ja02242a004*

8.3.161 MLANGSLV – DEFINE LANGMUIR MAXIMUM SOLVENT CONCENTRATION FOR ALL GRID CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, MLANGSLV, defines the coal bed methane Langmuir Adsorption[84] maximum solvent concentration for each grid cell used to scale the Langmuir isotherm solvent table allocated to the cell, for when the Coal Bed Methane option has been activated via the COAL keyword in the RUNSPEC section. In addition, the Solvent phase must have been declared by the SOLVENT keyword in the RUNSPEC section. See the COALNUM keyword in the GRID section for allocating the Langmuir solvent tables to the grid blocks, and also the LANGMUIR keyword in the PROPS section for defining the Langmuir Adsorption Isotherm tables. Keywords COALADS and COALPP, also in the PROPS section, are used to specify the relative adsorption data in runs containing the solvent phase.

Note that if he Dual Porosity model has been activated by either the DUALPORO or the DUALPERM keywords in the RUNSPEC section, then MLANGSLV applies to only the matrix grid block.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[84] *Langmuir, Irving (June 1918). "The Adsorption of Gases on Plane Surface of Glass, Mica and Platinum". The Research Laboratory of the General Electric Company. 40 (9): 1361–1402. doi:10.1021/ja02242a004*

8.3.162 MSFN – MISCIBLE NORMALIZED RELATIVE PERMEABILITY TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MSFN keyword defines the miscible normalized relative permeability tables for when the MISCIBLE and or SOLVENT options have been activated in the RUNSPEC section using the respective keyword. The MISCIBLE keyword invokes a three component formulation (oil, water and solvent gas or an oil, water and solvent oil). Whereas the SOLVENT keyword results in a four component model (oil, water and gas plus a solvent). This keyword should only be used if the MISCIBLE and or SOLVENT options have been activated.

No.	Name	Description	Default
1	SGAS	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the gas plus solvent saturation.	None
2	KRSG	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the gas plus solvent relative permeability multiplier.	None
3	KRO	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the oil relative permeability multiplier.	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/

Table 8.69: MSFN Keyword Description

Example

```
--
--        MISCIBLE NORMALIZED RELATIVE PERMEABILITY TABLES
--
MSFN
--        SGAS        KRSG          KRO
--        FRAC
--        --------   --------      --------
           0.0000     0.0000        1.0000
           1.0000     1.0000        0.0000                    / TABLE NO. 01

--        SGAS        KRSG          KRO
--        FRAC
--        --------   --------      --------
           0.0000     0.0000        1.0000
           0.2000     0.2000        0.8000
           0.4000     0.3000        0.7000
           0.6000     0.4000        0.6000
           0.8000     0.5000        0.4000
           1.0000     1.0000        0.0000                    / TABLE NO. 02
```

The above example defines two MSN tables for use the MISCIBLE and SOLVENT options.

8.3.163 MULTIPLY – Multiply a Specified Array by a Constant

The MULTIPLY keyword multiplies a specified array or part of an array by a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

See *MULTIPLY – Multiply a Specified Array by a Constant* in the GRID section for a full description.

8.3.164 MULTIREG – Multiply an Array by a Constant based on a Region Number

The MULTIREG keyword multiplies an array or part of an array by a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTIREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the MULTIREG keyword is being used.

See *MULTIREG – Multiply an Array by a Constant based on a Region Number* in the GRID section for a full description.

8.3.165 NOWARNEP – DEACTIVATE END-POINT SCALING WARNING MESSAGES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NOWARNEP keyword deactivates the writing out of warning messages associated with checking the consistency of saturation table end-points; however error messages are still reported by the simulator.

Hence, OPM Flow ignores this keyword but it is documented here for completeness.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
--
--       DEACTIVATE END-POINT SCALING WARNING MESSAGES
--
NOWARNEP
```

The above example switches off the writing out of warning messages associated with checking the consistency of saturation table end-points;

8.3.166 OILDENT – DEFINE OIL DENSITY TEMPERATURE COEFFICIENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

OILDENT defines the oil density as a function of temperature coefficients for when OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC. The reference pressure for this table is given by the VISCREF keyword in the PROPS section. Note this is an OPM Flow keyword used with OPM Flow's "black-oil" thermal model that is not available in the commercial simulator's "black-oil" thermal formulation.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	TEMP is a real positive value greater than zero that defines the absolute reference temperature used with TEXP1 and TEXP2 to estimate the change in oil density with respect to temperature.			
		°R 527.67	°K 293.15	°K 293.15	Defined
2	TEXP1	TEXP1 is a real positive value greater than zero that defines the oil thermal expansion coefficient of the first order.			
		1/°R 1.67×10^{-4}	1/°K 3.0×10^{-4}	1/°K 3.0×10^{-4}	Defined
3	TEXP2	TEXP2 is a real positive value greater than zero that defines the oil thermal expansion coefficient of the second order.			
		$1/°R^2$ 9.26×10^{-7}	$1/°K^2$ 3.0×10^{-6}	$1/°K^2$ 3.0×10^{-6}	Defined

Notes:

1) The keyword is followed by NTPVT records as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each data set is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.70: OILDENT Keyword Description

Example

The following example shows the OILDENT keyword using the default values, for when the thermal option has been activated by the THERMAL keyword in the RUNSPEC section and for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to two.

```
--
--       OIL DENSITY TEMPERATURE COEFFICIENTS (OPM FLOW THERMAL KEYWORD)
--
--       OIL        DENSITY   DENSITY
--       TEMP       COEFF1    COEFF2
--       --------   -------   -------
OILDENT
         1*         1*        1*                          / TABLE NO. 01
         1*         1*        1*                          / TABLE NO. 02
```

There is no terminating "/" for this keyword.

8.3.167 OILVISCT – DEFINE OIL VISCOSITY VERSUS TEMPERATURE FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

OILVISCT defines the oil viscosity as a function of temperature for when OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. The reference pressure and solution gas-oil ratio of the oil for this table is given by the VISCREF keyword in the PROPS section. Note this is an OPM Flow keyword used with OPM Flow's "black-oil" thermal model that is not available in the commercial simulator's "black-oil" thermal formulation.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	A columnar vector of real monotonically increasing down the column values that defines the temperature values.			
		°F	°C	°C	None
2	VIS	A columnar vector of real increasing down the column values that defines the oil viscosity for the corresponding temperature values (TEMP). VIS should be given at the reference pressure and solution gas-oil ratio as defined by PRESS and RS variables on the VISCREF keyword.			
		cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.71: OILVISCT Keyword Description

There is no terminating "/" for this keyword.

Example

The following example shows the OILVISCT keyword for when the thermal option has been activated by the THERMAL keyword in the RUNSPEC section and for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set equal to one.

```
--
--       OIL VISCOSITY VERSUS TEMPERATURE TABLES (OPM FLOW EXTENSION KEYWORD)
--
--       OIL        OIL
--       TEMP       VISC
--       --------   -------
OILVISCT
           100.0    0.600
           110.0    0.650
           120.0    0.680
           150.0    0.720
           165.0    0.725                                  / TABLE NO. 01
```

8.3.168 OPERATE – Define Mathematical Operations on Arrays

This keyword, OPERATE, defines mathematical operations on property arrays (NTG, PORO etc.) and optionally using another property array as input to the function. The keyword allows for various mathematical functions and their associated variables to be defined and applied to the selected array data. Input constants can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

See *OPERATE – Define Mathematical Operations on Arrays* in the GRID section for a full description.

8.3.169 OPERATER – Define Mathematical Operations on Arrays by Region

This keyword defines the mathematical operations on arrays for specific regions in the commercial simulator and is currently not supported by OPM Flow. However, similar functionality is provided by the ADD and MULTIPLY keywords.

See *OPERATER – Define Mathematical Operations on Arrays by Region* in the GRID section for a full description.

8.3.170 OVERBURD – DEFINE ROCK OVERBURDEN PRESSURE VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The OVERBURD keyword defines the overburden pressures versus depth relationship to be applied for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section.

The rock compaction pore volume and transmissibility multipliers, entered via the ROCKTAB, ROCK2D and ROCK2DTR keywords, are applied to the pore pressure, unless the OVERBURD keyword is included in the input deck. When the OVERBURD keyword is present the multipliers are applied to the effective pore volume pressure, that is $P_{(effective)} = P_{(Pressure)} - P_{(overburden)}$. If the keyword is not present in the input deck then the overburden pressure is set to zero.

This keyword should only be used if compaction option has been enabled.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth for corresponding overburden pressure parameter PRESS.			
		feet	m	cm	None
2	PRESS	A columnar vector of real monotonically increasing down the column values that defines the corresponding overburden pressure for the given DEPTH.			
		psia	bars	atm	None

Notes:

1) The keyword is followed by NTROCC tables as declared on the ROCKCOMP keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.72: OVERBURD Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

See also the ROCKTAB, ROCK2D, ROCK2DTR, and ROCKWNOD keywords in the PROPS section.

Examples

The example below defines three overburden tables, assuming NTROCC is equal to three on the ROCKCOMP keyword and NPPVT is greater than or equal to four on the TABDIMS keyword.

```
--
--        OVERBURDEN PRESSURE VERSUS DEPTH TABLES
--
OVERBURD
--        DEPTH     OVERBURDEN
--        FEET      PRESSURE
--        ------    ----------
          1000.0     300.000
          2000.0     600.000
          3000.0     900.000
          4000.0    1200.000                                / TABLE N0. 01
--        DEPTH     OVERBURDEN
--        FEET      PRESSURE
--        ------    ----------
          1000.0     200.000
          2000.0     400.000
          3000.0     800.000
          4000.0    1000.000                                / TABLE N0. 02
--        DEPTH     OVERBURDEN
--        FEET      PRESSURE
--        ------    ----------
          1000.0     400.000
          2000.0     800.000
          3000.0    1100.000
          4000.0    1500.000                                / TABLE N0. 03
```

Note that there must be exactly NTROCC tables entered for this keyword, otherwise an error will occur.

```
--
--        ROCK COMPACTION TABLES
--
ROCKTAB
--        PRESS     PORV      TX(YZ)
--                  MULT      MULT
--        ------    ------    ------
          1000.0    0.9600    0.9650
          1500.0    0.9800    0.9850
          3000.0    0.9900    0.9950
          4500.0    1.0000    1.0000
          4750.0    1.0100    1.0100                          / TABLE NO. 01
--        PRESS     PORV      TX(YZ)
--                  MULT      MULT
--        ------    ------    ------
          1000.0    0.9600    0.9650
          1500.0    0.9800    0.9850
          3000.0    0.9900    0.9950
          4500.0    1.0000    1.0000
          4750.0    1.0100    1.0100                          / TABLE NO. 02
--        PRESS     PORV      TX(YZ)
--                  MULT      MULT
--        ------    ------    ------
          1000.0    0.9600    0.9650
          2000.0    0.9800    0.9850
          3000.0    0.9900    0.9950
          4000.0    1.0100    1.0100                          / TABLE NO. 03
```

The net result of the two examples in this case is identical.

8.3.171 PCG – END-POINT SCALING OF GRID CELL MAXIMUM GAS CAPILLARY PRESSURE (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PCG defines the maximum drainage gas-oil capillary pressure values for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The keyword can be used with all grid types.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness. See also the IPCG keyword for the equivalent imbibition functionality.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PCG	PCG is an array of positive real numbers assigning the maximum drainage gas-oil capillary pressure values for each cell in the model. Repeat counts may be used, for example 30*100.0.			
		psia	bars	atm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) If the HYSTER on the SATOPTS keyword in the RUNSPEC section has been activated to invoke hysteresis then PCG scales the drainage curve and IPCG scales the imbibition curve.

3) The keyword is terminated by "/".

Table 8.73: PCG Keyword Description

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{PCG}{P_{c_{TABLE-MAX}}} \right) \tag{8.14}$$

Where:

P_c = the resulting drainage gas-oil capillary pressure for a grid cell.

PCG = the maximum capillary pressure from the PCG array for a given cell.

$P_{c_{TABLE}}$ = the capillary pressure in the drainage capillary pressure table allocated to the grid block.

$P_{c_{TABLE-MAX}}$ = the maximum capillary pressure in the drainage capillary pressure table allocated to the grid block at $S_g = 1 - S_{wco}$.

Example

```
--
--        DEFINE GRID BLOCK PCG DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PCG
          100*50.0  100*75.0  100*125.0                                          /
```

The above example defines the PCW for 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.172 PCG32D – GAS-OIL CAPILLARY PRESSURE VERSUS OIL AND WATER SATURATION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, PCG32D, enables the gas-oil capillary pressure data to be entered as a function of both oil and water saturations. The keyword should be used in conjunction with the SGF32D keyword in the PROPS section. See also the PCW32D keyword in the PROPS section that provides similar functionality for the water-oil capillary pressure data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.173 PCW – END-POINT SCALING OF GRID CELL WATER CAPILLARY PRESSURE (DRAINAGE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PCW defines the maximum drainage water-oil or water-gas capillary pressure values for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. The keyword can be used with all grid types.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PCW	PCW is an array of positive real numbers assigning the maximum drainage water capillary pressure values for each cell in the model. Repeat counts may be used, for example 30*100.0.			
		psia	bars	atm	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) If the HYSTER on the SATOPTS keyword in the RUNSPEC section has been activated to invoke hysteresis then PCW scales the drainage curve and IPCW scales the imbibition curve.

3) The keyword is terminated by "/".

Table 8.74: PCW Keyword Description

See also the IPCW keyword for the equivalent imbibition functionality.

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{PCW}{P_{c_{TABLE-MAX}}} \right) \tag{8.15}$$

Where:

P_c = the resulting drainage water capillary pressure for a grid cell.

PCW = the maximum capillary pressure from the PCW array for a given cell.

$P_{c_{TABLE}}$ = the capillary pressure in the drainage capillary pressure table allocated to the grid block.

$P_{c_{TABLE-MAX}}$ = the maximum capillary pressure in the drainage capillary pressure table allocated to the grid block (that is at the connate water saturation).

Example

```
--
--       DEFINE GRID BLOCK PCW DATA FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
PCW
         100*50.0  100*75.0  100*125.0                                        /
```

The above example defines the PCW for 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.174 PCW32D – WATER-OIL CAPILLARY PRESSURE VERSUS OIL AND GAS SATURATION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, PCW32D, enables the water-oil capillary pressure data to be entered as a function of both oil and gas saturations. The keyword should be used in conjunction with the SWF32D keyword in the PROPS section. See also the PCG32D keyword in the PROPS section that provides similar functionality for the gas-oil capillary pressure data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.175 PECOEFS – Define Petro-Elastic Model Coefficients

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PECOEFS keyword defines the Petro-Elastic model coefficients.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.176 PEGTAB – PETRO-ELASTIC PRESSURE SHEAR MODULUS TABLE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PEGTAB series of keywords define a series of coefficients of a polynomial function used in the calculation of the shear modulus in the petro-elastic model. The series of keywords consist of: PEGTAB0 PEGTAB1, PEGTAB2, PEGTAB3, PEGTAB4, PEGTAB5, PEGTAB6, and PEGTAB7.

This series of keywords are ignored by OPM Flow and have no effect on the simulation.

8.3.177 PEKTAB – PETRO-ELASTIC PRESSURE BULK MODULUS TABLE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PEKTAB series of keywords define a series of coefficients of a polynomial function used in the calculation of the bulk modulus in the petro-elastic model. The series of keywords consist of: PEKTAB0 PEKTAB1, PEKTAB2, PEKTAB3, PEKTAB4, PEKTAB5, PEKTAB6, and PEKTAB7.

This series of keywords are ignored by OPM Flow and have no effect on the simulation.

8.3.178 PERMFACT– PERMEABILITY MULTIPLICATION FACTOR AS A FUNCTION OF POROSITY CHANGE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PERMFACT defines the permeability multiplication factor due to a change in porosity. Currently the keyword is used in conjunction with OPM Flow's Salt Precipitation model, in which the pore space is reduced due to salt precipitating in the pore space, causing a reduction in porosity and an associated reduction in permeability. OPM Flow's Salt Precipitation model is activated in the input deck via the BRINE and PRECSALT keywords, together with activating the simulator's vaporized water phase via the VAPWAT keyword. All three keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note

This is an OPM Flow specific keyword for the simulator's Salt Precipitation model that is activated by the BRINE and PRECSALT keywords and declaring that vaporized water is present in the run via the VAPWAT in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	POROFAC	A real monotonically increasing positive columnar vector that defines the porosity ($\frac{\phi}{\phi_0}$) factor for the corresponding PERMFAC vector. In the simulator's Salt Precipitation model, the maximum value of ϕ is ϕ_0, implying maximum value of one.			
		dimensionless	dimensionless	dimensionless	None
2	PERMFAC	A real positive increasing columnar vector that defines the permeability (k) multiplier associated with POROFAC and used to scale a grid blocks permeability due to the reduction in pore volume caused by salt precipitation. Where: $PERMFAC = m(\phi)$ $with\ k = m(\phi)k_0$			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) There must be same number of entries for each column.
4) Each table is terminated by a single "/" and the keyword is terminated by "/".

Table 8.75: PERMFACT Keyword Description

The porosity reduction is a function of the volume fraction of salt (s_s) precipitated out of the vaporized water phase, that is:

$$\phi = (1 - s_s)\phi_o \tag{8.16}$$

The porosity and associated permeability factor data can be calculated using a permeability-porosity relationship, for example:

$$\frac{k}{k_o} = \left(\frac{\phi - \phi_c}{\phi_o - \phi_c}\right)^{\gamma} \tag{8.17}$$

Where:

k_o and ϕ_o	=	the initial permeability and porosity,
k and ϕ	=	the actual permeability and porosity that changes due to precipitation or dissolution of the salt,
ϕ_c	=	the residual porosity at which permeability is zero, and
γ	=	a positive exponent.

See also Kozeny-Carment (extended)[85, 86 and 87] and Verma-Pruess[88] for additional functional forms that can be used to derive the tabulated data that can be entered via the PERMFACT keyword.

Example

The example below defines two PERMFACT tables assuming NTPVT equals two and NPPVT is greater five on the TABDIMS keyword in the RUNSPEC section.

```
--
--       PERMEABILITY FACTOR REDUCTION DUE TO SALT PRECIPITATION
--       (OPM FLOW KEYWORD)
--
PERMFACT
--       PORO        PERM
--       FACTOR      FACTOR
--       -------     --------
         0.00         0.0000
         0.25         0.0625
         0.50         0.2500
         0.75         0.0625
         1.00         1.0000                                  / TABLE NO. 01
--       -------     --------
         0.00         0.0000
         0.25         0.0625
         0.50         0.2500
         0.75         0.0625
         1.00         1.0000                                  / TABLE NO. 02
/
```

Both tables use equation (8.17) with ϕ_c equal to zero and γ equal to 2.0. Note that PERMFACT changes the permeability in all three dimensions, that is the PERMX, PERMY and PERMZ arrays are all modified.

Finally, notice that the terminating "/" for this keyword.

[85] *J. Kozeny, "Ueber kapillare Leitung des Wassers im Boden." Sitzungsber Akad. Wiss., Wien, 136(2a): 271-306, 1927.*

[86] *P.C. Carman, "Fluid flow through granular beds." Transactions, Institution of Chemical Engineers, London, 15: 150-166, 1937.*

[87] *P.C. Carman, "Flow of gases through porous media." Butterworths, London, 1956.*

[88] *Verma, A., & Pruess, K. (1988). Thermohydrological conditions and silica redistribution near high-level nuclear wastes emplaced in saturated geological formations. Journal of Geophysical Research, 93, 1159–1173.*

8.3.179 PLMIXPAR – DEFINE THE POLYMER TODD-LONGSTAFF MIXING PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLMIXPAR keyword defines the Todd-Longstaff[89] mixing parameters for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section. This keyword must be present in the input deck if the POLYMER keyword has been activated.

Note that this keyword is used only for the polymer option, if the MISCIBLE keyword in the RUNSPEC section has been invoked then in addition the TLMIXPAR keyword is also required to define the Todd-Longstaff mixing parameters for the MISCIBLE option.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PLMVIS	A real positive value that is greater than or equal to zero and less than or equal to one, that defines the viscosity Todd-Longstaff mixing parameter for each polymer region.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NPLMIX tables as declared on the REGDIMS keyword in the RUNSPEC section, for each rock region. There should be only one row per table.
2) Each entry is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.76: PLMIXPAR Keyword Description

Example

```
--
--       POLYMER TODD-LONGSTAFF MIXING PARAMETERS
--
PLMIXPAR
--       PLM
--       VISCOS
--       -------
         0.3500                                          / TABLE NO. 01
         0.2500                                          / TABLE NO. 02
         0.6500                                          / TABLE NO. 03
```

The above example defines three polymer Todd-Longstaff mixing parameter data sets, based on the NPLMIX variable on the REGDIMS keyword in the RUNSPEC section being equal to three.

[89] *Todd, M. and Longstaff, W. "The Development, Testing and Application of a Numerical Simulator for Predicting Miscible Flood Performance," paper SPE 3484, Journal of Canadian Petroleum Technology (1972) 24, No. 7, 874-882.*

8.3.180 PLYADS - DEFINE POLYMER ROCK ADSORPTION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYADS keyword defines the rock polymer adsorption tables for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section. Alternatively, the functions can be entered via the PLYADSS keyword in the PROPS section for when salt sensitivity is to be considered.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	POLCON	A columnar vector of real monotonically increasing down the column values that defines the polymer concentration in the solution surrounding the rock. The first entry should be zero to define a no polymer concentration.			
		lb/stb	kg/sm^3	gm/scc	None
2	POLRATIO	A columnar vector of real increasing down the column values that defines the mass of adsorbed polymer per unit mass of rock of the saturated concentration of polymer adsorbed by the rock. The first entry should be zero to define a zero ratio of polymer concentration.			
		lb/lb	kg/kg	gm/gm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.77: PLYADS Keyword Description

See also the PLYADSS keyword in the PROPS section to also define rock polymer adsorption tables when the polymer concentration is a function of salinity.

Example

```
--
--       POLYMER ROCK ADSORPTION TABLE
--
PLYADS
--       POLYMER    POLYMER
--       POLCON     POLRATIO
--       -------    --------
             0.0     0.00000
             2.0     0.00003
             4.0     0.00005
             6.0     0.00007
             8.0     0.00009
            10.0     0.00011
            12.0     0.00012
            14.0     0.00015                                / TABLE NO. 01
--       POLYMER    POLYMER
--       POLCON     POLRATIO
--       -------    --------
             0.0     0.00000
             3.0     0.00004
             5.0     0.00006
             7.0     0.00008
             8.0     0.00009
            10.0     0.00011                                / TABLE NO. 02
```

The above example defines two polymer rock adsorption tables assuming NTSFUN equals two and NSSFUN is greater than or equal to eight on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.181 PLYADSS - DEFINE POLYMER ROCK ADSORPTION WITH SALT DEPENDENCE TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYADSS keyword defines the rock polymer adsorption tables for when the polymer and the salt options has been activated by the POLYMER and BRINE keywords in the RUNSPEC section.

Note that the BRINE option is not currently supported by OPM Flow; however, the polymer rock adsorption functions without salt dependence may be entered via the PLYADS keyword in the PROPS section, for when salt sensitivity is not to be considered.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	POLCON	A columnar vector of real monotonically increasing down the column values that defines the polymer concentration in the solution surrounding the rock. The first entry should be zero to define a no polymer and no salt concentration data set. POLCON should only be given for the first entry of the POLCON/POLRATIO set and skipped until another POLCON/POLRATIO table is entered.			
		lb/stb	kg/sm^3	gm/scc	None
2	POLRATIO	A columnar vector of real increasing down the column values that defines the mass of adsorbed polymer per unit mass of rock of the saturated concentration of polymer adsorbed by the rock for a given POLCON and the salt concentration given by SALTCON on the ADSALNOD keyword in the PROPS section. The first table data set entry should be zero to define a no polymer and no salt concentration data set. Subsequent POLRATIO values define the POLCON/POLRATIO combinations for a given salt concentration as listed (and in the same order) by the SALTCON variable on the ADSALNOD keyword in the PROPS section. Each POLCON/POLRATIO/SALT data sets should be terminated by a "/"			
		lb/lb	kg/kg	gm/gm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.78: PLYADSS Keyword Description

See also the PLYADS keyword in the PROPS section to also define rock polymer adsorption tables when the polymer concentration is not a function of salinity.

Example

```
--
--       SETS SALT CONCENTRATION FOR POLYMER SOLUTION ADSORPTION
--       VIA SATNUM ARRAY ALLOCATION
--
--       SALT
--
ADSALNOD
         1.0
         5.0
         10.5
         25.0      / SATNUM TABLE NO. 01
--
--       POLYMER ROCK ADSORPTION WITH SALT DEPENDANCY TABLE
--
PLYADSS
--       POLYMER    POLYMER
--       POLCON     POLRATIO
--       -------    --------
             0.0     0.00000
                     0.00000
                     0.00000
                     0.00000                                / TABLE NO. 01
--       POLYMER    POLYMER
--       POLCON     POLRATIO
--       -------    --------
             1.0     0.00002
                     0.00003
                     0.00004
                     0.00005                                / TABLE NO. 02

--       POLYMER    POLYMER
--       POLCON     POLRATIO
--       -------    --------
             2.0     0.00003
                     0.00004
                     0.00005
                     0.00006                                / TABLE NO. 03
--       POLYMER    POLYMER
--       POLCON     POLRATIO
--       -------    --------
             3.0     0.00004
                     0.00005
                     0.00006
                     0.00007                                / TABLE NO. 04
```

The above example defines four polymer rock adsorption tables for four salt concentration on the ADSALNOD keyword, assuming NTSFUN equals one and NSSFUN is greater than or equal to four on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.182 PLYATEMP – DEFINE POLYMER ADSORPTION TABLE TEMPERATURE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the polymer adsorption temperature for subsequent polymer adsorption tables entered via the PLYADS and PLYADSS keywords in the PROPS section. The Polymer option must have been activated by the POLYMER keyword in the RUNSPEC section and the Thermal option invoked by the THERMAL keyword, also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PLYATEMP	Single real positive value that defines polymer adsorption temperature for subsequent polymer adsorption tables.			
		°F	°C	°C	None

Notes:

1) The keyword is terminated by "/".

Table 8.79: PLYATEMP Keyword Description

Example

The example shows how to enter the polymer adsorption data using the PLYADS keyword for two different temperatures.

```
--
--        RESERVOIR
--        TEMPERATURE
--        -----------
PLYATEMP
          60.0                                          / TEMPERATURE
--
--        POLYMER ROCK ADSORPTION TABLE
--
PLYADS
--        POLYMER     POLYMER
--        POLCON      POLRATIO
--        -------     --------
              0.0      0.00000
              2.0      0.00003
              4.0      0.00005
              6.0      0.00007
              8.0      0.00009
             10.0      0.00011
             12.0      0.00012
             14.0      0.00015                            / TABLE NO. 01
```

```
--
--        POLYMER    POLYMER
--        POLCON     POLRATIO
--        -------    --------
              0.0     0.00000
              3.0     0.00004
              5.0     0.00006
              7.0     0.00008
              8.0     0.00009
             10.0     0.00011                              / TABLE NO. 02
--
--        RESERVOIR
--        TEMPERATURE
--        -----------
PLYATEMP
          120.0                                           / TEMPERATURE
--
--        POLYMER ROCK ADSORPTION TABLE
--
PLYADS
--        POLYMER    POLYMER
--        POLCON     POLRATIO
--        -------    --------
              0.0     0.00000
              2.0     0.00003
              4.0     0.00005
              6.0     0.00007
              8.0     0.00009
             10.0     0.00011
             12.0     0.00012
             14.0     0.00015                              / TABLE NO. 01
--
--        POLYMER    POLYMER
--        POLCON     POLRATIO
--        -------    --------
              0.0     0.00000
              3.0     0.00004
              5.0     0.00006
              7.0     0.00008
              8.0     0.00009
             10.0     0.00011                              / TABLE NO. 02
```

Here the first PLYATEMP keyword defines the temperature to be 60 °F for the subsequent two polymer rock adsorption tables, assuming NTSFUN equals four and NSSFUN is greater than or equal to eight on the TABDIMS keyword in the RUNSPEC section. The next PLYATEMP keyword defines the temperature to be 120 °F for the subsequent two polymer rock adsorption tables.

8.3.183 PLYCAMAX - Define Polymer-Rock Maximum Adsorption by Cell

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYCAMAX keyword defines the maximum polymer-rock adsorption value used in the calculation of the resistance factor for the water phase by individual grid block, for when the Polymer option has been activated by the POLYMER keyword in the RUNSPEC section. See the POLMAX parameter on the PLYROCK keyword in the PROPS section for setting the property for the whole grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.184 PLYDHFLF - DEFINE POLYMER THERMAL DEGRADATION HALF-LIFE TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYDHFLF keyword defines the polymer thermal degradation half-life with respect to temperature functions for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	A columnar vector of real monotonically increasing down the column values that defines the polymer thermal degradation temperature.			
		°F	°C	°C	None
2	POLHFLF	A columnar vector of real values that defines the corresponding polymer half-life.			
		days	days	hours	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.80: PLYDHFLF Keyword Description

Example

```
--
--       POLYMER THERMAL DEGRADATION HALF-LIFE TABLE
--
PLYDHFLF
--       POLYMER    POLYMER
--       TEMP       HALF-LIFE
--       -------    ---------
             0.0     365.000
            40.0     200.000
            80.0     150.000
           120.0     100.000                              / TABLE NO. 01
--       POLYMER    POLYMER
--       POLCON     POLRATIO
--       -------    --------
             0.0     365.000
            50.0     175.000
            75.0     140.000
           100.0     120.000
           125.0      90.000
           150.0      85.000                              / TABLE NO. 02
```

The example defines two polymer thermal degradation half-life tables, based on the NTPVT variable on the TABDIMS keyword in the RUNSPEC section being equal to two and NPPVT variable on the same keyword being greater than or equal to six.

8.3.185 PLYESAL – DEFINE POLYMER EFFECTIVE SALINITY COEFFICIENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, PLYESAL, defines the polymer effective salinity coefficient as well as enabling the effective salinity calculation for polymer adsorption. The keyword should only be used if the BRINE keyword has been declared to activate the brine phase, the ECLMC keyword to enable the Multi-Component Brine model, and the POLYMER keyword has been used to activate the polymer phase. All three keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.186 PLYKRRF – Define Polymer Rock Permeability Reduction by Cell

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYKRRF keyword defines the polymer rock permeability reduction factor to the water phase by individual cell, for when the Polymer option has been activated by the POLYMER keyword in the RUNSPEC section. PLYKRRF should consist of an array of real positive values that are greater than or equal to one. See the PERMFAC parameter on the PLYROCK keyword in the PROPS section for setting the property for the whole grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.187 PLYMAX - DEFINE POLYMER-SALT VISCOSITY MIXING CONCENTRATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYMAX keyword defines maximum polymer and salt concentrations that are to be used in the mixing parameter calculation of the fluid component viscosities, for when the Polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

Note that If the BRINE option has not be activated by the BRINE keyword in the RUNSPEC section, then the salt concentrations in the second column are ignored.

Currently the BRINE option is not implemented in OPM Flow and therefore SALTCON is ignored.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	POLCON	A real value that defines the polymer concentration in the solution which is used to calculate maximum polymer fluid component viscosity.			
		lb/stb	kg/sm^3	gm/scc	None
2	SALTCON	A real value that defines the salt concentration in the solution which is used to calculate maximum polymer fluid component viscosity. Note that If the BRINE option has not been activated by the BRINE keyword in the RUNSPEC section, then this variable is ignored; however, there should still be dummy entries in this case. This variable is ignored as the BRINE option is not implemented in OPM Flow.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section, for each rock region. There should be only one row per table.

2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.81: PLYDMAX Keyword Description

Example

```
--
--        POLYMER-SALT VISCOSITY MIXING CONCENTRATIONS
--
PLYMAX
--        POLYMER     SALT
--        POLCON      SALTCON
--        -------     --------
          0.0100       0.0500                              / TABLE NO. 01
          0.0075       0.0400                              / TABLE NO. 02
          0.0050       0.0300                              / TABLE NO. 03
```

The above example defines three polymer-salt viscosity mixing concentrations, based on the NPLMIX variable on the REGDIMS keyword in the RUNSPEC section being equal to three.

8.3.188 PLYRMDEN - Define Polymer Model In Situ Rock Density

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYRMDEN keyword defines the in situ rock density at reservoir conditions by individual cell, for when the Polymer option has been activated by the POLYMER keyword in the RUNSPEC section. PLYRMDEN should consist of an array of real positive values. See the DENSITY parameter on the PLYROCK keyword in the PROPS section for setting the property for the whole grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.189 PLYROCK - DEFINE POLYMER-ROCK PROPERTIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYROCK keyword defines rock properties for when the Polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PSPACE	A real positive value that is greater than or equal to zero and less the maximum water saturation and less than one, that defines available pore space for this rock type.			
		dimensionless	dimensionless	dimensionless	None
2	PERMFAC	A real positive value that is greater than or equal to one that defines decrease in the rock permeability to the water phase when the maximum amount of polymer has been adsorbed.			
		dimensionless	dimensionless	dimensionless	None
3	DENSITY	A real value that defines the rock in-situ density, that is at reservoir conditions.			
		lb/rtb	kg/rm^3	gm/rcc	None
4	ADINDX	A positive integer of 1 or 2 that defines the polymer desorption option. 1) then polymer desorption may occur by retracing the polymer adsorption isotherm when the local polymer concentration in the solution decreases. 2) then no polymer desorption may occur.			
		dimensionless 1	dimensionless 1	dimensionless 1	Defined
5	POLMAX	A real positive non-zero value that defines the maximum polymer adsorption to be used in the calculation of the resistance factor for the water phase.			
		lb/lb	kg/kg	gm/gm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section, for each polymer flooding region. There should be only one row per table.

2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.82: PLYROCK Keyword Description

Example

```
--
--       POLYMER-ROCK PROPERTIES
--
PLYROCK
--       PORE      PERM      INSITU    DESORP  MAX
--       SPACE     FACTOR    DENSITY   OPTN    POLY
--       ------   --------   -------   ------  -------
         0.1200    1.7500    1800.0      1     0.00012     / TABLE NO. 01
         0.1300    1.8500    1980.0      2     0.00015     / TABLE NO. 02
         0.1500    1.9500    2005.0      1     0.00014     / TABLE NO. 03
```

The above example defines three polymer-rock tables, based on the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section being equal to three.

There is no terminating "/" for this keyword.

8.3.190 PLYSHEAR – ACTIVATE AND DEFINE POLYMER SHEARING PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYSHEAR keyword activates and the defines the polymer shear thinning-thickening option for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	VELOCITY	A columnar vector of real monotonically increasing down the column values that defines the water-polymer flow velocity. The VELOCITY value for the first row in the table should be zero.			
		feet/day	m/day	cm/hour	None
2	VISFAC	A columnar vector of real values that defines a factor that scales the effective water and polymer viscosities for when shear thinning-thickening of the polymer occurs. Normally VISFAC value for the first row in the table should be one.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.83: PLYSHEAR Keyword Description

Example

```
--
--       ACTIVATE AND DEFINE POLYMER SHEARING PARAMETERS
--
PLYSHEAR
--       WAT-POLY    VISCOSITY
--       VELOCITY    FACTOR
--       --------    ---------
             0.0       1.000
             1.0       0.900
             3.0       0.800
             6.0       0.700                                  / TABLE NO. 01
--       WAT-POLY    VISCOSITY
--       VELOCITY    FACTOR
--       --------    ---------
             0.0       1.000
             1.0       0.900
             2.0       0.800
             4.0       0.750
             6.0       0.700
             8.0       0.650                                  / TABLE NO. 02
```

The above example activates the polymer shear thinning-thickening option and defines two polymer shear thinning-thickening tables, based on the NTPVT variable on the TABDIMS keyword in the RUNSPEC section being equal to two and NPPVT variable on the same keyword being greater than or equal to six.

8.3.191 PLYSHLOG - ACTIVATE AND DEFINE THE POLYMER SHEARING LOGARITHMIC PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates and defines the parameters for the logarithm-based polymer shear thinning/thickening option.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	POLCON	A real positive value that defines the reference polymer concentration for the VELOCITY and VISFAC data for this keyword.			
		lb/stb	kg/sm^3	gm/scc	None
1-2	SALTCON	A real positive value that defines the reference salt concentration for the VELOCITY and VISFAC data for this keyword. Note that If the BRINE option has not been activated by the BRINE keyword in the RUNSPEC section, then this variable is ignored. This variable is ignored as the BRINE option is not implemented in OPM Flow.			
		lb/stb	kg/sm^3	gm/scc	None
1-3	TEMP	A real positive value defines the reference polymer temperature for the VELOCITY and VISFAC data for this keyword. Note that If the TEMP option has not been activated by the TEMP keyword in the RUNSPEC section, then this variable is ignored. This variable is ignored as the TEMP and POLYMER options combination is not implemented in OPM Flow.			
		°F	°C	°C	None
1-4	/	Record terminated by a "/"			Not Applicable
2-1	VELOCITY	A columnar vector of real monotonically increasing down the column values that defines the water-polymer flow velocity for the reference conditions of POLCON, SALTCON and TEMP. The VELOCITY value for the first row in the table should be a very small value that is greater than zero and less than 1 x 10^{-6}.			
		feet/day	m/day	cm/hour	None
2-2	VISFAC	A columnar vector of real positive values that define the dimensionless shear effect multiplier for the given VELOCITY entry for the reference conditions of POLCON, SALTCON and TEMP. Normally VISFAC value for the first row in the table should be one.			
		dimensionless	dimensionless	dimensionless	None
1-4	/	Record terminated by a "/"			Not Applicable

No.	Name	Description			Default
		Field	Metric	Laboratory	

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must be entered with two records, with entries 1-1, 1-2, 1-3 and 1-4 representing record number one and 2-1, 2-2 and 2-3 representing record number two in the "No." column in this table.
3) Each of the records are terminated by a "/" and is explicitly shown in the above rows.
4) For record number two a minimum of two rows and a maximum of NPPVT rows, as declared on the TABDIMS keyword in the RUNSPEC section, are required.
5) There is no "/" terminator for the keyword.

Table 8.84: PLYSHLOG Keyword Description

See the PLYSHEAR keyword for the alternative polymer shear thinning/thickening option that is also implemented in OPM Flow.

Example

The following example show how to enter two PLYSHLOG tables given that the NTPVT variable on the TABDIMS keyword in the RUNSPEC section is set equal to two.

```
--
--        POLYMER SHEARING LOGARITHMIC PARAMETERS
--
PLYSHLOG
--        REF         REF        REF
--        POLCON      SALTCON    TEMP
--        --------    -------    ----
          0.5
/
--
--        VELOCITY    VISFAC
--        --------    -------
          0.0000001    1.00
          0.000001     1.10
          0.0001       1.30
          0.001        1.47
          0.01         1.67
          0.1          2.00
          1.0          2.20
          10.0         2.30
          100.0        2.40
          1000.0       2.40
                                                          / TABLE NO. 01
--        REF         REF        REF
--        POLCON      SALTCON    TEMP
--        --------    -------    ----
          0.5
/
```

```
--
--        VELOCITY    VISFAC
--        --------    -------
          0.0000001    1.00
          0.000001     1.10
          0.0001       1.35
          0.001        1.57
          0.01         1.87
          0.1          2.20
          1.0          2.40
          10.0         2.60
          100.0        2.65
          1000.0       2.65
                                                    / TABLE NO. 02
```

The example activates the polymer logarithmic shear thinning-thickening option and defines two polymer shear thinning-thickening tables, based on the NTPVT variable on the TABDIMS keyword in the RUNSPEC section being equal to two and NPPVT variable on the same keyword being greater than or equal to ten.

8.3.192 PLYTRRF – DEFINE POLYMER ROCK PERMEABILITY REDUCTION VERSUS TEMPERATURE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYTRRF keyword defines the polymer rock permeability reduction factor to the water phase as a function of temperature, for when the Polymer option has been activated by the POLYMER keyword in the RUNSPEC section. See the PLYTRRF keyword for the options on how this data is used in the polymer model and the PERMFAC parameter on the PLYROCK keyword for setting the property for the whole grid for a constant temperature. Both keywords are in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.193 PLYTRRFA – DEFINE POLYMER ROCK PERMEABILITY REDUCTION VERSUS TEMPERATURE OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYTRRFA keyword defines the how the polymer rock permeability reduction factor to the water phase as a function of temperature data, entered via the PLYTRRA keyword in the PROPS section, should be used. This keyword should only be used if the Polymer option has been activated by the POLYMER keyword in the RUNSPEC section. See the PERMFAC parameter on the PLYROCK keyword in the PROPS section for setting the property for the whole grid for a constant temperature.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.194 PLYVISC – DEFINE POLYMER VISCOSITY SCALING FACTORS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PLYSVISC defines the polymer viscosity scaling factors used to determine the relationship of pure water viscosity with respect to increasing polymer concentration within a grid block. The polymer option must be activated by the POLYMER keyword in the RUNSPEC section in order to use this keyword.

The BRINE option in the RUNSPEC should be deactivated if this keyword is to be used.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	POLCON	A columnar vector of real monotonically increasing down the column values that defines the polymer concentration in the solution surrounding the rock. The first entry should be zero to define a no polymer concentration.			
		lb/stb	kg/sm^3	gm/scc	None
2	VISFAC	A columnar vector of real increasing or equal values that defines a factor that scales the effective viscosity of the solution for the given POLCON entry. Normally VISFAC value for the first row in the table should be one.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.85: PLYVISC Keyword Description

Example

```
--
--       POLYMER VISCOSITY SCALING FACTOR TABLES
--
PLYVISC
--       POLYMER     VISCOSITY
--       POLCON      VISFAC
--       --------    ---------
          0.0000       1.000
          0.0002      10.000
          0.0004      20.000
          0.0008      40.000                              / TABLE NO. 01
```

```
--        POLYMER     VISCOSITY
--        POLCON      VISFAC
--        --------    ---------
           0.0000       1.000
           0.0003      10.000
           0.0005      20.000
           0.0007      40.000
           0.0009      45.000
           0.0011      55.000                                / TABLE NO. 02
```

The example defines two polymer viscosity scaling factor tables, based on the NTPVT variable on the TABDIMS keyword in the RUNSPEC section being equal to two and NPPVT variable on the same keyword being greater than or equal to six.

8.3.195 PLYVISCS – DEFINE POLYMER-SALT VISCOSITY SCALING FACTORS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PLYSVISCS defines the polymer-salt viscosity scaling factor tables applied to pure water that are used to determine the viscosity of a polymer-salt mixture with respect to increasing polymer concentration within a grid block. The polymer option must be activated by the POLYMER keyword, as well as the brine phase declared by the BRINE keyword in the RUNSPEC section in order to use this keyword. However the ECLM keyword in the RUNSPEC must not be used with this keyword.

See also the PLYVSCST keyword in the PROPS section to enter polymer viscosity scaling factor data that is dependent on both salt and reservoir temperature.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.196 PLYVISCT – DEFINE POLYMER-TEMPERATURE VISCOSITY SCALING FACTORS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PLYSVISCT defines the polymer-temperature viscosity scaling factor tables applied to pure water that are used to determine the viscosity of the polymer at a given temperature with respect to increasing polymer concentration within a grid block. Both the polymer option must be activated by the POLYMER keyword and the temperature option invoked by the TEMP keyword in the RUNSPEC section in order to use this keyword. However the BRINE keyword in the RUNSPEC must not be used with this keyword, that is the salt sensitivity options should be deactivated.

See also the PLYVSCST keyword in the PROPS section to enter polymer viscosity scaling factor data that is dependent on both salt and reservoir temperature.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.197 PLYVSCST – DEFINE POLYMER-SALT-TEMPERATURE VISCOSITY SCALING FACTORS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PLYVSCST defines the polymer-salt-temperature viscosity scaling factor tables applied to pure water that are used to determine the viscosity of the polymer at a given salt concentration and for a given temperature, with respect to increasing polymer concentration within a grid block. Both the polymer option must be activated by the POLYMER keyword and the temperature option invoked by the TEMP keyword in the RUNSPEC section in order to use this keyword. In addition, the BRINE keyword in the RUNSPEC must also be invoked. The keyword is used in conjunction with the SALTNODE keyword to define the various salt concentrations and the TEMPNODE keyword to define the various reservoir temperatures. Both keywords are in the PROPS section.

See also the PLYVISCS keyword in the PROPS section to enter polymer viscosity scaling factor data that is dependent just salt concentration and the PLYVISCT keyword in the PROPS section to enter polymer viscosity scaling factor data that is dependent just on reservoir temperature.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.198 PMAX – Maximum and Minimum Pressure for Total Compressibility Check

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PMAX keyword defines the maximum and minimum pressures expected to be encountered during the run. The data is used to perform the PVT total compressibility check that ensures that the total compressibility of a mixture of oil-gas, for when the gas-oil ratio is increasing for an oil, or the condensate gas ratio is increasing for a gas condensate, is positive respect to pressure. The total compressibility check is used to ensure that the entered oil and gas PVT data is consistent. If the check fails for given oil-gas mixture at a given pressure, resulting in a negative total compressibility, then this will result in numerical instabilities in the run causing this simulator difficulties in converging to a solution.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.199 PMISC – DEFINE MISCIBILITY VERSUS PRESSURE TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PMISC defines the transition between immiscible and miscible displacement as a function of oil pressure tables, for when the MISCIBLE keyword in the RUNSPEC section has be activated. If this keyword is absent from the input deck and MISCIBLE keyword in the RUNSPEC keyword has been activated, then miscibility is independent of the oil phase pressure.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	A columnar vector of real monotonically increasing down the column values that defines the oil phase pressure.			
		psia	barsa	atma	None
2	MISC	A columnar vector of real equal or increasing down the column values that defines the corresponding miscibility factor. MISC is a scaling that should lie be zero and one, where zero means no miscibility and one means full miscibility.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTMISC tables as declared on the MISCIBLE keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSMISC rows as declared on the MISCIBLE keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.86: PMISC Keyword Description

Example

```
--
--       MISCIBILITY VERSUS PRESSURE TABLES
--
PMISC
--       OIL        MISCIBILE
--       PRESS      FACTOR
--       -------    ---------
          1000.0       0.000
          2000.0       0.250
          3000.0       1.000
          4000.0       1.000                                  / TABLE NO. 01
--       OIL        MISCIBILE
--       PRESS      FACTOR
--       -------    ---------
          1500.0       0.000
          2000.0       0.000
          2500.0       0.250
          3000.0       0.350
          3500.0       1.000
          4000.0       1.000                                  / TABLE NO. 02
```

The above example defines two miscibility versus pressure tables assuming NTMISC equals two and NSMISC is greater than or equal to six on the MISCIBLE keyword in the RUNSPEC section.

8.3.200 PPCWMAX – DEFINE SWATINIT CALCULATED CAPILLARY PRESSURE CONSTRAINTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PPCWMAX keyword defines the maximum capillary pressure allowed when scaling the capillary pressure tables to match the inputted SWATINIT array. This is primary used for when the SWATINIT array has values of water saturation above the connate water saturation significantly outside than capillary pressure transition zone, that is high on the structure. In this case OPM Flow may generate large values for the capillary pressure which may result in numerical converge problems. This keyword sets the maximum allowable calculated capillary pressure and how the water saturation should be treated when the limit is exceeded.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PCWO	A columnar vector of real values that defines the maximum allowable capillary pressure for each SATNUM region. The default value of infinity means there is no limit applied.			
		psia	barsa	atma	Infinity
2	OPTN	A columnar vector of character strings that should be set to: 1) NO: To ignore the SWATINIT value for the offending cell for when PCWO is exceeded. In this cases the capillary pressure for the block is set to the maximum (PCWO) and the water saturation is re-calculated based on PCWO. 2) YES: To set the SWATINIT value to the connate water saturation for the offending cell for when PCWO is exceeded. In this case the capillary pressure is set to the maximum value of the appropriate SATNUM table and the initial water saturation is calculated to be consistent with the tables maximum capillary pressure. This results in the capillary pressures not being re-scale for the offending cell.			No

Notes:

1) The keyword is followed by NTSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each row show contain two values representing PCWO and OPTN values.
3) Each row is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.87: PPCWMAX Keyword Description

Note

Using this keyword to limit the re-scaled grid block capillary pressure values will effect the fluids in-place when the simulator has to re-calculate values due to the capillary pressure limit being exceeded.

In addition the high grid block capillary pressures may be indicative of an inconsistency between the tabular SATNUM capillary pressure values and the provided SWATINIT array. This inconsistency may be a result of the SWATINIT array being derived using a saturation height function, as is customary in static modeling software, and the numerical models tabulated capillary pressure.

Example

```
--
--       SET MAXIMUM PC FOR SWATINIT INITIALIZATION
--       MAX       MATCH
--       PC        SWATINIT
--       --------  --------
PPCWMAX
         100.0     YES                                    / TABLE NO 01
         125.0     YES                                    / TABLE NO 02
         135.0     YES                                    / TABLE NO 03
```

The above example sets the maximum capillary pressure for three saturation regions to 100, 125 and 135 with SWATINIT reset to the connate water saturation for when the capillary pressure limit is exceeded.

8.3.201 PROPS - Define the Start of the PROPS Section of Keywords

Description

The PROPS activation keyword marks the end of the EDIT section and the start of the PROPS section that defines the key fluid and rock property data property data for the simulator

There is no data required for this keyword.

Example

```
-- ==============================================================================
--
-- PROPS SECTION
--
-- ==============================================================================
PROPS
```

The above example marks the end of the EDIT section and the start of the PROPS section in the OPM Flow data input file.

8.3.202 PVCDO - OIL PVT PROPERTIES FOR DEAD OIL (CONSTANT COMPRESSIBILITY)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVCDO defines the oil PVT properties for dead oil[90] with constant compressibility. If the oil has a constant and uniform dissolved gas concentration, Gas-Oil Ratio ("GOR"), and if the reservoir pressure never drops below the saturation pressure (bubble point pressure), then the model can be run more efficiently by omitting the GAS and DISGAS keywords from the RUNSPEC section, treating the oil as a dead oil, and defining a constant Rs (GOR) value with keyword RSCONST or RSCONSTT in the PROPS section. This results in the model being run as a dead oil problem with no active gas phase. However, OPM Flow takes into account the constant Rs in the calculations and reporting.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	PRESS is a real positive value defining the oil reference pressure for the other parameters for this data set.			
		psia	barsa	atma	None
2	OFVF	OFVF is a real positive value defining the oil formation volume factor (Bo) at the reference pressure.			
		rb/stb	rm^3/sm^3	rcc/scc	None
3	OCOMP	OCOMP is a real positive value defining the oil compressibility (Co) at the oil reference pressure and is defined as: $$C_o = -\frac{1}{B_o}\left(\frac{dB_o}{dP}\right)$$			
		1/psia	1/barsa	1/atma	None
4	OVISC	OVISC is a real positive value defining the oil viscosity (μ_o) at the oil reference pressure.			
		cP	cP	cP	None
5	OVISCOMP	OVISCOMP is a real positive value defining the oil viiscosibility (μ_{oc}) at the oil reference pressure, Uwc(Pref) and is defined as: $$\mu_{oc} = -\frac{1}{\mu_o}\left(\frac{d\mu_o}{dP}\right)$$			
		1/psia	1/barsa	1/atma	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.88: PVCDO Keyword Description

See also the RSCONST and RSCONSTT keywords to define the constant Rs for dead oil and PVDO as an alternative keyword to enter the dead oil properties.

[90] *"Dead" oil is oil that it contains no dissolved gas or a relatively thick oil or residue that has lost its volatile components.*

Example

```
--
--       OIL PVT TABLE FOR DEAD WITH CONSTANT COMPRESSIBILITY
--
PVCDO
--       REF PRES  BO         CO        VISC     VISC
--       PSIA      RB/STB     1/PSIA    CPOISE   GRAD
--       --------  --------   -------   ------   ------
          3840.0    1.080     1.5E-6     1.750    0.0       / TABLE NO. 01
          3840.0    1.100     1.5E-6     1.050    0.0       / TABLE NO. 02
          3840.0    1.120     1.6E-6     0.950    0.0       / TABLE NO. 03
          3840.0    1.140     1.7E-6     0.850    0.0       / TABLE NO. 04
          3840.0    1.160     1.7E-6     0.800    0.0       / TABLE NO. 05
```

The above example defines five dead oil PVT tables with constant compressibility and viscosity, and assumes that NTPVT equals five on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.203 PVCO - OIL PVT PROPERTIES FOR LIVE OIL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVCO defines the oil PVT properties for live[91] and the keyword should only be used if the there is both oil and gas phases in the model. This keyword should be used when the DISGAS keyword has be declared in the RUNSPEC section indicating that dissolved gas (more commonly referred to as solution gas) is present in the oil. The keyword may be used for oil-water and oil-water-gas input decks. This is an alternative keyword to the PVTO keyword in the PROPS section that also enables entering live oil PVT data. Here, the PVCO keyword assumes that for the undersaturated oil with a given Gas-Oil Ratio ("GOR" or "Rs"), the oil compressibility is independent of the pressure. Hence, is not necessary to enter the undersaturated oil formation volume factor versus pressure data. Similarly, the viscosity of the same type of oil is assumed to have a pressure independent "viscosibility" derivative, and therefore it is not necessary to enter undersaturated viscosity versus pressure data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	PRESS is a real columnar vector of real monotonically increasing down the column values that defines the oil phase saturation pressure (bubble-point pressure), that defines the RS, oil formation volume factor and the oil viscosity at PRESS.			
		psia	barsa	atma	None
2	RS	RS is a real monotonically increasing down the column values that defines the saturated gas-oil ratio ("GOR") or Rs, for the given value of PRESS.			
		Mscf/stb	sm^3/sm^3	scc/scc	1*
3	OFVF	OFVF is a real positive value defining the oil saturated formation volume factor (Bo) at the saturation pressure PRESS.			
		rb/stb	rm^3/sm^3	rcc/scc	None
4	OVISC	OVISC is a real positive value defining the oil viscosity (μ_o) at the oil saturated reference pressure, PRESS.			
		cP	cP	cP	1*
5	OCOMP	OCOMP is a real positive value defining the oil compressibility (Co) at the saturated oil reference pressure and is defined as: $$C_o = -\frac{1}{B_o}\left(\frac{dB_o}{dP}\right)$$			
		1/psia	1/barsa	1/atma	1*

[91] *"Live" oil is oil that contains gas in solution, which is normally the case for most conventional oil reservoirs. However, for oil reservoirs classified as heavy oil reservoirs, the in situ dissolved gas may be negligible and oil would then be classified as gas-free oil which is commonly referred to as "dead" oil.*

No.	Name	Description			Default
		Field	Metric	Laboratory	
6	OVISCOMP	OVISCOMP is a real positive value defining the oil viiscosibility (μ_{oc}) at the saturated oil reference pressure with the given RS, where (μ_{oc}) is defined as: $$\mu_{oc} = -\frac{1}{\mu_o}\left(\frac{d\mu_o}{dP}\right)$$			1*
		1/psia	1/barsa	1/atma	

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Items (2) to (6) may be defaulted, in which case linear interpolation will be used to calculate the missing values. In addition, OVISCOMP, item (6),may be completely defaulted, which sets this data to zero.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.89: PVCO Keyword Description

Example

```
--
--        OIL PVT TABLE FOR LIVE OIL
--
PVCO
--        PSAT       RS         BO        VISC     OIL       OIL
--        PSIA       MSCF/STB   RB/STB    CPOISE   COMPRES   VISCOS
--        --------   --------   -------   ------   -------   ------
             14.7     0.0010    1.05340   1.7230   3.0E-5    1*
            500.0     0.0890    1.08890   1.1670   1*        1*
           1000.0     0.2060    1.13850   0.8570   1*        1*
           1500.0     0.3360    1.19640   0.6840   1*        1*
           2000.0     0.4750    1.26110   0.5750   1*        1*
           2500.0     0.6220    1.33160   0.5000   1*        1*
           3000.0     0.7750    1.40740   0.4450   1*        1*
           3500.0     0.9330    1.48790   0.4020   1*        1*
           4000.0     1.0960    1.57280   0.3680   1*        1*
           4258.0     1.1800    1.61760   0.3530   1*        1*
           4500.0     1.2630    1.66190   0.3400   1*        1*
           5000.0     1.4340    1.75480   0.3170   1*        1*
           5500.0     1.6060    1.85020   0.2980   1*        1*     / TABLE NO. 01
--
--        PSAT       RS         BO        VISC     OIL       OIL
--        PSIA       MSCF/STB   RB/STB    CPOISE   COMPRES   VISCOS
--        --------   --------   -------   ------   -------   ------
             14.7     0.0010    1.05340   1.7230   3.0E-5    1*
            500.0     0.0890    1.08890   1.1670   1*        1*
           1000.0     0.2060    1.13850   0.8570   1*        1*
           1500.0     0.3360    1.19640   0.6840   1*        1*
           2000.0     0.4750    1.26110   0.5750   1*        1*
           2500.0     0.6220    1.33160   0.5000   1*        1*
           3000.0     0.7750    1.40740   0.4450   1*        1*
           3500.0     0.9330    1.48790   0.4020   1*        1*
           4000.0     1.0960    1.57280   0.3680   1*        1*
           4258.0     1.1800    1.61760   0.3530   1*        1*
           4500.0     1.2630    1.66190   0.3400   1*        1*
           5000.0     1.4340    1.75480   0.3170   1*        1*
           5500.0     1.6060    1.85020   0.2980   1*        1*     / TABLE NO. 02
```

The above example defines two live oil PVT tables with constant compressibility above the saturation pressure, and assumes that NTPVT equals two on the TABDIMS keyword in the RUNSPEC section.

8.3.204 PVDG - GAS PVT PROPERTIES FOR DRY GAS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVDG defines the gas PVT properties for dry gas[92]. If the gas has a constant and uniform vaporized oil concentration, Condensate-Gas Ratio ("CGR"), and if the reservoir pressure never drops below the saturation pressure (dew point pressure), then the model can be run more efficiently by omitting the OIL and VAPOIL keywords from the RUNSPEC section, treating the gas as a dry gas, and defining a constant Rv (CGR) value with keyword RVCONST or RVCONSTT in the PROPS section. This results in the model being run with as a dry gas problem with no active oil (condensate) phase. However, OPM Flow takes into account the constant Rv in the calculations and reporting.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	A columnar vector of real monotonically increasing down the column values that defines the gas phase pressure.			
		psia	barsa	atma	None
2	GFVF	A columnar vector of real decreasing down the column values that defines the corresponding gas phase formation volume factor.			
		rb/Mscf	rm^3/sm^3	rcc/scc	None
3	GVISC	A columnar vector of real increasing down the column values that defines the corresponding gas phase viscosity.			
		cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.90: PVDG Keyword Description

See also the RVCONST and RVCONSTT keywords to define the constant Rv for dry gas.

[92] *Natural gas that occurs in the absence of condensate or liquid hydrocarbons, or gas that had condensable hydrocarbons removed, is called dry gas. It is primarily methane with some intermediates. The hydrocarbon mixture is solely gas in the reservoir and there is no liquid (condensate surface liquid) formed either in the reservoir or at surface. The term dry indicates that the gas does not contain heavier hydrocarbons to form liquids at the surface conditions. Dry gas typically has GOR's greater than 100,000 scf/stb or 18,000 Sm3/m3.*

Example

```
--
--        GAS PVT TABLE FOR DRY GAS
--
PVDG
--        PRES      BG          VISC
--        PSIA      RB/MSCF     CPOISE
--        ------    --------    ------
            14.7    197.8092    0.0129
            50.0     65.9364    0.0130
           100.0     31.6495    0.0130
           230.0     13.8813    0.0131
           460.0      6.8210    0.0132
           690.0      4.4703    0.0135
           920.0      3.2968    0.0138
          1150.0      2.6113    0.0141
          1380.0      2.1560    0.0145
          1610.0      1.8316    0.0150
          1840.0      1.5952    0.0155
          2070.0      1.4129    0.0161
          2300.0      1.2700    0.0167
          2372.0      1.2305    0.0169
          2530.0      1.1551    0.0174
          2760.0      1.0621    0.0181
          2990.0      0.9841    0.0189
          3220.0      0.9190    0.0196
          3450.0      0.8638    0.0204
          4500.0      0.6910    0.0242
          6000.0      0.5616    0.0293                        / TABLE N0. 01
--
--        PRES      BG          VISC
--        PSIA      RB/MSCF     CPOISE
--        ------    --------    ------
            14.7    265.0126    0.0133
            50.0     66.2531    0.0133
           100.0     33.1266    0.0133
           230.0     14.4552    0.0134
           460.0      7.0357    0.0136
           690.0      4.6493    0.0138
           920.0      3.4417    0.0140
          1150.0      2.7227    0.0144
          1380.0      2.2522    0.0147
          1610.0      1.9158    0.0151
          1840.0      1.6702    0.0156
          2070.0      1.4805    0.0162
          2300.0      1.3317    0.0167
          2372.0      1.2927    0.0169
          2530.0      1.2119    0.0173
          2760.0      1.1135    0.0180
          2990.0      1.0325    0.0187
          3220.0      0.9637    0.0194
          3450.0      0.9055    0.0201
          4500.0      0.7228    0.0236
          6000.0      0.5837    0.0285                        / TABLE N0. 02
```

The above example defines two dry PVT tables assuming NTPVT equals two and NPPVT is greater than or equal to 22 on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.205 PVDO – OIL PVT PROPERTIES FOR DEAD OIL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVDO defines the oil PVT properties for dead oil[93]. If the oil has a constant and uniform dissolved gas concentration, Gas-Oil Ratio ("GOR"), and if the reservoir pressure never drops below the saturation pressure (bubble point pressure), then the model can be run more efficiently by omitting the GAS and DISGAS keywords from the RUNSPEC section, treating the oil as a dead oil, and defining a constant Rs (GOR) value with keyword RSCONST or RSCONSTT in the PROPS section. This results in the model being run as a dead oil problem with no active gas phase. However, OPM Flow takes into account the constant Rs in the calculations and reporting.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	A columnar vector of real monotonically increasing down the column values that defines the oil phase pressure.			
		psia	barsa	atma	None
2	OFVF	A columnar vector of real decreasing down the column values that defines the corresponding oil phase formation volume factor.			
		rb/stb	rm^3/sm^3	rcc/scc	None
3	OVISC	A columnar vector of real increasing down the column values that defines the corresponding oil phase viscosity.			
		cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.91: PVDO Keyword Description

See also the RSCONST and RSCONSTT keywords to define the constant Rs for dead oil and PVCDO as an alternative keyword to enter the dead oil properties.

[93] *"Dead" oil is oil that it contains no dissolved gas or a relatively thick oil or residue that has lost its volatile components.*

Example

```
--
--      OIL PVT TABLE FOR DEAD OIL
--
PVDO
--      PSAT      BO        VISC
--      PSIA      RB/STB    CPOISE
--      --------  -------   ------
           400    1.0102     1.16
          1200    1.0040     1.164
          2000    0.9960     1.167
          2800    0.9880     1.172
          3600    0.9802     1.177
          4400    0.9724     1.181
          5200    0.9646     1.185
          5600    0.9607     1.19                          / TABLE NO. 01
--      --------  -------   ------
           800    1.0255     1.14
          1600    1.0172     1.14
          2400    1.0091     1.14
          3200    1.0011     1.14
          4000    0.9931     1.14
          4800    0.9852     1.14
          5600    0.9774     1.14                          / TABLE NO. 02
```

The above example defines two dead oil PVT tables with variable viscosity and compressibility with respect to pressure, and assumes that NTPVT equals two and NPPVT is greater than or equal to eight on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.206 PVDS - SOLVENT PVT PROPERTIES FOR THE SOLVENT MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVDS defines the solvent PVT properties for use with SOLVENT option. The solvent is treated as an additional dry gas phase within the model. This keyword should only be used if the SOLVENT model has been invoked in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	A columnar vector of real monotonically increasing down the column values that defines the solvent phase pressure.			
		psia	barsa	atma	None
2	GFVF	A columnar vector of real decreasing down the column values that defines the corresponding solvent phase formation volume factor.			
		rb/Mscf	rm^3/sm^3	rcc/scc	None
3	GVISC	A columnar vector of real increasing down the column values that defines the corresponding solvent phase viscosity.			
		cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.92: PVDS Keyword Description

Example

```
--
--        GAS SOLVENT PVT TABLE
--
PVDS
--        PRES      BG          VISC
--        PSIA      RB/MSCF     CPOISE
--        ------    --------    ------
           700.0      4.4703    0.0135
           920.0      3.2968    0.0138
          1150.0      2.6113    0.0141
          1380.0      2.1560    0.0145
          1610.0      1.8316    0.0150
          1840.0      1.5952    0.0155
          2070.0      1.4129    0.0161
          2300.0      1.2700    0.0167
          2372.0      1.2305    0.0169
          2530.0      1.1551    0.0174
          2760.0      1.0621    0.0181
          2990.0      0.9841    0.0189
          3220.0      0.9190    0.0196
          3450.0      0.8638    0.0204
          4500.0      0.6910    0.0242
          6000.0      0.5616    0.0293                        / TABLE N0. 01
--
--        PRES      BG          VISC
--        PSIA      RB/MSCF     CPOISE
--        ------    --------    ------
           700.0      4.6493    0.0138
           920.0      3.4417    0.0140
          1150.0      2.7227    0.0144
          1380.0      2.2522    0.0147
          1610.0      1.9158    0.0151
          1840.0      1.6702    0.0156
          2070.0      1.4805    0.0162
          2300.0      1.3317    0.0167
          2372.0      1.2927    0.0169
          2530.0      1.2119    0.0173
          2760.0      1.1135    0.0180
          2990.0      1.0325    0.0187
          3220.0      0.9637    0.0194
          3450.0      0.9055    0.0201
          4500.0      0.7228    0.0236
          6000.0      0.5837    0.0285                        / TABLE N0. 02
```

The above example defines two solvent PVT tables assuming NTPVT equals two and NPPVT is greater than or equal to 16 on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.207 PVTG - GAS PVT PROPERTIES FOR WET GAS WITH VAPORIZED OIL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVTG defines the gas PVT properties for wet gas[94]. This keyword should be used when the VAPOIL keyword has be declared in the RUNSPEC section indicating that that vaporized oil (more commonly referred to as condensate) is present in the wet gas phase. The keyword may be used for gas-water and oil-water-gas input decks that contain the oil and gas phases.

No.	Name		Description			Default
			Field	Metric	Laboratory	
1	PRESS		A real monotonically increasing down the column vector that defines the gas phase pressure, associated with the saturated condensate-gas ratio ("CGR") or Rv, the gas formation volume factor and the gas viscosity for the corresponding pressure for the stated saturated RVS. For a given PRESS the variability of the gas formation volume factor and the gas viscosity with respect to the under-saturated Rv is optionally included as a sub table under RVU, FVFU and VISU columns, that is it is not necessary to repeat PRESS for each sub table entry. However, each sub table must be terminated by a "/". The under saturated Rv entries are optional, except for perhaps the last PRESS entry to define the PVT properties above the initial saturation pressure.			
			psia	barsa	atma	None
2	RVS	RVU	A columnar vector of real positive number for both the saturated (RVS) and under saturated (RVU) Rv sub table entries. The RVS entry on the main table is the saturated CGR at the pressure indicated by PRESS and may be increasing or decreasing in value as PRESS varies. Subsequent under-saturated Rv for a sub table at the given PRESS, as defined by RVU, are monotonically decreasing for entries in a given sub table.			
			stb/Mscf	sm^3/sm^3	rcc/scc	None
3	FVFS	FVFU	A columnar vector of real decreasing down the column values that defines the corresponding gas phase formation volume factor for a given pressure (PRESS) and for a given Rv (either RVS or RVU).			
			rb/Mscf	rm^3/sm^3	rcc/scc	None
4	VISS	VISU	VISS a columnar vector of real increasing down the column values that defines the corresponding gas phase viscosity for a given pressure (PRESS) and for a given RVS. VISU a columnar vector of real decreasing from VISS down the column values that defines the corresponding gas phase viscosity for a given pressure (PRESS) and for a given RVU.			
			cP	cP	cP	None

[94] *Natural gas that contains significant heavy hydrocarbons such as propane, butane and other liquid hydrocarbons is known as wet gas or rich gas. The general rule of thumb is if the gas contains less methane (typically less than 85% methane) and more ethane, and other more complex hydrocarbons, it is labeled as wet gas. Wet gas normally has GOR's less than 100,000 scf/stb or 18,000 Sm3/m3, with the condensate having a gravity greater than 50 °API.*

No.	Name	Description			Default
		Field	Metric	Laboratory	

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows and NRPVT Rv entries as declared on the TABDIMS keyword in the RUNSPEC section.
3) Apart from the PRES data there must be same number of entries for each column.
4) Each sub table defining the under saturated gas properties must be terminated by "/".
5) Each main table is terminated by a single "/" on a separate line and there is no "/" terminator for the keyword.

Table 8.93: PVTG Keyword Description

Example

```
--
--       GAS PVT TABLE FOR WET GAS WITH VAPORIZED OIL
--
PVTG
--       PRES       RV          BG          VISC
--       PSIA     STB/MSCF     RB/MSCF      CPOISE
--      ------    ---------    -------      ------
          300     0.000132      0.042340     0.01344
                  0             0.042310     0.01389      /
          600     0.000124      0.020460     0.01420
                  0             0.020430     0.01450      /
          900     0.000126      0.013280     0.01526
                  0             0.013250     0.01532      /
         1200     0.000135      0.009770     0.01660
                  0             0.009730     0.01634      /
         1500     0.000149      0.007730     0.01818
                  0             0.007690     0.01752      /
         1800     0.000163      0.006426     0.01994
                  0             0.006405     0.01883      /
         2100     0.000191      0.005541     0.02181
                  0             0.005553     0.02021      /
         2400     0.000225      0.004919     0.02370
                  0             0.004952     0.02163      /
                                                          / TABLE NO. 1
--       PRES       RV          BG          VISC
--       PSIA     STB/MSCF     RB/MSCF      CPOISE
--      ------    ---------    -------      ------
          300     0.000132      0.042340     0.01344
          600     0.000124      0.020460     0.01420
          900     0.000126      0.013280     0.01526
         1200     0.000135      0.009770     0.01660
         1500     0.000149      0.007730     0.01818
         1800     0.000163      0.006426     0.01994
         2100     0.000191      0.005541     0.02181
         2400     0.000225      0.004919     0.02370
                  0             0.004952     0.02163      /
                                                          / TABLE NO. 2
```

The above example defines two wet PVT tables assuming NTPVT equals two, NPPVT is greater than or equal to eight, and NRPVT greater than or equal to two on the TABDIMS keyword in the RUNSPEC section.

Notice that there is no terminating "/" for this keyword only for a table and a sub table.

8.3.208 PVTGW - GAS PVT PROPERTIES FOR DRY GAS WITH VAPORIZED WATER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVTGW defines the gas PVT properties for dry gas[95] with vaporized water. This keyword should be used when the VAPWAT keyword has be declared in the RUNSPEC section indicating that that vaporized water is present in the dry gas phase. The keyword may be used for gas-water and oil-water-gas input decks that contain the dry gas and vaporized water phases.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note

This is an OPM Flow specific keyword for the simulator's Water Vaporization Model that is activated by declaring that vaporized water is present in the run.

No.	Name		Description			Default
			Field	Metric	Laboratory	
1	PRESS		A real monotonically increasing down the column vector that defines the gas phase pressure, associated with the corresponding saturated water-gas ratio ("WGR") or Rw, the gas formation volume factor, and the gas viscosity for the stated saturated RWS. For a given PRESS the variability of the gas formation volume factor and the gas viscosity with respect to the under-saturated Rw is optionally included as a sub table under RWU, FVFU and VISU columns, that is it is not necessary to repeat PRESS for each sub table entry. However, each sub table must be terminated by a "/". The under saturated Rw entries are optional, except for perhaps the last PRESS entry to define the PVT properties above the initial saturation pressure.			None
			psia	barsa	atma	
2	RWS	RWU	A columnar vector of real positive numbers for both the saturated (RWS) and under saturated (RWU) Rw sub table entries. The RWS entry on the main table is the saturated WGR at the pressure indicated by PRESS and may be increasing or decreasing in value as PRESS varies. Subsequent under-saturated Rw for a sub table at the given PRESS, as defined by RWU, are monotonically decreasing for entries in a given sub table.			None
			stb/Mscf	sm^3/sm^3	rcc/scc	
3	FVFS	FVFU	A columnar vector of real decreasing down the column values that defines the corresponding gas phase formation volume factor for a given pressure (PRESS) and for a given Rw (either RWS or RWU).			None
			rb/Mscf	rm^3/sm^3	rcc/scc	

[95] *Natural gas that occurs in the absence of condensate or liquid hydrocarbons, or gas that had condensable hydrocarbons removed, is called dry gas. It is primarily methane with some intermediates. The hydrocarbon mixture is solely gas in the reservoir and there is no liquid (condensate surface liquid) formed either in the reservoir or at surface. The term dry indicates that the gas does not contain heavier hydrocarbons to form liquids at the surface conditions. Dry gas typically has GOR's greater than 100,000 scf/stb or 18,000 Sm3/m3.*

No.	Name		Description			Default
			Field	Metric	Laboratory	
4	VISS	VISU	VISS a columnar vector of real increasing down the column values that defines the corresponding gas phase viscosity for a given pressure (PRESS) and for a given RWS. VISU a columnar vector of real decreasing from VISS down the column values that defines the corresponding gas phase viscosity for a given pressure (PRESS) and for a given RWU.			
			cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows and NRPVT Rw entries as declared on the TABDIMS keyword in the RUNSPEC section.
3) Apart from the PRES data there must be same number of entries for each column.
4) Each sub table defining the under saturated gas properties must be terminated by "/".
5) Each main table is terminated by a single "/" on a separate line and there is no "/" terminator for the keyword.

Table 8.94: PVTGW Keyword Description

See also the PVTG keyword in the PROPS section that defines the wet gas PVT for when vaporized oil is present in the gas phase. Alternatively, the PVTGWO in the PROPS section may be utilized instead of PVTWO to fully define the wet gas PVT properties, for when both vaporized oil and water are present in the gas phase.

Example

```
--
--        GAS PVT TABLE FOR DRY GAS WITH VAPORIZED WATER (OPM FLOW KEYWORD)
--
PVTGW
--        PRES        RW          BG          VISC
--        PSIA      STB/MSCF    RB/MSCF      CPOISE
--       ------     ---------   -------      ------
           300      0.000479     0.042340     0.01344
                    0            0.042310     0.01389      /
           600      0.000469     0.020460     0.01420
                    0            0.020430     0.01450      /
           900      0.000403     0.013280     0.01526
                    0            0.013250     0.01532      /
          1200      0.000354     0.009770     0.01660
                    0            0.009730     0.01634      /
          1500      0.000272     0.007730     0.01818
                    0            0.007690     0.01752      /
          1800      0.000225     0.006426     0.01994
                    0            0.006405     0.01883      /
          2100      0.000191     0.005541     0.02181
                    0            0.005553     0.02021      /
          2400      0.000163     0.004919     0.02370
                    0            0.004952     0.02163      /
                                                           / TABLE NO. 1
```

```
--        PRES        RW           BG           VISC
--        PSIA      STB/MSCF     RB/MSCF       CPOISE
--       ------     ---------    -------       ------
           300      0.000479      0.042340      0.01344
           600      0.000469      0.020460      0.01420
           900      0.000403      0.013280      0.01526
          1200      0.000354      0.009770      0.01660
          1500      0.000272      0.007730      0.01818
          1800      0.000225      0.006426      0.01994
          2100      0.000191      0.005541      0.02181
          2400      0.000163      0.004919      0.02370      /
                                                             / TABLE NO. 2
```

The above example defines two dry gas PVT tables assuming NTPVT equals two and NPPVT is greater than or equal to eight on the TABDIMS keyword in the RUNSPEC section.

Notice that there is no terminating "/" for this keyword only for a table and a sub table.

8.3.209 PVTGWO - Gas PVT Properties for Wet Gas with Vaporized Water and Oil

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVTGWO defines the gas PVT properties for wet gas[96] with vaporized water and oil. This keyword should be used when the VAPOIL and VAPWAT keywords have be declared in the RUNSPEC section indicating that that vaporized oil and water is present in the wet gas phase. The keyword may be used for oil-water-gas input decks that contain the wet gas with vaporized oil and water phases.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note

This is an OPM Flow specific keyword for the simulator's Water Vaporization Model that is activated by declaring that vaporized water is present in the run.

No.	Name		Description			Default
			Field	Metric	Laboratory	
1	PRESS		A real monotonically increasing down the column vector that defines the gas phase pressure, associated with the saturated water-gas ratio ("WGR") or Rw, the saturated condensate-gas ratio ("CGR") or Rv, the gas formation volume factor, and the gas viscosity for the corresponding pressure for the stated saturated RWS. For a given PRESS the variability of the gas formation volume factor and the gas viscosity with respect to the under-saturated Rw is optionally included as a sub table under RWU, FVFU and VISU columns, that is it is not necessary to repeat PRESS for each sub table entry. However, each sub table must be terminated by a "/". The under saturated Rw entries are optional, except for perhaps the last PRESS entry to define the PVT properties above the initial saturation pressure.			
			psia	barsa	atma	None
2	RWS	RWU	A columnar vector of real positive numbers for both the saturated (RWS) and under saturated (RWU) Rw sub table entries. The RWS entry on the main table is the saturated WGR at the pressure indicated by PRESS and may be increasing or decreasing in value as PRESS varies. Subsequent under-saturated Rw for a sub table at the given PRESS, as defined by RWU, are monotonically decreasing for entries in a given sub table.			
			stb/Mscf	sm^3/sm^3	rcc/scc	None

[96] *Natural gas that contains significant heavy hydrocarbons such as propane, butane and other liquid hydrocarbons is known as wet gas or rich gas. The general rule of thumb is if the gas contains less methane (typically less than 85% methane) and more ethane, and other more complex hydrocarbons, it is labeled as wet gas. Wet gas normally has GOR's less than 100,000 scf/stb or 18,000 Sm3/m3, with the condensate having a gravity greater than 50 °API.*

No.	Name		Description			Default
			Field	Metric	Laboratory	
3	RVS	RVU	A columnar vector of real positive numbers for both the saturated (RVS) and under saturated (RVU) Rv sub table entries. The RVS entry on the main table is the saturated CGR at the pressure indicated by PRESS and may be increasing or decreasing in value as PRESS varies. Subsequent under-saturated Rv for a sub table at the given PRESS, as defined by RVU, are monotonically decreasing for entries in a given sub table.			
			stb/Mscf	sm^3/sm^3	rcc/scc	
4	FVFS	FVFU	A columnar vector of real decreasing down the column values that defines the corresponding gas phase formation volume factor for a given pressure (PRESS) and for a given Rw (either RWS or RWU).			
			rb/Mscf	rm^3/sm^3	rcc/scc	None
5	VISS	VISU	VISS a columnar vector of real increasing down the column values that defines the corresponding gas phase viscosity for a given pressure (PRESS) and for a given RWS. VISU a columnar vector of real decreasing from VISS down the column values that defines the corresponding gas phase viscosity for a given pressure (PRESS) and for a given RWU.			
			cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows and NRPVT Rw entries as declared on the TABDIMS keyword in the RUNSPEC section.
3) Apart from the PRES data there must be same number of entries for each column.
4) Each sub table defining the under saturated gas properties must be terminated by "/".
5) Each main table is terminated by a single "/" on a separate line and there is no "/" terminator for the keyword.

Table 8.95: PVTGW Keyword Description

See also the PVTG keyword in the PROPS section that defines the wet gas PVT for when only vaporized oil is present in the gas phase. Alternatively, the PVTGW in the PROPS section may be utilized instead of the PVTGWO keyword if only vaporized vaporized water is present in the gas phase.

Example

```
--
--       GAS PVT TABLE FOR WET GAS WITH VAPORIZED WATER & OIL (OPM FLOW KEYWORD)
--
PVTGWO
--       PRES     RW         RV         BG        VISC
--       PSIA   STB/MSCF   STB/MSCF   RB/MSCF    CPOISE
--      ------  --------   ---------  -------    ------
          300   0.000479   0.000132   0.042340   0.01344
                0          0          0.042310   0.01389   /
          600   0.000469   0.000124   0.020460   0.01420
                0          0          0.020430   0.01450   /
          900   0.000403   0.000126   0.013280   0.01526
                0          0          0.013250   0.01532   /
         1200   0.000354   0.000135   0.009770   0.01660
                0          0          0.009730   0.01634   /
         1500   0.000272   0.000149   0.007730   0.01818
                0          0          0.007690   0.01752   /
         1800   0.000225   0.000163   0.006426   0.01994
                0          0          0.006405   0.01883   /
         2100   0.000191   0.000191   0.005541   0.02181
                0          0          0.005553   0.02021   /
         2400   0.000163   0.000225   0.004919   0.02370
                0          0          0.004952   0.02163   /
                                                            / TABLE NO. 1
--       PRES     RW         RV         BG        VISC
--       PSIA   STB/MSCF   STB/MSCF   RB/MSCF    CPOISE
--      ------  --------   ---------  -------    ------
          300   0.000479   0.000132   0.042340   0.01344
          600   0.000469   0.000124   0.020460   0.01420
          900   0.000403   0.000126   0.013280   0.01526
         1200   0.000354   0.000135   0.009770   0.01660
         1500   0.000272   0.000149   0.007730   0.01818
         1800   0.000225   0.000163   0.006426   0.01994
         2100   0.000191   0.000191   0.005541   0.02181
         2400   0.000163   0.000225   0.004919   0.02370   /
                                                            / TABLE NO. 2
```

The above example defines two wet PVT tables assuming NTPVT equals two and NPPVT is greater than or equal to eight on the TABDIMS keyword in the RUNSPEC section.

Notice that there is no terminating "/" for this keyword only for a table and a sub table.

8.3.210 PVTO - OIL PVT PROPERTIES FOR LIVE OIL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVTO defines the oil PVT properties for live[97] and the keyword should only be used if the there is both oil and gas phases in the model. This keyword should be used when the DISGAS keyword has be declared in the RUNSPEC section indicating that dissolved gas (more commonly referred to as solution gas) is present in the oil. The keyword may be used for oil-water and oil-water-gas input decks.

No.	Name		Description			Default
			Field	Metric	Laboratory	
1	RS		A real monotonically increasing down the column values that defines the saturated gas-oil ratio ("GOR") or Rs, that defines the oil formation volume factor and the oil viscosity for the tabulated corresponding pressure for stated saturated RS. For a given RS the variability of the oil formation volume factor and the oil viscosity with respect to the saturated RS and pressure is optionally included as a sub table under PRSU, FVFU and VISU columns, that is it is not necessary to repeat RS for each sub table entry. However, each sub table must be terminated by a "/". The under-saturated PRSU entries are optional, except for perhaps the last RS entry to define the PVT properties above the initial saturation pressure. If there are no following under-saturated PRSU entries then the RS entry row should be terminated by a "/", if there are under-saturated PRSU entries then the last PRSU entry row should be terminated by a "/".			
			Mscf/stb	sm^3/sm^3	scc/scc	None
2	PRSS	PRSU	PRSS is a real columnar vector of real monotonically increasing down the column values that defines the oil phase saturation pressure (bubble-point pressure), that defines the oil formation volume factor and the oil viscosity for the corresponding PRSS pressure for a given saturated RS. PRSU is a real columnar vector of real monotonically increasing down the column values that defines the oil phase under-saturated pressure that defines the oil formation volume factor and the oil viscosity for the corresponding PRSU pressure for a given saturated RS. Note that PRSU should be greater than PRSS.			
			psia	barsa	atma	None
3	FVFS	FVFU	FVFS is a columnar vector of real increasing down the column values that defines the corresponding oil phase saturated formation volume factor for a given pressure (PRSS) and for a given RS. FVFU is a columnar vector of real decreasing down the column values that defines the corresponding oil phase under-saturated formation volume factor for a given pressure (PRSU) and for a given RS.			
			rb/stb	rm^3/sm^3	rcc/scc	None

[97] *"Live" oil is oil that contains gas in solution, which is normally the case for most conventional oil reservoirs. However, for oil reservoirs classified as heavy oil reservoirs, the in situ dissolved gas may be negligible and oil would then be classified as gas-free oil which is commonly referred to as "dead" oil.*

No.	Name		Description			Default
			Field	Metric	Laboratory	
4	VISS	VISU	VISS a columnar vector of real increasing down the column values that defines the corresponding oil phase saturated viscosity for a given pressure (PRSS) and for a given RS. If this is the only entry for a given RS and PRSS then the record should be terminate by a "/". VISU a columnar vector of real decreasing from VISS down the column values that defines the corresponding oil phase under-saturated viscosity for a given pressure (PRSU) and for a given RS. If this is the only entry for a given RS and PRSU then the record should be terminate by a "/".			
			cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows and NRPVT Rs entries as declared on the TABDIMS keyword in the RUNSPEC section.
3) Apart from the RS data there must be same number of entries for each column.
4) Each sub table defining the under saturated gas properties must be terminated by "/".
5) Each main table is terminated by a single "/" on a separate line and there is no "/" terminator for the keyword.

Table 8.96: PVTO Keyword Description

Example

The following example defines live oil PVT tables assuming NTPVT equals two, NPPVT is greater than or equal to eight, and NRPVT greater than or equal to two on the TABDIMS keyword in the RUNSPEC section.

```
--
--       OIL PVT TABLE FOR LIVE OIL
--
PVTO
--       RS        PSAT      BO        VISC
--       MSCF/STB  PSIA      RB/STB    CPOISE
--       --------  --------  -------   ------
          0.0010      14.7   1.05340   1.7230  /
          0.0890     500.0   1.08890   1.1670  /
          0.2060    1000.0   1.13850   0.8570  /
          0.3360    1500.0   1.19640   0.6840  /
          0.4050    1750.0   1.22800   0.6240  /
          0.4750    2000.0   1.26110   0.5750  /
          0.5480    2250.0   1.29570   0.5340  /
          0.6220    2500.0   1.33160   0.5000  /
          0.6980    2750.0   1.36890   0.4700  /
          0.7750    3000.0   1.40740   0.4450  /
          0.8530    3250.0   1.44710   0.4220  /
          0.9330    3500.0   1.48790   0.4020  /
          1.0140    3750.0   1.52980   0.3840  /
          1.0960    4000.0   1.57280   0.3680  /
          1.1800    4258.0   1.61760   0.3530  /
          1.2630    4500.0   1.66190   0.3400  /
          1.3480    4750.0   1.70780   0.3280  /
          1.4340    5000.0   1.75480   0.3170  /
          1.6060    5500.0   1.85020   0.2980
                    6242.0   1.83040   0.3186  /
                                                / TABLE NO. 1
```

```
--
--
--        RS         PSAT       BO         VISC
--        MSCF/STB   PSIA       RB/STB     CPOISE
--        --------   --------   -------    ------
           0.0010       14.7    1.05340    1.7230  /
           0.0390      250.0    1.06830    1.4220  /
           0.0890      500.0    1.08890    1.1670  /
           0.1460      750.0    1.11250    0.9850  /
           0.2060     1000.0    1.13850    0.8570  /
           0.2700     1250.0    1.16660    0.7590  /
           0.3360     1500.0    1.19640    0.6840  /
           0.4050     1750.0    1.22800    0.6240  /
           0.4750     2000.0    1.26110    0.5750  /
           0.5480     2250.0    1.29570    0.5340  /
           0.6220     2500.0    1.33160    0.5000  /
           0.6980     2750.0    1.36890    0.4700  /
           0.7750     3000.0    1.40740    0.4450  /
           0.8530     3250.0    1.44710    0.4220  /
           0.9330     3500.0    1.48790    0.4020  /
           1.0140     3750.0    1.52980    0.3840  /
           1.0960     4000.0    1.57280    0.3680  /
           1.1800     4258.0    1.61760    0.3530  /
           1.2630     4500.0    1.66190    0.3400  /
           1.3480     4750.0    1.70780    0.3280  /
           1.4340     5000.0    1.75480    0.3170  /
           1.6060     5500.0    1.85020    0.2980
                      6242.0    1.83040    0.3186  /
                                                   / TABLE NO. 2
```

Notice that there is no terminating "/" for this keyword only for a table and a sub table.

8.3.211 PVTW - DEFINE WATER FLUID PROPERTIES FOR VARIOUS REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVTW defines the water properties for various regions in the model. The number of PVTW vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the PVTW tables to different grid blocks in the model is done via the PVTNUM keyword in the REGION section. One data set consists of one record or line which is terminated by a "/". If the water phase is active in the model, which is normally the case, then this keyword must be defined in the OPM Flow input deck.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRES	PRES is a real number defining the water reference pressure (P) for the other parameters for this data set.			
		psia	barsa	atma	None
2	WFVF	WFVF is a real number defining the water formation volume factor (Bw) at the water reference pressure.			
		rb/stb 1.0	rm^3/sm^3 1.0	rcc/scc 1.0	Defined
3	WCOMP	WCOMP is a real number defining the water compressibility (Cw) at the water reference pressure and is defined as: $$C_w = -\frac{1}{B_w}\left(\frac{dB_w}{dP}\right)$$			
		1/psia 0.00004	1/barsa 0.00004	1/atma 0.00004	Defined
4	WVISC	WVISC is a real number defining the water viscosity (μ_w) at the water reference pressure.			
		cP 0.50	cP 0.50	cP 0.50	Defined
5	WVISCOMP	WVISCOMP is a real number defining the water viscosibility (μ_{wc}) at the water reference pressure, μ_{wc}(Pref) and is defined as: $$\mu_{wc} = -\frac{1}{\mu_w}\left(\frac{d\mu_w}{dP}\right)$$			
		1/psia 0.0	1/barsa 0.0	1/atma 0.0	Defined

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.97: PVTW Keyword Description

Examples

The following shows the PVTW keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to one.

```
--
--        WATER PVT TABLE
--
PVTW
--        REF PRES  BW         CW        VISC     VISC
--        PSIA      RB/STB     1/PSIA    CPOISE   GRAD
--        --------  --------   -------   ------   ------
          4840.0    1.019     2.7E-6     0.370    1*          / TABLE NO. 01
```

The next example shows the PVTW keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to three.

```
--
--        WATER PVT TABLE
--
PVTW
--        REF PRES  BW         CW        VISC     VISC
--        PSIA      RB/STB     1/PSIA    CPOISE   GRAD
--        --------  --------   -------   ------   ------
          4640.0    1.008     2.5E-6     0.350    1*          / TABLE NO. 01
          4840.0    1.019     2.7E-6     0.370    1*          / TABLE NO. 02
          4940.0    1.030     2.8E-6     0.390    1*          / TABLE NO. 03
```

The above example defines three water PVT tables and assumes that NTPVT equals three on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.212 PVTWSALT - DEFINE BRINE WATER FLUID PROPERTIES FOR VARIOUS REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVTWSALT defines the brine water properties for various regions in the model, for when the brine phase has been activated by the BRINE keyword in the RUNSPEC section. In this case PVTWSALT is used instead of PVTW in the input file. However, if the ECLMC keyword has been entered in the RUNSPEC section to invoke the Multi-Component Brine model, the PVTW keyword should be used instead of PVTWSALT, as with this combination the salinity effect on the density is ignored.

The number of PVTWSALT table data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the PVTWSALT tables to different grid blocks in the model is done via the PVTNUM keyword in the REGION section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	PRESS	Single real positive value that defines the reference pressure for the data in the following records (P_{ref}). PRESS should be approximately equal to the average reservoir pressures in the model. The simulator users the previous time step values to forecast the current time step water properties by linear interpolation. If PRESS is not representative of the average reservoir pressures in the model then the linear interpolation might result in nonphysical values of the water saturation and water viscosity.			
		psia	barsa	atma	None
1-2	SALTSURF	A real value that defines the reference salt concentration in the solution in the surface stock tank water ($C_{s,ref}$) If defaulted SALTSURF is taken as the minimum salt concentration entered in the SALTCON columnar vector in the second record for this keyword. This should be in most cases be zero.			
		lb/stb	kg/sm^3	gm/scc	Defined
1-3	/	Record terminated by a "/"			Not Applicable
2-1	SALTCONC	A columnar vector of real decreasing or equal values down the column that defines the salt concentration in the solution (C_s).			
		lb/stb	kg/sm^3	gm/scc	None
2-2	WFVF	WFVF is a real columnar vector defining the water formation volume factor (Bw) at the reference pressure PRESS, for the corresponding salt concentration SALTCON.			
		rb/stb	rm^3/sm^3	rcc/scc	None
2-3	WCOMP	WCOMP is a real columnar vector defining the water compressibility (Cw) at the water reference pressure PRESS, for the corresponding salt concentration SALTCON. The water compressibility is defined as: $$C_w = -\frac{1}{B_w}\left(\frac{dB_w}{dP}\right)$$			
		1/psia	1/bars	1/atma	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
2.4	WVISC	WVISC is a real columnar vector defining the water viscosity (μ_w) at the water reference pressure PRESS, for the corresponding salt concentration SALTCON.			
		cP	cP	cP	None
2.5	WVISCOMP	WVISCOMP is a real columnar vector defining the water viscosibility (μ_{wc}) at the water reference pressure PRESS, for the corresponding salt concentration SALTCON. The water viscosibility is defined as: $$\mu_{wc} = -\frac{1}{\mu_w}\left(\frac{d\mu_w}{dP}\right)$$			
		1/psia	1/barsa	1/atma	None
2-6	/	Table and record terminated by a "/"			Not Applicable

Notes:

1) The keyword is followed by NTPVT data sets as declared on the TABDIMS keyword in the RUNSPEC section and each data set consists of two records, with items 1-1 to 1-3 representing record one items and 2-1 to 2-6 representing record number two items, etc., in the "No." column in this table.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.98: PVTWSALT Keyword Description

As mentioned above, the simulator first calculates the water properties as functions of the salt concentration at the previous time step by linear interpolation in salt concentration for water compressibility (C_w), water viscosibility (μ_{wc}), $\frac{1}{B_w}$ and $\frac{1}{B_w\ \mu_w}$. It then calculates the values of B_w and $B_w\ \mu_w$ at the current time step using the current pressure P, using the following equations:

$$B_w(P, C_s) = \frac{B_w(P_{ref}, C_{s,ref})}{1 + C_w(P - P_{ref}) + \frac{(C_w(P - P_{ref}))^2}{2}} \tag{8.18}$$

and

$$B_w(P, C_s)\ \mu_w(P, C_s) = \frac{B_w(P_{ref}, C_{s,ref})\ \mu_w(P_{ref}, C_{s,ref})}{1 + (C_w - \mu_{wc})(P - P_{ref}) + \frac{((C_w - \mu_{wc})(P - P_{ref}))^2}{2}} \tag{8.19}$$

See also the BDENSITY keyword in the PROPS section that defines the brine surface densities for the salt concentrations declared on the PVTSALT keyword. Note that if the BDENSITY keyword is absent from the input file then the brine surface densities will be set to the water density values declared via the DENSITY keyword in the PROPS section. In this case there is no variation in brine surface density with respect to salt concentration.

Example

The following shows the PVTWSALT keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set equal to two and NPPVT is set to greater than four on the TABDIMS keyword.

```
--
--       WATER SALT PVT TABLE
--
PVTWSALT
--       REF PRES  REF SALT
--       PSIA      LB/STB
--       --------  --------
         4500.0    0.000                                  / TABLE NO. REF. DATA
--
--       SALTCONC  BW         CW        VISC     VISC
--       LB/STB    RB/STB     1/PSIA    CPOISE   GRAD
--       --------  --------   -------   ------   ------
            0.0    1.020      2.7E-6    0.370    0.0
            2.0    1.010      2.7E-6    0.370    0.0
            4.0    1.000      2.7E-6    0.370    0.0
           10.0    0.950      2.7E-6    0.370    0.0     / TABLE NO. 01 SALT DATA
--
--       REF PRES  REF SALT
--       PSIA      LB/STB
--       --------  --------
         4000.0    0.000                                  / TABLE NO. 02 REF. DATA
--
--       SALTCONC  BW         CW        VISC     VISC
--       LB/STB    RB/STB     1/PSIA    CPOISE   GRAD
--       --------  --------   -------   ------   ------
            0.0    1.005      2.5E-6    0.320    0.0
            3.0    1.000      2.5E-6    0.320    0.0
            6.0    0.985      2.5E-6    0.320    0.0
           12.0    0.930      2.5E-6    0.320    0.0     / TABLE NO. 02 SALT DATA
```

Note that each table is terminated by "/" and there is no "/" terminator for the keyword.

8.3.213 PVZG - GAS PVT PROPERTIES FOR DRY GAS (Z-FACTOR)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PVZG defines the gas PVT properties for dry gas[98] via the gas compressibility factor (z-factor), instead of the gas formation volume factor. If the gas has a constant and uniform vaporized oil concentration, Condensate-Gas Ratio ("CGR"), and if the reservoir pressure never drops below the saturation pressure (dew point pressure), then the model can be run more efficiently by omitting the OIL and VAPOIL keywords from the RUNSPEC section, treating the gas as a dry gas, and defining a constant Rv (CGR) value with keyword RVCONST or RVCONSTT in the PROPS section. This results in the model being run with as a dry gas problem with no active oil (condensate) phase. However, OPM Flow takes into account the constant Rv in the calculations and reporting.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	RTEMP	Single real positive value that defines the reservoir temperature for the data in the following records.			
		°F	°C	°C	
1-2	/	Record terminated by a "/"			Not Applicable
2-1	PRESS	A columnar vector of real monotonically increasing down the column values that defines the gas phase pressure.			
		psia	barsa	atma	None
2-2	GZFAC	A columnar vector of real values that defines the corresponding gas phase z-factor at the given pressure, PRESS.			
		dimensionless	dimensionless	dimensionless	None
2-3	GVISC	A columnar vector of real increasing down the column values that defines the corresponding gas phase viscosity.			
		cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT data sets as declared on the TABDIMS keyword in the RUNSPEC section and each data set consists of two records, with items 1-1 to 1-2 representing record one items and 2-1 to 2-3 representing record number two items, etc., in the "No." column in this table.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.99: PVZG Keyword Description

See also the RVCONST and RVCONSTT keywords to define the constant Rv for dry gas.

[98] *Natural gas that occurs in the absence of condensate or liquid hydrocarbons, or gas that had condensable hydrocarbons removed, is called dry gas. It is primarily methane with some intermediates. The hydrocarbon mixture is solely gas in the reservoir and there is no liquid (condensate surface liquid) formed either in the reservoir or at surface. The term dry indicates that the gas does not contain heavier hydrocarbons to form liquids at the surface conditions. Dry gas typically has GOR's greater than 100,000 scf/stb or 18,000 Sm3/m3.*

The ideal gas law provides a relationship between the pressure, the temperature and the specific volume of an ideal gas (pure component). This relationship is modified by use of a compressibility factor, Z[99], to account for deviations, from ideal, to the behavior of real gases. The PVT relation for a real gas can be defined by:

$$PV = ZnRT \tag{8.20}$$

As the gas formation volume factor is used to relate the volume of gas, as measured at reservoir conditions, to the volume of gas as measured at standard conditions (60 °F and 14.7 psia, or 15 °C and 101.325 kPa). This gas property is then defined as the actual volume occupied by a certain amount of gas at a specified pressure and temperature, divided by the same amount of gas at standard conditions. Thus, using the above equation one can obtain the gas volumes at reservoir and standard conditions, i.e.

$$V_{sc} = \frac{Z_{sc} nRT_{sc}}{P_{sc}} \tag{8.21}$$

$$V_i = \frac{Z_i n RT_i}{P_i} \tag{8.22}$$

Thus the gas formation volume factor can be expressed as:

$$E = \frac{V_{sc}}{V_i} \tag{8.23}$$

And substituting equation (8.21) and (8.22) into (8.23) we obtain

$$E = \left(\frac{P_i}{P_{sc}}\right)\left(\frac{T_{sc}}{T_i}\right)\left(\frac{1}{Z_i}\right) \tag{8.24}$$

Incorporating standard pressure and temperature values gives in SI units we have:

$$E = \left(\frac{P_i}{101.325}\right)\left(\frac{273.15 + 15}{T_i}\right)\left(\frac{1}{Z_i}\right) = 2.84\left(\frac{P_i}{Z_i T_i}\right) \tag{8.25}$$

or in field units

$$E = \left(\frac{P_i}{14.7}\right)\left(\frac{460 + 60}{T_i}\right)\left(\frac{1}{Z_i}\right) = 35.37\left(\frac{P_i}{Z_i T_i}\right) \tag{8.26}$$

Where,

E	= gas formation volume factor (scf /rcft or Sm^3/m^3)
P	= pressure (psia or kPa)
P_{sc}	= pressure standard conditions (psia or kPa)
P_i	= initial reservoir pressure (psia or kPa)
V	= volume (ft^3 or m^3)
T	= absolute temperature (°R or K)
T_{sc}	= temperature at standard conditions (°R or K)
T_i	= initial reservoir temperature (°R or K)
R	= gas constant (10.73 or 8.314)

RTEMP on this keyword is the T_i in the above equations and P_i is PRESS columnar vector.

[99] *Standing, M. B.:"Volumetric and Phase Behaviour of Oil Field Hydrocarbon Systems", Renihold Publishing Corp., New York City (1952).*

Example

```
---
--       GAS PVT TABLE USING GAS Z-FACTOR
--
PVZG
--       RESERVOIR TEMPERATURE FOR Z TO BG CONVERSION
--
         180.0                                          /
--
--        PRES       ZG          VISC
--        PSIA     DIMLESS      CPOISE
--       ------    ---------    -------
           14.7    0.998970     0.0130
          250.0    0.976260     0.0131
          500.0    0.954790     0.0134
          750.0    0.932050     0.0137
         1000.0    0.912990     0.0142
         1250.0    0.896320     0.0147
         1500.0    0.881610     0.0152
         1750.0    0.870830     0.0159
         2000.0    0.863130     0.0166
         2250.0    0.858920     0.0173
         2500.0    0.857800     0.0181
         2750.0    0.860430     0.0189
         3000.0    0.866440     0.0197
         3250.0    0.874980     0.0206
         3500.0    0.885470     0.0214
         3750.0    0.898350     0.0223
         4000.0    1.025120     0.0277                    / TABLE NO 01
--
--       GAS PVT TABLE USING GAS Z-FACTOR
--
PVZG
--       RESERVOIR TEMPERATURE FOR Z TO BG CONVERSION
--
         180.0                                          /
--
--        PRES       ZG          VISC
--        PSIA     DIMLESS      CPOISE
--       ------    ---------    -------
           14.7    0.998970     0.0130
          250.0    0.976260     0.0131
          500.0    0.954790     0.0134
          750.0    0.932050     0.0137
         1000.0    0.912990     0.0142
         1250.0    0.896320     0.0147
         1500.0    0.881610     0.0152
         1750.0    0.870830     0.0159
         2000.0    0.863130     0.0166
         2250.0    0.858920     0.0173
         2500.0    0.857800     0.0181
         2750.0    0.860430     0.0189
         3000.0    0.866440     0.0197
         3250.0    0.874980     0.0206
         3500.0    0.885470     0.0214
         3750.0    0.898350     0.0223
         4000.0    1.025120     0.0277                    / TABLE NO 01
```

The above example defines two dry PVZG tables assuming NTPVT equals two and NPPVT is greater than or equal to 17 on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.214 PYEND – END THE DEFINITION OF A PYINPUT SECTION

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords. A PYINPUT Definition Section is terminated by a PYEND keyword on a separate single line.

See *PYEND – End the Definition of a PYINPUT Section* in the GRID section for a full description.

8.3.215 PYINPUT – DEFINE THE START OF A PYINPUT SECTION

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords used by the simulator. PYINPUT declares the start of a PYINPUT Definition Section on a single separate line, which is then followed by various standard Python commands, with one command per line.

See *PYINPUT – Define the Start of a PYINPUT Section* in the GRID section for a full description.

8.3.216 QHRATING – Define River Mass Flow versus Depth Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The QHRATING keyword defines a river's mass flow rate versus depth tables, for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.217 REFINE – Start the Definition of a Local Grid Refinement

The REFINE keyword defines the start of a Cartesian or radial local grid refinement ("LGR") definition that sets the properties of the selected LGR. The keyword is then followed by the property keywords associated with the section where the keyword is being invoked. For example, if the REFINE keyword is used in the GRID section then most of the keywords in that section can be used to set the grid properties for the LGR.

See *REFINE – Start the Definition of a Local Grid Refinement* in the GRID section for a full description.

8.3.218 RIVRXSEC – Define River Cross-Section versus Depth Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RIVRXSEC keyword defines a river's cross-sectional area and perimeter versus depth parameters. The River option must be activated via the RIVRDIMS keyword in the RUNSPEC section in order to use this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.219 RKTRMDIR - Activate ROCKTAB Keyword Directional Transmissibility Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the directional transmissibility multipliers for the ROCKTAB keyword. This results in two additional columns being inputted on the ROCKTAB keyword. This feature is currently not supported in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.220 ROCK - DEFINE THE ROCK COMPRESSIBILITY FOR VARIOUS REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ROCK defines the rock compressibility for various regions in the model. The number of ROCK vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the ROCK tables to different grid blocks in the model is done via the PVTNUM keyword in the REGION section. One data set consists of one record or line which is terminated by a "/".

This keyword must be defined in the OPM Flow input deck.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRES	PRES is a real number defining the rock reference pressure for the other parameters for this data set.			
		psia 1.032	barsa 1.032	atma 1.032	Default
2	RCOMP	RCOMP is a real number defining the rock compressibility (C_f) at the rock reference pressure and is defined as: $$C_f = -\frac{1}{V}\left(\frac{dV}{dP}\right)$$			
		1/psia 0.0	1/barsa 0.0	1/atma 0.0	Defined

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.100: ROCK Keyword Description

Examples

The following shows the ROCK keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to one.

```
--
--        ROCK COMPRESSIBILITY
--
--        REFERENCE PRESSURE IS TAKEN FROM THE HCPV WEIGHTED RESERVOIR PRESSURE
--        AS THE PORV IS ALREADY AT RESERVOIR CONDITIONS (OPM FLOW USES THE
--        REFERENCE PRESSURE) TO CONVERT THE GIVEN PORV TO RESERVOIR CONDITIONS
--        USING THE DATA ON THE ROCK KEYWORD)
--
--        REF PRES  CF
--        PSIA      1/PSIA
--        --------  --------
ROCK
          3966.9    5.0E-06                                / ROCK COMPRESSIBILITY
```

The next example shows the ROCK keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to three.

```
--
--       ROCK COMPRESSIBILITY
--
--       REFERENCE PRESSURE IS TAKEN FROM THE HCPV WEIGHTED RESERVOIR PRESSURE
--       AS THE PORV IS ALREADY AT RESERVOIR CONDITIONS (OPM FLOW USES THE
--       REFERENCE PRESSURE) TO CONVERT THE GIVEN PORV TO RESERVOIR CONDITIONS
--       USING THE DATA ON THE ROCK KEYWORD)
--
--       REF PRES  CF
--       PSIA      1/PSIA
--       --------  --------
ROCK
         3566.9    5.0E-06                        / ROCK COMPRSSIBILITY REGION 1
         3966.9    5.5E-06                        / ROCK COMPRSSIBILITY REGION 2
         4566.9    6.0E-06                        / ROCK COMPRSSIBILITY REGION 3
```

The above example defines three ROCK tables and assumes that NTPVT equals three on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.221 ROCK2D – PORE VOLUME COMPACTION VERSUS PRESSURE AND SW TABLES

Description

The ROCK2D keyword defines rock compressibility pore volume multipliers as a function of pressure and water saturation ("Sw") for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section. The pressure values are defined on this keyword and the water saturations are declared on the associated ROCKWNOD keyword in the PROPS section

The rock compaction pore volume and transmissibility multipliers, entered via the ROCKTAB, ROCK2D and ROCK2DTR keywords, are applied to the pore pressure, unless the OVERBURD keyword in PROPS section is included in the input deck. When the OVERBURD keyword is present the multipliers are applied to the effective pore volume pressure, that is $P_{(effective)} = P_{(Pressure)} - P_{(overburden)}$. If the keyword is not present in the input deck then the overburden pressure is set to zero.

This keyword should only be used if compaction option has been enabled.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	A columnar vector of real monotonically increasing down the column values that defines the corresponding overburden pressure for the subsequent MULT columnar vector.			
		psia	bars	atm	None
2	MULT	A columnar vector of real equal or decreasing down the column values that are less than or equal to one, that defines the rock compressibility pore volume multipliers corresponding to PRESS and for each water saturation entry in the ROCKWNOD keyword.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTROCC tables as declared on the ROCKCOMP keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.101: ROCK2D Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

See also the OVERBURD, ROCKTAB, ROCK2DTR, and ROCKWNOD keywords in the PROPS section.

Example

The following example defines two pore volume compaction tables, assuming NTROCC is equal to two on the ROCKCOMP keyword and NSSFUN is greater than or equal to four on the TABDIMS keyword.

```
--
--       ROCK COMPACTION VERSUS PRESSURE AND SW TABLES
--
ROCK2D
--       PRESS    PORV          FIRST ROCK2D TABLE DATA
--       PSIA     MULTIPLER
--       ------   ----------
            0.0      0.850
                     0.850
                     0.850
                     0.085                                / P-SW SET TABLE NO. 01
--       PRESS    PORV
--       PSIA     MULTIPLER
--       ------   ----------
         1000.0      0.900
                     0.900
                     0.900
                     0.900                                / P-SW SET TABLE NO. 01
--       PRESS    PORV
--       PSIA     MULTIPLER
--       ------   ----------
         2500.0      0.950
                     0.950
                     0.950
                     0.950                                / P-SW SET TABLE NO. 01
--       PRESS    PORV
--       PSIA     MULTIPLER
--       ------   ----------
         5000.0      1.000
                     1.000
                     1.000
                     1.000                                / P-SW SET TABLE NO. 01
--
--       PRESS    PORV          SECOND ROCK2D TABLE DATA
--       PSIA     MULTIPLER
--       ------   ----------
            0.0      0.800
                     0.800
                     0.800
                     0.800                                / P-SW SET TABLE NO. 02
--       PRESS    PORV
--       PSIA     MULTIPLER
--       ------   ----------
         1000.0      0.880
                     0.880
                     0.880
                     0.880                                / P-SW SET TABLE NO. 02
--       PRESS    PORV
--       PSIA     MULTIPLER
--       ------   ----------
         2500.0      0.950
                     0.950
                     0.950
                     0.950                                / P-SW SET TABLE NO. 02
--       PRESS    PORV
--       PSIA     MULTIPLER
--       ------   ----------
         5000.0      1.000
                     1.000
                     1.000
                     1.000                                / P-SW SET TABLE NO. 02
```

Note that there must be exactly NTROCC tables entered for this keyword, otherwise an error will occur.

8.3.222 ROCK2DTR – TRANSMISSIBILITY COMPACTION VERSUS PRESSURE AND SW TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCK2DTR keyword defines rock compressibility transmissibility multipliers as a function of pressure and water saturation ("Sw") for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section. The pressure values are defined on this keyword and the water saturations are declared on the associated ROCKWNOD keyword in the PROPS section

The rock compaction pore volume and transmissibility multipliers, entered via the ROCKTAB, ROCK2D and ROCK2DTR keywords, are applied to the pore pressure, unless the OVERBURD keyword in PROPS section is included in the input deck. When the OVERBURD keyword is present the multipliers are applied to the effective pore volume pressure, that is $P_{(effective)} = P_{(Pressure)} - P_{(overburden)}$. If the keyword is not present in the input deck then the overburden pressure is set to zero.

This keyword should only be used if compaction option has been enabled.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	A columnar vector of real monotonically increasing down the column values that defines the corresponding overburden pressure for the subsequent MULT columnar vector.			
		psia	bars	atm	None
2	MULT	A columnar vector of real equal or decreasing down the column values that are less than or equal to one, that defines the rock compressibility transmissibility multipliers corresponding to PRESS and for each water saturation entry in the ROCKWNOD keyword.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTROCC tables as declared on the ROCKCOMP keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.102: ROCK2DTR Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

See also the OVERBURD, ROCKTAB, ROCK2D, and ROCKWNOD keywords in the PROPS section.

Example

The following example defines two rock compressibility transmissibility compaction tables, assuming NTROCC is equal to two on the ROCKCOMP keyword and NSSFUN is greater than or equal to four on the TABDIMS keyword.

```
--
--       TRANSMISSIBILITY COMPACTION VERSUS PRESSURE AND SW TABLES
--
ROCK2DTR
--       PRESS    TRAN          FIRST ROCK2DTR TABLE DATA
--       PSIA     MULTIPLER
--       ------   ----------
            0.0      0.850
                     0.850
                     0.850
                     0.085                                / P-SW SET TABLE NO. 01
--       PRESS    TRAN
--       PSIA     MULTIPLER
--       ------   ----------
         1000.0      0.900
                     0.900
                     0.900
                     0.900                                / P-SW SET TABLE NO. 01
--       PRESS    TRAN
--       PSIA     MULTIPLER
--       ------   ----------
         2500.0      0.950
                     0.950
                     0.950
                     0.950                                / P-SW SET TABLE NO. 01
--       PRESS    TRAN
--       PSIA     MULTIPLER
--       ------   ----------
         5000.0      1.000
                     1.000
                     1.000
                     1.000                                / P-SW SET TABLE NO. 01
--
--       PRESS    TRAN          SECOND ROCK2DTR TABLE DATA
--       PSIA     MULTIPLER
--       ------   ----------
            0.0      0.800
                     0.800
                     0.800
                     0.800                                / P-SW SET TABLE NO. 02
--       PRESS    TRAN
--       PSIA     MULTIPLER
--       ------   ----------
         1000.0      0.880
                     0.880
                     0.880
                     0.880                                / P-SW SET TABLE NO. 02
--       PRESS    TRAN
--       PSIA     MULTIPLER
--       ------   ----------
         2500.0      0.950
                     0.950
                     0.950
                     0.950                                / P-SW SET TABLE NO. 02
--       PRESS    TRAN
--       PSIA     MULTIPLER
--       ------   ----------
         5000.0      1.000
                     1.000
                     1.000
                     1.000                                / P-SW SET TABLE NO. 02
```

Note that there must be exactly NTROCC tables entered for this keyword, otherwise an error will occur.

8.3.223 ROCKOPTS – DEFINE ROCK COMPACTION AND COMPRESSIBILITY OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCKOPTS keyword defines various option with respect to rock compaction and rock compressibility.

No.	Name	Description	Default
1	ROCKOPT1	ROCKOPT1 is a character string that defines the treatment of how the overburden pressures supplied by the OVERBURD keyword are applied to the tabulated pressures in the ROCKTAB keywords: 1) STRESS: Use this option if the overburden pressures on the OVERBURD keyword are greater than the fluid pressure which results in the effective fluid pressure being negative. To avoid the rock compaction tables being entered with negative pressure values use this option. In this case the pore volume and transmissibility multipliers will be tabulated against the effective overburden pressure. 2) PRESSURE: In this case the pore volume and transmissibility multipliers should be effective pressure. This the default value. ROCKOPT1 should be set to PRESSURE if the OVERBURD is not used in the input deck.	PRESSURE
2	ROCKOPT2	ROCKOPT2 is a character string that sets the reference pressure option: 1) STORE: Copies the initial calculated grid block pressures into the overburden pressure array, resulting in the pore volumes being referenced at the initial pressures instead of the reference pressures as per the ROCKTAB keyword. 2) NOSTORE: This option results in the pore volumes being referenced as per the ROCKTAB keyword. This is the default value. Note that STORE option should not be used with the OVERBURD keywords as the OVERBURD data will be overwritten.	NOSTORE
3	ROCKOPT3	ROCKOPT3 is a character string that defines which region array should be used to allocate the various ROCK and ROCKTAB tabless. ROCKOPT3, should be set to ROCKNUM, SATNUM or PVTNUM.	PVTNUM
4	ROCKOPT4	ROCKOPT4 is a character string that sets the initial conditions for the HYSTER and BOBERG options: 1) DEFLATION: This option defines the reservoir rock to be fully compacted and the deflation curve is used to calculated the initial pore volume and transmissibility multipliers. This is the default value. 2) ELASTIC: This option sets the pore volume and transmissibility multipliers to one, as the reservoir rock is set to lie on the elastic curve.	DEFLATION

Notes:

1) The keyword is terminated by "/".

Table 8.103: ROCKOPTS Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ROCKOPT1  ROCKOPT2   ROCKOPT3  ROCKOPT3
--       PRS/STRE  NO/STORE   ARRAY
--       --------  --------   --------  --------
ROCKOPTS
         PRESSURE  NOSTORE    PVTNUM    DEFLATION          / ROCK COMP OPTIONS
```

The above example defines the default values for the ROCKOPTS keyword.

8.3.224 ROCKPAMA – DEFINE COAL PALMER-MANSORRI ROCK MODEL PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ROCKPAMA defines the Palmer-Mansoori[100] and [101] parameters used for this rock model, for when the Coal Bed Methane option has been activated via the COAL keyword, and PALM-MAN has been declared for the ROCKOPT variable on the ROCKCOMP keyword; both keywords are in the RUNSPEC section. The Palmer-Mansoori rock model is used to calculate the impact on pore volume and permeability due to rock compaction.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[100] *Palmer, I. and Mansoori, J. "How Permeability Depends on Stress and Pore Pressure in Coalbeds: A New Model," paper SPE 52607, SPE Reservoir Evaluation & Engineering (1998) 1, No. 6, 539-544.*

[101] *Clarkson, C.R., Pan, Z., Palmer, I. and Harpalani, S. "Predicting Sorption-Induced Strain and Permeability Increase With Depletion for Coalbed-Methane Reservoirs", SPE 114778-PA, SPE Journal (2010) 15, No. 1, 152–159.*

8.3.225 ROCKTAB – ROCK COMPACTION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCKTAB keyword defines the rock compaction attributes to be applied for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section. ROCKTAB defines pore volume and transmissibility multipliers versus pressure that are used in the compaction calculations. If the RKTRMDIR has been activated in the PROPS section, then the transmissibility multiplier is directional dependent and two additional columns are used to define the y and z direction transmissibility multipliers.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	If the ROCKOPT1 variable has been set to PRESSURE on the ROCKOPTS keyword in the PROPS section, then PRESS should be a columnar vector of real monotonically increasing down the column values, that define the reference pressure for which the other parameters correspond to. If ROCKOPT1 has been set to STRESS, then PRESS should be a columnar vector of real monotonically decreasing down the column values.			
		psia	bars	atm	None
2	PORV	A columnar vector of real positive values that are either equal or increasing down the column that define the rock pore volume multiplier for a given PRESS.			
		dimensionless	dimensionless	dimensionless	None
3	TRANS	If the RKTRMDIR is absent from the input deck, then TRANS is a columnar vector of real positive values that are either equal or increasing down the column that define the x, y, and z directional transmissibility multipliers for the corresponding PRESS. If the RKTRMDIR is present in the input deck, then TRANS is a columnar vector of real positive values that are either equal or increasing down the column that define only the x directional transmissibility multipliers for the corresponding PRESS.			
		dimensionless	dimensionless	dimensionless	None
4	TRANSY	If the RKTRMDIR is absent from the input deck, then TRANSY is ignored. If the RKTRMDIR is present in the input deck, then TRANSY is a columnar vector of real positive values that are either equal or increasing down the column that define only the y directional transmissibility multipliers for the corresponding PRESS.			
		dimensionless	dimensionless	dimensionless	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
5	TRANSZ	If the RKTRMDIR is absent from the input deck, then TRANSZ is ignored. If the RKTRMDIR is present in the input deck, then TRANSZ is a columnar vector of real positive values that are either equal or increasing down the column that define only the z directional transmissibility multipliers for the corresponding PRESS.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTROCC tables as declared on the ROCKCOMP keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.104: ROCKTAB Keyword Description

Examples

The example below defines two rock compaction tables, assuming NTROCC is equal to two on the ROCKCOMP keyword and NPPVT is greater than or equal to five on the TABDIMS keyword and that the RKTRMDIR keyword is present in the input deck.

```
--
--        ROCK COMPACTION TABLES
--
ROCKTAB
--        PRESS     PORV      TX(YZ)    TY        TZ
--                  MULT      MULT      MULT      MULT
--        ------    ------    ------    ------    ------
          1000.0    0.9600    0.9650    0.9650    0.9650
          1500.0    0.9800    0.9850    0.9850    0.9500
          3000.0    0.9900    0.9950    0.9950    0.9950
          4500.0    1.0000    1.0000    1.0000    1.0000
          4750.0    1.0100    1.0100    1.0100    1.0100        / TABLE NO. 01
--        PRESS     PORV      TX(YZ)    TY        TZ
--                  MULT      MULT      MULT      MULT
--        ------    ------    ------    ------    ------
          1000.0    0.9600    0.9650    0.9650    0.9650
          1500.0    0.9800    0.9850    0.9850    0.9500
          3000.0    0.9900    0.9950    0.9950    0.9950
          4500.0    1.0000    1.0000    1.0000    1.0000
          4750.0    1.0100    1.0100    1.0100    1.0100        / TABLE NO. 02
```

As the x, y and z directional transmissibility multipliers are identical in the above example, we could eliminate the RKTRMDIR keyword from the input deck and enter the data in the three column format, as shown on the next page.

```
--
--       ROCK COMPACTION TABLES
--
ROCKTAB
--       PRESS    PORV     TX(YZ)
--                MULT     MULT
--       ------   ------   ------
         1000.0   0.9600   0.9650
         1500.0   0.9800   0.9850
         3000.0   0.9900   0.9950
         4500.0   1.0000   1.0000
         4750.0   1.0100   1.0100                        / TABLE NO. 01
--       PRESS    PORV     TX(YZ)
--                MULT     MULT
--       ------   ------   ------
         1000.0   0.9600   0.9650
         1500.0   0.9800   0.9850
         3000.0   0.9900   0.9950
         4500.0   1.0000   1.0000
         4750.0   1.0100   1.0100                        / TABLE NO. 02
```

The net result of the two examples in this case is identical.

8.3.226 ROCKTABH – ROCK COMPACTION HYSTERESIS TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCKTABH keyword defines the rock compaction hysteresis attributes to be applied for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section. ROCKTABH defines pore volume and transmissibility multipliers versus pressure that are used in the compaction calculations. If the RKTRMDIR has been activated in the PROPS section, then the transmissibility multiplier is directional dependent and two additional columns are used to define the y and z direction transmissibility multipliers. The keyword should only be used if the Rock Compaction Hysteresis option has been activated by either setting the ROCKOPT parameter on the ROCKCOMP keyword to HYSTER or BOBERG.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	If the ROCKOPT1 variable has been set to PRESSURE on the ROCKOPTS keyword in the PROPS section, then PRESS should be a columnar vector of real monotonically increasing down the column values, that define the reference pressure for which the other parameters correspond to. If ROCKOPT1 has been set to STRESS, then PRESS should be a columnar vector of real monotonically decreasing down the column values.			
		psia	bars	atm	None
2	PORV	A columnar vector of real positive values that are either equal or increasing down the column that define the rock pore volume multiplier for a given PRESS.			
		dimensionless	dimensionless	dimensionless	None
3	TRANS	If the RKTRMDIR is absent from the input deck, then TRANS is a columnar vector of real positive values that are either equal or increasing down the column that define the x, y, and z directional transmissibility multipliers for the corresponding PRESS. If the RKTRMDIR is present in the input deck, then TRANS is a columnar vector of real positive values that are either equal or increasing down the column that define only the x directional transmissibility multipliers for the corresponding PRESS.			
		dimensionless	dimensionless	dimensionless	None
4	TRANSY	If the RKTRMDIR is absent from the input deck, then TRANSY is ignored. If the RKTRMDIR is present in the input deck, then TRANSY is a columnar vector of real positive values that are either equal or increasing down the column that define only the y directional transmissibility multipliers for the corresponding PRESS.			
		dimensionless	dimensionless	dimensionless	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
5	TRANSZ	If the RKTRMDIR is absent from the input deck, then TRANSZ is ignored. If the RKTRMDIR is present in the input deck, then TRANSZ is a columnar vector of real positive values that are either equal or increasing down the column that define only the z directional transmissibility multipliers for the corresponding PRESS.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTROCC tables as declared on the ROCKCOMP keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.105: ROCKTABH Keyword Description

Each data set consists of columnar vectors of pore volume and transmissibility multipliers versus pressure that specify the elastic contraction and expansion and of the reservoir rock. The deflation curve is derived from the first data elements on each elastic curve. If the ROCKOPT parameter on the ROCKCOMP keyword has been set to HYSTER, then the dilation curves are extrapolated to infinite pressure, that is the curves are unbounded. However, if ROCKCOMP is set to BOBERG the last points of each elastic curve are used as the dilation curves.

Example

The example below defines two rock compaction tables, assuming NTROCC is equal to two on the ROCKCOMP keyword and NPPVT is greater than or equal to four on the TABDIMS keyword and that the RKTRMDIR keyword is not present in the input deck.

```
--
--        ROCK COMPACTION HYSTERESIS TABLES
--
ROCKTABH
--        PRESS     PORV      TX(YZ)    TY        TZ
--                  MULT      MULT      MULT      MULT
--        ------    ------    ------    ------    ------
          1500.0    0.9600    0.9800
          2500.0    0.9700    0.9850
          3500.0    0.9800    0.9900
          4500.0    0.9900    0.9950                          / NPPVT = 1
          2500.0    0.9900    0.9900
          3500.0    0.9950    0.9950
          4750.0    0.9980    0.9980                          / NPPVT = 2
          3500.0    1.0000    1.0000
          5500.0    1.0100    1.0100                          / NPPVT = 3
          4500.0    1.0100    1.0100
          5750.0    1.0200    1.0200                          / NPPVT = 4

                                                              / TABLE NO. 01
--        PRESS     PORV      TX(YZ)    TY        TZ
--                  MULT      MULT      MULT      MULT
--        ------    ------    ------    ------    ------
          1500.0    0.9400    0.9700
          2750.0    0.9400    0.9700                          / NPPVT = 1
          2250.0    0.9800    0.9900
          3250.0    0.9800    0.9900                          / NPPVT = 2
          3000.0    1.0000    1.0000
          4250.0    1.0000    1.0000                          / NPPVT = 3
          4550.0    1.0200    1.0100
          5750.0    1.0200    1.0100                          / NPPVT = 4
                                                              / TABLE NO. 02
```

Here the deflation curve is define for table number one is:

```
          1500.0    0.9600    0.9800
          2500.0    0.9900    0.9900
          3500.0    1.0000    1.0000
          4500.0    1.0100    1.0100
```

and for table number 2:

```
          1500.0    0.9400    0.9700
          2250.0    0.9800    0.9900
          3250.0    1.0000    1.0000
          4250.0    1.0200    1.0100
```

And the dilation curve is define for table number one is:

```
          4500.0    0.9900    0.9950
          4750.0    0.9980    0.9980
          5500.0    1.0100    1.0100
          5750.0    1.0200    1.0200
```

and for table number 2:

```
          2250.0    0.9400    0.9700
          3250.0    0.9800    0.9900
          4250.0    1.0000    1.0000
          5250.0    1.0200    1.0100
```

8.3.227 ROCKTABW – Rock Compaction Tables (Water Induced)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCKTABW keyword defines the rock compaction tables induced by increasing water saturation within a grid cell due to water invasion, for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section. ROCKTABW defines pore volume and transmissibility multipliers versus water saturation that are used in the compaction calculations. The keyword should be used together with the ROCK, ROCKTAB or ROCKTABH keywords that specify the pore volume and transmissibility multipliers as functions of pressure. Alternatively the ROCKWNOD, ROCK2D and ROCK2DTR keywords can be used to enter two dimensional tables of the data. All keywords are in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.228 ROCKTHSG – ROCK COMPACTION HYSTERESIS TABLES (DUAL POROSITY)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCKTHSG keyword defines the rock compaction hysteresis attributes to be applied for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section and the either the Dual Permeability or Dual Porosity models are activated by the DUALPERM and DUALPORO keywords in the RUNSPEC section. ROCKTHSG specifies sigma multipliers versus pressure that are used in the dual porosity rock compaction calculations. The keyword should only be used if the Rock Compaction Hysteresis option has been activated by either setting the ROCKOPT parameter on the ROCKCOMP keyword to one of the available options.

Each data set consists of columnar vectors of sigma multipliers versus pressure that specify the elastic contraction and expansion and of the reservoir rock. The deflation curve is derived from the first data elements on each elastic curve. If the ROCKOPT parameter on the ROCKCOMP keyword has been set to HYSTER, then the dilation curves are extrapolated to infinite pressure, that is the curves are unbounded. However, if ROCKCOMP is set to BOBERG the last points of each elastic curve are used as the dilation curves.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

8.3.229 ROCKTSIG – ROCK COMPACTION TABLES (DUAL POROSITY)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCKTSIG keyword defines the rock compaction attributes to be applied for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section, and the either the Dual Permeability or Dual Porosity models are activated by the DUALPERM and DUALPORO keywords in the RUNSPEC section. ROCKTSIG specifies sigma multipliers versus pressure that are used in the dual porosity rock compaction calculations. The keyword should only be used if the Rock Compaction Hysteresis option has been activated by either setting the ROCKOPT parameter on the ROCKCOMP keyword to one of the available options.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.230 ROCKWNODE – WATER SATURATION VALUES FOR COMPACTION PRESSURE-SW TABLES

Description

The ROCK2D and the ROCK2DTR keywords in the PROPS section define rock compressibility pore volume and transmissibility multipliers as a function of pressure and water saturation ("Sw"), for when the rock compaction option has been invoked by the ROCKCOMP keyword in the RUNSPEC section. The pressure values are defined on ROCK2D and the ROCK2DTR keywords together with the multipliers. This keyword ROCKWNODE, defines the water saturations that are used in conjunction with the ROCK2D and the ROCK2DTR keywords.

This keyword should only be used if compaction option has been enabled.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWAT	A columnar vector of real monotonically increasing down the column values that defines the water saturations to be associated with the data on the ROCK2D and the ROCKTR keywords.			
		psia	bars	atm	None

Notes:

1) The keyword is followed by NTROCC tables as declared on the ROCKCOMP keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.106: ROCKWNOD Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

See also the OVERBURD, ROCKTAB, ROCK2D and ROCK2DTR keywords in the PROPS section.

Example

The following example defines two ROCKWNODE tables for the pore volume and transmissibility compaction tables, assuming NTROCC is equal to two on the ROCKCOMP keyword and NSSFUN is greater than or equal to four on the TABDIMS keyword.

```
--
--       WATER SATURATION VALUES FOR COMPACTION PRESSURE-SW TABLES
--
ROCKWNOD
--       COMPACT
--       SWAT
--       ------
          0.000
          0.200
          0.400
          1.000                                          / P-SW SET TABLE NO. 01
--       COMPACT
--       SWAT
--       ------
          0.000
          0.250
          0.750
          1.000                                          / P-SW SET TABLE NO. 02
```

Note that there must be exactly NTROCC tables entered for this keyword, otherwise an error will occur.

8.3.231 RPTPROPS – DEFINE PROPS SECTION REPORTING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data in the PROPS section that is to be printed to the output print file in human readable format. The keyword has two distinct forms, the first of which consists of the keyword followed by a series of integers on the next line indicating the data to be printed (see the first example). This is the original formal in the commercial simulator and was subsequently superseded by the second format. The second format consists of the keyword followed by a series of character strings that indicate the data to be printed. In most cases the character string is the keyword used to load the data in the OPM Flow input deck, for example PVDG for the dry gas PVT tables. Its is anticipated that OPM Flow will eventually support the functionality of the second format only, the first format although recognized will be completely ignored.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	PVTDG	Print dry gas PVT tables	N/A
2	PVTG	Print wet gas PVT tables	N/A
3	SGFN	Print gas relative permeability saturation function tables.	N/A
4	SGL	Print connate gas saturation array.	N/A
….		….	N/A

Notes:

1) The keyword is terminated by "/".

Table 8.107: RPTPROPS Keyword Description

Note

Except for tabular like data, PVTDG etc., this keyword has the potential to produce very large print files that some text editors may have difficulty loading. A more efficient solution for array type data is to load the *.INIT file into OPM ResInsight to view the data graphically, this also has the benefit of being able to filter the grid based on I, J, K ranges and grid properties.

Examples

The first example shows the original format of this keyword; although the keyword and format are recognized by OPM Flow, the format is ignored and is unlikely to be implemented in in the simulator.

```
--
--        DEFINE PROPS SECTION REPORT OPTION (ORIGINAL FORMAT)
-
RPTPROPS
          1        2*0      1        3*1                                        /
```

The next example shows the second format of the keyword which may be supported in a future release of OPM Flow.

```
--
--        DEFINE PROPS SECTION REPORT OPTIONS
--
RPTPROPS
          PVDO     SOF2     SGFN     SWFN                                       /
```

8.3.232 RSCONST – DEFINE CONSTANT GOR (RS) FOR ALL DEAD OIL PVT FLUIDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RSCONST defines a constant Gas-Oil Ratio ("GOR"), for all dead oil[102] PVT fluids. If the oil has a constant and uniform dissolved gas concentration, GOR, and if the reservoir pressure never drops below the saturation pressure (bubble point pressure), then the model can be run more efficiently by omitting the GAS and DISGAS keywords from the RUNSPEC section, treating the oil as a dead oil, and defining a constant Rs (GOR) value with keywords RSCONST or RSCONSTT in the PROPS section. This results in the model being run as a dead oil problem with no active gas phase. However, OPM Flow takes into account the constant Rs in the calculations and reporting.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	RS	A real positive value that defines the dead oil GOR for all oil PVT tables in the model			
		Mscf/stb	sm^3/sm^3	scc/scc	None
2	PRESS	A real positive value that defines that saturation pressure (bubble point pressure) for all the oil PVT tables in the model.			
		psia	barsa	atma	None

Notes:

1) The keyword is terminated by "/".

Table 8.108: RSCONST Keyword Description

See also the RSCONSTT keyword to define a different constant Rs to the various dead oil PVT tables and the PVDO and PVCDO keywords to enter the dead oil properties. All of the aforementioned keywords are in the PROPS section.

Example

The example sets the dead oil GOR to 5 scf/stb and the bubble point pressure to 14.7 psia.

```
--
--        DEAD OIL PVT CONSTANT GOR AND SATURATION PRESSURE
--
RSCONST
--        RS        PSAT
--        MSCF/STB  PSIA
--        --------  ------
           0.0050    14.7                                  /
```

[102] *"Dead" oil is oil that it contains no dissolved gas or a relatively thick oil or residue that has lost its volatile components.*

8.3.233 RSCONSTT – DEFINE CONSTANT GOR (RS) FOR EACH DEAD OIL PVT FLUID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RSCONSTT defines a constant Gas-Oil Ratio ("GOR"), for each dead oil[103] PVT fluid in the model. If the oil has a constant and uniform dissolved gas concentration, GOR, and if the reservoir pressure never drops below the saturation pressure (bubble point pressure), then the model can be run more efficiently by omitting the GAS and DISGAS keywords from the RUNSPEC section, treating the oil as a dead oil, and defining a constant Rs (GOR) value with keywords RSCONST or RSCONSTT in the PROPS section. This results in the model being run as a dead oil problem with no active gas phase. However, OPM Flow takes into account the constant Rs in the calculations and reporting.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	RS	A real positive columnar vector that defines the dead oil GOR for each oil PVT table in the model			None
		Mscf/stb	sm^3/sm^3	scc/scc	
2	PRESS	A real positive columnar vector that defines the saturation pressure (bubble point pressure) for each the oil PVT table in the model.			None
		psia	barsa	atma	

Notes:

1) The keyword is followed by NTPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each row must contain two values representing the RS and PRESS variables.
3) Each row is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.109: RSCONSTT Keyword Description

See also the RSCONST keyword to define a constant Rs to all the various dead oil PVT tables and the PVDO and PVCDO keywords to enter the dead oil properties. All of the aforementioned keywords are in the PROPS section.

Example

The example sets the dead oil GOR to 5, 6.5 and 8.0 scf/stb for PVT tables one, two and three, respectively and the bubble point pressure to 14.7 psia for all three tables.

```
--
--        DEAD OIL PVT CONSTANT GOR AND SATURATION PRESSURE
--
RSCONSTT
--        RS         PSAT
--        MSCF/STB   PSIA
--        --------   ------
           0.0050     14.7                                  / TABLE NO. 01
           0.0065     14.7                                  / TABLE NO. 02
           0.0080     14.7                                  / TABLE NO. 03
```

[103] "Dead" oil is oil that it contains no dissolved gas or a relatively thick oil or residue that has lost its volatile components.

8.3.234 RSGI – DEFINE GAS-OIL RATIO VERSUS PRESSURE AND GI TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RSGI keyword specifies the saturated oil Gas-Oil Ratio ("GOR") factors used to specify the variation of the maximum possible GOR of oil with respect to pressure and Gi values, for when the GIMODEL keyword in the RUNSPEC section has been used to activate the GI Pseudo Compositional option for the run. See also the GINODE, RSGI, RVGI, BGGI and BOGI keywords in the PROPS section to describe the fluid properties for the GI Pseudo Compositional option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.235 RTEMP - DEFINE THE INITIAL RESERVOIR TEMPERATURE FOR THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the reservoir temperature for when OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. The RTEMPA keyword is alias for RTEMP; however the former is ignored by OPM Flow.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	RTEMP	Single real positive value that defines the reservoir temperature for the model.			
		°F	°C	°C	None

Notes:

2) The keyword is terminated by "/".

Table 8.110: RTEMP Keyword Description

See also the RTEMPVD keyword in SOLUTION section to define the reservoir temperature as a function of depth.

Example

```
--
--        RESERVOIR
--        TEMPERATURE
--        -----------
RTEMP
          190.0                                          / RESERVOIR TEMPERATURE
```

The above example defines the reservoir temperature to be 190 °F.

8.3.236 RTEMPA - DEFINE THE INITIAL RESERVOIR TEMPERATURE FOR THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the reservoir temperature for when temperature or thermal options has been activated by the either the TEMP or THERMAL keywords in the RUNSPEC section in the commercial simulator.

The RTEMP keyword is alias for RTEMPA; however the latter is ignored by OPM Flow.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	RTEMPA	Single real positive value that define the reservoir temperature for the model.			
		°F	°C	°C	None

Notes:

1) The keyword is terminated by "/".

Table 8.111: RTEMPA Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness. Use the RTEMP keyword instead to set the reservoir temperature.

Example

```
--
--        RESERVOIR
--        TEMPERATURE
--        -----------
RTEMPA
          190.0                                          / RESERVOIR TEMPERATURE
```

The above example defines the reservoir temperature to be 190 °F.

8.3.237 RVCONST – DEFINE CONSTANT CGR (RV) FOR ALL DRY GAS PVT FLUIDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RVCONST defines a constant Condensate-Gas Ratio ("CGR" or Rv), for all dry gas[104] PVT fluids. If the gas has a constant and uniform dissolved condensate concentration, and if the reservoir pressure never drops below the saturation pressure (dew point pressure), then the model can be run more efficiently by omitting the OIL and VAPGAS keywords from the RUNSPEC section, treating the gas as a dry gas, and defining a constant Rv (CGR) value with keywords RVCONST or RVCONSTT in the PROPS section. This results in the model being run as a dry gas problem with no active oil phase. However, OPM Flow takes into account the constant Rv in the calculations and reporting.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	RV	A real positive value that defines the dry gas CGR for all dry gas PVT tables in the model			
		stb/Mscf	sm^3/sm^3	scc/scc	None
2	PRESS	A real positive value that defines that saturation pressure (dew point pressure) for all the dry gas PVT tables in the model.			
		psia	barsa	atma	0.0

Notes:

1) The keyword is terminated by "/".

Table 8.112: RVCONST Keyword Description

See also the RVCONSTT keyword to define a different constant Rv to the various dry gas PVT tables and the PVDG keyword to enter the dry gas properties. All of the aforementioned keywords are in the PROPS section.

Example

The example sets the dry gas CGR to 5 stb/MMscf and the bubble point pressure to 14.7 psia.

```
--
--        DRY GAS PVT CONSTANT GCR AND SATURATION PRESSURE
--
RVCONST
--        RV        PSAT
--        STB/MSCF  PSIA
--        --------  ------
           0.0050    14.7                                  /
```

[104] *Natural gas that occurs in the absence of condensate or liquid hydrocarbons, or gas that had condensable hydrocarbons removed, is called dry gas. It is primarily methane with some intermediates. The hydrocarbon mixture is solely gas in the reservoir and there is no liquid (condensate surface liquid) formed either in the reservoir or at surface. The term dry indicates that the gas does not contain heavier hydrocarbons to form liquids at the surface conditions. Dry gas typically has GOR's greater than 100,000 scf/stb or 18,000 Sm3/m3.*

8.3.238 RVCONSTT – DEFINE CONSTANT CGR (RV) FOR EACH DRY GAS PVT FLUID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RVCONSTT defines a constant Condensate-Gas Ratio ("CGR" or Rv), for each dry gas[105] PVT fluid. If the gas has a constant and uniform dissolved condensate concentration, and if the reservoir pressure never drops below the saturation pressure (dew point pressure), then the model can be run more efficiently by omitting the OIL and VAPGAS keywords from the RUNSPEC section, treating the gas as a dry gas, and defining a constant Rv (CGR) value with keywords RVCONST or RVCONSTT in the PROPS section. This results in the model being run as a dry gas problem with no active oil phase. However, OPM Flow takes into account the constant Rv in the calculations and reporting.

This keyword is ignored by OPM Flow but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	RS	A real positive value that defines the dry gas CGR for each dry gas PVT table in the model			
		stb/Mscf	sm^3/sm^3	scc/scc	None
2	PRESS	A real positive value that defines that saturation pressure (dew point pressure) for each dry gas PVT table in the model.			
		psia	barsa	atma	0.0

Notes:

1) The keyword is followed by NTPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each row must contain two values representing the RV and PRESS variables.
3) Each row is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.113: RVCONSTT Keyword Description

See also the RVCONST keyword to define a constant Rv to all the various dry gas PVT tables and the PVDG keyword to enter the dry gas properties. All of the aforementioned keywords are in the PROPS section.

Example

The example sets the dry gas CGR to 5, 6.5 and 8.0 stb/MMscf for PVT tables one, two and three, respectively and the bubble point pressure to 14.7 psia for all three tables.

```
--
--       DRY GAS PVT CONSTANT GCR AND SATURATION PRESSURE
--
RVCONSTT
--       RV        PSAT
--       STB/MSCF  PSIA
--       --------  ------
          0.0050     14.7                                  / TABLE NO. 01
          0.0065     14.7                                  / TABLE NO. 02
          0.0080     14.7                                  / TABLE NO. 03
```

[105] *Natural gas that occurs in the absence of condensate or liquid hydrocarbons, or gas that had condensable hydrocarbons removed, is called dry gas. It is primarily methane with some intermediates. The hydrocarbon mixture is solely gas in the reservoir and there is no liquid (condensate surface liquid) formed either in the reservoir or at surface. The term dry indicates that the gas does not contain heavier hydrocarbons to form liquids at the surface conditions. Dry gas typically has GOR's greater than 100,000 scf/stb or 18,000 Sm3/m3.*

8.3.239 RVGI – DEFINE CONDENSATE-GAS RATIO VERSUS PRESSURE AND GI TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RVGI keyword specifies the saturated gas Condensate-Gas Ratio ("CGR") factors used to specify the variation of the maximum possible CGR of gas with respect to pressure and Gi values, for when the GIMODEL keyword in the RUNSPEC section has been used to activate the GI Pseudo Compositional option for the run. See also the GINODE, RSGI, RVGI, BGGI and BOGI keywords in the PROPS section to describe the fluid properties for the GI Pseudo Compositional option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.240 RWGSALT – WATER VAPORIZATION VERSUS PRESSURE AND SALT CONCENTRATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RWGSALT defines the relationship of water vaporization versus pressure and salt concentration. This keyword should be used when the VAPWAT keyword has be declared in the RUNSPEC section indicating that vaporized water is present in the gas phase. In addition, if the Salt Precipitation model has been activated via the BRINE and PRECSALT keywords, also in the RUNSPEC section, then this keyword must be present. The keyword may be used for gas-water and oil-water-gas input decks that contain the either dry or wet gas and vaporized water phases.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note

This is an OPM Flow specific keyword for the simulator's Water Vaporization and Salt Precipitation Models, note that these are extensions to the simulator's standard Brine model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	A real monotonically increasing down the column values that define the gas phase pressure, that together with salt concentration, defines the vaporized water in gas ratio ("VWGR") or Rw			
		psia	barsa	atma	None
2	SALTCONC	A real monotonically increasing positive columnar vector defining the salt concentration in water.			
		lb/stb	kg/sm^3	gm/scc	None
3	RW	A columnar vector of real positive number values defining the vaporized water in gas ratio (Rw) that for a given PRESS and SALTCON.			
		stb/Mscf	sm^3/sm^3	rcc/scc	None

Notes:

1) Each table is terminated by "/" including the last table; however, there is no "/" terminator for the keyword.

Table 8.114: RWGSALT Keyword Description

Since the water component is in both the water and the gas phases, RWGSALT controls the amount of water component evaporated from the water phase into the gas phase, which is a function of both the water phase salinity and a grid cells pressure. The keyword should be used in conjunction with the dry gas PVTGW keyword or the wet gas PVTGWO keyword, both of which are in the PROPS section.

Example

The example defines two RWGSALT tables assuming NTPVT equals two and NPPVT is greater than or equal to eight on the TABDIMS keyword in the RUNSPEC section.

```
--
--       WATER VAPORIZATION TABLE FOR BRINE  (OPM FLOW KEYWORD)
--
RWGSALT
--       PRES     SALTCONC    RW
--       PSIA     LB/STB      STB/MSCF
--       ------  ----------   ---------
          300     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
          600     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
          900     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         1200     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         1500     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         1800     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         2100     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         2400     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
                                                          / Table NO. 1
--       PRES     SALTCONC    RW
--       PSIA     LB/STB      STB/MSCF
--       ------  ----------   ---------
         300      0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         600      0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         900      0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         1200     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         1500     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         1800     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         2100     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
         2400     0           0.000132
                  0.5         0.000132
                  1           0.000132                    /
                                                          / Table NO. 2
```

8.3.241 SALTNODE – SALT CONCENTRATION BASED PVTNUM ARRAY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SALTNODE defines the salt concentration value based on a cells PVTNUM number. The SALTNODE property is used in the calculation of a polymer viscosity when the polymer and the salt options has been activated by the POLYMER and BRINE keywords in the RUNSPEC section. In the RUNSPEC section the number of PVTNUM functions is declared by NTPVT variable on the TABDIMS keyword and allocated to individual cells by the PVTNUM property array in the REGIONS section. NPPVT on the TABDIMS keyword in the RUNSPEC section defines the maximum number of rows (or pressure values) in the PVT tables and also sets the maximum number of entries for each SALNODE data set. The number of values for each data set must correspond to the number of polymer solution adsorption entries on the PLYADSS keyword. For example if there are three sets of PVT tables and four values on the PLYADSS keyword, then three SALTNODE data sets with four values of salt concentrations need to be entered.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SALTNODE	A real monotonically increasing positive columnar vector defining the salt concentration for a given PVTNUM table.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) Each table is terminated by "/" including the last table; however, there is no "/" terminator for the keyword.

Table 8.115: SALTNODE Keyword Description

An alternative manner of entering the salt concentrations is by utilizing the PVTNUM region array by using the ADSALNOD keyword in the PROPS section.

Example

Given three sets of relative permeability tables and four values on the PLYADSS keyword and two SALNODE data sets with four values of salt concentrations then the data should be entered as follows:

```
--
--    SETS SALT CONCENTRATION FOR POLYMER SOLUTION ADSORPTION
--    VIA PVTNUM ARRAY ALLOCATION
--
--    SALT
--
SALTNODE
      1.0
      5.0
      10.5
      25.0      / PVTNUM TABLE NO. 01
      1.0
      3.0
      7.5
      15.0      / PVTNUM TABLE NO. 02
```

See also the ADSALNOD keyword.

8.3.242 SALTSOL – DEFINE THE SALT SOLUBILITY LIMIT FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SALTSOL defines a grid blocks maximum salt solubility for all cells. The keyword should only be used with OPM Flow's Salt Precipitation model which is activated via the PRECSALT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note

This is an OPM Flow specific keyword for the simulator's Salt Precipitation model that is activated by the PRECSALT keyword and declaring that vaporized water is present in the run via the VAPWAT in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SALTSOL	A real positive value that defines the maximum salt solubility for all grid blocks.			None
		lb/stb	kg/sm^3	gm/scc	

Notes:

1) The keyword is terminated by "/".

Table 8.116: SALTSOL Keyword Description

See also the PRECSALT and VAPWAT keywords in the RUNSPEC section and the PVTGW and PVTGWO keywords in the PROPS section.

Example

The example set the maximum salt solubility for all cells in the model to 134.6 lb/stb.

```
--
--        SET SALT SOLUBILITY LIMIT FOR ALL CELLS (OPM FLOW KEYWORD)
--
SALTNODE
          134.6                                                  /
```

The 134.6 lb/stb, (380 kg/sm^3 or 0.384 gm/scc for metric and laboratory units, respectively) is based on the solubility of NACL at 212 °F (100 °C) and should be used with care.

8.3.243 SCALECRS – DEFINE END-POINT SCALING OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SCALECRS keyword sets the end-point scaling option to be either two-point or three-point scaling, for when the End-Point Scaling option has been invoked by the ENDSCALE keyword in the RUNSPEC section. This determines which end-points on the relative permeability curves are used for scaling based on the supplied end-point arrays (SGCR, SWCR, etc.).

No.	Name	Description	Default
1	SCALEOPT	SCALEOPT is a character string that sets the end-point scaling option and should be set to either NO or YES: 1) NO: Activates two-point end-point scaling. 2) YES: Activates three-point end-point	NO
Notes: 1) The keyword is terminated by "/".			

Table 8.117: SCALECRS Keyword Description

The end-point scaled for each option and the arrays used in the end-point scaling are summarized in the following table:

Option	Phases	Relative Permeability End-Point	Minimum Saturation End-Point	Middle Saturation End-Point	Maximum Saturation End-Point
Two-Point	Water	KRW	SWCR		SWU
	Oil	KRG	SGCR		SGU
	Oil-Water	KRORW	SOWCR		(1.0 – SWL - SGL)
	Oil-Gas	KRORG	SOGCR		(1.0 – SWL - SGL)
Three-Point	Water	KRW	SWCR	(1.0 – SOWCR - SGL)	SWU
	Oil	KRG	SGCR	(1.0 - SOGCR-SWL)	SGU
	Oil-Water	KRORW	SOWCR	(1.0 – SWCR - SGL)	(1.0 – SWL - SGL)
	Oil-Gas	KRORG	SOGCR	(1.0 – SGCR - SGL)	(1.0 – SWL - SGL)
	Two Phase Gas-Water Simulations				
	Water	KRW	SWCR	(1.0 - SGCR)	SWU
	Gas	KRG	SGCR	(1.0 -SWCR)	SGU

Table 8.118: End-Point Arrays Used in the End-Point Scaling Options

See also the TZONE keyword in the PROPS section that sets the transition zone end-point scaling options for the oil, gas and water phases.

Example

```
--
--       TWO-POINT END-POINT SCALING IS NO THREE POINT IS YES
--
--       SCALEOPT
--       ---------
SCALECRS
         YES                                                / SCALING OPTION
```

The above example activates three-point end-point scaling of the relative permeability curves.

8.3.244 SCALELIM – End-Point Scaling versus Depth Maximum Water Saturation

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the maximum water saturation allowed in a cell for when the end-point versus depth tables are used in the End-Point Scaling option to calculate the water saturation for a grid block. The End-Point Scaling option must be invoked by the ENDSCALE keyword in the RUNSPEC section to use this keyword, and the keyword may only be used in two phase runs containing water, or if the Miscible Flood option has been activated by the MISCIBLE keyword in the RUNSPEC section. This keyword functionality is not supported in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.245 SDENSITY – DEFINE THE MISCIBLE OR SOLVENT SURFACE GAS DENSITY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SDENSITY keyword defines density at surface conditions of either the miscible injection gas for when the MISCIBLE option has been invoked in the RUNSPEC section, or the solvent for when the SOLVENT option has been invoked in the RUNSPEC section. This keyword must be invoked if either the MISCIBLE or SOLVENT options have been activated in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SDENSITY	SDENSITY is a real positive number defining the density at surface conditions of either: 1) the miscible injection gas for when the MISCIBLE option has been invoked in the RUNSPEC section, or, 2) the solvent for when the SOLVENT option has been invoked in the RUNSPEC section.			
		lb/ft^3	kg/m^3	gm/cc	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.119: SDENSITY Keyword Description

In addition to this keyword, the surface density or gravity of the in-place natural gas must be entered using either the DENSITY or GRAVITY keywords.

Examples

The following shows the SDENSITY keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to one.

```
--
--        MIS-SOL
--        DENSITY
--        -------
SDENSITY
          0.04520                                        / MIS-SOL DENSITY
```

The next example shows the SDENSITY keyword for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to three.

```
--
--        MIS-SOL
--        DENSITY
--        -------
SDENSITY
          0.04520                                        / MIS-SOL DENSITY 1
          0.05520                                        / MIS-SOL DENSITY 2
          0.06420                                        / MIS-SOL DENSITY 3
```

There is no terminating "/" for this keyword.

8.3.246 SGCR – END-POINT SCALING GRID CELL CRITICAL GAS SATURATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SGCR defines the critical gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The critical gas saturation is defined as the maximum gas saturation for which the gas relative permeability is zero in a two-phase relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGCR	SGCR is an array of real numbers assigning the critical gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.03			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the critical gas saturation used with the end-point scaling option. If directional end-point scaling has been activated then the SGCRX± , SGCRX± and SGCRX± series of keyword should be used.
2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
3) The keyword is terminated by "/".

Table 8.120: SGCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SGCRX, SGCRY and SGCRZ instead of SGCR. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SGCRX, SGCRX-, SGCRY, SGCRY-, SGCRZ and SGCRZ-, instead of the SGCR keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SGCR DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SGCR
          300*0.050                                                    /
```

The above example defines a constant critical gas saturation of 0.05 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.247 SGCWMIS – MISCIBLE CRITICAL GAS VERSUS WATER SATURATION FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SGCWMIS defines the dependency between the miscible critical gas saturation and the water saturation, for when the MISCIBLE keyword in the RUNSPEC section has been activated. The keyword can only be used with the MISCIBLE option and for when the oil, water and gas phases are active in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWAT	A columnar vector of real monotonically increasing down the column values starting from zero and terminating atone, that defines the water saturation.			
		dimensionless	dimensionless	dimensionless	None
2	SGCMIS	A columnar vector of real equal or increasing down the column values that are greater than or equal to zero and less than one, that define the corresponding miscible gas critical gas saturation for the corresponding water saturation SWAT.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTMISC tables as declared on the MISCIBLE keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSMISC rows as declared on the MISCIBLE keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.121: SGCWMIS Keyword Description

Example

```
--
--        MISCIBLE CRITICAL GAS VERSUS WATER SATURATION TABLE
--
SGCWMIS
--        SWAT       SGCRMIS
--        FRAC       FRAC
--        -------    --------
           0.0000     0.0000
           0.2000     0.0300
           1.0000     0.0300                                  / TABLE NO. 01
--        SWAT       SGCRMIS
--        FRAC       FRAC
--        -------    --------
           0.0000     0.0000
           0.3000     0.0500
           1.0000     0.0500                                  / TABLE NO. 02
```

The above example defines two miscible critical gas saturation versus water saturation tables assuming NTMISC equals two and NSMISC is greater than or equal to three on the MISCIBLE keyword in the RUNSPEC section.

8.3.248 SGF32D – Gas Saturation Tables versus Oil and Water Saturations

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SGF32D keyword defines the gas relative permeability as a function of both oil and water saturations. This keyword should only be used if the gas is present in the run.

This keyword is ignored by OPM Flow and has no effect on the simulation

See also the SWOF, SGOF, SLGOF series of keywords and the SWFN, SGFN, SGWFN, SOF2, SOF3, SOF32D series of keywords to enter relative permeability data.

8.3.249 SGFN – GAS SATURATION TABLES (FORMAT TYPE 2)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SGFN keyword defines the gas relative permeability and oil-gas capillary pressure data versus gas saturation tables for when gas is present in the input deck. This keyword should only be used if the gas is present in the run.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGAS	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the gas saturation.			
		dimensionless	dimensionless	dimensionless	None
2	KRG	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the gas relative permeability.			
		dimensionless	dimensionless	dimensionless	None
3	PCOG	A columnar vector of real values that are either equal or increasing down the column that defines the oil-gas relative capillary pressure.			
		psia	bars	atm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.122: SGFN Keyword Description

Example

```
--
--       GAS RELATIVE PERMEABILITY TABLES (SGFN)
--
SGFN
--       SGAS       KRG        PCGO
--       FRAC                  PSIA
--       --------  --------   -------
             0.00    0.0000       1*
             0.20    0.0002       1*
             0.85    0.4450       1*                        / TABLE NO. 01
--       --------  --------   -------
             0.00    0.0000       1*
             0.20    0.0002       1*
--       --------  --------   -------
             0.60    0.1412       1*
             0.70    0.2412       1*
             0.85    0.4450       1*                        / TABLE NO. 02
```

The example defines two SGFN tables for when gas is present in the input deck.

8.3.250 SGL – END-POINT SCALING GRID CELL CONNATE GAS SATURATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SGL defines the connate gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The connate gas saturation is defined as the minimum gas saturation in a two-phase gas relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGL	SGL is an array of real numbers assigning the connate gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.03			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the connate gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the SGLX± , SGLY± and SGZ± series of keyword should be used.
2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
3) The keyword is terminated by "/".

Table 8.123: SGL Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SGLX, SGLY and SGLZ instead of SGL. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SGLX, SGLX-, SGLY, SGLY-, SGLZ and SGLZ-, instead of the SGL keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SGL DATA FOR ALL CELLS
–        (FOR NX x NY x NZ = 300)
--
SGL
          300*0.030                                                    /
```

The above example defines a constant connate gas saturation of 0.03 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.251 SGLPC – END-POINT SCALING GRID CELL CAPILLARY PRESSURE CONNATE GAS SATURATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SGLPC defines the connate gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The connate gas saturation is defined as the minimum gas saturation in a two-phase gas relative permeability table. The keyword only applies the scaling to the drainage capillary pressures tables, unlike the SGL keyword that applies the scaling to both the capillary pressure and relative permeability tables. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGLPC	SGLPC is an array of real numbers assigning the connate gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. If SGLPC is omitted from the input deck the values will be defaulted to those on the SGL series of keywords. If the SGL series of keywords are missing from the input deck then the values are taken from the cell allocated capillary pressure table. Repeat counts may be used, for example 30*0.03			Taken from SGL or from the cell allocated capillary pressure table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the connate gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the SGLX± , SGLY± and SGZ± series of keyword should be used.

2) The keyword is terminated by "/".

Table 8.124: SGLPC Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SGLX, SGLY and SGLZ instead of SGL or SGLPC. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SGLX, SGLX-, SGLY, SGLY-, SGLZ and SGLZ-, instead of the SGL or SGLPC keywords.

Missing Some Functionality - Use with Caution.

Example

```
--
--       DEFINE GRID BLOCK END-POINT SGLPC DATA FOR ALL CELLS
--       (FOR NX x NY x NZ = 300)
--
SGLPC
         300*0.030                                                    /
```

The above example defines a constant connate gas saturation of 0.03 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.252 SGOF – GAS-OIL SATURATION TABLES VERSUS GAS (FORMAT TYPE 1)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SGOF keyword defines the oil and gas relative permeability and oil-gas capillary versus gas saturation tables for when oil and gas are present in the input deck. This keyword should only be used if the gas is present in the run.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGAS	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the gas saturation.			
		dimensionless	dimensionless	dimensionless	None
2	KRG	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the gas relative permeability.			
		dimensionless	dimensionless	dimensionless	None
3	KRO	A columnar vector of real values that are either equal or decreasing down the column and that are greater than or equal to zero and less than or equal to one that defines the oil relative permeability with respect to gas and connate water saturation. When water is active in the run, the first entry the column, that is at krog(Sg = 0), must be the same as the first entry in the corresponding SWOF table, that is at krow(So = 1 - Swco). The last value in the column should be zero.			
		dimensionless	dimensionless	dimensionless	None
4	PCOG	A columnar vector of real values that are either equal or increasing down the column that defines the oil-gas relative capillary pressure.			
		psia	bars	atm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.125: SGOF Keyword Description

Example

```
--
--        GAS-OIL RELATIVE PERMEABILITY TABLES (SGOF)
SGOF
--        SG          KRG       KROG      PCOG
--        FRAC                            PSIA
--        -------   --------  -------   -------
          0.00000   0.000000  0.90000    0.0000
          0.03000   0.000000  0.82500    0.0000
          0.80000   0.900000  0.00000    0.0000              / TABLE No. 01
--        -------   --------  -------   -------
          0.00000   0.000000  0.90000    0.0000
          0.03000   0.000000  0.82500    0.0000
          0.04420   0.024200  0.80000    0.0000
          0.05850   0.048500  0.77500    0.0000
          0.07270   0.072700  0.75000    0.0000
          0.08700   0.097000  0.72500    0.0000
          0.10120   0.121200  0.70000    0.0000
          0.11550   0.145500  0.67500    0.0000
          0.12970   0.169700  0.65000    0.0000
          0.14390   0.193900  0.62500    0.0000
          0.15820   0.218200  0.60000    0.0000
          0.17240   0.242400  0.57500    0.0000
          0.18670   0.266700  0.55000    0.0000
          0.20090   0.290900  0.52500    0.0000
          0.21520   0.315200  0.50000    0.0000
          0.22940   0.339400  0.47500    0.0000
          0.24360   0.363600  0.45000    0.0000
          0.25790   0.387900  0.42500    0.0000
          0.27210   0.412100  0.40000    0.0000
          0.28640   0.436400  0.37500    0.0000
          0.30060   0.460600  0.35000    0.0000
          0.31480   0.484800  0.32500    0.0000
          0.32910   0.509100  0.30000    0.0000
          0.34330   0.533300  0.27500    0.0000
          0.35760   0.557600  0.25000    0.0000
          0.37180   0.581800  0.22500    0.0000
          0.38610   0.606100  0.20000    0.0000
          0.40030   0.630300  0.17500    0.0000
          0.41450   0.654500  0.15000    0.0000
          0.42880   0.678800  0.12500    0.0000
          0.44300   0.703000  0.10000    0.0000
          0.45730   0.727300  0.07500    0.0000
          0.47150   0.751500  0.05000    0.0000
          0.48580   0.775800  0.02500    0.0000
          0.50000   0.800000  0.00000    0.0000
          0.80000   0.900000  0.00000    0.0000              / TABLE No. 02
```

The example defines two SGOF tables for use when oil, gas and water are present in the run.

8.3.253 SGU – END-POINT SCALING GRID CELL GAS SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SGU defines the maximum gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The maximum gas saturation is defined as the maximum gas saturation in a two-phase gas relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGU	SGU is an array of real numbers assigning the maximum gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.70			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the maximum gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the SGUX± , SGUX± and SGU± series of keyword should be used.
2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
3) The keyword is terminated by "/".

Table 8.126: SGU Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SGUX, SGUY and SGUZ instead of SGU. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SGUX, SGUX-, SGUY, SGUY-, SGUZ and SGUZ-, instead of the SGU keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SGU DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SGU
          300*0.700                                                    /
```

The above example defines a constant connate gas saturation of 0.70 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.254 SGWFN – GAS-WATER SATURATION TABLES (FORMAT TYPE 2)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SGWFN keyword defines the gas and water relative permeability and gas-water capillary pressure data versus gas saturation tables for when gas and water are present in the input deck. This keyword should only be used if the gas and water are present in the run.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGAS	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the gas saturation.			
		dimensionless	dimensionless	dimensionless	None
2	KRG	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the gas relative permeability. Note that the first entry in the column must be zero.			
		dimensionless	dimensionless	dimensionless	None
3	KRW	A columnar vector of real values that are either equal or decreasing down the column and that are greater than or equal to zero and less than or equal to one that defines the water relative permeability with respect to gas saturation. The last value in the column should be zero.			
		dimensionless	dimensionless	dimensionless	None
4	PCGW	A columnar vector of real values that are either equal or increasing down the column that defines the gas-water relative capillary pressure.			
		psia	bars	atm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.127: SGWFN Keyword Description

Example

```
--
--        GAS-WATER RELATIVE PERMEABILITY TABLES (SGWFN)
SGWFN
--        SG          KRG       KRW       PCOW
--        FRAC                            PSIA
--        --------    --------  -------   -------
          0.000000    0.0000    0.9000    0.000000
          0.200000    0.0002    0.7664    0.000000
          0.699099    0.4973    0.0000    0.000000
          0.700000    1.0000    0.0000    0.000000            / TABLE NO. 01
--        --------    --------  -------   -------
          0.000000    0.0000    0.9000    0.000000
          0.200000    0.0002    0.7664    0.000000
          0.245309    0.0004    0.7443    0.000000
          0.261989    0.0010    0.6907    0.000000
          0.303091    0.0044    0.5671    0.000000
          0.368269    0.0191    0.3962    0.000000
          0.435026    0.0519    0.2528    0.000000
          0.486387    0.0940    0.1643    0.000000
          0.522283    0.1339    0.1137    0.000000
          0.550683    0.1725    0.0803    0.000000
          0.575342    0.2115    0.0559    0.000000
          0.599076    0.2542    0.0367    0.000000
          0.621294    0.2991    0.0223    0.000000
          0.642171    0.3458    0.0120    0.000000
          0.658984    0.3868    0.0061    0.000000
          0.671123    0.4183    0.0030    0.000000
          0.679268    0.4403    0.0015    0.000000
          0.684963    0.4562    0.0008    0.000000
          0.688893    0.4674    0.0004    0.000000
          0.692025    0.4765    0.0002    0.000000
          0.694641    0.4841    0.0001    0.000000
          0.696976    0.4910    0.0000    0.000000
          0.699099    0.4973    0.0000    0.000000
          0.700000    1.0000    0.0000    0.000000            / TABLE NO. 02
```

The example defines two SGWFN tables for use when oil, gas and water are present in the run.

8.3.255 SHRATE - Activate and Define the Polymer Shearing Logarithmic Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the logarithm-based polymer shear thinning/thickening option and defines the shear rate constant. This keyword can only be used in conjunction with the PLYSHLOG in the PROPS section

This keyword is ignored by OPM Flow and has no effect on the simulation.

See the PLYSHEAR keyword for the alternative polymer shear thinning/thickening option that is implemented in OPM Flow.

8.3.256 SKRO – END-POINT SCALING OF GRID CELL KRO(SWL) (SURFACTANT)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SKRO defines the scaling parameter for the surfactant oil relative permeability value at the connate water saturation (SWL), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Surfactant option must be enabled by either the SURFST or SURFSTES keywords in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SKRO	SKRO is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling SKRO values for each cell in the model. Repeat counts may be used, for example 50*0.500.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 8.128: SKRO Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be scale on the relative permeability values using the SKRO, SKRORG, SKRORW, SKRW and SKRWR surfactant relative permeability grid cell arrays for the relative permeability end-point data.

Example

The example defines an input box for the whole grid and for layers one to three, for layer one SKRO is set equal to 0.850, for layer two SKRO equals 0.875, and for layer three SKRO equals 0.900.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET SKRO VALUES FOR THREE LAYERS IN THE MODEL
--
SKRO
          1000*0.855  1000*0.875  1000.0.900               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

8.3.257 SKRORG – END-POINT SCALING OF GRID CELL KRO(SGCR) (SURFACTANT)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SKRORG defines the scaling parameter for the surfactant relative permeability of oil at the critical gas saturation (SGCR), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Surfactant option must be enabled by either the SURFST or SURFSTES keywords in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SKRORG	SKRORG is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling SKRORG values for each cell in the model. Repeat counts may be used, for example 50*0.850.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 8.129: SKRORG Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be scale on the relative permeability values using the SKRO, SKRORG, SKRORW, SKRW and SKRWR surfactant relative permeability grid cell arrays for the relative permeability end-point data.

Example

The example users the EQUALS keyword to set layer one SKRORG equal to 0.750, layer two SKRORG equals 0.775, and layer three SKRORG equals 0.800.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          SKRORG       0.7550        1*  1*   1*  1*    1   1  / SKRORG FOR LAYER 1
          SKRORG       0.7750        1*  1*   1*  1*    2   2  / SKRORG FOR LAYER 2
          SKRORG       0.8000        1*  1*   1*  1*    3   3  / SKRORG FOR LAYER 3
/
```

8.3.258 SKRORW – END-POINT SCALING OF GRID CELL KRO(SWCR) (SURFACTANT)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SKRORW defines the scaling parameter for the surfactant relative permeability of oil at the critical water saturation (SWCR), for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Surfactant option must be enabled by either the SURFST or SURFSTES keywords in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SKRORW	SKRORW is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling SKRORW values for each cell in the model. Repeat counts may be used, for example 50*0.850			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 8.130: SKRORW Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be scale on the relative permeability values using the SKRO, SKRORG, SKRORW, SKRW and SKRWR surfactant relative permeability grid cell arrays for the relative permeability end-point data.

Example

The example defines an input box for the whole grid and for layers one to three, for layer one SKRORW is set equal to 0.750, for layer two SKRORW equals 0.775, and for layer three SKRORW equals 0.800.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET SKRORW VALUES FOR THREE LAYERS IN THE MODEL
--
SKRORW
          1000*0.755  1000*0.775  1000.0.800               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

8.3.259 SKRW – END-POINT SCALING OF GRID CELL KRW(SW =1.0) (SURFACTANT)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SKRW defines the scaling parameter at the maximum surfactant water relative permeability value (SWU), that is for S_w = 1.0, for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword. In addition, the Surfactant option must be enabled by either the SURFST or SURFSTES keywords in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SKRW	SKRW is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling SKRW values for each cell in the model. Repeat counts may be used, for example 50*1.000.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 8.131: SKRW Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be scale on the relative permeability values using the SKRO, SKRORG, SKRORW, SKRW and SKRWR surfactant relative permeability grid cell arrays for the relative permeability end-point data.

Example

The example users the EQUALS keywordto set SKRW for layer one equal to 0.850, layer two SKRW to 0.875, and layer three KRW to 0.900.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          SKRW         0.8550        1*  1*   1*  1*    1   1  / SKRW FOR LAYER 1
          SKRW         0.8750        1*  1*   1*  1*    2   2  / SKRW FOR LAYER 2
          SKRW         0.9000        1*  1*   1*  1*    3   3  / SKRW FOR LAYER 3
/
```

8.3.260 SKRWR – END-POINT SCALING OF GRID CELL KRWR(SOWCR) (SURFACTANT)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SKRWR defines the scaling parameter at the critical oil to water saturation value (SOWCR), for the surfactant water relative permeability curve, for all the cells in the model via an array. The ENDSCALE keyword in the RUNSPEC section should be activated to enable end-point scaling and the use of this keyword.In addition, the Surfactant option must be enabled by either the SURFST or SURFSTES keywords in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SKRWR	SKRWR is an array of positive real numbers which are greater than zero and less than or equal to 1.0, that are the assigned scaling SKRWR values for each cell in the model. Repeat counts may be used, for example 50*1.000.			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 8.132: SKRWR Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be scale on the relative permeability values using the SKRO, SKRORG, SKRORW, SKRW and SKRWR surfactant relative permeability grid cell arrays for the relative permeability end-point data.

Example

The first example defines an input box for the whole grid and for layers one to three, for layer one SKRWR is set equal to 0.750, for layer two SKRWR equals 0.775, and for layer three SKRWR equals 0.800.

```
--
--        DEFINE INPUT BOX FOR EDITING INPUT ARRAYS (NX=100, NY=100)
--
--        ---------- BOX ---------
--        I1  I2   J1  J2   K1  K2
BOX
          1*  1*   1*  1*   1   3                          / DEFINE BOX AREA
--
--        SET SKRWR VALUES FOR THREE LAYERS IN THE MODEL
--
SKRWR
          1000*0.755  1000*0.775  1000.0.800               /
--
--        DEFINE END OF INPUT BOX EDITING OF INPUT ARRAYS
--
ENDBOX
```

8.3.261 SLGOF – GAS-OIL SATURATION TABLES VERSUS GAS (FORMAT TYPE 1)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SLGOF keyword defines the oil and gas relative permeability and oil-gas capillary pressure versus liquid saturation tables for when oil and gas are present in the input deck. This keyword should only be used if both oil and gas are present in the run.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SLIQ	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the gas saturation. The first entry should correspond to residual liquid, that is Swc + Sorg and the last entry should be 1.0 to correspond to a gas saturation of zero.			
		dimensionless	dimensionless	dimensionless	None
2	KRG	A columnar vector of real values that are either equal or decreasing down the column and that are greater than or equal to zero and less than or equal to one that defines the gas relative permeability..			
		dimensionless	dimensionless	dimensionless	None
3	KRO	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the oil relative permeability with respect to gas and connate water saturation. When water is active in the run, the last entry the column, that is at krog(Sg = 0), must be the same as the first entry in the corresponding SWOF table, that is at krow(So = 1 - Swco). The first value in the column should be zero.			
		dimensionless	dimensionless	dimensionless	None
4	PCOG	A columnar vector of real values that are either equal or decreasing down the column that defines the oil-gas relative capillary pressure.			
		psia	bars	atm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.133: SLGOF Keyword Description

Example

```
--
--        GAS-OIL RELATIVE PERMEABILITY TABLES (SLGOF)
SLOF
--        SLIQ       KRG       KROG      PCOG
--        FRAC                           PSIA
--        -------   --------  -------   -------
          0.30060    0.55000  0.0000     0.0000
          0.31480    0.42500  0.2848     0.0000
          0.32910    0.35000  0.3091     0.0000
          0.34330    0.27500  0.4333     0.0000
          0.35760    0.25000  0.5576     0.0000
          0.37180    0.22500  0.5818     0.0000
          0.38610    0.20000  0.6061     0.0000
          0.40030    0.17500  0.6303     0.0000
          0.41450    0.15000  0.6545     0.0000
          0.42880    0.12500  0.6788     0.0000
          0.44300    0.10000  0.7030     0.0000
          0.45730    0.07500  0.7273     0.0000
          0.47150    0.05000  0.7515     0.0000
          0.48580    0.02500  0.7758     0.0000
          0.50000    0.00000  0.8000     0.0000
          0.80000    0.00000  0.9000     0.0000             / TABLE No. 01
--        -------   --------  -------   -------
          0.30060    0.55000  0.0000     0.0000
          0.31480    0.42500  0.2848     0.0000
          0.32910    0.35000  0.3091     0.0000
          0.34330    0.27500  0.4333     0.0000
          0.35760    0.25000  0.5576     0.0000
          0.37180    0.22500  0.5818     0.0000
          0.38610    0.20000  0.6061     0.0000
          0.40030    0.17500  0.6303     0.0000
          0.41450    0.15000  0.6545     0.0000
          0.42880    0.12500  0.6788     0.0000
          0.44300    0.10000  0.7030     0.0000
          0.45730    0.07500  0.7273     0.0000
          0.47150    0.05000  0.7515     0.0000
          0.48580    0.02500  0.7758     0.0000
          0.50000    0.00000  0.8000     0.0000
          0.80000    0.00000  0.9000     0.0000             / TABLE No. 02
```

The example defines two SGOF tables for use when oil, gas and water are present in the run.

8.3.262 SOCRS – END-POINT SCALING GRID CELL MISCIBLE CRITICAL OIL SATURATION WITH RESPECT TO WATER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SOCRS defines the miscible critical oil saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The critical oil saturation with respect to water is defined as the maximum oil saturation for which the oil relative permeability is zero in a two-phase oil-water relative permeability table. The keyword is used with the Surfactant model to re-scale the surfactant relative permeability saturation tables allocated to a grid block by the by the SURFNUM keyword in the REGIONS section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SOCRS	SOCRS is an array of real numbers assigning the critical oil saturation with respect to water values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.30			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the critical gas saturation used with the end-point scaling option. If directional end-point scaling has been activated then the SOCRSX± , SOCRSX± and SOCRSX± series of keyword should be used.
2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
3) The keyword is terminated by "/".

Table 8.134: SOGCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOCRS, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SOCRS DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SOCRS
          300*0.200                                                    /
```

The above example defines a constant critical oil saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.263 SOF2 – OIL SATURATION TABLES WITH RESPECT TO GAS OR WATER (FORMAT TYPE 2)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOF2 keyword defines the oil relative permeability versus oil saturation tables for when oil and gas or oil and water are present in the input deck. The keyword is also used to define the relative permeability of the miscible hydrocarbon phase in SOLVENT runs This keyword should only be used if the oil is present in the run.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SOIL	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the oil or the hydrocarbon solvent saturation. For two phase runs the oil saturation should be entered and for when the SOLVENT option has been activated in the RUNSPEC section the total hydrocarbon phase (including the solvent) should be entered, that is SOIL = So + Sg + Ss.			
		dimensionless	dimensionless	dimensionless	None
3	KRO	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the oil relative permeability with respect to gas and connate water saturation. For two phase runs the oil relative permeability should be entered and for when the SOLVENT option has been activated in the RUNSPEC section the relative permeability of the miscible hydrocarbon phase with respect to water. The last value in the column should be zero.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.135: SOF2 Keyword Description

Not this keyword should only be used for when the SOLVENT keyword in the RUNSPEC section has been activated. It should not be use for two-phase oil-water runs.

Example

```
--
--       OIL RELATIVE PERMEABILITY TABLES (SOF2)
--
SOF2
--       SOIL         KRO
--       FRAC         FRAC
--       --------     --------
            0.00      0.000000
            0.05      1.197e-5
            0.10      0.000191
            0.15      0.000969
            0.20      0.003065
            0.25      0.007483
            0.30      0.015517
            0.35      0.028747
            0.40      0.049041
            0.45      0.078555
            0.56      0.119730
            0.55      0.175297
            0.60      0.248272
            0.65      0.341961
            0.70      0.459956
            0.75      0.606134
            0.80      0.784664
            0.85      1.000000                          / TABLE NO. 01
--       --------     --------
            0.00      0.000000
            0.05      1.197e-5
            0.10      0.000191
            0.15      0.000969
            0.20      0.003065
            0.25      0.007483
            0.30      0.015517
            0.35      0.028747
            0.40      0.049041
            0.45      0.078555
            0.56      0.119730
            0.55      0.175297
            0.60      0.248272
            0.65      0.341961
            0.70      0.459956
            0.75      0.606134
            0.80      0.784664
            0.85      1.000000                          / TABLE NO. 02
```

The example defines two SOF2 tables for when oil and gas or oil and water are present in the input deck.

8.3.264 SOF3 – OIL SATURATION TABLES WITH RESPECT TO GAS AND WATER (FORMAT TYPE 2)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOF3 keyword defines the oil relative permeability versus oil saturation tables for when oil, gas and water are present in the input deck. The keyword should only be used if oil, gas and water are present in the input deck.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SOIL	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the oil or the hydrocarbon solvent saturation. The final entry should be at the connate water saturation, that is 1- Swc.			
		dimensionless	dimensionless	dimensionless	None
3	KROW	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the oil relative permeability with respect to oil and water saturation. The first value in the column should be zero.			
		dimensionless	dimensionless	dimensionless	None
4	KROG	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the oil relative permeability with respect to oil, gas and connate water saturation. The first value in the column should be zero.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.136: SOF3 Keyword Description

Example

```
--
--       OIL RELATIVE PERMEABILITY TABLES (SOF3)
--
SOF3
--       SOIL         KRO          KROG
--       FRAC         FRAC         FRAC
--       --------     --------     --------
            0.00      0.000000     0.00000
            0.05      1.197e-5     0.00000
            0.10      0.000191     0.00000
            0.15      0.000969     0.00000
            0.20      0.003065     0.00000
            0.25      0.007483     0.00000
            0.30      0.015517     0.05932
            0.35      0.028747     0.13158
            0.40      0.049041     0.21082
            0.45      0.078555     0.29960
            0.56      0.119730     0.40095
            0.55      0.175297     0.51818
            0.60      0.248272     0.65476
            0.65      0.341961     0.81420
            0.70      0.459956     1.00000
            0.75      0.606134     1.00000
            0.80      0.784664     1.00000
            0.85      1.000000     1.00000                 / TABLE NO. 1
--       --------     --------     --------
            0.00      0.000000     0.00000
            0.05      1.197e-5     0.00000
            0.10      0.000191     0.00000
            0.15      0.000969     0.00000
            0.20      0.003065     0.00000
            0.25      0.007483     0.00000
            0.30      0.015517     0.05932
            0.35      0.028747     0.13158
            0.40      0.049041     0.21082
            0.45      0.078555     0.29960
            0.56      0.119730     0.40095
            0.55      0.175297     0.51818
            0.60      0.248272     0.65476
            0.65      0.341961     0.81420
            0.70      0.459956     1.00000
            0.75      0.606134     1.00000
            0.80      0.784664     1.00000
            0.85      1.000000     1.00000                 / TABLE NO. 2
```

The example defines two SOF3 tables for when oil, gas and water are present in the input deck.

8.3.265 SOF32D – Oil Saturation Tables with Respect to Water and Gas (Three Phase)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOF32D keyword defines the three phase oil relative permeability versus water and gas saturation tables for when oil, gas and water are present in the input deck. The keyword should only be used if oil, gas and water are present in the input deck. Normally the simulator calculates the three-phase oil relative permeabilities based on the entered two phase tables of water-oil and gas-oil, combined with the STONE1 and STONE2 keywords in the PROPS section that determine the method used to generate the thee phase oil relative permeability curves. SOF32D allows for the direct input of the three phase tables, as such the STONE1 and STONE2 keywords should not be entered if SOF32D is used in the input deck.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.266 SOGCR – END-POINT SCALING GRID CELL CRITICAL OIL SATURATION WITH RESPECT TO GAS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SOGCR defines the critical oil saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The critical oil saturation with respect to gas is defined as the maximum oil saturation for which the oil relative permeability is zero in a two-phase gas-oil relative permeability table. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SOGCR	SOGCR is an array of real numbers assigning the critical oil saturation with respect to gas values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.30 dimensionless			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the critical gas saturation used with the end-point scaling option. If directional end-point scaling has been activated then the SOGCRX± , SOGCRX± and SOGCRX± series of keyword should be used.
2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
3) The keyword is terminated by "/".

Table 8.137: SOGCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SOGCRX, SOGCRY and SOGCRZ instead of SOGCR. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SOGCRX, SOGCRX-, SOGCRY, SOGCRY-, SOGCRZ and SOGCRZ-, instead of the SOGCR keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SOGCR DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SOGCR
          300*0.200                                                    /
```

The above example defines a constant critical gas saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.267 SOMGAS – STONE1 MODEL MINIMUM OIL SATURATION VERSUS GAS SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the minimum oil saturation as a function of gas saturation for Stone's[106] first three phase oil relative permeability model as modified by Aziz and Settari[107]. If the STONE1 and STONE2 keywords are not present in the input deck then the default three phase oil relative permeability model is employed. The SOMGAS and STONE1 keywords should only be used in three phase runs containing the oil, gas and water phases. The keyword is optional.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[106] *Stone, H. L. "Probability Model for Estimating Three-Phase Relative Permeability," paper SPE 2116, Journal of Canadian Petroleum Technology (1973) 22, No. 2, 214-218.*

[107] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

8.3.268 SOMWAT – STONE1 MODEL MINIMUM OIL SATURATION VERSUS WATER SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the minimum oil saturation as a function of water saturation for Stone's[108] first three phase oil relative permeability model as modified by Aziz and Settari[109]. If the STONE1 and STONE2 keywords are not present in the input deck then the default three phase oil relative permeability model is employed. The SOMWAT and STONE1 keywords should only be used in three phase runs containing the oil, gas and water phases. The keyword is optional.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[108] *Stone, H. L. "Probability Model for Estimating Three-Phase Relative Permeability," paper SPE 2116, Journal of Canadian Petroleum Technology (1973) 22, No. 2, 214-218.*

[109] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

8.3.269 SORWMIS – MISCIBLE RESIDUAL OIL VERSUS WATER SATURATION FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SORWMIS defines the dependency between the miscible residual oil saturation and the water saturation, for when the MISCIBLE keyword in the RUNSPEC section has been activated. The keyword can only be used with the MISCIBLE option and for when the oil, water and gas phases are active in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWAT	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the water saturation.			
		dimensionless	dimensionless	dimensionless	None
2	SORMIS	A columnar vector of real equal or increasing down the column values that are greater than or equal to zero and less than one, that define the corresponding miscible residual oil saturation for the corresponding water saturation SWAT.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTMISC tables as declared on the MISCIBLE keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSMISC rows as declared on the MISCIBLE keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.138: SORWMIS Keyword Description

Example

```
--
--        MISCIBLE RESIDUAL OIL VERSUS WATER SATURATION TABLE
--
SORWMIS
--        SWAT        SORWMIS
--        FRAC        FRAC
--        -------     --------
           0.0000      0.0000
           0.2000      0.0000
           1.0000      0.0000                                  / TABLE NO. 01
--        SWAT        SORWMIS
--        FRAC        FRAC
--        -------     --------
           0.0000      0.0000
           0.3000      0.1000
           0.7500      0.1500                                  / TABLE NO. 02
```

The above example defines two miscible residual oil versus water saturation tables assuming NTMISC equals two and NSMISC is greater than or equal to three on the MISCIBLE keyword in the RUNSPEC section.

8.3.270 SOWCR – END-POINT SCALING GRID CELL CRITICAL OIL SATURATION WITH RESPECT TO WATER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SOWCR defines the critical oil saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The critical oil saturation with respect to water is defined as the maximum oil saturation for which the oil relative permeability is zero in a two-phase oil-water relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SOWCR	SOWCR is an array of real numbers assigning the critical oil saturation with respect to water values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.30			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the critical gas saturation used with the end-point scaling option. If directional end-point scaling has been activated then the SOWCRX± , SOWCRX± and SOWCRX± series of keyword should be used.

2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.

3) The keyword is terminated by "/".

Table 8.139: SOWCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SOWCRX, SOWCRY and SOWCRZ instead of SOWCR. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SOWCRX, SOWCRX-, SOWCRY, SOWCRY-, SOWCRZ and SOWCRZ-, instead of the SOWCR keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SOWCR DATA FOR ALL CELLS
-         (FOR NX x NY x NZ = 300)
--
SOWCR
          300*0.200                                                    /
```

The above example defines a constant critical oil saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.271 SPECHEAT – DEFINE THE SPECIFIC HEAT OF OIL, WATER AND GAS

Description

SPECHEAT defines the specific heat of the oil, water and gas phases for various PVT regions in the model for when the THERMAL option has been activated in the RUNSPEC section. The number of SPECHEAT vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the SPECHEAT data sets to different grid blocks in the model is done via the PVTNUM keyword in the REGION section.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	A columnar vector of real monotonically increasing down the column values that define the temperature for the corresponding oil, water and gas specific heat values.			
		°F	°C	°C	None
2	OILSHEAT	OILSHEAT is a columnar vector of positive real numbers defining the specific heat of oil at the corresponding temperature, TEMP.			
		Btu/lb/°R	kJ/kg/K	J/gm/K	None
3	WATSHEAT	WATSHEAT is a columnar vector of positive real numbers defining the specific heat of water at the corresponding temperature, TEMP.			
		Btu/lb/°R	kJ/kg/K	J/gm/K	None
4	GASSHEAT	GASHEAT is a columnar vector of positive real numbers defining the specific heat of gas at the corresponding temperature, TEMP.			
		Btu/lb/°R	kJ/kg/K	J/gm/K	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.140: SPECHEAT Keyword Description

See also the SPECROCK keyword to define the reservoir rock specific heat.

Example

The example below defines three fluid phases specific heat versus temperature tables assuming NTPVT equals three and NPPVT is greater than or equal to two on the TABDIMS keyword in the RUNSPEC section.

```
--
--       SPECIFIC HEAT OF OIL, WATER AND GAS TABLE
--
SPECHEAT
--       TEMP       SPECHEAT   SPECHEAT   SPECHEAT
--                  OIL        WATER      GAS
--       -------    --------   --------   --------
           0.000     0.5000     1.5000     0.5000
         250.000     0.5000     1.5000     0.5000          / TABLE NO. 01
--       TEMP       SPECHEAT   SPECHEAT   SPECHEAT
--                  OIL        WATER      GAS
--       -------    --------   --------   --------
           0.000     0.5500     1.5000     0.5000
         260.000     0.5500     1.5000     0.5000          / TABLE NO. 02
--       TEMP       SPECHEAT   SPECHEAT   SPECHEAT
--                  OIL        WATER      GAS
--       -------    --------   --------   --------
           0.000     0.5500     1.5500     0.5000
         270.000     0.6000     1.5500     0.5000          / TABLE NO. 03
```

There is no terminating "/" for this keyword.

8.3.272 SPECROCK – DEFINE THE SPECIFIC HEAT OF THE RESERVOIR ROCK

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SPECROCK defines the specific heat of the reservoir rock for various PVT regions in the model for when the THERMAL option has been activated in the RUNSPEC section. The number of SPECROCK vector data sets is defined by the NTSFUN parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the SPECROCK data sets to different grid blocks in the model is done via the SATNUM keyword in the REGION section.

This keyword can only be used if OPM's Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	A columnar vector of real monotonically increasing down the column values that define the temperature for the corresponding rock specific heat values.			
		°F	°C	°C	None
2	ROCKHEAT	ROCKHEAT is a columnar vector of positive real numbers defining the specific heat of the rock at the corresponding temperature, TEMP.			
		Btu/ft^3/°R	kJ/m^3/K	J/cc/K	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.141: SPECROCK Keyword Description

See also the SPECHEAT keyword to define the specif heat relationships for the oil, water and gas phases.

Example

The example below defines three rock specific heat versus temperature tables assuming NTSFUN equals three and NSSFUN is greater than or equal to two on the TABDIMS keyword in the RUNSPEC section.

```
--
--       SPECIFIC HEAT OF ROCK
--
SPECROCK
--       TEMP       SPECHEAT
--                  ROCK
--       -------    --------
           0.000     20.000
         250.000     20.000                                / TABLE NO. 01
--       -------    --------
           0.000     21.000
         260.000     21.000                                / TABLE NO. 02
--       -------    --------
           0.000     23.000
         270.000     23.000                                / TABLE NO. 03
```

There is no terminating "/" for this keyword.

8.3.273 SSFN – SOLVENT AND GAS RELATIVE PERMEABILITY TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SSFN keyword defines the miscible normalized relative permeability tables for when the SOLVENT option has been activated in the RUNSPEC section using the respective keyword. The MISCIBLE keyword invokes a three component formulation (oil, water and solvent gas or an oil, water and solvent oil). Whereas, the SOLVENT keyword results in a four component model (oil, water and gas, plus a solvent). This keyword should only be used if the SOLVENT options have been activated.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGAS	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the gas plus solvent saturation ration which is defined as either: $\frac{S_g}{(S_g + S_s)}$ or $\frac{S_s}{(S_g + S_s)}$ Where Sg is the gas saturation and Ss is the solvent saturation.			
		dimensionless	dimensionless	dimensionless	None
2	KRG^t	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the gas relative permeability. The resulting gas relative permeability is calculated from: $k_{rg} = k_{rgt}(S_g + S_s)k_{rg}^{\ t}$ where krg^t is the data in this column and krgt is the gas relative permeability from the SGFN keyword..			
		dimensionless	dimensionless	dimensionless	None
3	KRS^t	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the solvent relative permeability. The resulting solvent relative permeability is calculated from: $k_{rs} = k_{rgt}(S_g + S_s)k_{rs}^{\ t}$ where krS^t is the data in this column and krgt is the gas relative permeability from the SGFN keyword..			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.142: SSFN Keyword Description

Example

```
--
--       SOLVENT RELATIVE PERMEABILITY TABLES
--
SSFN
--       SGAS       KRGT         KRST
--       FRAC
--       --------  --------     --------
          0.0000    0.0000       0.0000
          1.0000    1.0000       1.0000                    / TABLE NO. 01
--       --------  --------     --------
          0.0000    0.0000       0.0000
          0.2000    0.2000       0.3000
          0.4000    0.3000       0.5000
          0.6000    0.4000       0.7000
          0.8000    0.5000       0.7500
          1.0000    1.0000       1.0000                    / TABLE NO. 02
```

The above example defines two SSFN tables for use with the MISCIBLE and SOLVENT options.

8.3.274 SSGCR – END-POINT SCALING GRID CELL SURFACTANT CRITICAL GAS SATURATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SSGCR defines the surfactant critical gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword and the surfactant phase has been activated by the SURFACT keyword in the RUNSPEC section. The critical gas saturation is defined as the maximum gas saturation for which the gas relative permeability is zero in a two-phase relative permeability table. SSGCR is used to scale the surfactant oil relative permeability to gas data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSGCR	SSGCR is an array of real numbers assigning the surfactant critical gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.03			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
2) The keyword is terminated by "/".

Table 8.143: SSGCR Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SSWL, SSWCR, SSWU, SSGL, SSGCR, SSGU, SSOWCR, and SSOGCR saturation grid arrays for the saturation end-points, and the SKRG, SKROG, SKROW and SKRW relative permeability grid cell arrays for the relative permeability end-point data.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SSGCR DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SSGCR
          300*0.050                                                    /
```

The above example defines a constant surfactant critical oil saturation with respect to gas of 0.05 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.275 SSGL – END-POINT SCALING GRID CELL SURFACTANT CONNATE GAS SATURATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SSGL defines the surfactant connate gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword and the surfactant phase has been activated by the SURFACT keyword in the RUNSPEC section. The connate gas saturation is defined as the minimum gas saturation in a two-phase gas relative permeability table. SSGL is used to scale the surfactant oil and water relative permeability data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSGL	SSGL is an array of real numbers assigning the surfactant connate gas saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.03			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
2) The keyword is terminated by "/".

Table 8.144: SSGL Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SSWL, SSWCR, SSWU, SSGL, SSGCR, SSGU, SSOWCR, and SSOGCR saturation grid arrays for the saturation end-points, and the SKRG, SKROG, SKROW and SKRW relative permeability grid cell arrays for the relative permeability end-point data.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SSGL DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SSGL
          300*0.030                                                    /
```

The above example defines a constant surfactant connate gas saturation of 0.03 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.276 SSOGCR – END-POINT SCALING GRID CELL SURFACTANT CRITICAL OIL SATURATION WITH RESPECT TO GAS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SSOGCR defines the surfactant critical oil saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword and the surfactant phase has been activated by the SURFACT keyword in the RUNSPEC section. The critical oil saturation with respect to gas is defined as the maximum oil saturation for which the oil relative permeability is zero in a two-phase gas-oil relative permeability table. SSOGCR scales the surfactant oil relative permeability to gas data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSOGCR	SSOGCR is an array of real numbers assigning the surfactant critical oil saturation with respect to gas values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.30 dimensionless			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
2) The keyword is terminated by "/".

Table 8.145: SSOGCR Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SSWL, SSWCR, SSWU, SSGL, SSGCR, SSGU, SSOWCR, and SSOGCR saturation grid arrays for the saturation end-points, and the SKRG, SKROG, SKROW and SKRW relative permeability grid cell arrays for the relative permeability end-point data.

Example

```
--
--       DEFINE GRID BLOCK END-POINT SSOGCR DATA FOR ALL CELLS
--       (FOR NX x NY x NZ = 300)
--
SSOGCR
         300*0.200                                                    /
```

The above example defines a surfactant constant critical oil saturation with respect to gas of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.277 SSOWCR – END-POINT SCALING GRID CELL SURFACTANT CRITICAL OIL SATURATION WITH RESPECT TO WATER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SSOWCR defines the surfactant critical oil saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword and the surfactant phase has been activated by the SURFACT keyword in the RUNSPEC section. The critical oil saturation with respect to water is defined as the maximum oil saturation for which the oil relative permeability is zero in a two-phase oil-water relative permeability table. SSOWCR scales the surfactant oil relative permeability to water data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSOWCR	SSOWCR is an array of real numbers assigning the surfactant critical oil saturation with respect to water values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.30			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
2) The keyword is terminated by "/".

Table 8.146: SSOWCR Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SSWL, SSWCR, SSWU, SSGL, SSGCR, SSGU, SSOWCR, and SSOGCR saturation grid arrays for the saturation end-points, and the SKRG, SKROG, SKROW and SKRW relative permeability grid cell arrays for the relative permeability end-point data.

Example

```
--
--       DEFINE GRID BLOCK END-POINT SSOWCR DATA FOR ALL CELLS
--       (FOR NX x NY x NZ = 300)
--
SSOWCR
         300*0.200                                                    /
```

The above example defines a constant critical oil saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.278 SSWCR – END-POINT SCALING GRID CELL CRITICAL WATER SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SSWCR defines the surfactant critical water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword and the surfactant phase has been activated by the SURFACT keyword in the RUNSPEC section. The critical water saturation is defined as the maximum water saturation for which the water relative permeability is zero in a two-phase relative permeability table. SSWCR scales the surfactant water relative permeability data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSWCR	SSWCR is an array of real numbers assigning the surfactant critical water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.20			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
2) The keyword is terminated by "/".

Table 8.147: SSWCR Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SSWL, SSWCR, SSWU, SSGL, SSGCR, SSGU, SSOWCR, and SSOGCR saturation grid arrays for the saturation end-points, and the SKRG, SKROG, SKROW and SKRW relative permeability grid cell arrays for the relative permeability end-point data.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SSWCR DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SSWCR
          300*0.200                                                    /
```

The above example defines a constant surfactant critical water saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.279 SSWL – END-POINT SCALING GRID CELL SURFACTANT CONNATE WATER SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SSWL defines the surfactant connate water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword and the surfactant phase has been activated by the SURFACT keyword in the RUNSPEC section. The connate water saturation is defined as the minimum water saturation in a two-phase water relative permeability table. SSWL scales the surfactant oil relative permeability to water and gas data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSWL	SSWL is an array of real numbers assigning the connate water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.15			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
2) The keyword is terminated by "/".

Table 8.148: SSWL Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SSWL, SSWCR, SSWU, SSGL, SSGCR, SSGU, SSOWCR, and SSOGCR saturation grid arrays for the saturation end-points, and the SKRG, SKROG, SKROW and SKRW relative permeability grid cell arrays for the relative permeability end-point data.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SSWL DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SSWL
          300*0.150                                                    /
```

The above example defines a constant surfactant connate water saturation of 0.15 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.280 SSWU – END-POINT SCALING GRID CELL SURFACTANT MAXIMUM WATER SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SSWU defines the surfactant maximum water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword and the surfactant phase has been activated by the SURFACT keyword in the RUNSPEC section. The maximum water saturation is defined as the maximum water saturation in a two-phase water relative permeability table. SSWU scales the surfactant water relative permeability data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSWU	SSWU is an array of real numbers assigning the surfactant maximum water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.70			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
2) The keyword is terminated by "/".

Table 8.149: SSWU Keyword Description

End-point scaling allows the entered surfactant relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SSWL, SSWCR, SSWU, SSGL, SSGCR, SSGU, SSOWCR, and SSOGCR saturation grid arrays for the saturation end-points, and the SKRG, SKROG, SKROW and SKRW relative permeability grid cell arrays for the relative permeability end-point data.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SSWU DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SSWU
          300*0.700                                                    /
```

The above example defines a constant surfactant connate gas saturation of 0.70 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.281 STOG Define Capillary Pressure Oil-Gas Surface Tension versus Pressure

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The STOG keyword defines capillary pressure oil-gas surface tension versus pressure tables used in adjusting the pressure independent capillary pressure vectors in the SGFN, SGOF or SLGOF saturation tables, entered by their respective keywords in the PROPS section. The SATOPTS keyword in the RUNSPEC section should state the SURFTENS character string to activate the Capillary Pressure Surface Tension Pressure Dependency option. If the STOG keyword is not supplied then no capillary pressure surface tension pressure scaling will occur and the capillary pressure values on the SGFN, SGOF or SLGOF saturation tables will be used directly.

Capillary pressure surface tension pressure scaling can also be used with multi-segment wells, but this facility has not been incorporated in OPM Flow's multi-segment well implementation.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.282 STONE – ACTIVATE STONE'S SECOND THREE PHASE OIL RELATIVE PERMEABILITY MODEL (ALIAS FOR STONE2)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword is an alias for STONE2 keyword that activates Stone's[110] second three phase oil relative permeability model as modified by Aziz and Settari[111]. If the STONE, STONE1 and STONE2 keywords are not present in the input deck then the default three phase oil relative permeability model is employed. The STONE keyword should only be used in three phase runs containing the oil, gas and water phases.

There is no data required for this keyword.

Example

```
--
--       ACTIVATE STONE'S SECOND THREE PHASE RELATIVE PERMEABILITY MODEL
--
STONE
```

The above example switches on the Modified Stone three phase relative permeability model.

[110] *Stone, H. L. "Estimation of Three-Phase Relative Permeability and Residual Oil Data," Journal of Canadian Petroleum Technology (1973) 12, No. 4, 53-61.*

[111] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

8.3.283 STONE1 – ACTIVATE STONE'S FIRST THREE PHASE OIL RELATIVE PERMEABILITY MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates Stone's[112] first three phase oil relative permeability model as modified by Aziz and Settari[113]. If the STONE1 and STONE2 keywords are not present in the input deck then the default three phase oil relative permeability model is employed. The STONE1 keyword should only be used in three phase runs containing the oil, gas and water phases.

There is no data required for this keyword.

Example

```
--
--       ACTIVATE STONE'S FIRST THREE PHASE RELATIVE PERMEABILITY MODEL
--
STONE1
```

The above example switches on the Modified Stone three phase relative permeability model.

[112] *Stone, H. L. "Probability Model for Estimating Three-Phase Relative Permeability," paper SPE 2116, Journal of Canadian Petroleum Technology (1973) 22, No. 2, 214-218.*

[113] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

8.3.284 STONE1EX – DEFINE STONE'S FIRST THREE PHASE OIL RELATIVE PERMEABILITY PARAMETER

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the exponent used in Stone's[114] first three phase oil relative permeability model as modified by Aziz and Settari[115]. The STONE1EX keyword should only be used in three phase runs containing the oil, gas and water phases and when the STONE1 keyword in the SOLUTION section has been used to activate Stone's first three phase oil relative permeability model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	STONEPAR1	A real positive value that defines the exponent to be used in the Modified Stone first three phase oil relative permeability model.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTSFUN records as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each record must contain only one value and is terminated by "/"
3) There is no "/" terminator for the keyword.

Table 8.150: STONE1EX Keyword Description

If the STONE, STONE1 and STONE2 keywords are not present in the input deck then the default three phase oil relative permeability model is employed.

Example

Given NTSFUN equals five on the TABDIMS keyword in the RUNSPEC section, then:

```
--
--       DEFINE STONE'S FIRST THREE PHASE RELATIVE PERMEABILITY MODEL PARAMETER
--
STONE1EX
         1.000                                        / SATURATIOM TABLE NO. 01
         1.000                                        / SATURATIOM TABLE NO. 02
         2.000                                        / SATURATIOM TABLE NO. 03
         1.000                                        / SATURATIOM TABLE NO. 04
         3.000                                        / SATURATIOM TABLE NO. 05
```

Defines the exponents to be used in the Modified Stone first three phase oil relative permeability model, for each of the five saturation tables.

[114] *Stone, H. L. "Probability Model for Estimating Three-Phase Relative Permeability," paper SPE 2116, Journal of Canadian Petroleum Technology (1973) 22, No. 2, 214-218.*

[115] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

8.3.285 STONE2 – ACTIVATE STONE'S SECOND THREE PHASE OIL RELATIVE PERMEABILITY MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates Stone's[116] second three phase oil relative permeability model as modified by Aziz and Settari[117]. If the STONE, STONE1 and STONE2 keywords are not present in the input deck then the default three phase oil relative permeability model is employed. The STONE2 keyword should only be used in three phase runs containing the oil, gas and water phases.

There is no data required for this keyword.

Example

```
--
--       ACTIVATE STONE'S SECOND THREE PHASE RELATIVE PERMEABILITY MODEL
--
STONE2
```

The above example switches on the Modified Stone three phase relative permeability model.

[116] *Stone, H. L. "Estimation of Three-Phase Relative Permeability and Residual Oil Data," Journal of Canadian Petroleum Technology (1973) 12, No. 4, 53-61.*

[117] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

8.3.286 STOW DEFINE CAPILLARY PRESSURE OIL-WATER SURFACE TENSION VERSUS PRESSURE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The STOW keyword defines capillary pressure oil-water surface tension versus pressure tables used in adjusting the pressure independent capillary pressure vectors in the SWFN or SWOF saturation tables, entered by their respective keywords in the PROPS section. The SATOPTS keyword in the RUNSPEC section should state the SURFTENS character string to activate the Capillary Pressure Surface Tension Pressure Dependency option. If the STOW keyword is not supplied then no capillary pressure surface tension pressure scaling will occur and the capillary pressure values on the SWFN or SWOF saturation tables will be used directly.

Capillary pressure surface tension pressure scaling can also be used with multi-segment wells, but this facility has not been incorporated in OPM Flow's multi-segment well implementation.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.287 STWG Define Capillary Pressure Water-Gas Surface Tension versus Pressure

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The STWG keyword defines capillary pressure water-gas surface tension versus pressure tables for use with multi-segment wells. This facility has not been incorporated in OPM Flow's multi-segment well implementation. Note that STWG is not required for Capillary Pressure Surface Tension Pressure Dependency option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.288 SURFADDW – DEFINED SURFACTANT ADSORBED CONCENTRATION VERSUS WETTABILITY FRACTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SURFADDW defines tables of surfactant adsorbed concentration versus wettability fraction for when the SURFACTW keyword in the RUNSPEC section as been declared to activate the surfactant phase with changing wettability. The tables consists of columnar vectors of adsorbed surfactant concentration versus a wettability fraction that indicates the fraction of phase wettability. Here, a wettability fraction of zero indicates a 100% water wet rock resulting in the SURFWNUM allocated saturation tables being used, and a value of one meaning 100% oil wet rock, with the SATNUM allocated saturations tables being employed. Both the SURFWNUM and SATNUM keywords are in the REGIONS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.289 SURFADS - DEFINE SURFACTANT ROCK ADSORPTION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SURFADS keyword defines the rock surfactant adsorption tables for when the surfactant option has been activated by the SURFACT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SURCON	A columnar vector of real monotonically increasing down the column values that defines the surfactant concentration in the solution surrounding the rock. The first entry should be zero to define a no surfactant concentration.			
		lb/stb	kg/sm^3	gm/scc	None
2	SURRATIO	A columnar vector of real increasing down the column values that defines the mass of adsorbed surfactant per unit mass of rock of the saturated concentration of surfactant adsorbed by the rock. The first entry should be zero to define a zero ratio of surfactant concentration.			
		lb/lb	kg/kg	gm/gm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.151: SURFADS Keyword Description

See also the ADSORP keyword in the PROPS section that employs adsorption functions, as oppose to adsorption tables, to define rock surfactant adsorption behavior.

Example

```
--
--       SURFACTANT ROCK ADSORPTION TABLE
--
SURFADS
--       SURF       SURF
--       SURCON     SURRATIO
--       -------    --------
             0.0     0.00000
             2.0     0.00003
             4.0     0.00005
             6.0     0.00007
             8.0     0.00009
            10.0     0.00011
            12.0     0.00012
            14.0     0.00015                                / TABLE NO. 01
--       SURF       SURF
--       SURCON     SURRATIO
--       -------    --------
             0.0     0.00000
             3.0     0.00004
             5.0     0.00006
             7.0     0.00008
             8.0     0.00009
            10.0     0.00011                                / TABLE NO. 02
```

The above example defines two surfactant rock adsorption tables assuming NTSFUN equals two and NSSFUN is greater than or equal to eight on the TABDIMS keyword in the RUNSPEC section.

There is no terminating "/" for this keyword.

8.3.290 SURFCAPD – Capillary Number versus Miscibility Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SURFCAPD keyword defines the relationship between the log of the capillary number and the level of miscibility, for when the Surfactant option has been activated by the SURFACT keyword in the RUNSPEC section. A value of zero for the level of miscibility means fully immiscible conditions and consequently a value of one implies fully miscible conditions.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.291 SURFESAL – DEFINE SURFACTANT EFFECTIVE SALINITY COEFFICIENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, SURFESAL, defines the surfactant effective salinity coefficient as well as enabling the effective salinity calculation for surfactant adsorption. The keyword should only be used if the BRINE keyword has been declared to activate the brine phase, the ECLMC keyword to enable the Multi-Component Brine model, and the SURFACT keyword has been used to activate the surfact phase. All three keywords are in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.292 SURFROCK - DEFINE SURFACTANT-ROCK PROPERTIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SURFROCK keyword defines rock properties for when the Surfactant option has been activated by the SURFACTANT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	ADINDX	A positive integer of 1 or 2 that defines the surfactant desorption option. 1) then surfactant desorption may occur by retracing the surfactant adsorption isotherm when the local surfactant concentration in the solution decreases. 2) then no surfactant desorption may occur.			
		dimensionless 1	dimensionless 1	dimensionless 1	Defined
2	DENSITY	A real value that defines the rock in-situ density, that is at reservoir conditions.			
		lb/rtb	kg/rm^3	gm/rcc	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section, for each surfactant flooding region. There should be only one row per table.

2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.152: SURFROCK Keyword Description

Example

```
--
--        SURFACTANT-ROCK PROPERTIES
--
SURFROCK
--        DESORP    INSITU
--        OPTN      DENSITY
--        ------    -------
            1       1800.0                                  / TABLE NO. 01
            2       1980.0                                  / TABLE NO. 02
            1       2005.0                                  / TABLE NO. 03
```

The above example defines three surfactant-rock tables, based on the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section being equal to three.

There is no terminating "/" for this keyword.

8.3.293 SURFST - Surfactant Water-Oil Surface Tension versus Surfactant Concentration

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SURFST keyword defines surfactant water-oil surface tension versus surfactant concentration in the water phase tables, used in adjusting the pressure independent capillary pressure vectors in the SWFN or SWOF saturation tables, entered by their respective keywords in the PROPS section. SURFST is also used to adjust the relative permeability curves on the aforementioned tables via the capillary number. The Surfactant option must have been activated by the SURFACTANT keyword in the RUNSPEC section to use this keyword and either this keyword or the SURFSTES keyword, also in the PROPS section, is obligatory in this case.

See also the SURFSTES that defines the surfactant water-oil surface tension as a function of surfactant concentration in the water phase and salt concentration or the effective salinity.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.294 SURFSTES - Surfactant Water-Oil Surface Tension versus Surfactant and Salt Concentrations

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SURFSTES keyword defines surfactant water-oil surface tension versus surfactant concentration in the water phase tables, used in adjusting the pressure independent capillary pressure vectors in the SWFN or SWOF saturation tables, entered by their respective keywords in the PROPS section. SURFSTES is also used to adjust the relative permeability curves on the aforementioned tables via the capillary number. The Surfactant option must have been activated by the SURFACTANT keyword in the RUNSPEC section to use this keyword and either this keyword or the SURFST keyword, also in the PROPS section, is obligatory in this case. In addition, the BRINE keyword in the RUNSPEC section must be activated and the ESSNODE keyword in the PROPS section must be used to define the salt concentration or the effective salinity.

See also the SURFSTS that defines the surfactant water-oil surface tension as a function of surfactant concentration in the water phase only.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.295 SURFVISC – SURFACTANT SOLUTION VISCOSITY VERSUS CONCENTRATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SURFSVISC defines the surfactant viscosity relationship of solution water viscosity with respect to increasing surfactant concentration within a grid block. The surfactant option must be activated by the SURFACT keyword in the RUNSPEC section in order to use this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SURFCON	A columnar vector of real monotonically increasing down the column values that defines the surfactant concentration in the solution surrounding the rock. The first entry should be zero to define a no surfactant concentration.			
		lb/stb	kg/sm^3	gm/scc	None
2	SURFVISC	A columnar vector of real positive values that defines the solution water viscosity of the solution for the given SURFCON entry at the reference pressure value, PRES, entered on the PVTW keyword in the PROPS section.			
		cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.153: SURFVISC Keyword Description

Example

```
--
--       SURFACTANT SOLUTION WATER VISCOSITY TABLES
--
SURFVISC
--       SURF         VISCOSITY
--       SURFCON      SURFVISC
--       --------    -----------
          0.0000      0.3500
          0.0100      0.3900
          0.0200      0.4200
          0.0300      0.4300                                  / TABLE NO. 01
```

```
--        SURF         VISCOSITY
--        SURFCON      VISFAC
--        --------    ---------
           0.0000       1.000
           0.0003      10.000
           0.0005      20.000
           0.0007      40.000
           0.0009      45.000
           0.0011      55.000                              / TABLE NO. 02
```

The example defines two surfactant viscosity scaling factor tables, based on the NTPVT variable on the TABDIMS keyword in the RUNSPEC section being equal to two and NPPVT variable on the same keyword being greater than or equal to six.

8.3.296 SWCR – END-POINT SCALING GRID CELL CRITICAL WATER SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SWCR defines the critical water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The critical water saturation is defined as the maximum water saturation for which the water relative permeability is zero in a two-phase relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWCR	SWCR is an array of real numbers assigning the critical water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.20			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the critical water saturation used with the end-point scaling option. If directional end-point scaling has been activated then the SWCRX± , SWCRX± and SWCRX± series of keyword should be used.
2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
3) The keyword is terminated by "/".

Table 8.154: SWCR Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWCRX, SWCRY and SWCRZ instead of SWCR. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWCRX, SWCRX-, SWCRY, SWCRY-, SWCRZ and SWCRZ-, instead of the SWCR keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SWCR DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SWCR
          300*0.200                                                    /
```

The above example defines a constant critical water saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.297 SWF32D – WATER SATURATION TABLES WITH RESPECT TO OIL AND GAS (THREE PHASE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SWF32D keyword defines the three phase water relative permeability versus oil and gas saturation tables for when oil, gas and water are present in the input deck. The keyword should only be used if oil, gas and water are present in the input deck. Normally the simulator calculates the three-phase oil relative permeabilities based on the entered two phase tables of water-oil and gas-oil, combined with the STONE1 and STONE2 keywords in the PROPS section that determine the method used to generate the thee phase water relative permeability curves. SWF32D allows for the direct input of the three phase tables, as such the STONE1 and STONE2 keywords should not be entered if SWF32D is used in the input deck.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.298 SWFN – WATER SATURATION TABLES (FORMAT TYPE 2)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SWFN keyword defines the water relative permeability and water-oil capillary pressure data versus water saturation tables for when water is present in the input deck. This keyword should only be used if water is present in the run.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWAT	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the water saturation.			
		dimensionless	dimensionless	dimensionless	None
2	KRW	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the water relative permeability with respect to gas saturation. The first value in the column should be zero.			
		dimensionless	dimensionless	dimensionless	None
3	PCWO	A columnar vector of real values that are either equal or increasing down the column that defines the water-oil relative capillary pressure. If the SWATINIT keyword has been used to initialize the model then columnar vector has to be strictly monotonically increasing.			
		psia	bars	atm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.155: SWFN Keyword Description

Example

```
--
--        WATER RELATIVE PERMEABILITY TABLES (SWFN)
--
SWFN
--        SWAT        KRW         PCOW
--        FRAC        FRAC        PSIA
--        --------    --------    -------
             0.15      0.00000      1*
             0.20      6.25e-6      1*
             0.25      0.00010      1*
             0.30      0.00050      1*
             0.35      0.00160      1*
             0.40      0.00390      1*
             0.45      0.00810      1*
             0.50      0.01500      1*
             0.55      0.02560      1*
             0.60      0.04100      1*
             0.65      0.06250      1*
             0.70      0.09150      1*
             0.75      0.12960      1*
             0.80      0.17850      1*
             0.85      0.24010      1*
             0.90      0.31640      1*
             0.95      0.40960      1*
             1.00      0.52200      1*                        / TABLE NO. 1
--        --------    --------    -------
             0.15      0.00000      1*
             0.20      6.25e-6      1*
             0.25      0.00010      1*
             0.30      0.00050      1*
             0.35      0.00160      1*
             0.40      0.00390      1*
             0.45      0.00810      1*
             0.50      0.01500      1*
             0.55      0.02560      1*
             0.60      0.04100      1*
             0.65      0.06250      1*
             0.70      0.09150      1*
             0.75      0.12960      1*
             0.80      0.17850      1*
             0.85      0.24010      1*
             0.90      0.31640      1*
             0.95      0.40960      1*
             1.00      0.52200      1*                        / TABLE NO. 2
```

The example defines two SWFN tables for use when water is present in the run. In the tables the water-oil capillary pressure data has been defaulted with "1*" and will be set to zero as there are no other values for the water-oil capillary pressure columns.

8.3.299 SWL – END-POINT SCALING GRID CELL CONNATE WATER SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SWL defines the connate water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The connate water saturation is defined as the minimum water saturation in a two-phase water relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWL	SWL is an array of real numbers assigning the connate water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.15			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the connate gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the SWLX± , SWLY± and SWZ± series of keyword should be used.

2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.

3) The keyword is terminated by "/".

Table 8.156: SWL Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWLX, SWLY and SWLZ instead of SWL. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWLX, SWLX-, SWLY, SWLY-, SWLZ and SWLZ-, instead of the SWL keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SWL DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SWL
          300*0.150                                                    /
```

The above example defines a constant connate water saturation of 0.15 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.300 SWLPC – END-POINT SCALING GRID CELL CAPILLARY PRESSURE CONNATE WATER SATURATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SWLPC defines the connate water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The connate water saturation is defined as the minimum water saturation in a two-phase water relative permeability table. The keyword only applies the scaling to the drainage capillary pressures tables, unlike the SWL keyword that applies the scaling to both the capillary pressure and relative permeability tables. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWLPC	SWLPC is an array of real numbers assigning the connate water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. If SWLPC is omitted from the input deck the values will be defaulted to those on the SWL series of keywords. If the SWL series of keywords are missing from the input deck then the values are taken from the cell allocated capillary pressure table. Repeat counts may be used, for example 30*0.03			Taken from SGL or from the cell allocated capillary pressure table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the connate gas saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the SWLX± , SWLY± and SWZ± series of keyword should be used.

2) The keyword is terminated by "/".

Table 8.157: SWLPC Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWLX, SWLY and SWLZ instead of SWL or SWLPC. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWLX, SWLX-, SWLY, SWLY-, SWLZ and SWLZ-, instead of the SWL or SWLPC keywords.

Missing Some Functionality - Use with Caution.

Example

```
--
--       DEFINE GRID BLOCK END-POINT SWLPC DATA FOR ALL CELLS
--       (FOR NX x NY x NZ = 300)
--
SWLPC
         300*0.150                                                    /
```

The above example defines a constant connate water saturation of 0.15 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.301 SWOF – WATER-OIL SATURATION TABLES (FORMAT TYPE 1)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SWOF keyword defines the water and oil relative permeability and water-oil capillary pressure data versus water saturation tables for when water and oil are present in the input deck. This keyword should only be used if water and oil present in the run.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWAT	A columnar vector of real monotonically increasing down the column values starting from zero and terminating at one, that defines the water saturation. The first entry is the connate water saturation Swc and the last entry should be 1.0.			
		dimensionless	dimensionless	dimensionless	None
2	KRW	A columnar vector of real values that are either equal or increasing down the column and that are greater than or equal to zero and less than or equal to one that defines the water relative permeability with respect to gas saturation. The first value in the column should be zero.			
		dimensionless	dimensionless	dimensionless	None
3	KRO	A columnar vector of real values that are either equal or decreasing down the column and that are greater than or equal to zero and less than or equal to one that defines the oil relative permeability with respect to oil and water saturation. When gas is active in the run, the first entry the column, that is at krow(So = 1-Swc), must be the same as the first entry in the corresponding SGOF or SLGOF table, that is at krog(Sg = 0). The first value in the column should be one.			
		dimensionless	dimensionless	dimensionless	None
4	PCWO	A columnar vector of real values that are either equal or increasing down the column that defines the water-oil relative capillary pressure. If the SWATINIT keyword has been used to initialize the model then columnar vector has to be strictly monotonically increasing.			
		psia	bars	atm	None

Notes:

1) The keyword is followed by NTSFUN tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NSSFUN rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.158: SWOF Keyword Description

Example

```
--
--        WATER-OIL RELATIVE PERMEABILITY TABLES (SWOF)
--
SWOF
--        SWAT       KRW       KROW      PCOW
--        FRAC                           PSIA
--        --------   --------  -------   -------
          0.200000   0.0000    0.9000    0.000000
          0.238616   0.0002    0.7664    0.000000
          0.245309   0.0004    0.7443    0.000000
          0.261989   0.0010    0.6907    0.000000
          0.303091   0.0044    0.5671    0.000000
          0.368269   0.0191    0.3962    0.000000
          0.435026   0.0519    0.2528    0.000000
          0.486387   0.0940    0.1643    0.000000
          0.522283   0.1339    0.1137    0.000000
          0.550683   0.1725    0.0803    0.000000
          0.575342   0.2115    0.0559    0.000000
          0.599076   0.2542    0.0367    0.000000
          0.621294   0.2991    0.0223    0.000000
          0.642171   0.3458    0.0120    0.000000
          0.658984   0.3868    0.0061    0.000000
          0.671123   0.4183    0.0030    0.000000
          0.679268   0.4403    0.0015    0.000000
          0.684963   0.4562    0.0008    0.000000
          0.688893   0.4674    0.0004    0.000000
          0.692025   0.4765    0.0002    0.000000
          0.694641   0.4841    0.0001    0.000000
          0.696976   0.4910    0.0000    0.000000
          0.699099   0.4973    0.0000    0.000000
          0.700000   0.5000    0.0000    0.000000
          1.000000   0.9000    0.0000    0.000000          / TABLE NO. 01--
--        --------   --------  -------   -------
          0.200000   0.0000    0.9000    0.000000
          0.238616   0.0002    0.7664    0.000000
          0.245309   0.0004    0.7443    0.000000
          0.261989   0.0010    0.6907    0.000000
          0.303091   0.0044    0.5671    0.000000
          0.368269   0.0191    0.3962    0.000000
          0.435026   0.0519    0.2528    0.000000
          0.486387   0.0940    0.1643    0.000000
          0.522283   0.1339    0.1137    0.000000
          0.550683   0.1725    0.0803    0.000000
          0.575342   0.2115    0.0559    0.000000
          0.599076   0.2542    0.0367    0.000000
          0.621294   0.2991    0.0223    0.000000
          0.642171   0.3458    0.0120    0.000000
          0.658984   0.3868    0.0061    0.000000
          0.671123   0.4183    0.0030    0.000000
          0.679268   0.4403    0.0015    0.000000
          0.684963   0.4562    0.0008    0.000000
          0.688893   0.4674    0.0004    0.000000
          0.692025   0.4765    0.0002    0.000000
          0.694641   0.4841    0.0001    0.000000
          0.696976   0.4910    0.0000    0.000000
          0.699099   0.4973    0.0000    0.000000
          0.700000   0.5000    0.0000    0.000000
          1.000000   0.9000    0.0000    0.000000          / TABLE NO. 01
```

The example defines two SWFN tables for use when water and oil are present in the run. In the tables the water-oil capillary pressure data has been set to zero.

8.3.302 SWU – END-POINT SCALING GRID CELL MAXIMUM WATER SATURATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SWU defines the maximum water saturation for all the cells in the model via an array when the end-point scaling option has been invoked via the ENDSCALE keyword in the RUNSPEC section. The maximum water saturation is defined as the maximum water saturation in a two-phase water relative permeability table.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWU	SWU is an array of real numbers assigning the maximum water saturation values to each cell in the model. The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword. Repeat counts may be used, for example 30*0.70			Taken from cell allocated relative permeability table.
		dimensionless	dimensionless	dimensionless	

Notes:

1) Note this the directional independent version of the maximum water saturation array used with the end-point scaling option. If directional end-point scaling has been activated then the SWUX± , SWUX± and SWU± series of keyword should be used.
2) If the value for a cell has been defaulted then OPM Flow users the value from the cell's relative permeability table.
3) The keyword is terminated by "/".

Table 8.159: SWU Keyword Description

End-point scaling allows the entered relative permeability functions to be re-scaled based on the saturation end-points allocated to each cell by the SWL, SWCR, SWU, SGL, SGCR, SGU, SOWCR, and SOGCR saturation grid arrays for the saturation end-points, and the KRG, KROG, KROW and KRW relative permeability grid cell arrays for the relative permeability end-point data. In addition end-point scaling may be directional dependent in which case the directional dependent versions of the aforementioned arrays should be used, that is SWUX, SWUY and SWUZ instead of SWU. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is SWUX, SWUX-, SWUY, SWUY-, SWUZ and SWUZ-, instead of the SWU keyword.

Example

```
--
--        DEFINE GRID BLOCK END-POINT SWU DATA FOR ALL CELLS
--        (FOR NX x NY x NZ = 300)
--
SWU
          300*0.700                                                    /
```

The above example defines a constant connate gas saturation of 0.70 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.303 TEMPNODE - Temperature Table for Polymer Solution Viscosity

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the reservoir temperature table used to calculate the polymer solution viscosity when the temperature option has been activated by the TEMP keyword in the RUNSPEC section in the commercial simulator. Naturally, the polymer option must also be activated by the POLYMER keyword in the RUNSPEC section in order to use this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.304 TEMPTVD – Activate Temperature Flux Limited Transport Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TEMPTVD activates the Temperature Flux Limited Transport option in the commercial simulator, to reduce numerical dispersion for when either the TEMP or THERMAL keywords in the RUNSPEC section have been declared.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.305 TLMIXPAR – DEFINE THE MISCIBLE TODD-LONGSTAFF MIXING PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TLMIXPAR keyword defines the Todd-Longstaff[118] mixing parameters, for when either the miscible or solvent options have been activated by the MISCIBLE or SOLVENT keyword in the RUNSPEC section. This keyword must be present in the input deck if the MISCIBLE or SOLVENT keywords have been activated.

Note that If the POLYMER option has been activated by the POLYMER keyword in the RUNSPEC section, then this keyword is ignored and the mixing parameters are taken from the PLMIXPAR keyword instead.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TLMVIS	A real positive value that is greater than or equal to zero and less than or equal to one, that defines the viscosity Todd-Longstaff mixing parameter for each miscibility region.			
		dimensionless	dimensionless	dimensionless	None
2	TLMDEN	A real positive value that is greater than or equal to zero and less than or equal to one, that defines the density Todd-Longstaff mixing parameter for each miscibility region.			The same value as entered for TLMVIS
		dimensionless	dimensionless	dimensionless	

Notes:

1) The keyword is followed by NTMISC tables as declared on the MISCIBLE keyword in the RUNSPEC section, for each rock region. There should be only one row per table.

2) Each entry is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.160: TLMIXPAR Keyword Description

Example

```
--
--       TODD-LONGSTAFF MIXING PARAMETERS
--
TLMIXPAR
--       TLM        TLM
--       VISCOS     DENSITY
--       -------    --------
         0.3500      0.3500                                  / TABLE NO. 01
         0.2500      1*                                      / TABLE NO. 02
         0.6500      0.7500                                  / TABLE NO. 03
```

The above example defines three Todd-Longstaff mixing parameter data sets, based on the NTMISC variable on the MISCIBLE keyword in the RUNSPEC section being equal to three.

[118] *Todd, M. and Longstaff, W. "The Development, Testing and Application of a Numerical Simulator for Predicting Miscible Flood Performance," paper SPE 3484, Journal of Canadian Petroleum Technology (1972) 24, No. 7, 874-882.*

8.3.306 TOLCRIT – DEFINE THE CRITICAL SATURATION TOLERANCE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Critical fluid saturations are determine from the relative permeability tables, that is the last saturation in a relative permeability table where the relative permeability of a phase is set equal to zero. Since floating-point numbers (as implemented in computers) are never exact, one cannot compare floating point numbers for exact equality. Thus, this keywords defines a value below which is considered equivalent to zero in determining the critical saturation for a phase.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TOLCRIT	TOLCRIT is a real positive number greater than zero and less than one that defines the critical saturation tolerance used to determine the critical saturation of a fluid in the relative permeability tables. The default value of 1×10^{-6} means that saturation values less than this value will be treated as being equal to zero.			
		dimensionless	dimensionless	dimensionless	1×10^{-6}

Notes:

1) The keyword is terminated by "/".

Table 8.161:TOLCRIT Keyword Description

See also section *8.2.2 Saturation Tables (Relative Permeability and Capillary Pressure Tables)* for a description of the relative permeability tables and the various end-point definitions, including oil, water and gas critical saturations.

Example

```
---
--       SET THE CRITICAL SATURATION TOLERANCE
--
TOLCRIT
         1.0E-6                                                                  /
```

The above example defines the critical saturation tolerance to be the default value of 1×10^{-6}.

8.3.307 TPAMEPS – VOLUMETRIC STRAIN VERSUS COAL GAS CONCENTRATION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TPAMEPS defines the volumetric strain versus coal gas concentration tables, for when the Coal Bed Methane option has been activated via the COAL keyword, and PALM-MAN has been declared for the ROCKOPT variable on the ROCKCOMP keyword; both keywords are in the RUNSPEC section. The Palmer-Mansoorii[119] and [120] rock model is used to calculate the impact on pore volume and permeability due to rock compaction.

See also the ROCKPARMA keyword in the PROPS section that defines the Palmer-Mansoori parameters.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[119] *Palmer, I. and Mansoori, J. "How Permeability Depends on Stress and Pore Pressure in Coalbeds: A New Model," paper SPE 52607, SPE Reservoir Evaluation & Engineering (1998) 1, No. 6, 539-544.*

[120] *Clarkson, C.R., Pan, Z., Palmer, I. and Harpalani, S. "Predicting Sorption-Induced Strain and Permeability Increase With Depletion for Coalbed-Methane Reservoirs", SPE 114778-PA, SPE Journal (2010) 15, No. 1, 152–159.*

8.3.308 TPAMEPSS - Volumetric Strain versus Coal Solvent Concentration Tables

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TPAMEPSS defines the volumetric strain versus coal solvent concentration tables, for when the Coal Bed Methane option has been activated via the COAL keyword, and PALM-MAN has been declared for the ROCKOPT variable on the ROCKCOMP keyword; both keywords are in the RUNSPEC section. The Palmer-Mansoorii[121] and [122] rock model is used to calculate the impact on pore volume and permeability due to rock compaction.

See also the ROCKPARMA keyword in the PROPS section that defines the Palmer-Mansoori parameters.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[121] *Palmer, I. and Mansoori, J. "How Permeability Depends on Stress and Pore Pressure in Coalbeds: A New Model," paper SPE 52607, SPE Reservoir Evaluation & Engineering (1998) 1, No. 6, 539-544.*

[122] *Clarkson, C.R., Pan, Z., Palmer, I. and Harpalani, S. "Predicting Sorption-Induced Strain and Permeability Increase With Depletion for Coalbed-Methane Reservoirs", SPE 114778-PA, SPE Journal (2010) 15, No. 1, 152–159.*

8.3.309 TRACER – DEFINE PASSIVE TRACER VARIABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TRACER keyword defines a series of passive tracers that are associated with a phase (oil, water, or gas) in the model. The maximum number of tracers for each phase are declared on the TRACERS keyword in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NAME	A three letter character string defining the tracer's name. Note it is best to void names beginning with the letters F, S, and T as these names may create naming issues in post-processing software.			None
2	PHASE	A three letter character string that defines the tracer given by NAME to a particular fluid phase. The character should be set to OIL, WAT or GAS.			None
3	UNITS	The units for the tracer. This should be the same as the PHASE in the model.			Same as the phases in the model
		Liquid: stb Gas: Mscf	Liquid: sm^3 Gas: sm^3	Liquid: scc Gas: scc	
4	SOLPHASE	A three or four letter character string defining the partitioned tracer's solution phase. The character string should be set to OIL, WAT, GAS or MULT. Note that SOLPHASE only needs to be defined if the partitioned tracer option has been activate with the PARTTRAC keyword in the RUNSPEC section.			None
5	KPNUM	The table number to be used with the partitioned tracers defined by the PARTTRAC, TRACERKP and TRACERKM keywords. Note that KPNUM only needs to be defined if the partitioned tracer option has been activate with the PARTTRAC keyword in the RUNSPEC section.			None
6	PARPHASE	A three letter character string defining the phase used for the adsorption calculation for when the MULT option has been for SOLPHASE. The character string should be set to OIL, WAT, GAS or ALL. Note that PARPHASE only needs to be defined if the partitioned tracer option has been activate with the PARTTRAC keyword in the RUNSPEC section.			None

Notes:

1) Each record (or row) should be terminated by a "/" and the keyword is terminated by "/".

Table 8.162: TRACER Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       DEFINE TRACER NAMES
--
--       TRACER   TRACER
--       NAME     PHASE
--       ------   ------
TRACER
        'IGS'     'GAS'                                    / GAS INJECTOR
        'DGS'     'GAS'                                    / DISOLVED GAS
        'IW1'     'WAT'                                    / WAT INJECTOR 1
        'Iw2'     'WAT'                                    / WAT INJECTOR 2
/
```

The above example defines four passive tracers one for a gas injection well, one for tracking the dissolved gas, and two to track the injected water from two water injection wells.

8.3.310 TRACERKM – MULTI-PARTITIONED TRACER OPTION K(P) TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, TRACERKM, defines the Multi-Partitioned Tracer option K(P) tables, for when the Partitioned Tracer option has been activate with the PARTTRAC keyword in the RUNSPEC section, and the SOLPHASE parameter on the TRACER keyword in the PROPS section has been set to MULT to activate the Multi-Partitioned Tracer option. Multi-partitioned tracers can partition into any number of phases (oil, water, gas etc.) and have adsorption, decay and diffusion parameters specific to each phase; whereas the standard partitioned tracers only have a "free" and "solution" phases. For the TRACERKM keyword the K(P) tables relate the ratio of the reference phase to the other phases versus pressure. So for example, given a multi-partitioned tracer in oil, water and gas, with the water phase acting as the reference phase, then TRACERKM would consist of columnar vectors of:

$$K_{ow}(P) = \frac{C_{oil}}{C_{water}} \quad \text{and} \quad K_{gw}(P) = \frac{C_{gas}}{C_{water}} \tag{8.27}$$

Where:

$K_{ow}(P)$ = multi-partitioned oil-water K(P)
$K_{gw}(P)$ = multi-partitioned gas-water K(P)
C_{oil} = oil concentration
C_{gas} = gas concentration
C_{water} = water concentration

See also the TRACERKP keyword in the PROPS section that provides similar data for standard partitioned tracers.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.311 TRACERKP – STANDARD PARTITIONED TRACER OPTION K(P) TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, TRACERKP, defines the Standard Partitioned Tracer option K(P) tables, for when the Partitioned Tracer option has been activate with the PARTTRAC keyword in the RUNSPEC section. Standard partitioned tracers only have a "free" and "solution" phases; whereas, Multi-partitioned tracers can partition into any number of phases (oil, water, gas etc.) and have adsorption, decay and diffusion parameters specific to each phase. For the TRACERKP keyword the K(P) tables relate the ratio of the reference phase (the "free" phase) to the solution phase versus pressure. So for example, given a standard partitioned tracer in oil and gas, with the oil phase acting as the reference phase, then TRACERKP would consist of columnar vectors of:

$$K(P) = \frac{C_{gas}}{C_{oil}} \tag{8.28}$$

Where:

K(P) = standard partitioned K(P)
C_{oil} = oil concentration
C_{gas} = gas concentration

See also the TRACERKM keyword in the PROPS section that provides similar data for tmulti-partitioned tracers.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.312 TRACITVD – Activate and Define Tracer Implicit Flux Limited Transport Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TRACITVD activates the Tracer Implicit Flux Limited Transport option and sets various parameters for this option. Basically the option is used to control numerical dispersion for tracers. Both the TRACERS keyword in the RUNSPEC section and the TRACER keyword in the PROPS section must be declared to activate tracers and to define the tracers.

See also the TRACTVD keyword in the PROPS section activates the Tracer Explicit Flux Limited Transport option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.313 TRACTVD – Activate Tracer Explicit Flux Limited Transport Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TRACTVD activates the Tracer Explicit Flux Limited Transport option. Basically the option is used to control numerical dispersion for tracers. Both the TRACERS keyword in the RUNSPEC section and the TRACER keyword in the PROPS section must be declared to activate tracers and to define the tracers.

See also the TRACITVD keyword in the PROPS section activates the Tracer Implicit Flux Limited Transport option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.314 TRADS – ENVIRONMENTAL TRACER ADSORPTION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, TRADS, specifies the environmental tracer adsorption tables that describe how a tracer is absorbed by the surrounding rock, for when the MXENVTR parameter has been set to greater than zero on the TRACERS keyword in the RUNSPEC section to activate environmental tracers. The keyword can only be used with environmental tracers.

Unlike other keywords, the TRADS keyword must be concatenated with the three character name of the tracer declared by TRACER keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.315 TRDCY – ENVIRONMENTAL TRACER DECAY TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, TRDCY, specifies the environmental tracer decay tables that specifies the tracer decay half-life, for when the MXENVTR parameter has been set to greater than zero on the TRACERS keyword in the RUNSPEC section to activate environmental tracers. The keyword can only be used with environmental tracers.

Unlike other keywords, the TRSCY keyword must be concatenated with the three character name of the tracer declared by TRACER keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.316 TRDIF – TRACER DIFFUSION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, TRDIF, specifies the tracer diffusion tables that specify the diffusion coefficient for a tracer. The keyword can be used with Environmental Tracers if the MXENVTR parameter has been set greater than zero on the TRACERS keyword in the RUNSPEC section. When used with a Standard Partitioned Tracer the diffusion coefficient applies to the solution phase, whereas as for a Multi-Partitioned Tracer the diffusion coefficient can be entered for each defined tracer phase. Unlike other keywords, the TRADS keyword must be concatenated with the three character name of the tracer declared by TRACER keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.317 TRDIS – Tracer Dispersion Table Number Allocation

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, TRDIS, specifies the tracer diffusion tables that should be allocated to a tracer, the actual dispersion tables are specified by the DISPERSE keyword in the PROPS section. The keyword can be used with Environmental Tracers if the MXENVTR parameter has been set greater than zero on the TRACERS keyword in the RUNSPEC section. The option does not work with two-phase Standard Partitioned Tracers and Multi-Partitioned Tracers. Unlike other keywords, the TRADS keyword must be concatenated with the three character name of the tracer declared by TRACER keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.318 TRNHD – Activate Dispersion Non-Homogeneous Diffusion Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TRNHD keyword activates the Dispersion Non-Homogeneous Diffusion option for when tracer dispersion is independent of velocity or tracer concentration. Unlike other keywords, the TRNHD keyword must be concatenated with the name of the tracer declared by TRACER keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.319 TRROCK – Environmental Tracer-Rock Property Data

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, TRROCK, specifies the environmental tracer rock data for the tracer adsorption model, for when the MXENVTR parameter has been set to greater than zero on the TRACERS keyword in the RUNSPEC section to activate environmental tracers. The keyword can only be used with environmental tracers.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.320 TZONE – END-POINT SCALING TRANSITION ZONE OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TZONE keyword sets the transition end-point scaling options for the oil, water and gas phases, for when the End-Point Scaling option has been activated by the ENDSCALE keyword in the RUNSPEC section. The keyword determines if the phase critical saturation should or should not be set to the initial immobile saturation in areas where the initial saturation is below the entered critical saturation.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	OILZONE	OILZONE is a single character that sets the oil phase transition zone end-point scaling option and should be set to either T or F: 1) T: for true, results in the SOWCR values being adjusted to the initial immobile saturation for oil-water or oil-water-miscible gas simulations. For oil-gas simulations the SOGCR values are modified to be the initial immobile saturation. The modifications only occur in cells where the initial saturation is below the entered critical saturation. 2) F: for false, means the critical saturations are not modified.	F
2	WATZONE	WATZONE is a single character that sets the water phase transition zone end-point scaling option and should be set to either T or F: 1) T: for true, results in the SWCR values being adjusted to the initial immobile saturations. The modifications only occur in cells where the initial saturation is below the entered critical saturation values (SWCR). 2) F: for false, means the critical saturations are not modified.	F
3	GASZONE	GASZONE is a single character that sets the gas phase transition zone end-point scaling option and should be set to either T or F: 1) T: for true, results in the SGCR values being adjusted to the initial immobile saturation for oil-gas or gas-water simulations. The modifications only occur in cells where the initial saturation is below the entered critical saturation (SGCR). 2) F: for false, means the critical saturations are not modified.	F
Notes: 1) The keyword is terminated by "/".			

Table 8.163: TZONE Keyword Description

See also the SCALECRS keyword in the PROPS section that sets the end-point scaling option to be either two-point or three-point scaling.

Example

```
--
--       END-POINT SCALING TRANSITION ZONE OPTIONS
--
--       OILZONE  WATZONE  GASZONE
--       -------  -------  -------
TZONE
         F        T        F                                / SCALING OPTION
```

The above example results in the SWCR values being adjusted to the initial immobile saturations.

8.3.321 VDFLOW – VELOCITY DEPENDENT FLOW COEFFICIENT FOR GRID BLOCK FLOW (GRID)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

VDFLOW activates non-Darcy flow between grid blocks and defines a constant non-Darcy flow coefficient for the whole grid, the coefficient only applies to the gas phase. The coefficient is normally derived from well tests or calculated analytically based on the coefficient of inertial resistance, usually known as β, in Forchheimer's flow equation[123, 124 and 125]. Dake[126], in chapter eight, reports a typical value of β to be 10.0^7 cm^{-1}.

See also the VDFLOWR keyword in the PROPS section that allows the non-Darcy coefficient to be entered for individual regions, and the WDFAC and WDFACCOR keywords in the SCHEDULE section that assigns the non-Darcy coefficient to well connections.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[123] *Geertsma, J., 1974. Estimating the Coefficient of Inertial Resistance in Fluid Flow Through Porous Media. Soc.Pet.Eng.J., October: 445-450.*

[124] *Gewers, C.W.W. and Nichol, L.R., 1969. Gas Turbulence Factor in a Microvugular Carbonate. J.Can.Pet.Tech., April.*

[125] *Wong, S.W., 1970. Effects of Liquid Saturation on Turbulence Factors for Gas Liquid Systems. J.Can.Pet.Tech., October*

[126] *Dake, L.P. Fundamentals of Reservoir Engineering, Amsterdam, The Netherlands, Elsevier Science BV (1978) Chapter 8.6, pages 252-257.*

8.3.322 VDFLOWR – VELOCITY DEPENDENT FLOW COEFFICIENT FOR GRID BLOCK FLOW (REGION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

VDFLOW activates non-Darcy flow between grid blocks and defines a constant non-Darcy flow coefficient for individual regions allocated by the SATNUM keyword in the REGIONS section. Note that the coefficient only applies to the gas phase. The coefficient is normally derived from well tests or calculated analytically based on the coefficient of inertial resistance, usually known as β, in Forchheimer's flow equation[127, 128 and 129]. Dake[130], in chapter eight, reports a typical value of β to be 10.0^7 cm^{-1}.

See also the VDFLOW keyword in the PROPS section that allows the non-Darcy coefficient to be entered for the whole grid, and the WDFAC and WDFACCOR keywords in the SCHEDULE section that assigns the non-Darcy coefficient to well connections.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[127] *Geertsma, J., 1974. Estimating the Coefficient of Inertial Resistance in Fluid Flow Through Porous Media. Soc.Pet.Eng.J., October: 445-450.*

[128] *Gewers, C.W.W. and Nichol, L.R., 1969. Gas Turbulence Factor in a Microvugular Carbonate. J.Can.Pet.Tech., April.*

[129] *Wong, S.W., 1970. Effects of Liquid Saturation on Turbulence Factors for Gas Liquid Systems. J.Can.Pet.Tech., October*

[130] *Dake, L.P. Fundamentals of Reservoir Engineering, Amsterdam, The Netherlands, Elsevier Science BV (1978) Chapter 8.6, pages 252-257.*

8.3.323 VEFRAC – VERTICAL EQUILIBRIUM RELATIVE PERMEABILITY FRACTION (GRID)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the Vertical Equilibrium ("VE") relative permeability weighting factor (α) used to calculate the VE relative permeability curves to be used in the simulation, for when the VE option has been activated by the VE keyword in the RUNSPEC section. If α = 1.0, then the VE model calculated relative permeability curves will be used, and if α = 0.0, then the curves entered via the SWOF, SGOF, SLGOF series of keywords or the SWFN, SGFN, SGWFN, SOF2, SOF3, SOF32D series of keywords, will be used. A value of α between zero and one will result in weighted average relative permeability curves being employed, that is:

$$VE_{(average)} = (1.0 - \alpha) \times (SATNUM_{curves}) + \alpha \times (VE\ Model_{curves}) \quad \textbf{(8.29)}$$

Note that VEFRAC sets α for the whole grid; whereas, the VEFRACV keyword in the PROPS section assigns α on a cell by cell basis, See also the VEFRACP and VEFRACPV keywords that apply the weighting factors to the capillary pressure data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.324 VEFRACP – Vertical Equilibrium Capillary Pressure Fraction (Grid)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the Vertical Equilibrium ("VE") capillary pressure weighting factor (α) used to calculate the VE capillary pressure curves to be used in the simulation, for when the VE option has been activated by the VE keyword in the RUNSPEC section. If α = 1.0, then the VE model calculated capillary pressure curves will be used, and if α = 0.0, then the curves entered via the SWOF, SGOF, SLGOF series of keywords or the SWFN, SGFN, SGWFN, SOF2, SOF3, SOF32D series of keywords, will be used. A value of α between zero and one will result in weighted average capillary pressure curves being employed, that is:

$$VE_{(average)} = (1.0 - \alpha) \times (SATNUM_{curves}) + \alpha \times (VE\ Model_{curves}) \quad \textbf{(8.30)}$$

Note that VEFRACP sets α for the whole grid; whereas, the VEFRACPV keyword in the PROPS section assigns α on a cell by cell basis, See also the VEFRAC and VEFRACV keywords that apply the weighting factors to the relative permeability data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.325 VEFRACPV – Vertical Equilibrium Capillary Pressure Fraction (Cell)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the Vertical Equilibrium ("VE") capillary pressure weighting factor (α) used to calculate the VE capillary pressure curves to be used in the simulation, for when the VE option has been activated by the VE keyword in the RUNSPEC section. If α = 1.0, then the VE model calculated capillary pressure curves will be used, and if α = 0.0, then the curves entered via the SWOF, SGOF, SLGOF series of keywords or the SWFN, SGFN, SGWFN, SOF2, SOF3, SOF32D series of keywords, will be used. A value of α between zero and one will result in weighted average capillary pressure curves being employed, that is:

$$VE_{(average)} = (1.0 - \alpha) \times (SATNUM_{curves}) + \alpha \times (VE\ Model_{curves}) \quad \textbf{(8.31)}$$

Note that VEFRACPV sets α on a cell by cell basis; whereas, the VEFRACP keyword in the PROPS section assigns α for the whole grid, See also the VEFRAC and VEFRACV keywords that apply the weighting factors to the relative permeability data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.326 VEFRACV – VERTICAL EQUILIBRIUM RELATIVE PERMEABILITY FRACTION (CELL)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the Vertical Equilibrium ("VE") relative permeability weighting factor (α) used to calculate the VE relative permeability curves to be used in the simulation, for when the VE option has been activated by the VE keyword in the RUNSPEC section. If α = 1.0, then the VE model calculated relative permeability curves will be used, and if α = 0.0, then the curves entered via the SWOF, SGOF, SLGOF series of keywords or the SWFN, SGFN, SGWFN, SOF2, SOF3, SOF32D series of keywords, will be used. A value of α between zero and one will result in weighted average relative permeability curves being employed, that is:

$$VE_{(average)} = (1.0 - \alpha) \times (SATNUM_{curves}) + \alpha \times (VE\ Model_{curves}) \quad \textbf{(8.32)}$$

Note that VEFRACVV sets α on a cell by cell basis; whereas, the VEFRAC keyword in the PROPS section assigns α for the whole grid, See also the VEFRACP and VEFRACPV keywords that apply the weighting factors to the capillary pressure data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

8.3.327 VISCREF - DEFINE VISCOSITY-TEMPERATURE REFERENCE CONDITIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

VISCREF defines the reference conditions for the viscosity-temperature tables, GASVISCT, OILVISCT and WATVISCT, for when the thermal option has been activated by THERMAL keyword in the RUNSPEC section. This keyword can only be used if the thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRES	PRES is a real positive number defining the reference pressure for the viscosity and temperature tables			None
		psia	barsa	atma	
2	RS	RS is a real positive number defining the reference gas-oil ratio for when the model contains gas dissolved as activated by the DISGAS keyword in the RUNSPEC section			None
		Mscf/stb	sm^3/sm^3	scc/scc	
3	API	API is a real number defining the oil API for when the API tracking option has been invoked by the API keyword in the RUNSPEC section. Note that OPM Flow does not support API tracking, and therefore this variable is ignored.			None
		°API	°API	°API	

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.164:VISCREF Keyword Description

OPM Flow currently does not support API tracking and therefore item (3) of this keyword is ignored. See also the OILVISCT, GASVISCT and WATVISCT keywords in the PROPS section.

Example

The following example shows the VISCREF keyword for when the thermal option has been activated by the TEMP keyword in the RUNSPEC section and for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to five.

```
--
--        REF         REF        REF
--        PRESSURE    GOR        API
--        --------    -------    -------
VISCREF
           3000.0     0.500                                  / TABLE NO. 01
           3200.0     0.550                                  / TABLE NO. 02
           3300.0     0.580                                  / TABLE NO. 03
           3400.0     0.620                                  / TABLE NO. 04
           3500.0     0.625                                  / TABLE NO. 05
```

There is no terminating "/" for this keyword.

8.3.328 WAGHYSTR – DEFINE WATER-ALTERNATING-GAS HYSTERESIS PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the parameters for the Water-Alternating-Gas ("WAG") hysteresis option, for when the hysteresis option has been activated by the WAGHYSTR variable on the SATOPTS keyword in the RUNSPEC section.

The WAG recovery mechanism is an Enhanced Oil Recovery ("EOR") process to optimize oil recovery by improving volumetric sweep efficiency. It was originally proposed as a method to improve the sweep efficiency of gas by using water to control the mobility ratio and to stabilize the front (Caudle and Dyes, 1958[131]; Christensen et al., 1998[132]; and Christensen et al., 2001[133]). WAG injection can lead to improved oil recovery by combining better mobility control and contacting upswept zones, and by leading to improved microscopic displacement. Although initially the inject gas was immiscible with respect to the oil (WAG Immiscible) the more common process is WAG Miscible, with alternating different types of hydrocarbon gases and non-hydrocarbon gases, such as N_2 and CO_2 Gases. WAG flooding has been successfully applied to various fields worldwide.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[131] *Caudle, B. H., & Dyes, A. B. (1958, January 1). Improving Miscible Displacement by Gas-Water Injection. Society of Petroleum Engineers.*

[132] *Christensen, J. R., Stenby, E. H., & Skauge, A. (1998, January 1). Review of WAG Field Experience. Society of Petroleum Engineers. doi:10.2118/39883-MS.*

[133] *Christensen, J. R., Stenby, E. H., & Skauge, A. (2001, April 1). Review of WAG Field Experience. Society of Petroleum Engineers. doi:10.2118/71203-PA.*

8.3.329 WATDENT – DEFINE WATER DENSITY TEMPERATURE COEFFICIENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WATDENT defines the water density as a function of temperature coefficients for when the thermal option has been activated by the THERMAL keyword in the RUNSPEC. The reference pressure for this table is given by the VISCREF keyword in the PROPS section.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	TEMP is a real positive value greater than zero that defines the absolute reference temperature used with TEXP1 and TEXP2 to estimate the change in water density with respect to temperature.			
		°R 527.67	°K 293.15	°K 293.15	Defined
2	TEXP1	TEXP1 is a real positive value greater than zero that defines the water thermal expansion coefficient of the first order.			
		1/°R 1.67×10^{-4}	1/°K 3.0×10^{-4}	1/°K 3.0×10^{-4}	Defined
3	TEXP2	TEXP2 is a real positive value greater than zero that defines the water thermal expansion coefficient of the second order.			
		$1/°R^2$ 9.26×10^{-7}	$1/°K^2$ 3.0×10^{-6}	$1/°K^2$ 3.0×10^{-6}	Defined

Notes:

1) The keyword is followed by NTPVT records as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each data set is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.165: WATDENT Keyword Description

Example

The following example shows the WATDENT keyword using the default values, for when the thermal option has been activated by the THERMAL keyword in the RUNSPEC section and for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to two.

```
--
--       WATER DENSITY TEMPERATURE COEFFICIENTS (OPM FLOW EXTENSION KEYWORD)
--
--       WATER      DENSITY   DENSITY
--       TEMP       COEFF1    COEFF2
--       --------   -------   -------
WATDENT
         1*         1*        1*                          / TABLE NO. 01
         1*         1*        1*                          / TABLE NO. 02
```

There is no terminating "/" for this keyword.

8.3.330 WATVISCT – DEFINE WATER VISCOSITY VERSUS TEMPERATURE FUNCTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WATVISCT defines the water viscosity as a function of temperature for when thermal option has been activated by the THERMAL keywords in the RUNSPEC. The reference pressure for this table is given by the VISCREF keyword in the PROPS section.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMP	A columnar vector of real monotonically increasing down the column values that defines the temperature values.			
		°F	°C	°C	None
2	VIS	A columnar vector of real decreasing down the column values that defines the water viscosity for the corresponding temperature values (TEMP). VIS should be given at the reference pressure defined by the PRESS variable on the VISCREF keyword.			
		cP	cP	cP	None

Notes:

1) The keyword is followed by NTPVT tables as declared on the TABDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NPPVT rows as declared on the TABDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 8.166: WATVISCT Keyword Description

Example

The following example shows the WATVISCT keyword for when the thermal option has been activated by the THERMAL keyword in the RUNSPEC section and for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set equal to one.

```
--
--       WATER VISCOSITY VERSUS TEMPERATURE TABLES
--
--       WATER      WATER
--       TEMP       VISC
--       --------   -------
WATVISCT
           100.0    0.625
           110.0    0.620
           120.0    0.580
           150.0    0.550
           165.0    0.500                                  / TABLE NO. 01
```

There is no terminating "/" for this keyword.

CHAPTER 9: REGIONS SECTION

9.1 INTRODUCTION

The REGIONS section defines how various properties in the PROPS and SOLUTION sections are allocated to individual cells within the model, as well as defining various fluid in-place reporting regions. This is accomplished by assigning an integer value to each cell that represents the data set of the property to be assigned to the grid block.

9.2 DATA REQUIREMENTS

OPM Flow, like most numerical modeling software, users a default value of one for the various region arrays and thus if there is only one PVT data set for example, then there is no need to define the region array associated with allocating the PVT tables (PVTNUM), as all cells will be allocated PVT table number one. However, if there are more than one PVT table entered in the PROPS section and PVTNUM is not defined in the model, then PVT tables greater than one will not be used and there will be no warning message indicting the fact.

Properties Section	**Property Allocation**	**REGIONS Section Keyword**
SOLUTION	Equilibrium region allocation based on the EQUIL keyword records.	EQLNUM
REGION	Fluid In-Place reporting via the FIPNUM array that divides the model into different fluid in-place reporting regions.	FIPNUM
PROPS	PVT table allocation of the DENSITY, PVDG, PVDO, PVTG, PVTO, PVCO, PVTW and ROCK tables	PVTNUM
PROPS	Saturation (relative permeability) table allocation of the SGFN, SWFN, SOF2, SOF3, SGOF, and SWOF tables.	SATNUM
Function Specific Regions		
PROPS	ENPTVD and ENKRVD versus depth table allocation for when ENDSCALE option has been activated in the RUNSPEC section.	ENDNUM
PROPS	Imbibition saturation table allocation of the SWFN, SOF2, SOF3 or SWOF imbibition tables.	IBMNUM
PROPS	Miscible regions based on the TLMIXPAR records when the MISCIBLE or SOLVENT keywords have been activated in the RUNSPEC section.	MISNUM
PROPS	Rock compaction table allocation for when the ROCKCOMP keyword as been activated in the RUNSPEC section, that allocates the ROCKTAB series of tables to a cell.	ROCKNUM
PROPS	Surfactant saturation (relative permeability) tables allocation allocating the SWFN, SOF2, SOF3 or SWOF as miscible tables.	SURFNUM
PROPS	High salinity water wet saturation table allocation using the high salinity water wet saturation SWFN and SOFN tables.	SURFWNUM

Notes:

1) Only EQLNUM, FIPNUM, PVTNUM, SATNUM , IMBUM and MISNUM are available in OPM Flow.
2) Note that is common to set the FIPNUM array to be equal to the EQLNUM to have fluid in-place reporting for each equilibrium region, this can be done by using the COPY keyword to copy the EQLNUM array to the FIPNUM array.

Table 9.1: REGION Section Allocation Array Summary

The allocation is based on a complete property data set, that is all the property data associated with a given data set is allocated to the cell. For example, if the fluid properties for the model are the same, (for example, PVTO and PVDG keyword data) but the rock compressibility is varying with depth resulting in, say three different ROCK keyword records, then there has to be three complete data sets in order to allocate the three ROCK records. This would mean that the PVTO and PVDG keywords, in this instance, would have to be repeated three times to match the three ROCK keyword records.

Example SATNUM and EQUIL arrays from the Volve[134] field are displayed in Figure 9.1 and Figure 9.2, respectively.

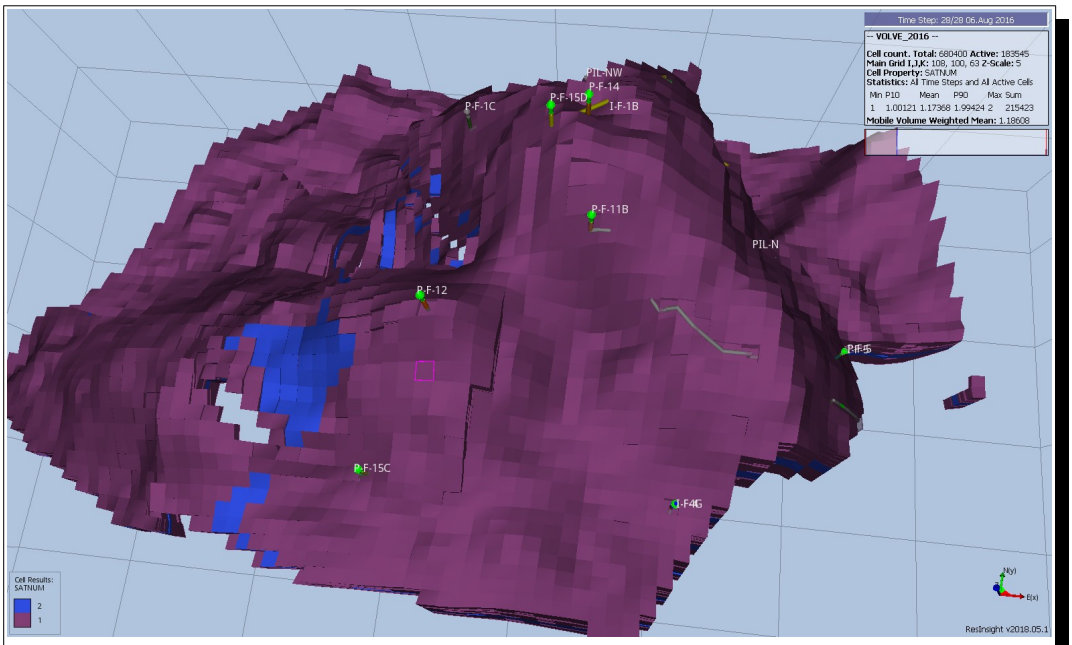


Figure 9.1: Volve Full Field Model SATNUM Array

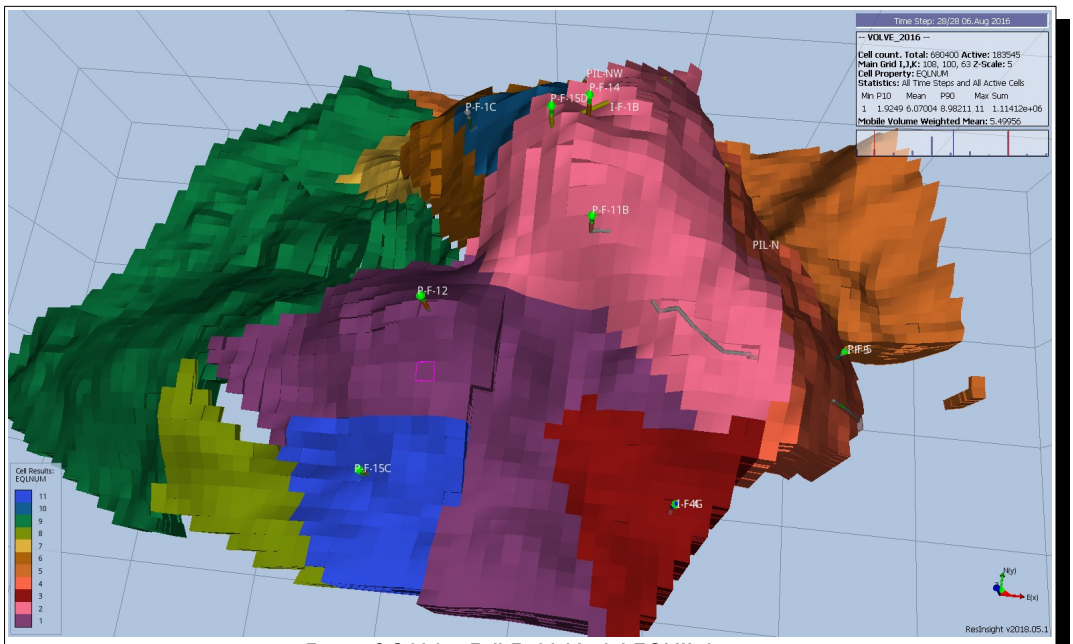


Figure 9.2: Volve Full Field Model EQUIL Array

[134] *The Volve Data was approved for data sharing in 2018 by the initiative of the last Operating company, Equinor and approved by the license partners ExxonMobil E&P Norway AS and Bayerngas Norge AS in the end of 2017.*

9.3 KEYWORD DEFINITIONS

9.3.1 ADD – ADD A CONSTANT TO A SPECIFIED ARRAY

The ADD keyword adds a constant to a specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the ADD keyword is being applied.

See *ADD – Add a Constant to a Specified Array* in the GRID section for a full description.

9.3.2 ADDREG – ADD A CONSTANT TO AN ARRAY BASED ON A REGION NUMBER

The ADDREG keyword adds a constant to a specified array or part of an array based on cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the ADDREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the ADDREG keyword is being used.

See *ADDREG – Add a Constant to an Array based on a Region Number* in the GRID section for a full description.

9.3.3 BOUNDARY – DEFINE A BOUNDARY BOX FOR PRINTING

The BOUNDARY keyword defines a a rectangular grid for printing various arrays to the output print file (*.PRT); thus, avoiding printing all the elements in the selected array.

See *BOUNDARY – Define a Boundary Box for Printing* in the GRID section for a full description.

9.3.4 BOX - DEFINE A RANGE OF GRID BLOCKS TO ENTER PROPERTY DATA

BOX defines a range of grid blocks for which subsequent data is assigned for all the cells in the defined BOX. Note that the BOX grid is reset by the keyword ENDBOX by resetting the current defined BOX to be the whole grid. The keyword can be used for any array and for all grid types.

See *BOX - Define a Range of Grid Blocks to Enter Property Data* in the GRID section for a full description.

9.3.5 COPY – COPY ARRAY DATA TO ANOTHER ARRAY

The COPY keyword copies an array (or part of an array) to another array or part of an array. The arrays can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the COPY keyword is being used.

See *COPY – Copy Array Data to Another Array* in the GRID section for a full description.

9.3.6 COPYBOX – COPY ARRAY DATA DEFINED BY A BOX

The COPYBOX keyword copies an array (or part of an array) to part of the same array. The array can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the COPYBOX keyword is being used.

See *COPYBOX – Copy Array Data Defined by a Box* in the GRID section for a full description.

9.3.7 COPYREG – COPY AN ARRAY TO ANOTHER ARRAY BASED ON A REGION NUMBER

The COPYREG keyword copies a specified array or part of an array based on cells with a specific region number to another array. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the COPYREG keyword is read by the simulator. The property arrays can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the COPYREG keyword is being used.

See *COPYREG – Copy an Array to Another Array based on a Region Number* in the GRID section for a full description.

9.3.8 ENDBOX – DEFINE THE END OF THE BOX DEFINED GRID

This keyword marks the end of a previously defined BOX sub-grid as defined by a previously entered BOX keyword. The keyword resets the input grid to be the full grid as defined by the NX, NY, and NZ variables on the DIMENS keyword in the RUNSPEC section.

See *ENDBOX – Define the End of the BOX Defined Grid* in the GRID section for a full description.

9.3.9 ENDFIN – END THE DEFINITION OF A LOCAL GRID REFINEMENT

ENDFIN defines the end of a Cartesian or radial local grid refinement ("LGR") definition and a LGR property definition data set.

See *ENDFIN – End the Definition of a Local Grid Refinement* in the GRID section for a full description.

9.3.10 ENDNUM – DEFINE THE END-POINT SCALING DEPTH REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ENDNUM keyword defines the end-point scaling depth table region numbers for each grid block. The end-point scaling depth tables for various regions are defined by the ENPVTD[135] and the ENKRVD[136] keywords in the PROPS section. In the RUNSPEC section the NTENDP variable on the ENDSCALE keyword defines the maximum number of depth tables.

No.	Name	Description	Default
1	ENDNUM	ENDNUM defines an array of positive integers assigning a grid cell to a particular end-point scaling depth table region. The maximum number of ENDNUM regions is set by the NTENDP variable on the ENDSCALE keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a ENDNUM region number then the default value of one will be used.
3) The keyword is terminated by "/".

Table 9.2: ENDNUM Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Examples

The example below sets three ENDNUM regions for a 4 x 5 x 2 model.

```
--
--        DEFINE ENDNUM REGIONS FOR ALL CELLS
--
ENDNUM
          2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--        ARRAY       CONSTANT      ---------- BOX ---------
--                                  I1  I2   J1  J2   K1  K2
EQUALS
          ENDNUM      1             1*  1*   1*  1*   1*  1* / SET REGION 1
          ENDNUM      2             1   2    1   2    1   1  / SET REGION 2
          ENDNUM      3             1   2    1   2    2   2  / SET REGION 3
/
```

[135] *This keyword is ignored by OPM Flow and has no effect on the simulation*

[136] *This keyword is ignored by OPM Flow and has no effect on the simulation*

9.3.11 EQLNUM – DEFINE THE EQUILIBRATION REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EQLNUM keyword defines the equilibration region numbers for each grid block. The equilibration data for various regions are defined in the SOLUTION section. For example, the EQUIL keyword in the SOLUTION defines the initial pressures and fluid contacts for each equilibration region identified by the EQLNUM region array.

No.	Name	Description	Default
1	EQLNUM	EQLNUM defines an array of positive integers assigning a grid cell to a particular fluid in-place region. The maximum number of EQLNUM regions is set by the NTEQUIL variable on the EQLDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The EQULNUM and PVTNUM arrays need to be consistent, that is the all cells with the same EQLNUM can only belong to one PVTNUM region.
3) If a cell is not assigned a EQLNUM region number then the default value will be used.
4) The keyword is terminated by "/".

Table 9.3: EQLNUM Keyword Description

Examples

The example below sets three EQLNUM regions for a 4 x 5 x 2 model.

```
--
--        DEFINE EQLNUM REGIONS FOR ALL CELLS
--
EQLNUM
          2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          EQLNUM'     1            1*  1*   1*  1*   1*  1* / SET REGION 1
          EQLNUM'     2            1   2    1   2    1   1  / SET REGION 2
          EQLNUM'     3            1   2    1   2    2   2  / SET REGION 3
/
```

9.3.12 EQUALREG – Sets an Array to a Constant by Region Number

The EQUALREG keyword sets a specified array to a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the EQUALREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the EQUALREG keyword is being used.

See *EQUALREG – Sets an Array to a Constant by Region Number* in the GRID section for a full description.

9.3.13 EQUALS – Sets a Specified Array to a Constant

The EQUALS keyword sets a specified array or part of an array to a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the EQUALS keyword is being used.

See *EQUALS – Sets a Specified Array to a Constant* in the GRID section for a full description.

9.3.14 FILEUNIT – Activate Unit Consistency Verification

The FILEUNIT keyword defines the units of the of the data set, and is used to verify that the units in the input deck and any associated include files are consistent grid data. The keyword does not provide for the conversion between different sets of units.

See *FILEUNIT – Activate Unit Consistency Checking* in the GRID section for a full description.

9.3.15 FIP – DEFINE THE FLUID IN-PLACE NAMES AND REGION AND NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FIP keyword defines the fluid in-place name and the associated region numbers for each grid block. The simulator can print out summaries of the fluid in-place in each region, the current flow rates between regions, and the cumulative flows between regions. This keyword is not in the standard keyword format due to the fluid in-place name being concatenated to the keyword FIP to fully define the keyword.

Note that the total number of FIPNUM and FIP regions must be defined by the NMFIPR variable on the REGDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description	Default
1	FIP	A character string of up to eight characters, consisting of FIP as the first three characters followed by up to a five letter character string defining the fluid in-place's name.	None
2	FIPNUM	FIPNUM defines an array of positive integers greater than or equal to one, that assigns a grid cell to a particular fluid in-place region named by FIP. The maximum number of FIP and FIPNUM regions is set by the NTFIP variable on either REGDIMS or TABDIMS keywords in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a FIP region number by the end of the REGION section then the fault value of one will be used.
3) The keyword is terminated by "/".

Table 9.4: FIP Keyword Description

Example

The example below defines a region name of UNIT and sets three FIPUNIT regions for a 4 x 5 x 2 model.

```
--
--       DEFINE FIPUNIT FIP REGIONS FOR ALL CELLS
--
FIPUNIT
         2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
         3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

9.3.16 FIPNUM – DEFINE THE FLUID IN-PLACE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FIPNUM keyword defines the fluid in-place region numbers for each grid block. The simulator can print out summaries of the fluid in-place in each region, the current flow rates between regions, and the cumulative flows between regions.

Note that the total number of FIPNUM and FIP regions must be defined by the NMFIPR variable on the REGDIMS keyword in the RUNSPEC section.

No.	Name	Description	Default
1	FIPNUM	FIPNUM defines an array of positive integers greater than or equal to one, that assigns a grid cell to a particular fluid in-place region. The maximum number of FIPNUM regions is set by the NTFIP variable on either REGDIMS or TABDIMS keywords in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If acell is not assigned a FIPNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.5: FIPNUM Keyword Description

Note

In most simulation models the FIPNUM array is used to define various regions in the model for fluid in-place reporting and to identify (or report) the flow between the different regions. When calibrating a model's in-place volumes it would be useful to use the FIPNUM array combined with the MULTREGP keyword to accomplish this. However, the FIPNUM array cannot be used in the GRID section.

A work around is to:

1) Use the FIPNUM array but change the keyword to MULTNUM and incorporate this keyword or INCLUDE file in the GRID section.
2) Use the MULTREGP to calibrate the fluid in-place volumes for the various regions.
3) In the REGIONS section, use the COPY keyword to copy the MULTNUM array to the FIPNUM array.

The above work flow will ensure that both arrays and the reporting of fluid in-place regions are consistent.

Examples

The example below sets three FIPNUM regions for a 4 x 5 x 2 model.

```
--
--       DEFINE FIPNUM REGIONS FOR ALL CELLS
--
FIPNUM
         2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
         3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--       ARRAY       CONSTANT     ---------- BOX ---------
--                                I1  I2   J1  J2   K1  K2
EQUALS
         FIPNUM     1            1*  1*   1*  1*    1*  1* / SET REGION 1
         FIPNUM     2            1   2    1   2     1   1  / SET REGION 2
         FIPNUM     3            1   2    1   2     2   2  / SET REGION 3
/
```

9.3.17 FIPOWG – ACTIVATE OIL, GAS, AND WATER FIP ZONE REPORTING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The FIPOWG keyword activates automatic fluid in-place reporting based on the initial oil, gas and water zones defined by the initial equilibration. The fluid contacts on the EQUIL keyword in the SOLUTION section determine the reporting fluid category a grid cell belongs to. For example all grid cells with depths above the gas-oil contact on the EQUIL keyword will be assigned to the gas zone and reported accordingly. Similarly, grid cells with depths between the gas-oil contact and the water-oil contact will be assigned to the oil zone. And finally, grid cells with depths below the oil-water contact will be assigned to the water zone. The simulator can print out summaries of the fluid in-place in each region, the current flow rates between regions, and the cumulative flows between regions.

Note that the total number of FIP and FIPNUM regions must be defined by the NMFIPR variable on the REGDIMS keyword in the RUNSPEC section.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       ACTIVATE OIL, GAS, AND WATER FIP ZONE REPORTING
--
FIPOWG
```

The above example switches on automatic fluid in-place reporting based on the initial oil, gas and water zones defined by the initial equilibration.

9.3.18 GETDATA – LOAD AND ASSIGN DATA ARRAY FROM INIT OR RESTART FILE

The GETDATA keyword loads a data array from a previously generated INIT or RESTART file and assigns the loaded array to either same array in the run or another array name.

See *GETDATA – Load and Assign Data Array from INIT or RESTART Files* in the GRID section for a full description.

9.3.19 HBNUM – DEFINE HERSCHEL-BULKLEY REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HBNUM keyword defines the Herschel-Bulkley rheological property table region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which table of Herschel-Bulkley rheological property data is assigned to a grid block, for when the Polymer option has been invoked via the POLYMER keyword in the RUNSPEC section and the Non-Newtonian Fluid phase has been declared active by the NNEWTF keyword, also in the RUNSPEC section. The FHERCHBL keyword in the PROPS section is used to specify the Herschel-Bulkley rheological property table data.

This keyword is ignored by OPM Flow and has no effect on the simulation.

9.3.20 HM – HISTORY MATCH REGION GRADIENT PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HM series of keywords in the REGION section defines the history match gradient regions and sub-regions, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

For grid properties, the region name (or region property array) is based on the property arrays defined in Table 9.6.

Property Array	Region Name	Grid Property Data Desription
PERMX	HMPERMX	Permeability multipliers in the x-direction.
PERMXY	HMPRMXY	Permeability multipliers in the x-direction and y-direction
PERMY	HMPERMY	Permeability multipliers in the y-direction.
PERMZ	HMPERMZ	Permeability multipliers in the z-direction.
PORV	HMPORV	Pore volume multiplier
SIGMA	HMSIGMA	Dual porosity and/or dual permeability SIGMA multiplier
TRANX	HMTRANX	Transmissibility multipliers in the x-direction.
TRANXY	HMTRNXY	Transmissibility multipliers in the x-direction and y-direction
TRANY	HMTRANY	Transmissibility multipliers in the y-direction.
TRANZ	HMTRANZ	Transmissibility multipliers in the z-direction.

Table 9.6: HM Region Grid Gradient Parameter Keyword List

In addition, if the End-Point Scaling option has been activated by the ENDSCALE keyword in the RUNSPEC section, then the history match gradient regions and sub-regions for the end-point data can be specified. In this the keyword consists of the first two characters of "HM" followed by the end-point keyword (Table 9.7), for example, HMSWL.

Type	End-Point Keyword	Oil-Water End-Point Definitions
Saturation	HMSWL	Connate water saturation, that is the smallest water saturation in a water saturation function table.
	HMSWCR	Critical water saturation, that is the largest water saturation for which the water relative permeability is zero.
	HMSOWCR	Critical oil-in-water saturation, that is the largest oil saturation for which the oil relative permeability is zero in an oil-water system.
Relative	HMKRW	Relative permeability of water at the maximum water saturation (normally the maximum water saturation is one).

Type	End-Point Keyword	Oil-Water End-Point Definitions
Permeability	HMKRO	Relative permeability of oil at the maximum oil saturation.
	HMKRWR	Relative permeability of water at the residual oil saturation or the residual gas saturation in a gas-water run.
	HMKRORW	Relative permeability of oil at the critical water saturation.
Capillary Pressure	HMSWLPC	Capillary pressure connate water saturation, that is the smallest water saturation in a water saturation function table.
Type	**End-Point Keyword**	**Gas-Oil End-Point Definitions**
Saturation	HMSGL	Connate gas saturation, that is the smallest gas saturation in a gas saturation function table.
	HMSGCR	Critical gas saturation, that is the largest gas saturation for which the gas relative permeability is zero.
	HMSOGCR	Critical oil-in-gas saturation, that is the largest oil saturation for which the oil relative permeability is zero in an oil-gas-connate water system.
Relative Permeability	HMKRG	Relative permeability of gas at the maximum gas saturation.
	HMKRGR	Relative permeability of gas at the residual oil saturation or the critical water saturation in a gas-water run.
	HMKRORG	Relative permeability of oil at the critical gas saturation.
Capillary Pressure	HMSGLPC	Capillary pressure connate gas saturation, that is the smallest gas saturation in a gas saturation function table.

Table 9.7: HM Region End-Point Gradient Parameter Keyword List

9.3.21 HMPROPS – HISTORY MATCH END-POINT SECTION START

HMPROPS defines the start of a history match end-points section, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. In addition, the End-Point Scaling option must also be activated by the ENDSCALE keyword which is also in the RUNSPEC section. The keyword allows for the BOX, EQUALS, COPY, MINVALUE, MAXVALUE and ADD keywords to be used with the HM series of keywords that reference the end-point scaling arrays, that is: HMKRG, HMKRGR, HMKRO, HMKRORG, HMKRORW, HMKRW, HMKRWR, HMPCW, HMPCG, HMSGCR, HMSOWCR, HMSOGCR, HMSWCR, and HMSWL.

See *HMPROPS – History Match End-Point Section Start* in the PROPS section for a full description.

9.3.22 HWSNUM – DEFINE THE SATURATION TABLE REGION NUMBERS (HIGH SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HWSNUM keyword defines the saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the mode, for when the Low Salt and Surfactant Wettability options have been selected. The region number specifies which set of relative permeability tables are used to calculate the relative permeability and capillary pressure in a grid block.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	HWSNUM	HWSNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of HWSNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a SATNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.8: HWSNUM Keyword Description

Examples

The example below sets three HWSNUM regions for a 4 x 5 x 2 model.

```
--
--        DEFINE HWSNUM REGIONS FOR ALL CELLS
--
HWSNUM
          2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          HWSNUM      1            1*  1*   1*  1*   1*  1* / SET REGION 1
          HWSNUM      2            1   2    1   2    1   1  / SET REGION 2
          HWSNUM      3            1   2    1   2    2   2  / SET REGION 3
/
```

9.3.23 IMBNUM – DEFINE THE IMBIBITION SATURATION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IMBNUM keyword defines the imbibition saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) are used to calculate the relative permeability and capillary pressure in a grid block.

No.	Name	Description	Default
1	IMBNUM	IMBNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of IMBNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The keyword is terminated by "/".
3) If a cell is not assigned an IMBNUM region then the default value of one will be used.

Table 9.9: IMBNUM Keyword Description

In addition, saturation table assignment may be may be directional dependent in which case the directional dependent versions of the aforementioned array should be used, that is IMBNUMX, IMBNUMY and IMBNUMZ instead of IMBNUM. There is also the facility to make the directional end-point scaling reversible or non-reversible and if the non-reversible option is selected the non-reversible versions of the aforementioned arrays should be used, that is IMBNUMX, IMBNUMX-, IMBNUMY, IMBNUMY-, IMBNUMZ and IMBNUMZ-, instead of the IMBNUM keyword.

Note that The directional form of the keyword is recognized, but is not supported by OPM Flow.

Example

The example below sets three IMBNUM regions for a 4 x 5 x 2 model using the EQUALS keyword.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          IMBNUM       1             1*  1*   1*  1*   1*  1* / SET REGION 1
          IMBNUM       2             1   2    1   2    1   1  / SET REGION 2
          IMBNUM       3             1   2    1   2    2   2  / SET REGION 3
/
```

9.3.24 IMBNUMMF – DEFINE THE IMBIBITION SATURATION TABLE REGION NUMBERS (MATRIX-FRACTURE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The IMBNUMMF keyword defines the imbibition saturation tables (relative permeability and capillary pressure tables) region numbers for flow between the matrix and fracture blocks, for when the HYSTER option on the SATOPTS keyword has been invoked to activate the Hysteresis option, and the Dual Porosity or Dual Permeability models have been activated via the DUALPORO or DUALPERM keywords. All keywords are in the RUNSPEC section.

The region number specifies which set of relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) are used to calculate the relative permeability and capillary pressure between the matrix and fracture blocks. The keyword is optional and any cell not assigned a value will use the assignment from the IMBNUM array.

This keyword is ignored by OPM Flow and has no effect on the simulation.

9.3.25 IMPORT – IMPORT GRID FILE DATA AT THE CURRENT POSITION

The IMPORT keyword informs the simulator to continue reading input data from the specified IMPORT file. When the end of the IMPORT file is reached, input data is read from the next keyword in the current file. Normally IMPORT files are generated by grid pre-processoring software and the keyword allows for both formatted and unformatted (binary) files to be loaded.

See *IMPORT – Import Grid File Data at the Current Position* in the GRID section for a full description.

9.3.26 KRNUM – DEFINE THE DIRECTIONAL SATURATION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The KRNUM keyword defines the direction dependent saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block face, as such there must be one entry for each cell in the model. The region number specifies which set of relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) are used to calculate the relative permeability and capillary pressure in a grid block. The keyword should only be used if Directional Dependent Saturation Function option has been activated by the DIRECT parameter on the SATOPTS keyword in the RUNSPEC section. Otherwise the standard none directional relative permeability curves should be assigned by the SATNUM keyword in the REGIONS section.

This keyword is not in the standard keyword format due to the cell face (X, X+, Y, Y+, Z, and Z+ for Cartesian grids and R, R+, T, T+ for radial grids) being concatenated to the keyword KRNUM to fully define the keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	KRNUM	KRNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of KRNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a KRBNUM region then the default value of one will be used.
3) The keyword is terminated by "/".

Table 9.10: KRNUM Keyword Description

If the Directional Dependent Saturation Function option has been activated by the DIRECT parameter on the SATOPTS keyword in the RUNSPEC section, then the KRNUMX, KRNUMY and KRNUMZ form of the keyword should be used. Secondly, if the Non-Reversible End-Point Scaling option is selected by the IRREVERS parameter on the SATOPTS keyword in the RUNSPEC section, then the non-reversible versions of the KRNUM should be used, that is KRNUMX, KRNUMX-, KRNUMY, KRNUMY-, KRNUMZ and KRNUMZ-.

Example

The example below sets the directional saturation tables in all three directions using the EQUALS keyword.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          KRNUMX       1             1*  1*   1*  1*   1*  1* / SET X-DIR TABLES
          KRNUMY       2             1*  1*   1*  1*   1*  1* / SET Y-DIR TABLES
          KRNUZM       3             1*  1*   1*  1*   1*  1* / SET Z-DIR TABLES
/
```

9.3.27 KRNUMMF – Define the Saturation Table Region Numbers (Matrix-Fracture)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The KRNUMMF keyword defines the drainage saturation tables (relative permeability and capillary pressure tables) region numbers for flow between the matrix and fracture blocks, for when the Dual Porosity or Dual Permeability models have been activated via the DUALPORO or DUALPERM keywords in the RUNSPEC section.

The region number specifies which set of relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) are used to calculate the relative permeability and capillary pressure between the matrix and fracture blocks. The keyword is optional and any cell not assigned a value will use the assignment from the SATNUM array.

This keyword is ignored by OPM Flow and has no effect on the simulation.

9.3.28 LSLTWNUM – DEFINE THE LOW SALT WATER WET SATURATION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LSLTWNUM keyword defines the saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of relative permeability tables (SWFN, SOF3 and related keywords) are used to calculate the relative permeability and capillary pressure in a grid block. The keyword should only be used if the Low Salinity option for the Brine model and the Surfactant Wettability option have been activated by the LOWSALT and SURFACTW keywords, respectively, in the RUNSPEC section.

The water wet curves are calculated as a weighted average of the low salinity saturation tables (allocated by this keyword) and the high salinity water wet saturation tables (allocated by the SURFWNUM keyword in the REGIONS section), using the weights provided by the LSALTFNC keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	LSLTWNUM	LSLTWNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of LSLTWNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a LSLTWNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.11: LSLTWNUM Keyword Description

Example

The example below sets three LSLTWNUM regions for the model.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          LSLTWNUM    1            1*  1*   1*  1*   1*  1* / SET REGION 1
          LSLTWNUM    2            1   2    1   2    1   1  / SET REGION 2
          LSLTWNUM    3            1   2    1   2    2   2  / SET REGION 3
/
```

9.3.29 LSNUM – DEFINE THE LOW SALT OIL WET SATURATION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LSNUM keyword defines the saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of relative permeability tables (SWFN, SOF3 and related keywords) are used to calculate the relative permeability and capillary pressure in a grid block. The keyword should only be used if the Low Salinity option for the Brine model has been activated in the RUNSPEC section using the LOWSALT keyword.

The oil wet curves are calculated as a weighted average of the low salinity saturation tables (allocated by this keyword) and the high salinity oil wet saturation tables (allocated by the SATNUM keyword), using the weights provided by the LSALTFNC keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	LSNUM	LSNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of LSNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a LSNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.12: LSNUM Keyword Description

If the Surfactant Wettability option have been activated by the SURFACTW keyword, the LSNUM tables correspond to the immiscible low salinity curves.

Example

The example below sets three LSNUM regions for the model.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          LSNUM        1             1*  1*   1*  1*   1*  1* / SET REGION 1
          LSNUM        2             1   2    1   2    1   1  / SET REGION 2
          LSNUM        3             1   2    1   2    2   2  / SET REGION 3
/
```

9.3.30 LWSLTNUM – DEFINE THE LOW SALT OIL WET SATURATION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LWSLTNUM keyword defines the saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of relative permeability tables (SWFN, SOF3 and related keywords) are used to calculate the relative permeability and capillary pressure in a grid block. The keyword should only be used if the Low Salinity option for the Brine model has been activated by the LOWSALT kwyword in the RUNSPEC section.

The oil wet curves are calculated as a weighted average of the low salinity saturation tables (allocated by this keyword) and the high salinity oil wet saturation tables (allocated by the SATNUM keyword in the REGIONS section), using the weights provided by the LSALTFNC keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	LWSLTNUM	LWSLTNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of LSLTWNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a LWSLTNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.13: LWSLTNUM Keyword Description

Example

The example below sets three LWSLTNUM regions for the model.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          LWSLTNUM     1             1*  1*   1*  1*   1*  1* / SET REGION 1
          LWSLTNUM     2             1   2    1   2    1   1  / SET REGION 2
          LWSLTNUM     3             1   2    1   2    2   2  / SET REGION 3
/
```

9.3.31 LWSNUM – DEFINE THE LOW SALT WATER WET SATURATION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LWSNUM keyword defines the saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of relative permeability tables (SWFN, SOF3 and related keywords) are used to calculate the relative permeability and capillary pressure in a grid block. The keyword should only be used if the Low Salinity option for the Brine model and the Surfactant Wettability option have been activated by the LOWSALT and SURFACTW keywords, respectively, in the RUNSPEC section.

The water wet curves are calculated as a weighted average of the low salinity saturation tables (allocated by this keyword) and the high salinity water wet saturation tables (allocated by the HWSNUM keyword), using the weights provided by the LSALTFNC keyword in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	LWSNUM	LWSNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of LWSNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a LWSNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.14: LWSNUM Keyword Description

The HWSNUM allocated tables correspond to the immiscible high salinity water wet curves.

Example

The example below sets three LWSNUM regions for the model.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          LWSNUM       1             1*  1*   1*  1*   1*  1* / SET REGION 1
          LWSNUM       2             1   2    1   2    1   1  / SET REGION 2
          LWSNUM       3             1   2    1   2    2   2  / SET REGION 3
/
```

9.3.32 MISNUM – DEFINE THE MISCIBILITY REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MISNUM keyword defines the miscibility region number mixing tables as defined by the TLMIXPAR keyword in the PROPS section, for when the miscibility option has been activated by the MISCIBLE keyword in the RUNSPEC section. MISNUM also allocates miscible residual oil saturation versus water saturation tables (SORWMIS keyword in the PROPS section) used to calculate the relative permeability and PVT properties for a grid cell.

Note that although this keyword can only be used when the miscibility option is active, it is not necessary to use this keyword even if the MISCIBLE keyword in the RUNSPEC has been activated as the default value of one will be applied to all grid blocks. Secondly, a value of zero for a grid cell results in immiscible fluids in that grid cell.

No.	Name	Description	Default
1	MISNUM	MISNUM defines an array of positive integers greater than or equal to zero, that assign a grid cell to a particular table of mixing parameters as defined by the TLMIXPAR and SORWMIS keywords. A value of zero sets the fluids within a grid cell to be immiscible. The maximum number of MISNUM regions is set by the NTMIS variable on the MISCIBLE keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a MISNUM region then the default value of one will be used.
3) The keyword is terminated by "/".

Table 9.15: MISNUM Keyword Description

See also the TLMIXPAR and SORWMIS keyword in the PROPS section.

Example

The example below sets three MISNUM regions in the model on a layer by layer basis, using the EQUALS keyword.

```
--
--       ARRAY       CONSTANT     ---------- BOX ---------
--                                I1  I2   J1  J2   K1  K2
EQUALS
         MISNUM      1            1*  1*   1*  1*   1   12 / SET REGION 1
         MISNUM      2            1*  1*   1*  1*   13  55 / SET REGION 2
         MISNUM      3            1*  1*   1*  1*   56 120 / SET REGION 3
/
```

9.3.33 MULTIPLY – Multiply a Specified Array by a Constant

The MULTIPLY keyword multiplies a specified array or part of an array by a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

See *MULTIPLY – Multiply a Specified Array by a Constant* in the GRID section for a full description.

9.3.34 MULTIREG – Multiply an Array by a Constant based on a Region Number

The MULTIREG keyword multiplies an array or part of an array by a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTIREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the MULTIREG keyword is being used.

See *MULTIREG – Multiply an Array by a Constant based on a Region Number* in the GRID section for a full description.

9.3.35 OPERATE – Define Mathematical Operations on Arrays

This keyword, OPERATE, defines mathematical operations on property arrays (NTG, PORO etc.) and optionally using another property array as input to the function. The keyword allows for various mathematical functions and their associated variables to be defined and applied to the selected array data. Input constants can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

See *OPERATE – Define Mathematical Operations on Arrays* in the GRID section for a full description.

9.3.36 OPERNUM – Define Regions for Mathematical Operations on Arrays

This keyword defines the OPERATE region numbers for each grid block. The OPERATE keyword defines mathematical operations on arrays in the commercial simulator and is currently not supported by OPM Flow. However, similar functionality is provided by the ADD and MULTIPLY keywords combined with MULTNUM region array.

See *OPERNUM – Define Regions for Mathematical Operations on Arrays* in the GRID section for a full description.

9.3.37 OPERATER – Define Mathematical Operations on Arrays by Region

This keyword defines the mathematical operations on arrays for specific regions in the commercial simulator and is currently not supported by OPM Flow. However, similar functionality is provided by the ADD and MULTIPLY keywords.

See *OPERATER – Define Mathematical Operations on Arrays by Region* in the GRID section for a full description.

9.3.38 PENUM – Define the Petro-Elastic Region Numbers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PENNUM keyword defines the petro-elastic region number for each grid block that is used to assign the of petro-elastic coefficients, bulk moduls functions and shear modulus functions as defined by the PECOEFS, PEKTAB and PEGTAB series of keywords in the PROPS section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

9.3.39 PLMIXNUM – DEFINE THE POLYMER REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLMIXNUM keyword defines the polymer region number for each grid block that is used to assign the mixing tables as well as the maximum polymer and salt concentrations, as defined by the PLMIXPAR and PLYMAX keywords in the PROPS section, for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

The maximum polymer concentration and the associated salt concentration are declared on the PLYMAX keyword.

No.	Name	Description	Default
1	PLMIXNUM	PLMIXNUM defines an array of positive integers greater than or equal to one, that assign a grid cell to a particular table of mixing parameters as defined by the PLMIXPAR and PLYMAX keywords. The maximum number of PLMIXNUM regions is set by the NPLMIX variable on the REGDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a PLMIXNUM region then the default value of one will be used.
3) The keyword is terminated by "/".

Table 9.16: PLMIXNUM Keyword Description

See also the PLYADS, PLYADSS, PLYDHLF, PLYMAX, PLYROCK, PLYSHEAR, PLYSHLOG and PLYVISC keywords in the PROPS section.

Example

The example below sets three PLMIXNUM regions in the model on a layer by layer basis, using the EQUALS keyword.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          PLMIXNUM       1           1*  1*   1*  1*   1   12 / SET REGION 1
          PLMIXNUM       2           1*  1*   1*  1*   13  55 / SET REGION 2
          PLMIXNUM       3           1*  1*   1*  1*   56 120 / SET REGION 3
/
```

9.3.40 PVTNUM – DEFINE THE PVT REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PVTNUM keyword defines the PVT region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of PVT tables (DENSITY, PVDG, PVDO, PVTG, PVTO, PVCO, PVTW and ROCK) are used to calculate the PVT properties in a grid block.

No.	Name	Description	Default
1	PVTNUM	PVTNUM defines an array of positive integers assigning a grid cell to a particular PVT region. The maximum number of PVTNUM regions is set by the NTPVT variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword,in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) The EQULNUM and PVTNUM arrays need to be consistent, that is the all cells with the same PVTNUM can only belong to one EQLNUM region.
3) If a cell is not assigned a PVTNUM region then the default value will be used.
4) The keyword is terminated by "/".

Table 9.17: PVTNUM Keyword Description

Note

Care should be taken that cells in different PVTNUM regions are not in communication, since the fluid properties are associated with a cell. If for example, a rbbl or a rm^3 of oil flows from PVTNUM region 1 to PVTNUM region 2, then the oil properties of that oil will change from the PVT 1 data set to the PVT data set 2. This will result in material balance errors, that may or may not cause numerical issues.

To avoid this one should use the MULTNUM (or FLUXNUM, or OPERNUM) array with the MULTREGT array to ensure that the various PVTNUM regions are not in communication.

Examples

The example below sets three PVTNUM regions for a 4 x 5 x 2 model.

```
--
--        DEFINE PVTNUM REGION FOR ALL CELLS
--
PVTNUM
          2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          PVTNUM       1             1*  1*   1*  1*   1*  1* / SET REGION 1
          PVTNUM       2             1   2    1   2    1   1  / SET REGION 2
          PVTNUM       3             1   2    1   2    2   2  / SET REGION 3
/
```

There third example shows how to ensure the various PVT regions are isolated. First of all define the MULTNUM array in the GRID section and ensure all the regions are isolated.

```
-- ==============================================================================
--
-- GRID SECTION
--
-- ==============================================================================
GRID
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          MULTNUM      1             1*  1*   1*  1*   1*  1* / SET REGION 1
          MULTNUM      2             1   2    1   2    1   1  / SET REGION 2
          MULTNUM      3             1   2    1   2    2   2  / SET REGION 3
/
--
--        SET TRANSMISSIBILITES ACROSS DIFFERENT RESERVOIRS TO ZERO TO ISOLATE
--        RESERVOIRS
--
--        REGION    REGION    TRANS    DIREC    NNC     REGION ARRAY
--        FROM      TO        MULT     OPT      OPTS    M / F / O
MULTREGT
          1*        1*        0.0      1*      'ALL'    M         / ALL REGIONS SEALED
/
```

Then in the REGIONS section copy the MULTNUM array to the PVTNUM array.

```
-- ==============================================================================
--
-- REGIONS SECTION
--
-- ==============================================================================
REGIONS

--
--        COPY AN ARRAY TO ANOTHER ARRAY BASED ON A REGION NUMBER
--
--        ARRAY      ARRAY      REGION    REGION ARRAY
--        FROM       TO         NUMBER     M / F / O
COPYREG
          MULTNUM    PVTNUM     1          M                    / COPY MULT TO PVT 1
          MULTNUM    PVTNUM     2          M                    / COPY MULT TO PVT 2
          MULTNUM    PVTNUM     3          M                    / COPY MULT TO PVT 3
/
```

All the separate PVT regions are now isolated.

9.3.41 PYEND – END THE DEFINITION OF A PYINPUT SECTION

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords. A PYINPUT Definition Section is terminated by a PYEND keyword on a separate single line.

See *PYEND – End the Definition of a PYINPUT Section* in the GRID section for a full description.

9.3.42 PYINPUT – DEFINE THE START OF A PYINPUT SECTION

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords used by the simulator. PYINPUT declares the start of a PYINPUT Definition Section on a single separate line, which is then followed by various standard Python commands, with one command per line.

See *PYINPUT – Define the Start of a PYINPUT Section* in the GRID section for a full description.

9.3.43 REFINE – START THE DEFINITION OF A LOCAL GRID REFINEMENT

The REFINE keyword defines the start of a Cartesian or radial local grid refinement ("LGR") definition that sets the properties of the selected LGR. The keyword is then followed by the property keywords associated with the section where the keyword is being invoked. For example, if the REFINE keyword is used in the GRID section then most of the keywords in that section can be used to set the grid properties for the LGR.

See *REFINE – Start the Definition of a Local Grid Refinement* in the GRID section for a full description.

9.3.44 REGIONS - Define the Start of the REGIONS Section of Keywords

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The REGIONS activation keyword marks the end of the PROPS section and the start of the REGIONS section that defines how various fluid and rock property data defined in the PROPS section are allocated to the individual cells in the model.

There is no data required for this keyword.

Example

```
-- ==============================================================================
--
-- REGIONS SECTION
--
-- ==============================================================================
REGIONS
```

The above example marks the end of the PROPS section and the start of the REGIONS section in the OPM Flow data input file.

9.3.45 RESIDNUM – DEFINE VERTICAL EQUILIBRIUM RESIDUAL FLOW REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RESIDNUM keyword defines the Vertical Equilibrium ("VE") residual flow calculation saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) are used to calculate the relative permeability and capillary pressure in a grid block. The keyword should only be used if the Vertical Equilibrium option has been invoked via the VE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	RESIDNUM	RESIDNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of RESIDNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a RESIDNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.18: RESIDNUM Keyword Description

Note that any capillary pressure data on the relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) will be ignored by the VE option.

Example

The example below sets three RESIDNUM regions for the model, by first setting all values to one, then setting layers 2 to 10 to two, and finally setting layers 30 to 50 to three.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          SATNUM       1             1*  1*   1*  1*   1*  1* / SET REGION 1
          SATNUM       2             1   2    1   2    2   10 / SET REGION 2
          SATNUM       3             1   2    1   2    30  50 / SET REGION 3
/
```

9.3.46 ROCKNUM – DEFINE ROCK COMPACTION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ROCKNUM keyword defines the rock compaction table region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of rock compaction tables defined by the ROCKTAB keyword are used to calculate the rock compaction in a grid block.

No.	Name	Description	Default
1	ROCKNUM	ROCKNUM defines an array of positive integers assigning a grid cell to a particular rock compaction table region. The maximum number of ROCKNUM regions is set by the NTROCC variable on the ROCKCOMP keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a ROCKNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.19: ROCKNUM Keyword Description

Examples

The example below sets three ROCKNUM regions for a 4 x 5 x 2 model.

```
--
--       DEFINE ROCKNUM REGION FOR ALL CELLS
--
ROCKNUM
         2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
         3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--       ARRAY       CONSTANT     ---------- BOX ---------
--                                I1  I2   J1  J2   K1  K2
EQUALS
         ROCKNUM     1            1*  1*   1*  1*   1*  1* / SET REGION 1
         ROCKNUM     2            1   2    1   2    1   1  / SET REGION 2
         ROCKNUM     3            1   2    1   2    2   2  / SET REGION 3
/
```

9.3.47 RPTREGS – DEFINE REGIONS SECTION REPORTING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data in the REGIONS section that is to be printed to the output print file in human readable format. The keyword has two distinct forms, the first of which consists of the keyword followed by a series of integers on the next line indicating the data to be printed (see the first example). This is the original formal in the commercial simulator and was subsequently superseded by the second format. The second format consists of the keyword followed by a series of character strings that indicate the data to be printed. In most cases the character string is the keyword used to load the data in the OPM Flow input deck, for example FIPNUM for the fluid in-place array. Its is anticipated that OPM Flow will eventually support the functionality of the second format only, the first format although recognized will be completely ignored.

No.	Name	Description	Default
1	EQLNUM	Print the equilibration region array.	N/A
2	FIPNUM	Print the fluid in-place array.	N/A
3	PVTNUM	Print the PVT table assignment array.	N/A
4	SATNUM	Print the saturation function (relative permeability) assignment array.	N/A
….		….	N/A

Notes:

1) The keyword is terminated by "/".

Table 9.20: RPTREGS Keyword Description

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

Note

This keyword has the potential to produce very large print files that some text editors may have difficulty loading, coupled with the fact that reviewing the data in this format is very cumbersome.

A more efficient solution is to load the *.INIT file into OPM ResInsight to view the data graphically, this also has the benefit of being able to filter the grid based on I, J, K ranges and grid properties.

Examples

The first example shows the original format of this keyword; although the keyword and format are recognized by OPM Flow, the format is ignored and is unlikely to be implemented in in the simulator.

```
--
--        DEFINE REGIONS SECTION REPORT OPTION (ORIGINAL FORMAT)
-
RPTREGS
          1        2*0      1        3*1                                        /
```

The next example shows the second format of the keyword which may be supported in a future release of OPM Flow.

```
--        DEFINE REGIONS SECTION REPORT OPTIONS
--
RPTREGS
          FIPMUM   EQLNUM   PVTNUM   SATNUM                                      /
```

9.3.48 SATNUM – DEFINE THE SATURATION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SATNUM keyword defines the saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) are used to calculate the relative permeability and capillary pressure in a grid block.

No.	Name	Description	Default
1	SATNUM	SATNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of SATNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a SATNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.21: SATNUM Keyword Description

Examples

The example below sets three SATNUM regions for a 4 x 5 x 2 model.

```
--
--        DEFINE SATNUM REGIONS FOR ALL CELLS
--
SATNUM
          2  2  1  1  2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          3  3  1  1  3  3  1  1  1  1  1  1  1  1  1  1  1  1  1  1
/
```

Alternatively the EQUALS keyword could be employed to accomplish the same task, that is:

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          SATNUM      1            1*  1*   1*  1*   1*  1* / SET REGION 1
          SATNUM      2            1   2    1   2    1   1  / SET REGION 2
          SATNUM      3            1   2    1   2    2   2  / SET REGION 3
/
```

9.3.49 SURFNUM – DEFINE THE SURFACTANT MISCIBLE SATURATION TABLE REGION NUMBERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SURFNUM keyword defines the saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the model. The region number specifies which set of oil-water relative permeability tables (SWFN, SOF2, SOF3, and SWOF) are used to calculate the relative permeability and capillary pressure in a grid block. In this case the SURFNUM allocated tables assume that oil and water are miscible, whereas the SATNUM allocated tables are used to allocate the immiscible saturation tables. To use this keyword the Surfactant option must have been activated by the SURFACT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	SURFNUM	SURFNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of SURFNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a SURFNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.22: SURFNUM Keyword Description

Example

The example below sets three SURFNUM for the model.

```
--
--        ARRAY       CONSTANT     ---------- BOX ---------
--                                 I1  I2   J1  J2   K1  K2
EQUALS
          SURFNUM     1            1*  1*   1*  1*   1*  1* / SET REGION 1
          SURFNUM     2            1*  1*   1*  1*   1   1  / SET REGION 2
          SURFNUM     3            1*  1*   1*  1*   2   2  / SET REGION 3
/
```

9.3.50 SURFWNUM – DEFINE THE SATURATION TABLE REGION NUMBERS (HIGH SALINITY AND WATER WET)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SURFWNUM keyword defines the saturation tables (relative permeability and capillary pressure tables) region numbers for each grid block, as such there must be one entry for each cell in the mode, for when the Surfactant Wettability option has been selected. The region number specifies which set of relative permeability tables are used to calculate the relative permeability and capillary pressure in a grid block. Note that the keyword is obligatory if the SURFACTW keyword in the RUNSPEC section has been used to invoke the Surfactant Wettability option.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	SURFWNUM	SURFWNUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of SURFWNUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a SATNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.23: SURFWNUM Keyword Description

Example

The example below sets three SURFWNUM regions for the model.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          SURFWNUM     1             1*  1*   1*  1*   1*  1* / SET REGION 1
          SURFWNUM     2             1   2    1   2    1   1  / SET REGION 2
          SURFWNUM     3             1   2    1   2    2   2  / SET REGION 3
/
```

9.3.51 TNUM – DEFINE PASSIVE TRACER CONCENTRATION REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TNUM keyword defines the regions associated with the series of tracers associated with a phase (oil, water, or gas) in the model. The maximum number of tracers for each phase are declared on the TRACER keyword in the RUNSPEC section. Unlike other keywords, the TNUM keyword must be concatenated with the phase and the name of the tracer declared by TRACER keyword in the PROPS section. Table 9.24 outlines the format of the TNUM keyword name.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	TNUM	A four letter character equal to TNUM that is the root keyword name for this data set array.	None
2	PHASE	A one letter character string that must be equal to F or S, that is concatenated to TNUM. The letter F states that the tracer is for the "free" phase, for example oil or water, as well as gas cap gas (free gas). The letter S signifies that the tracer is a "solution" phase tracer, for example gas dissolved in oil (as activated by the DISGAS keyword in the RUNSPEC section), or condensate (vaporized oil) in the gas (as per the VAPOIL keyword in the RUNSPEC section). Note tracers that are defined by the letter S to be in the "solution" phase, must also be initialized by the "free" phase as well.	None
3	NAME	A three letter character string defining the tracer's name, which is concatenate to TNUM and PHASE to given the full name of the keyword Note it is best to void names beginning with the letters F, S, and T as these names may great naming issues in post-processing software.	None

Table 9.24:TNUM Keyword Name Format

Following the declaration of the full keyword name, TNUMPHASENAME, the keyword is followed by the data as outlined below.

No.	Name	Description	Default
1	TNUMREG	TUNREG defines an array of positive integers assigning a grid cell to a particular tracer table region. The maximum number of TNUMREG regions is set by the NTTRVD variable on the EQLDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a TNUMREG region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.25:TNUM Keyword Data Description

See also the TRACER keyword in the PROPS section and the TBLK keyword in the SOLUTION section.

Example

First define four passive tracers one for a free gas, one for dissolved gas, one for oil and one to track the water.

```
--
--       DEFINE TRACER NAMES
--
--       TRACER   TRACER
--       NAME     PHASE
--       ------   ------
TRACER
        'GCG'     'GAS'                                    / GAS CAP GAS
        'DGS'     'GAS'                                    / DISOLVED GAS
        'OIL'     'OIL'                                    / OIL
        'WAT'     'WAT'                                    / WAT
/
```

Given a 100 x 100 x 5 grid with DISGAS activated in the RUNSPEC section, then the following TNUM keywords define the various tracer regions given that NTTRVD equals four on the EQLDIMS keyword in the RUNSPEC section.

```
--
--       DEFINE PASSIVE TRACER CONCENTRATION REGIONS
--
TNUMFGCG
         1000*1
         1000*2
         1000*2
         1000*2
         1000*2
/
TNUMSDGS
         1000*1
         1000*1
         1000*1
         1000*1
         1000*1
/
TNUMFOIL
         1000*3
         1000*3
         1000*3
         1000*3
         1000*3
/
TNUMFWAT
         1000*4
         1000*4
         1000*4
         1000*4
         1000*4
/
```

The keyword name is derived from the TNUM keyword, plus either F or S, plus the tracer name declared in the TRACER keyword. For example for the gas cap (free gas) this would be TNUM+F+GAS to give the TNUMFGAS keyword. And for the dissolved (solution) gas this would be TNUM+S+DGS resulting in the TNUMSDGS keyword.

9.3.52 TRKPF – DEFINE PARTITIONED TRACER REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TRKPF keyword defines the regions associated with the series of partition tracers and the partitioning tables allocated to grid blocks in the model, for when the Partitioned Tracer option has been enabled by the PARTTRAC keyword in the RUNSPEC section. The maximum number of tracers for each phase are declared on the TRACER keyword in the RUNSPEC section. Unlike other keywords, the TRKPF keyword must be concatenated with the name of the tracer declared by TRACER keyword in the PROPS section. Table 9.26 outlines the format of the TRKPF keyword name.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	TRKPF	A five letter character string equal to TRKPF that is the root keyword name for this data set array.	None
2	NAME	A three letter character string defining the tracer's name, which is concatenate to TRKPF to given the full name of the keyword Note it is best to void names beginning with the letters F, S, and T as these names may great naming issues in post-processing software.	None

Table 9.26: TRKPF Keyword Name Format

Following the declaration of the full keyword name, TRKPFNAME, the keyword is followed by the data as outlined below.

No.	Name	Description	Default
1	TRKPFREG	TRKPFREG defines an array of positive integers assigning a grid cell to a particular tracer table region. The maximum number of TRKPFREG regions is set by the NTTRVD variable on the EQLDIMS keyword in the RUNSPEC section.	1

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a TRKPFREG region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.27: TRKPF Keyword Data Description

See also the TRACER and TRACERKP keywords in the PROPS section and the TBLK keyword in the SOLUTION section.

Example

First define one mult-partitioned tracer for the water phase.

```
--
--       DEFINE TRACER NAMES
--
--       TRACER   TRACER   TRACER  PARTITION  NUM   ADSOR
--       NAME     PHASE    VOLUME  PHASE      K(P)  PHASE
--       ------   ------   ------  ---------  ----  -----
TRACER
        'WAT'     'WAT'    1*      MULT       2     ALL    / WAT
/
```

Then for a given a 100 x 100 x 5 grid assign the partitioned tracer regions and K(P) tables, based on two regions.

```
--
--       DEFINE PARTITIONED TRACER REGIONS
--
TRKPFWAT
         1000*1
         1000*1
         1000*2
         1000*2
         1000*2
/
```

The keyword name is derived from the TRKPF keyword, plus the tracer name declared in the TRACER keyword, in this case the keyword name is TRKPFWAT.

9.3.53 WH2NUM – DEFINE WAG HYSTERESIS SATURATION TABLE REGION NUMBERS (TWO PHASE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WH2NUM keyword defines the two phase Water-Alternating-Gas ("WAG") hysteresis tables (relative permeability and capillary pressure tables) region numbers for each grid block, for when the hysteresis option has been activated by the WAGHYSTR variable on the SATOPTS keyword in the RUNSPEC section. The region number specifies which set of relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) are used to calculate the relative permeability and capillary pressure in a grid block. Note that this keyword if the two phase water relative permeabilities WAG option.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	WH2NUM	WH2NUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of WH2NUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	Taken from cell allocated SATNUM

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a WH2NUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.28: WH2NUM Keyword Description

Example

The example below sets three WH2NUM regions for a model.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          WH2NUM       1             1*  1*   1*  1*   1*  1* / SET REGION 1
          WH2NUM       2             1   2    1   2    1   1  / SET REGION 2
          WH2NUM       3             1   2    1   2    2   2  / SET REGION 3
/
```

9.3.54 WH3NUM – DEFINE WAG HYSTERESIS SATURATION TABLE REGION NUMBERS (THREE PHASE)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WH3NUM keyword defines the three phase Water-Alternating-Gas ("WAG") hysteresis tables (relative permeability and capillary pressure tables) region numbers for each grid block, for when the hysteresis option has been activated by the WAGHYSTR variable on the SATOPTS keyword in the RUNSPEC section. The region number specifies which set of relative permeability tables (SGFN, SWFN, SOF2, SOF3, SOF32D, SGOF, SLGOF and SWOF) are used to calculate the relative permeability and capillary pressure in a grid block. Note that this keyword if the three phase water relative permeabilities WAG option.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	WH3NUM	WH3NUM defines an array of positive integers assigning a grid cell to a particular saturation table region. The maximum number of WH3NUM regions is set by the NTSFUN variable on the TABDIMS keyword in the RUNSPEC section.	Taken from cell allocated SATNUM

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.
2) If a cell is not assigned a WH3NUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.29: WH3NUM Keyword Description

Example

The example below sets three WH3NUM regions for a model.

```
--
--        ARRAY        CONSTANT      ---------- BOX ---------
--                                   I1  I2   J1  J2   K1  K2
EQUALS
          WH3NUM       1             1*  1*   1*  1*   1*  1* / SET REGION 1
          WH3NUM       2             1   2    1   2    1   1  / SET REGION 2
          WH3NUM       3             1   2    1   2    2   2  / SET REGION 3
/
```

CHAPTER 10: SOLUTION SECTION

10.1 Introduction

To be written in a future release of the manual.

10.2 Data Requirements

To be written in a future release of the manual.

10.3 Keyword Definitions

10.3.1 ADD – Add a Constant to a Specified Array

The ADD keyword adds a constant to a specified array or part of an array. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the ADD keyword is being applied.

See *ADD – Add a Constant to a Specified Array* in the GRID section for a full description.

10.3.2 ADDREG – Add a Constant to an Array based on a Region Number

The ADDREG keyword adds a constant to a specified array or part of an array based on cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the ADDREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the ADDREG keyword is being used.

See *ADDREG – Add a Constant to an Array based on a Region Number* in the GRID section for a full description.

10.3.3 APIVD - EQUILIBRATION OIL API GRAVITY VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The APIVD keyword defines the oil API gravity versus depth tables for each equilibration region when API Tracking as been activated by the API keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth values for the corresponding vaporized oil-gas ratio values, API			
		feet	m	cm	None
2	API	A columnar vector of real values that defines the vaporized oil-gas ratio values, values at the corresponding DEPTH.			
		°API	°API	°API	None

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.1:APIVD Keyword Description

Example

Given NTEQUL equals three and NDRXVD is greater than or equal to two on the EQLDIMS keyword in the RUNSPEC section, then the following example defines the bubble-point versus depth functions.

```
--
--        DEPTH    API
--                 GRAVITY
--        ------   --------
APIVD
          3000.0    41.10
          8000.0    41.10                          / API VS DEPTH EQUIL REGN 01
--        ------   --------
          3000.0    41.10
          8000.0    38.50                          / API VS DEPTH EQUIL REGN 02
--        ------   --------
          3000.0    41.10
          8000.0    38.50                          / API VS DEPTH EQUIL REGN 03
```

Here three tables are entered; the first table has a constant API gravity versus depth relationship for equilibration region number one and the other two equilibration regions have the API gravity varying with depth.

10.3.4 AQANCONL – DEFINE ANALYTICAL CONNECTIONS TO A LGR GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

AQANCONL keyword defines how analytical aquifers are connected to a Local Grid Refinement ("LGR") simulation grid, this includes Carter-Tracy and Fetkovich analytical aquifers, both of which are implemented in OPM Flow. However, LGRs have not been implemented in OPM Flow.

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	AQUNUM	AQUNUM is a positive integer greater than or equal to one and less than the maximum number of analytical aquifers as defined by the NANAQ variable on the AQUDIMS keyword in the RUNSPEC section, that defines the aquifer to be connected to the grid.			None
2	LGRNAME	LGRNAME is a character string of up to eight characters that defines the name of the LGR to be connected to AQUNUM.			None
3	I1	A positive integer that defines the lower bound of the cells in the I-direction to be connected to the LGR grid and must be greater than or equal to one and less than or equal to I2 and NX.			1
4	I2	A positive integer that defines the upper bound of the of the cells in the I-direction to be connected to the LGR grid and must be greater than or equal to I1 and less than or equal to NX			NX
5	J1	A positive integer that defines the lower bound of the cells in the J-direction to be connected to the LGR grid and must be greater than or equal to one and less than or equal to J2 and NY.			1
6	J2	A positive integer that defines the upper bound of the cells in the J-direction to be connected to the LGR grid and must be greater than or equal to J1 and less than or equal to NY.			NY
7	K1	A positive integer that defines the lower bound of the cells in the K-direction to be to be connected to the LGR grid and must be greater than or equal to one and less than or equal to K2 and NZ.			1
8	K2	A positive integer that defines the upper bound of the cells in the K-direction to be connected to the LGRg rid and must be greater than or equal to K1 and less than or equal to NZ.			NZ
9	AQUFACE	AQUFACE is a character string that sets the connection "face" of the cells declared by this record and should be set to one of the following: 1) X+, Y+, or Z+ for the positive direction, or X-, Y- or Z- for the negative direction transmissibilities. 2) I+, J+, or K+ for the positive direction, or I-, J- or K- for the negative direction transmissibilities.			None
10	AQUFLUX	AQUFLUX is a positive real value that sets the fraction of the total influx between the aquifer and the defined cells declared on this keyword. If defaulted the cell face for each cell is applied and if a values is declared then then this values is applied to all cells declared by this record.			
		ft^2	m^2	cm^2	1*

No.	Name	Description			Default
		Field	Metric	Laboratory	
11	AQUCOEF	AQUCOEF is a real positive values that scales the calculated connection between the aquifer and the cells declared on this record.			
		dimensionless	dimensionless	dimensionless	1.0
12	AQUOPT	AQUOPT is a character string that sets the cell face connection and should be set to one of the following: 1) YES: Aquifer connections can adjoin to active cells allowing for connections inside the LGR grid. It is not recommended to use this option without thoroughly checking the connections in the model. 2) NO: Aquifer connections cannot adjoin to active cells preventing connections inside the LGR grid. This is the recommended and the default value.			NO

Notes:

1) Where NX, NY and NZ are the dimensions of the LGR grid as defined on the CARFIN or RADFIN keywords in the GRID section.
2) Each record must be terminated by a "/" and the keyword is terminated by "/".

Table 10.2: AQANCONL Keyword Description

Example

The following example defines aquifer number one connected to the I+ face of LGR called LGROP01, LGROP01 must have been previously defined via the CARFIN or RADFIN keywords in the GRID section.

```
--
--                        LGR ANALYTIC AQUIFER CONNECTION
--
--        ID    LGR        ---------- BOX ---------    CONNECT  AQF    AQF    ADJOIN
--        NUM   NAME       I1  I2   J1  J2   K1  K2    FACE     INFLX  MULTI  CELLS
AQANCONL
          1     LGROP01     1   1    1   25   1    2   'I+'     1*     1*      'NO'/
/
```

See the AQUCT keyword in the GRID section for a complete example on defining and connecting a Carter-Tracy aquifer to a simulation grid.

10.3.5 AQANNC – DEFINE ANALYTIC AQUIFER NON-NEIGHBOR CONNECTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

AQANNC defines the analytic aquifer non-neighbor connections.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

10.3.6 AQANTRC - Define Analytic Aquifer Initial Tracer Concentrations

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQANTRC keyword defines the initial tracer concentrations for analytic aquifers that have previously been defined by the AQCT keyword in the GRID, PROPS, or SOLUTION sections for Carter-Tracy analytical aquifers, or the AQFET and AQFETP keywords in the SOLUTION section for Fetkovich analytical aquifers.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

10.3.7 AQUALIST – Define An Analytic Aquifer Name to Aquifer Numbers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, AQULIST, defines an analytic aquifer name to aquifer numbers for greater readability in the output.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.8 AQUANCON – Define Analytical Connections to the Grid

The AQUANCON keyword defines how analytical aquifers are connected to the simulation grid, this includes Carter-Tracy and Fetkovich analytical aquifers, both of which are implemented in OPM Flow.

See *AQUANCON – Define Analytical Connections to the Grid* in the GRID section for a full description.

10.3.9 AQUCHGAS – Define Constant Pressure Gas Analytical Aquifer Properties

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUCHGAS keyword defines the properties of constant pressure gas analytical aquifers.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.10 AQUCHWAT – Define Constant Pressure Water Analytical Aquifer Properties

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUCHWAT keyword defines the properties of constant pressure water analytical aquifers.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.11 AQUCON – Define Numerical Aquifer Connections to the Grid

AQUCON keyword defines how numerical aquifers are connected to the simulation grid.

See *AQUCON – Define Numerical Aquifer Connections to the Grid* in the GRID section for a full description.

10.3.12 AQUCT – Define Carter-Tracy Analytical Aquifers

The AQUCT keyword defines a Carter Tracy aquifer, the properties of the aquifer, including the Carter-Tracy aquifer influence function associated with the aquifer, defined by the AQUTAB keyword in the PROPS section.

See *AQUCT – Define Carter-Tracy Analytical Aquifers* in the GRID section for a full description

10.3.13 AQUFET – DEFINE FETKOVICH ANALYTICAL AQUIFER AND CONNECTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUFET keyword defines Fetkovich[137] analytical aquifers, the aquifer properties, together with the cell connections to the aquifer. Each row entry in the AQUFETP keyword defines one Fetkovich analytical aquifer and one cell face to be connected to the aquifer.

This keyword is ignored by OPM Flow and has no effect on the simulation; however, see the AQUFETP keyword in the SOLUTION section and AQUANCON keyword in the GRID section, on how to define and connect Fetkovich analytical aquifers.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DATUM	DATUM is a single positive value that defines the Fetkovich reference datum depth for PRESS.			
		feet	m	cm	None
2	PRESS	PRESS is a single positive value that defines the aquifer pressure at DATUM. If PRESS is defaulted then the simulator will set the aquifer's initial reservoir pressure to be in equilibrium with the cells the aquifer is contacted to. Defaulting this parameter will avoid inconsistent equilibration pressures between the reservoir cells and the aquifer.			
		psia	barsa	atma	1*
3	PORV	A real positive value that defines the initial water volume of the aquifer.			
		stb	sm^3	scc	None
4	COMP	COMP is a real number defining the total compressibility (C_t) of the aquifer, that is the rock compressibility (C_f) plus the water compressibility (C_w) at the aquifer datum pressure (DATUM) and is defined as: $C_t = C_f + C_w$			
		1/psia	1/barsa	1/atma	None
5	PI	A real positive number that defines the aquifer productivity index based on the aquifer influx rate per unit pressure drop.			
		stb/d/psia	sm^3/barsa	scc/hr/atma	None
6	PVTW	A positive integer that defines the aquifer's PVTW water property table.			1
7	I1	A positive integer that defines the lower bound of the cells in the I-direction to be connected to the aquifer and must be greater than or equal to one and less than or equal to I2 and NX.			1
8	I2	A positive integer that defines the upper bound of the of the cells in the I-direction to be connected to the aquifer and must be greater than or equal to I1 and less than or equal to NX			NX

[137] *Fetkovich, M. J. "A Simplified Approach to Water Influx Calculations - Finite Aquifer Systems," Journal of Petroleum Technology, (1971) 23, No. 7, 814-828.*

No.	Name	Description			Default
		Field	Metric	Laboratory	
9	J1	A positive integer that defines the lower bound of the cells in the J-direction to be connected to the aquifer and must be greater than or equal to one and less than or equal to J2 and NY.			1
10	J2	A positive integer that defines the upper bound of the cells in the J-direction to be connected to the aquifer and must be greater than or equal to J1 and less than or equal to NY.			NY
11	K1	A positive integer that defines the lower bound of the cells in the K-direction to be to be connected to the aquifer and must be greater than or equal to one and less than or equal to K2 and NZ.			1
12	K2	A positive integer that defines the upper bound of the cells in the K-direction to be connected to the aquifer and must be greater than or equal to K1 and less than or equal to NZ.			NZ
13	AQUFACE	AQUFACE is a character string that sets the connection "face" of the cells declared by this record and should be set to one of the following: 1) X+, Y+, or Z+ for the positive direction, or X-, Y- or Z- for the negative direction transmissibilities. 2) I+, J+, or K+ for the positive direction, or I-, J- or K- for the negative direction transmissibilities.			None
14	SALTCON	SALTCON is a real positive number that defines the initial salt concentration in the aquifer. This variable is ignored by OPM Flow.			
		lb/stb	kg/sm^3	gm/scc	0.0

Notes:

1) The keyword is followed by up to NANAQ records as defined on the AQUDIMS keyword in the RUNSPEC section
2) The keyword should be terminated by a "/".

Table 10.3: AQUFET Keyword Description

Note this keyword should only be used in equilibration and enumerated initialize runs, that is it should be omitted from RESTART runs.

Note

If the model is unstable then this may be due to an aquifer not being in equilibrium with the connecting reservoir blocks, for example the aquifer is connected to only hydrocarbon reservoir cells. Try commenting out the aquifer and see if this resolves the instabilities.

Example

Given the following grid and aquifer dimensions in the RUNSPEC section:

```
-- ==============================================================================
--
-- RUNSPEC SECTION
--
-- ==============================================================================
RUNSPEC   --
--       MAX     MAX     MAX
--       NDIVIX  NDIVIY  NDIVIZ
DIMENS
         20      1       5                                                      /

--       AQF     AQF     AQF     AQF     AQF     AQF    AQF    AQF
--       MXAQN   MXNAQC  NIFTBL  NRIFTB  NANAQ   NCAMAX MXNALI MXAAQL
AQUDIMS
         1*      1*      5       100     1       1*     1*     1*              /
```

The Fetkovich Analytical aquifer is defined in the SOLUTION sections as:

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION --
--                       FETKOVICH AQUIFER DESCRIPTION AND CONNECTIONS
--
--       DATUM  AQF    AQF    AQF     AQF  AQF -------- BOX ------- CONNECT SALT
--       DEPTH  PRESS  VOLM   COMP    PI   PVT I1  I2  J1  J2  K1  K2 FACE  CONC
--
AQUFETP
         1130.  1*    1.0E+12 3.0E-5  500E3 1   1   1   1   1   1   1  'J-'  /
```

Here one Fetkovich Analytical aquifer is connected to a single cell (1, 1, 1) at the J- face (or X- face) of the grid.

10.3.14 AQUFETP – DEFINE FETKOVICH ANALYTICAL AQUIFERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUFETP keyword defines Fetkovich[138] analytical aquifers and the aquifer properties. Each row entry in the AQUFETP keyword defines one Fetkovich analytical aquifer. In order to fully define this type of aquifer, the aquifer must be connected to the reservoir using the AQUANCON keyword in the GRID or SOLUTION sections.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	AQUID	A positive integer greater than or equal to one and less than or equal to NANAQ on the AQUDIMS keyword in the RUNSPEC section, that defines the Fetkovich aquifer number			1
2	DATUM	DATUM is a single positive value that defines the Fetkovich reference datum depth for PRESS.			
		feet	m	cm	None
2	PRESS	PRESS is a single positive value that defines the aquifer pressure at DATUM. If PRESS is defaulted then the simulator will set the aquifer's initial reservoir pressure to be in equilibrium with the cells the aquifer is contacted to. Defaulting this parameter will avoid inconsistent equilibration pressures between the reservoir cells and the aquifer.			
		psia	barsa	atma	1*
4	PORV	A real positive value that defines the initial water volume of the aquifer.			
		stb	sm^3	scc	None
5	COMP	COMP is a real number defining the total compressibility (C_t) of the aquifer, that is the rock compressibility (C_f) plus the water compressibility (C_w) at the aquifer datum pressure (DATUM) and is defined as: $C_t = C_f + C_w$			
		1/psia	1/barsa	1/atma	None
6	PI	A real positive number that defines the aquifer productivity index based on the aquifer influx rate per unit pressure drop.			
		stb/d/psia	sm^3/barsa	scc/hr/atma	None
7	PVTW	A positive integer that defines the aquifer's PVTW water property table.			1
8	SALTCON	SALTCON is a real positive number that defines the initial salt concentration in the aquifer. This variable is ignored by OPM Flow.			
		lb/stb	kg/sm^3	gm/scc	0.0

[138] *Fetkovich, M. J. "A Simplified Approach to Water Influx Calculations - Finite Aquifer Systems," Journal of Petroleum Technology, (1971) 23, No. 7, 814-828.*

No.	Name	Description			Default
		Field	Metric	Laboratory	
9	TEMP	TEMP is a real positive number that defines the initial temperature of the aquifer at DATUM. This variable is ignored by OPM Flow.			
		°F	°C	°C	1*

Notes:

1) The keyword is followed by up to NANAQ records as defined on the AQUDIMS keyword in the RUNSPEC section

2) Each record is terminated by a "/" and the keyword should be terminated by a "/". Note the commercial simulator only requires a terminating "/" if the number of records on this keyword are less than NANAQU on the AQUDIMS keyword in the RUNSPEC section. If the number of records are equal to NANAQU and a terminating "/" has been entered then the commercial simulator will issue a warning message; however, the commercial simulator run will proceed as expected.

Table 10.4: AQUFETP Keyword Description

Note this keyword should only be used in equilibration and enumerated initialize runs, that is it should be omitted from RESTART runs.

Note

If the model is unstable then this may be due to an aquifer not being in equilibrium with the connecting reservoir blocks, for example the aquifer is connected to some hydrocarbon reservoir cells. Try commenting out the aquifer and see if this resolves the instabilities.

Example

Given the following grid and aquifer dimensions in the RUNSPEC section:

```
-- ==============================================================================
--
-- RUNSPEC SECTION
--
-- ==============================================================================
RUNSPEC  --
--       MAX     MAX     MAX
--       NDIVIX  NDIVIY  NDIVIZ
DIMENS
         20      1       5                                                      /

--       AQF     AQF     AQF     AQF     AQF     AQF     AQF     AQF
--       MXAQN   MXNAQC  NIFTBL  NRIFTB  NANAQ   NCAMAX  MXNALI  MXAAQL
AQUDIMS
         1*      1*      5       100     1       1*      1*      1*              /
```

The Fetkovich analytical aquifer is defined in the SOLUTION sections as:

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION --
--                        FETKOVICH AQUIFER DESCRIPTION
--
--       ID   DATUM   AQF    AQF    AQF     AQF    AQF   SALT
--       NUM  DEPTH   PRESS  VOLM   COMP    PI     PVT   CONC
--
AQUFETP
         1   1130.   1*    1.0E+12 3.0E-5  500E3  1     0.0                    /
/
```

And the connection of the aquifer is set in the GRID or the SOLUTION sections as:

```
--
--                        ANALYTIC AQUIFER CONNECTION
--
--        ID     ---------- BOX ---------   CONNECT  AQF    AQF      ADJOIN
--        NUMBER I1  I2   J1  J2   K1  K2   FACE     INFLX  MULTI    CELLS
AQUANCON
         1      1   1    1   1    1   1     J-      1.0    1.0      'NO'        /
/
```

Here one Fetkovich analytical aquifer is connected to a single cell (1, 1, 1) at the J- face (or X- face) of the cell.

10.3.15 AQUFLUX - Define Constant Flux Analytical Aquifer

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUFLUX keword defines the properties of Constant Flux Analytical Aquifers.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.16 BOUNDARY – DEFINE A BOUNDARY BOX FOR PRINTING

The BOUNDARY keyword defines a a rectangular grid for printing various arrays to the output print file (*.PRT); thus, avoiding printing all the elements in the selected array.

See *BOUNDARY – Define a Boundary Box for Printing* in the GRID section for a full description.

10.3.17 BOX - DEFINE A RANGE OF GRID BLOCKS TO ENTER PROPERTY DATA

BOX defines a range of grid blocks for which subsequent data is assigned for all the cells in the defined BOX. Note that the BOX grid is reset by the keyword ENDBOX by resetting the current defined BOX to be the whole grid. The keyword can be used for any array and for all grid types.

See *BOX - Define a Range of Grid Blocks to Enter Property Data* in the GRID section for a full description.

10.3.18 COPY – COPY ARRAY DATA TO ANOTHER ARRAY

The COPY keyword copies an array (or part of an array) to another array or part of an array. The arrays can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the COPY keyword is being used.

See *COPY – Copy Array Data to Another Array* in the GRID section for a full description.

10.3.19 COPYREG – COPY AN ARRAY TO ANOTHER ARRAY BASED ON A REGION NUMBER

The COPYREG keyword copies a specified array or part of an array based on cells with a specific region number to another array. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the COPYREG keyword is read by the simulator. The property arrays can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the COPYREG keyword is being used.

See *COPYREG – Copy an Array to Another Array based on a Region Number* in the GRID section for a full description.

10.3.20 DATUM – DEFINE THE DATUM DEPTH FOR THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DATUM keyword defines the datum depth for the model. This allows for all grid block pressures and potentials to be calculated at a common depth.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DATUM	DATUM is a single positive value that defines the datum depth for the model.			
		feet	m	cm	None
Notes: 1) The keyword is terminated by "/".					

Table 10.5: DATUM Keyword Description

See also the DATUMR and DATUMRX keywords in the SOLUTION section that also define the datum depth for the model.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--        DATUM
--        DEPTH
--        ------
DATUM
          5000.0                                        / DATUM DEPTH FOR REPORTING
```

The above example defines the datum for the model to be 5000.0

10.3.21 DATUMR – DEFINE DATUM DEPTHS FOR THE FIPNUM REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DATUMR keyword defines the datum depth for each fluid in-place region (FIPNUM) declared in the model. This allows for all grid block pressures and potentials to be calculated at a common depth within a FIPNUM region.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DATUMR	DATUMR is a vector of positive values that defines the datum depth for each fluid in-place region.			
		feet	m	cm	None

Notes:

1) The keyword is followed by FIPNUM values as defined on REGDIMS keyword in the RUNSPEC section.
2) The keyword is terminated by "/".

Table 10.6: DATUMR Keyword Description

See also the DATUM and DATUMRX keywords in the SOLUTION section that also define the datum depth for the model.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        DATUM
--        DEPTH
--        ------
DATUMR
          4800.0
          4900.0
          5000.0                                    / DATUM DEPTH FOR REPORTING
```

The above example defines the datum depth for three FIPNUM regions, for when FIPNUM has been set equal to three on the REGDIMS keyword in the RUNSPEC section.

10.3.22 DATUMRX – DEFINE DATUM DEPTHS FOR THE FIP ALLOCATED REGIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DATUMRX keyword defines the datum depth for each fluid in-place family region defined by the FIP keyword. This allows for all grid block pressures and potentials to be calculated at a common depth within a a give FIP region. The FIP keyword in the REGION sections allows one to define additional sets of fluid in-place regions to the standard FIPNUM keyword. For example, one could use FIPNUM to define the reservoir layers as fluid in-place regions and the FIP keyword to define he fluid in-place region for fault blocks.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	FIPNAME	A character string of up to five characters in length that defines the FIP family name for which the datum depth data is being defined. The default value of 1* will set DATUMR to the standard FIPNUM region numbers.			1*
2	DATUMR	DATUMR is a vector of positive values that defines the datum depth for each fluid in-place family region. There must be one entry for each region in the FIP family name. A maximum of NTFIP, as declared by the REGDIMS keyword in the RUNSPEC, values may be entered for each FIPNAME entry.			
		feet	m	cm	None

Notes:

1) The keyword is followed any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 10.7: DATUMR Keyword Description

See also the FIP keyword in the REGIONS section to define FIP family regions, and the DATUM and DATUMR keywords in the SOLUTION section that also define the datum depth for the model.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        FIP        DATUM
--        NAME       DEPTH
DATUMRX
          'FLTBL'    5000.0  5000.0  5000.0  5000.0    / DATUM DEPTH FOR REPORTING
          'LICBL'    5000.0  5050.0                    / DATUM DEPTH FOR REPORTING
/
```

The above example defines the datum depth for two FIP families, FLTBL and LICBL, with the datum set to a constant 5000.0 psia for FLTBL family and different values for each of the regions in the LICBL family of regions.

10.3.23 DYNAMICR – START OF DYNAMIC REGION PARAMETER DEFINITION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DYNAMICR keyword marks the start of a Dynamic Region section and defines the parameters used for Dynamic Regions that allows for property and reporting regions to vary as the run progresses, based on the parameters and logic defined by this keyword and section. A Dynamic Region section is terminated by the ENDDYN keyword in the SOLUTION or SCHEDULE sections.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.24 ENDBOX – DEFINE THE END OF THE BOX DEFINED GRID

This keyword marks the end of a previously defined BOX sub-grid as defined by a previously entered BOX keyword. The keyword resets the input grid to be the full grid as defined by the NX, NY, and NZ variables on the DIMENS keyword in the RUNSPEC section.

See *ENDBOX – Define the End of the BOX Defined Grid* in the GRID section for a full description.

10.3.25 ENDDYN– END OF DYNAMIC REGION PARAMETER DEFINITION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ENDDYN keyword marks the end of a Dynamic Region section that was started with the DYNAMICR keyword in the SOLUTION or SCHEDULE sections. Dynamic Regions allow for property and reporting regions to vary as the run progresses, based on the parameters and logic defined within the section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.26 ENDFIN – End the Definition of a Local Grid Refinement

ENDFIN defines the end of a Cartesian or radial local grid refinement ("LGR") definition and a LGR property definition data set.

See *ENDFIN – End the Definition of a Local Grid Refinement* in the GRID section for a full description.

10.3.27 EQUALREG – Sets an Array to a Constant by Region Number

The EQUALREG keyword sets a specified array to a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the EQUALREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the EQUALREG keyword is being used.

See *EQUALREG – Sets an Array to a Constant by Region Number* in the GRID section for a full description.

10.3.28 EQUALS – Sets a Specified Array to a Constant

The EQUALS keyword sets a specified array or part of an array to a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the EQUALS keyword is being used.

See *EQUALS – Sets a Specified Array to a Constant* in the GRID section for a full description.

10.3.29 EQUIL – DEFINE THE EQUILIBRATION INITIALIZATION DATA

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the parameters used to initialize the model for when equilibration is calculated by OPM Flow. This is the standard methodology to initialize a model, the non-standard formulation of entering the pressures and saturations for each grid cell is seldom employed in the industry. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DATUM	DATUM is a single positive value that defines the reference datum depth for PRESS.			
		feet	m	cm	0.0
2	PRESS	PRESS is a single positive value that defines the pressure at DATUM. If the DATUM depth lies above the GOC then PRESS is the pressure with respect to the gas phase. If the DATUM depth is below OWC then PRESS refers to the water phase pressure. Otherwise, PRESS refers to the oil phase pressure.			
		psia	barsa	atma	0.0
3	WATCONT	1) For three phase runs containing oil, gas and water WATCONT is the depth of the oil-water contact (OWC). 2) For two phase runs containing oil and water WATCONT is the depth of the oil-water contact (OWC). 3) For two phase runs containing gas and water WATCONT is the depth of the gas-water contact (GWC).			
		feet	m	cm	0.0
4	WATCAP	1) For three phase runs containing oil, gas and water WATCAP is the oil-water capillary pressure at the OWC. 2) For two phase runs containing oil and water WATCAP is the oil-water capillary pressure at the OWC. 3) For two phase runs containing gas and water WATCAP is the gas-water capillary pressure at the GWC			
		psia	barsa	atma	0.0
5	GASCONT	1) For three phase runs containing oil, gas and water GASCONT is the depth of the oil-water contact (OWC). Note in cases where there is no gas cap (or free gas) then GASCONT should be set to a value shallower than the top of the reservoir. In cases where there is initially no oil zone, as for a gas condensate field for example, the GASCONT should be set to the same depth as WATCONT. 2) For two phase runs containing oil and water GASCONT is ignored. 3) For two phase runs containing gas and water GASCONT is ignored.			0.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
		feet	m	cm	
6	GASCAP	1) For three phase runs containing oil, gas and water GASCAP is the gas-oil capillary pressure at the GWC. 2) For two phase runs containing oil and water GASCAP is ignored. 3) For two phase runs containing gas and water GASCAP is ignored.			
		psia	barsa	atma	0.0
7	EQLOPT1	EQLOPT1 is an integer value that sets the initialization option for when dissolved gas is present in the run, as activated by the DISGAS keyword in the RUNSPEC section. 1) A positive value of EQLOPT1 results in the gas-oil ratio being calculated from data entered on the PBVD (saturation pressure or bubble-point pressure versus depth table) or the RSVD keyword (gas-oil ratio versus depth table). If this option is selected than either PBVD or RSVD keywords must be present in the input deck. Note that the allocation of multiple PBVD and RSVD tables to each grid cell is through the EQLNUM keyword and not the PVTNUM keyword. 2) A zero value of EQLOPT1 results in the gas-oil ratio being set to the saturated gas-oil ratio at the GOC. In this case DATUM must be equal GASCONT and the PBVD and RSVD keywords may be omitted. 3) A negative value of EQLOPT1 results in the same option for when EQLOPT1 is zero. EQLOPT1 is ignored if there is no dissolved gas in the run.			
		dimensionless	dimensionless	dimensionless	0
8	EQLOPT2	EQLOPT2 is an integer value that sets the initialization option for when vaporized oil (condensate) is present in the run, as activated by the VAPOIL keyword in the RUNSPEC section. 1) A positive value of EQLOPT2 results in the condensate-gas ratio being calculated from data entered on the PDVD (saturation pressure or dew point pressure versus depth table) or the RVVD keyword (condensate-gas ratio versus depth table). If this option is selected than either PDVD or RVVD keywords must be present in the input deck Note that the allocation of multiple PDVD and RVVD tables to each grid cell is through the EQLNUM keyword and not the PVTNUM keyword. 2) A zero value of EQLOPT2 results in the condensate-gas ratio being set to the saturated condensate-gas ratio at the GOC. In this case DATUM must be equal GASCONT and the PDVD and RVVD keywords may be omitted. 3) A negative value of EQLOPT2 results in the same option for when EQLOPT2 is zero. EQLOPT2 is ignored if there is no vaporized oil in the run.			
		dimensionless	dimensionless	dimensionless	0

No.	Name	Description			Default
		Field	Metric	Laboratory	
9	EQLOPT3	EQLOPT3 is an integer value that sets the initialization accuracy options for the equilibration calculation. 1) A zero value of EQLOPT3 results in OPM Flow using the fluid saturations at the center of the grid block in the equilibration calculation. This results in a stable initialization at the expense of a potentially less accurate fluid in-place calculation, especially for large thick grid blocks with a fluid contact in the block. 2) A negative value of EQLOPT3 results in the simulator dividing each grid cell into $2\|N\| + 1$ horizontal sub-blocks for the equilibration calculation. This results in an accurate fluid in-place calculation at the expense of initialization stability, that is there may be some movement of fluids when there is no production at the start of the run. Increasing the value of N increases the accuracy of the calculation, with the maximum value of N being set to 20 by OPM Flow. 3) A positive value of EQLOPT3 results in the same option for when EQLOPT3 is negative, except that tilted fault blocks are used in the calculation. Again, increasing the value of N increases the accuracy of the calculation, with the maximum value of N being set to 20 by OPM Flow. Note this option should be used with Irregular Corner-Point Grids. EQLOPT3 is ignored for Radial Grids. Only EQLOPT3 equal to zero is supported by OPM Flow.			
		dimensionless	dimensionless	dimensionless	0
10		Not used.			
11		Not used			

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each record is terminated by a "/" and there is no "/" terminator for the keyword.

Table 10.8: EQUIL Keyword Description

See also the PRESSURE, SGAS, SOIL and SWAT keywords in the SOLUTION section to initialize the model using the non-standard formulation of entering the pressures and saturations for each grid cell.

Example

```
--
--        DATUM    DATUM    OWC      PCOW    GOC      PCGO    RS    RV    N
--        DEPTH    PRESS    DEPTH    ----    DEPTH    ----    OPT   OPT   OPT
EQUIL
          3650.0   1560.0   3712.0   0.00    1000.0   0.00    1     0     -5          /
          3650.0   1560.0   3741.0   0.00    1000.0   0.00    1     0     -5          /
          3650.0   1560.0   3741.0   0.00    1000.0   0.00    1     0     -5          /
```

The above example defines three equilibration records for when NTEQUL equals three on the EQLDIMS keyword in the RUNSPEC section. Here there is no gas cap and the GOC has been set to a value above the reservoirs (1000.0), and the default value of EQLOPT (-5) has been explicitly stated.

10.3.30 FILEUNIT – ACTIVATE UNIT CONSISTENCY VERIFICATION

The FILEUNIT keyword defines the units of the of the data set, and is used to verify that the units in the input deck and any associated include files are consistent grid data. The keyword does not provide for the conversion between different sets of units.

See *FILEUNIT – Activate Unit Consistency Checking* in the GRID section for a full description.

10.3.31 GASCONC – DEFINE THE INITIAL EQUILIBRATION COAL GAS CONCENTRATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GASCONC keyword defines the initial equilibration coal gas concentration values for all matrix grid cells in the model and should be used in conjunction with the GCVD keyword in the SOLUTION section, to fully describe the initial state of the model. The keyword should only be used if the coal phase has been activated in the model via the COAL keyword in the RUNSPEC section. Note both GASCONC and GCVD are optional as the simulator will calculate the coal gas concentration based on the equilibrium concentration and the block pressure.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GASCONC	GASCONC is an array of real positive numbers that define the initial equilibration coal gas concentration values to each matrix cell in the model. Repeat counts may be used, for example 20*75.0.			
		Mscf/ft^3	sm^3/m^3	scc/cc	None

Notes:

1) The number of entries should correspond to number of matrix cells in the model, that is (NX x NY x NZ) divided by two, as per the parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.9: GASCONC Keyword Description

See also the GCVD keyword in the SOLUTION section to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION COAL GAS CONCENTRATION FOR ALL CELLS
--        BASED ON NX = 100, NY = 100 AND NZ = 6
--
GASCONC
         1000*75.500    1000*65.500    1000*60.000                          /
```

The above example defines the initial equilibration coal gas concentration values to be 75.500 for all the matrix cells in the first layer, 65.500 for all the cells in the second layer, and finally 60.000 for all the cells in the third layer.

10.3.32 GASSATC – DEFINE THE INITIAL EQUILIBRATION SATURATED COAL GAS CONCENTRATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GASSATC keyword defines the initial equilibration saturated coal gas concentration values for all grid cells in the model. The keyword should only be used if the coal phase has been activated in the model via the COAL keyword in the RUNSPEC section. The keyword is used to re-scale the Langmuir isotherms entered via the LANGMUIR keyword in the PROPS section, in conjunction with a matrix grid blocks initial reservoir pressure. The keyword is optional, and if absent from the input file, the matrix grid block Langmuir isotherm is left unscaled.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GASSATC	GASSATC is an array of real positive numbers that define the initial equilibration saturated coal gas concentration values to each cell in the model. Repeat counts may be used, for example 20*75.0.			
		Mscf/ft^3	sm^3/m^3	scc/cc	None

Notes:

1) The number of entries should correspond to number of matrix cells in the model, that is (NX x NY x NZ) divided by two, as per the parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.10: GASSATC Keyword Description

See also the GASCONC and the GCVD keywords in the SOLUTION section to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION SAT COAL GAS CONCENTRATION ALL CELLS MODEL
--        BASED ON NX = 100, NY = 100 AND NZ = 6
--
GASSATC
          1000*75.500    1000*65.500    1000*60.000                              /
```

The above example defines the initial equilibration saturated coal gas concentration values to be 75.500 for all the matrix cells in the first layer, 65.500 for all the cells in the second layer, and finally 60.000 for all the cells in the third layer.

10.3.33 GCVD – DEFINE EQUILIBRATION COAL GAS CONCENTRATION VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GCVD keyword defines the initial coal gas concentration versus depth tables for each equilibration region for when the coal phase has been activated in the run via the COAL keyword in the RUNSPEC section. The keyword may be used in conjunction with the GASCONC keyword in the SOLUTION section, to fully describe the initial state of the model. Note both GASCONC and GCVD are optional as the simulator will calculate the coal gas concentration based on the equilibrium concentration and the block pressure.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth values for the corresponding coal gas concentration, GCVALS.			
		feet	m	cm	None
2	GCVALS	A columnar vector of real values that defines the coal gas concentration values at the corresponding DEPTH.			
		Mscf/ft^3	sm^3/m^3	scc/cc	None

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.11: GCVD Keyword Description

See also the GASCONC and GASSATC keywords in the SOLUTION section.

Example

Given NTEQUL equals three and NDRXVD is greater than or equal to two on the EQLDIMS keyword in the RUNSPEC section, then the following example defines the coal gas concentration versus depth functions.

```
--
--        DEPTH    GC
--                 MSCF/FT
--        ------   --------
GCVD
           100.0   75.5000
          1000.0   75.5000                          / GC VS DEPTH EQUIL REGN 01
--        ------   --------
           100.0   65.5000
          1000.0   65.5000                          / GC VS DEPTH EQUIL REGN 02
--        ------   --------
           100.0   60.0000
          1000.0   60.0000                          / GC VS DEPTH EQUIL REGN 03
```

Here three tables are entered with a constant coal gas concentration versus depth relationship for each equilibration region.

10.3.34 GETDATA – Load and Assign Data Array from INIT or RESTART File

The GETDATA keyword loads a data array from a previously generated INIT or RESTART file and assigns the loaded array to either same array in the run or another array name.

See *GETDATA – Load and Assign Data Array from INIT or RESTART Files* in the GRID section for a full description

10.3.35 GETGLOB – ACTIVATE LOADING OF GLOBAL GRID RESTART DATA OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GETGLOB, switches on the global grid read option for when the run is restarting from a RESTART file. Only the global grid will be loaded in the subsequent RESTART keyword and any Local Grid Refinements ("LGR") on the RESTART file will be ignored.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--        ACTIVATE LOADING OF GLOBAL GRID RESTART DATA OPTION
--
GETGLOB
```

The above example switches on the option to only load the global grid from the RESTART file.

10.3.36 GI - DEFINE THE INITIAL EQUILIBRATION GI VALUES FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GI keyword defines the initial equilibration GI values for all grid cells in the model and should be used in conjunction with the other enumeration equilibration keywords; PBUB, PDEW, PRESSURE, RS, RV, SOIL and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if the GI Pseudo Compositional option has been activated in the model via the GIMODEL keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

This keyword is ignored by OPM Flow and has no effect on the simulation.

See also the GIALL keyword in the PROPS section that sets the GI values as a function of pressure, as well as setting the corresponding RVGI, RSGI, BGGI and BOGI values at the same time.

10.3.37 HMAQUCT – History Match Carter-Tracy Aquifer Gradient Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMAQUCT keyword defines the history match analytical Carter-Tracy aquifer gradient parameters for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section, and analytical Carter-Tracy aquifers have been specified in the model via the AQUCT and connected to the grid using the AQUANCON or AQANCONL keywords. All keywords are in the SOLUTION section.

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of aquifers that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.38 HMAQUFET – HISTORY MATCH FETKOVICH AQUIFER GRADIENT PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMAQUFET keyword defines the history match analytical Fetkovich aquifer gradient parameters for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section, and analytical Fetkovich aquifers have been specified in the model via the AQUFET and/or the AQUFETP keywords and connected to the grid using AQUANCON or AQANCONL keywords. All keywords are in the SOLUTION section.

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of aquifers that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.39 HMMLCTAQ – HISTORY MATCH CARTER-TRACY AQUIFER GRADIENT MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMMLCTAQ keyword defines the history match analytical Carter-Tracy aquifer gradient multipliers for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section, and analytical Carter-Tracy aquifers have been specified in the model via the AQUCT and connected to the grid using the AQUANCON or AQANCONL keywords. All keywords are in the SOLUTION section.

Multipliers can be declared for the Carter-Tracy aquifer permeability, aquifer angle of influence and the aquifer depth.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.40 HMMLFTAQ – History Match Fetkovich Aquifer Gradient Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The HMAQUFET keyword defines the history match analytical Fetkovich aquifer gradient multipliers for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section, and analytical Fetkovich aquifers have been specified in the model via the AQUFET and/or the AQUFETP keywords and connected to the grid using AQUANCON or AQANCONL keywords. All keywords are in the SOLUTION section.

Multipliers can be declared for the Fetkovich aquifer water volume, aquifer permeability, and the aquifer depth.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.41 HMMLTWCN – HISTORY MATCH WELL CONNECTION AND SKIN MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, HMMLTWCN, defines the history match gradient multipliers for well connection factors and connection skins, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. Wells must be specified using the WELPSECS keyword in the SCHEDULE section and their connections defined by the COMPDAT and/or COMPDATL keywords, also in the SCHEDULE section

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.42 HMWELCON – HISTORY MATCH WELL CONNECTION AND SKIN PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, HMWELCON, defines the history match gradient parameters for well connection factors and connection skins, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. Wells must be specified using the WELPSECS keyword in the SCHEDULE section and their connections defined by the COMPDAT and/or COMPDATL keywords, also in the SCHEDULE section

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.43 IMPORT – Import Grid File Data at the Current Position

The IMPORT keyword informs the simulator to continue reading input data from the specified IMPORT file. When the end of the IMPORT file is reached, input data is read from the next keyword in the current file. Normally IMPORT files are generated by grid pre-processoring software and the keyword allows for both formatted and unformatted (binary) files to be loaded.

See *IMPORT – Import Grid File Data at the Current Position* in the GRID section for a full description.

10.3.44 MULTIPLY – Multiply a Specified Array by a Constant

The MULTIPLY keyword multiplies a specified array or part of an array by a constant. The constant can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

See *MULTIPLY – Multiply a Specified Array by a Constant* in the GRID section for a full description.

10.3.45 MULTIREG – Multiply an Array by a Constant based on a Region Number

The MULTIREG keyword multiplies an array or part of an array by a constant for cells with a specific region number. The region number array can be FLUXNUM, MULTNUM or OPERNUM and these arrays must be defined and be available before the MULTIREG keyword is read by the simulator. The constant can be real or integer depending on the property array type; however, the property arrays that can be operated on is dependent on which section the MULTIREG keyword is being used.

See *MULTIREG – Multiply an Array by a Constant based on a Region Number* in the GRID section for a full description.

10.3.46 OILAPI – DEFINE THE INITIAL EQUILIBRATION OIL API FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The OILAPI keyword defines the initial equilibration oil API gravity pressures for all grid cells in the model, for when the Oil API Tracking option as been invoked by the API keyword in the RUNSPEC section. The keyword should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords etc., to fully describe the initial state of the model.

The keyword is used by the Enumeration Initialization method to initialize the model, as opposed to the Equilibration Initialization method that utilizes the EQUIL keyword in the SOLUTION section. This is the non-standard formulation to initialize the model and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	OILAPI	OILAPI is an array of real positive numbers assigning the initial equilibration oil API gravity to each cell in the model. The American Petroleum Institute ("API") classifies oils based on an API gravity (γ_{API}), or degrees API (°API), the relationship between relative density (γ_o) of oil and API gravity (γ_{API}) is given by: $$\gamma_{API} = \frac{141.5}{\gamma_o} - 131.5$$ Repeat counts may be used, for example 20*38.5			
		°API	°API	°API	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.12: PRESSURE Keyword Description

See also the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION OIL API FOR ALL CELLS IN THE MODEL
--        BASED ON NX = 100, NY = 100 AND NZ = 3
--
OILAPI
          1000*40.2     1000*39.5     1000*38.2                                /
```

The above example defines the initial equilibration oil API gravity to be 40.2 for all the cells in the first layer, 39.5 for all the cells in the second layer, and finally 38.2 for all the cells in the third layer.

10.3.47 OPERATE – Define Mathematical Operations on Arrays

This keyword, OPERATE, defines mathematical operations on property arrays (NTG, PORO etc.) and optionally using another property array as input to the function. The keyword allows for various mathematical functions and their associated variables to be defined and applied to the selected array data. Input constants can be real or integer depending on the array type; however, the arrays that can be operated on is dependent on which section the keyword is being used.

See *OPERATE – Define Mathematical Operations on Arrays* in the GRID section for a full description.

10.3.48 OPERATER – Define Mathematical Operations on Arrays by Region

This keyword defines the mathematical operations on arrays for specific regions in the commercial simulator and is currently not supported by OPM Flow. However, similar functionality is provided by the ADD and MULTIPLY keywords.

See *OPERATER – Define Mathematical Operations on Arrays by Region* in the GRID section for a full description.

10.3.49 OUTSOL – Define Data to be Written to the RESTART File (Retired)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data and frequency of the data to be written to the RESTART file at each requested restart point. The keyword has been replaced by the RPTRST keyword in the SOLUTION and SCHEDULE sections and is therefore considered retired.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.50 NOHMD – Deactivate History Match Gradient Derivative Calculations

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NOHMD deactivates various history match gradient derivative calculations for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The keyword consists of a series of character strings that define which derivative should be switch off based on the keyword that requested the derivatives to be calculated, for example HMFAULTS keyword in the GRID section. If an empty list is entered then all the gradient derivative calculations previously requested are switch off. The keyword is useful for changing from history matching runs to predication cases, as the prediction cases will be more computationally efficient without the burden of the gradient derivative calculations.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.51 NOHMO – Deactivate History Match Gradient Derivative Calculations (Alias)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NOHMO deactivates various history match gradient derivative calculations for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The keyword consists of a series of character strings that define which derivative should be switch off based on the keyword that requested the derivatives to be calculated, for example HMFAULTS keyword in the GRID section. If an empty list is entered then all the gradient derivative calculations previously requested are switch off. The keyword is useful for changing from history matching runs to predication cases, as the prediction cases will be more computationally efficient without the burden of the gradient derivative calculations.

The keyword is an alias for the NOHMD keyword in the SOLUTION section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.52 PBUB – DEFINE THE INITIAL EQUILIBRATION BUBBLE-POINT PRESSURE FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PBUB keyword defines the initial equilibration buble-point saturation pressures values for all grid cells in the model and should be used in conjunction with the PDEW, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if dissolved gas has been activated in the model via the DISGAS keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PBUB	PBUB is an array of real positive numbers assigning the initial equilibration bubble-point saturation pressure values to each cell in the model. Repeat counts may be used, for example 20*3500.0			
		psia	barsa	atma	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.13: PBUB Keyword Description

See also the PBVD, PDEW, PRESSURE, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--      DEFINE INITIAL EQUILIBRATION PSAT VALUES FOR ALL CELLS IN THE MODEL
--      BASED ON NX = 100, NY = 100 AND NZ = 3
--
PBUB
        1000*3500.0    1000*3525.0    1000*0.3535.0                          /
```

The above example defines the initial equilibration bubble-point saturation pressure values to be 3500.0 for all the cells in the first layer, 3525.0 for all the cells in the second layer, and finally 3535.0 for all the cells in the third layer.

10.3.53 PBVD – EQUILIBRATION BUBBLE-POINT VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PBVD keyword defines the bubble-point pressure versus depth tables for each equilibration region that should be used when there is dissolved gas in the model (DISGAS has been activated in the RUNSPEC section) and the EQLOPT1 variable has been set to a positive integer on the EQUIL keyword in the SOLUTION section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth values for the corresponding bubble-point values, PBVALS.			
		feet	m	cm	None
2	PBVASL	A columnar vector of real values that defines the oil bubble-point values at the corresponding DEPTH.			
		psia	barsa	atma	None

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.14: PBVD Keyword Description

Alternatively, the dissolved gas-oil ratio versus depth tables may be entered using the RSVD keyword in the SOLUTION section instead of this keyword. See also the RSVD and EQUIL keywords in the SOLUTION section.

Example

Given NTEQUL equals three and NDRXVD is greater than or equal to two on the EQLDIMS keyword in the RUNSPEC section, then the following example defines the bubble-point versus depth functions.

```
--
--        DEPTH     PSAT
--                  PRESS
--        ------    ------
PBVD
          3000.0    3000.0
          8000.0    3025.0                          / PSAT VS DEPTH EQUIL REGN 01
--        ------    ------
          3000.0    3100.0
          8000.0    3125.0                          / PSAT VS DEPTH EQUIL REGN 02
--        ------    ------
          3000.0    3200.0
          8000.0    3225.0                          / PSAT VS DEPTH EQUIL REGN 03
```

Here three tables are entered and each table is terminated by "/" and there is no keyword terminating "/".

10.3.54 PDEW – DEFINE THE INITIAL EQUILIBRATION DEW-POINT PRESSURE FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PDEW keyword defines the initial equilibration dew-point pressure values for all grid cells in the model and should be used in conjunction with the PBUB, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if vaporized oil been activated in the model via the VAPOIL keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PDEW	PDEW is an array of real positive numbers assigning the initial equilibration dew-point pressure values to each cell in the model. Repeat counts may be used, for example 20*3525.0			
		psia	barsa	atma	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.15: PDEW Keyword Description

See also the PBUB, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--       DEFINE INITIAL EQUILIBRATION PSAT VALUES FOR ALL CELLS IN THE MODEL
--       BASED ON NX = 100, NY = 100 AND NZ = 3
--
PDEW
         1000*3500.0    1000*3525.0    1000*0.3535.0                          /
```

The above example defines the initial equilibration dew-point saturation pressure values to be 3500.0 for all the cells in the first layer, 3525.0 for all the cells in the second layer, and finally 3535.0 for all the cells in the third layer.

10.3.55 PDVD – DEFINE EQUILIBRATION DEW-POINT VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PDVD keyword defines the dew-point pressure versus depth tables for each equilibration region that should be used when there is vaporized oil in the model (VAPOIL has been activated in the RUNSPEC section) and the EQLOPT2 variable has been set to a positive integer on the EQUIL keyword in the SOLUTION section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth values for the corresponding dew-point values, PDVALS.			
		feet	m	cm	None
2	PDVALS	A columnar vector of real values that defines the gas dew-point values at the corresponding DEPTH.			
		psia	barsa	atma	None

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.16: PDVD Keyword Description

Alternatively, the vaporized oil-gas ratio (condensate-gas ratio) versus depth tables may be entered using the RVVD keyword in the SOLUTION section instead of this keyword.

See also the RVVD and EQUIL keywords in the SOLUTION section.

Example

Given NTEQUL equals three and NDRXVD is greater than or equal to two on the EQLDIMS keyword in the RUNSPEC section, then the following example defines the bubble-point versus depth functions.

```
--
--        DEPTH     PSAT
--                  PRESS
--        ------    ------
PDVD
          3000.0    2000.0
          8000.0    2025.0                          / PSAT VS DEPTH EQUIL REGN 01
--        ------    ------
          3000.0    2100.0
          8000.0    3125.0                          / PSAT VS DEPTH EQUIL REGN 02
--        ------    ------
          3000.0    2200.0
          8000.0    2225.0                          / PSAT VS DEPTH EQUIL REGN 03
```

Here three tables are entered and each table is terminated by "/" and there is no keyword terminating "/".

10.3.56 PRESSURE – DEFINE THE INITIAL EQUILIBRATION PRESSURES FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PRESSURE keyword defines the initial equilibration pressures for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, RS, RV, SGAS, SOIL and SWAT keywords etc., to fully describe the initial state of the model.

The keyword is used by the Enumeration Initialization method to initialize the model, as opposed to the Equilibration Initialization method that utilizes the EQUIL keyword in the SOLUTION section. This is the non-standard formulation to initialize the model and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESSURE	PRESSURE is an array of real positive numbers assigning the initial equilibration pressures to each cell in the model. Repeat counts may be used, for example 20*4200.0.			
		psia	barsa	atma	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.17: PRESSURE Keyword Description

See also the PBUB, PDEW, RS, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--       DEFINE INITIAL EQUILIBRATION PRESSURES FOR ALL CELLS IN THE MODEL
--       BASED ON NX = 100, NY = 100 AND NZ = 3
--
PRESSURE
         1000*4500.0   1000*4510.0   1000*4520.0                                /
```

The above example defines the initial equilibration pressures to be 4500.0 for all the cells in the first layer, 4510.0 for all the cells in the second layer, and finally 4520.0 for all the cells in the third layer.

10.3.57 PRVD – DEFINE THE INITIAL EQUILIBRATION PRESSURES VERSUS DEPTH

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PRVD keyword defines the initial reservoir pressure versus depth and should be used in conjunction with the PBUB, PDEW, RS, RV, SGAS, SOIL and SWAT keywords etc., to fully describe the initial state of the model. PRVD is an alternative to the PRESSURE keyword in the SOLUTION section, that defines the initial equilibration pressures for all grid cells in the model

The keyword is used by the Enumeration Initialization method to initialize the model, as opposed to the Equilibration Initialization method that utilizes the EQUIL keyword in the SOLUTION section. This is the non-standard formulation to initialize the model and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth values for the corresponding reservoir oil pressures values, PRESSURE.			
		feet	m	cm	None
2	PRESSURE	A columnar vector of real values that defines the initial equilibration oil pressure values at the corresponding DEPTH.			
		psia	barsa	atma	None

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.18: PRVD Keyword Description

See also the PBUB, PDEW, RS, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

Given NTEQUL equals three and NDRXVD is greater than or equal to five on the EQLDIMS keyword in the RUNSPEC section, then the following example defines the initial oil reservoir pressure versus depth

```
--
--        DEPTH    INIT
--                 PRESS
--        ------   ------
PRVD
          3000.0   3000.0
          4000.0   3345.0
          5000.0   3690.0
          7000.0   4700.0
          7200.0   4769.0                          / POIL VS DEPTH EQUIL REGN 01
--        ------   ------
          3000.0   3100.0
          4000.0   3445.0
          5000.0   3790.0
          7000.0   4700.0
          7200.0   4769.0                          / POIL VS DEPTH EQUIL REGN 02
--        ------   ------
          3000.0   3150.0
          4000.0   3495.0
          5000.0   3840.0
          7000.0   4700.0
          7200.0   4769.0                          / POIL VS DEPTH EQUIL REGN 03
```

Here three tables are entered and each table is terminated by "/" and there is no keyword terminating "/".

10.3.58 PYEND – End the Definition of a PYINPUT Section

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords. A PYINPUT Definition Section is terminated by a PYEND keyword on a separate single line.

See *PYEND – End the Definition of a PYINPUT Section* in the GRID section for a full description.

10.3.59 PYINPUT – Define the Start of a PYINPUT Section

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords used by the simulator. PYINPUT declares the start of a PYINPUT Definition Section on a single separate line, which is then followed by various standard Python commands, with one command per line.

See *PYINPUT – Define the Start of a PYINPUT Section* in the GRID section for a full description.

10.3.60 RAINFALL – Constant Flux Aquifer Rainfall Flux by Month

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This RAINFALL keyword defines the month by month rainfall flux for constant flux aquifers.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.61 RBEDCONT – Define River Grid Block Contact Area versus Depth

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RBEDCONT keyword defines the river grid block contact area versus depth tables, for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.62 REFINE – Start the Definition of a Local Grid Refinement

The REFINE keyword defines the start of a Cartesian or radial local grid refinement ("LGR") definition that sets the properties of the selected LGR. The keyword is then followed by the property keywords associated with the section where the keyword is being invoked. For example, if the REFINE keyword is used in the GRID section then most of the keywords in that section can be used to set the grid properties for the LGR.

See *REFINE – Start the Definition of a Local Grid Refinement* in the GRID section for a full description.

10.3.63 RESTART – RESTART RUN FROM AN EXISTING RESTART FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RESTART keyword defines the parameters to restart the simulation from a previous run that has written a RESTART file out to disk. Only restarting from RESTART files is permitted by OPM Flow; restarting from SAVE files is not implemented.

No.	Name	Description	Default
1	RSNAME	The RSNAME variable is a character string that defines the root name of the RESTART file to be read into the current input deck.	None
2	RSNUM	A positive integer that defines the restart point on the RESTART file to be read and to be used to initialize the model. When OPM Flow writes a restart point a message is printed to the *.PRT file indicating the time step the restart was written out.	None
3	RSTYPE	Not used.	None
4	RSFORMAT	Not used.	None

Notes:

1) The keyword is terminated by "/".

Table 10.19: RESTART Keyword Description

The most direct way to start a restart run is to:

1) Copy the existing data file that created the RESTART file and give it a new name. For example if the RESTART file is from a case named *NOR-OPM-A01DATA*, then the copied data file could be named *NOR-OPM-A01-R1.DATA*.

2) Edit the copied data file (*NOR-OPM-A01-R1.DATA*) and delete all equilibration keywords (EQUIL, RSVD, etc.) or the enumeration equilibration keywords (PRESSURE, SGAS, SOIL. SWAT, etc.) in the SOLUTION section used to initialize the model.

3) In the SOLUTION section of *NOR-OPM-A01-R1.DATA* file insert the RESTART keyword, using *NOR-OPM-A01* as RSNAME and the required RSNUM value for the time step to restart from.

4) In the SCHEDULE section of *NOR-OPM-A01-R1.DATA* file insert the SKIPREST keyword at the very beginning of the SCHEDULE section. The SKIPREST keyword causes the simulator to only read in data it requires for restarting the run up to the RESTART point (RSNUM). Note that certain keywords always need to be present in a restart run in the SCHEDULE section as the data is not stored on the RESTART file, for example the VFP tables (VFPPROD and VFPINJ keywords). The SKIPREST keyword automatically processes the input deck and reads the required data.

5) In the SCHEDULE section of *NOR-OPM-A01-R1.DATA* file after the RESTART point make any required changes, save the file and run the *NOR-OPM-A01-R1.DATA* with OPM Flow.

See also RPTRST, RPTSCHED and SKIPREST keywords.

Example

The example below defines a restart from the previously run NOR-OPM-A01 case at time step number 40.

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION
--
--       FLEXIBLE RESTART FROM PREVIOUS SIMULATION RUN
--
--       FILE                    RESTART   RESTART   FILE
--       NAME                    NUMBER    TYPE      FORMAT
RESTART
         'NOR-OPM-A01'           40        1*        1*     /
```

In addition in the SCHEDULE section the SKIPREST keyword should be used to correctly read in the schedule data up to the RESTART point.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE
--
--       ACTIVATE SKIPREST OPTION TO AVOID MODIFYING SCHEDULE SECTION
--
SKIPREST
```

Note is advisable to place the SKIPREST keyword at the very beginning of the SCHEDULE section.

10.3.64 RIVERSYS - Define River System (Branch Structure and Boundary Conditions)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RIVERSYS defines a river system by specifying the branch structure of the river together with the branch's associated boundary conditions, for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.65 RPTRST – DEFINE DATA TO BE WRITTEN TO THE RESTART FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data and frequency of the data to be written to the RESTART file at each requested restart point. In addition to the solution data arrays required to restart a run and the frequency of the data to be written, the user may request additional data to be written to the restart file for visualization in OPM ResInsight.

The format consists of the keyword followed by a series of character strings that indicate the data to be printed. In most cases the character string is the keyword used to load the data in the OPM Flow input deck, for example KRG for the gas relative permeability of each grid block at the requested times. Its is anticipated that OPM Flow will support additional functionality as development progresses.

No.	Name	Description	Array Name
1	ALLPROPS	An alias for DEN, KRG, KRO, KRW, and VISC restart variable names combined that writes all the properties associated with these keywords.	
2	BASIC	BASIC defines the frequency at which the restart data for restarting a run and the additional requested data is written to the RESTART file. The parameter is assigned a value, OPTION, using the form BASIC = OPTION, where OPTION is an integer variable set to: 1) OPTION = 1 then the restart files are written at every report time, but only the last one in the run is kept. This minimizes the restart file size but only the final results are stored, limiting the visualization in OPM ResInsight. 2) OPTION = 2 then the restart files are written at every report time step until this switch is reset and all the restarts are kept. 3) OPTION = 3 then the restart files are written every n^{th} report time step with the frequency determined by the mnemonic "FREQ=n". This feature is not currently supported by OPM Flow. 4) OPTION = 4 then the restart files are written at the first report step of each year. 5) OPTION = 5 then the restart files are written at the first report step of each month. 6) OPTION = 6 then the restart files are written at every time step. In addition for OPTION equal to 3, 4, and 5 the data may be written every n^{th} report time with the frequency determined by the mnemonic "FREQ=n". However, this feature is currently not currently supported in OPM Flow.	
3	DEN	Oil, gas and water fluid phases in-situ densities.	OIL_DEN GAS_DEN WAT_DEN
4	KRG	Gas relative permeability at the grid blocks gas saturation.	GASKR
5	KRO	Oil relative permeability at the grid blocks oil saturation.	OILKR
6	KRW	Water relative permeability at the grid blocks water saturation.	WATKR

No.	Name	Description	Array Name
7	RSSAT	Saturated dissolved gas-oil ratio for each grid block to enable restarts.	RSSAT
8	RVSAT	Saturated vaporized oil-gas ratio for each grid block to enable restarts.	RVSAT
9	VISC	Oil, gas and water fluid phases in-situ grid block viscosity data.	OIL_VISC GAS_VISC WAT_VISC
Notes: 1) The keyword is terminated by "/".			

Table 10.20: RPTRST Keyword Description

Note that OPM Flow automatically writes out all the data required to make a restart run as outlined in the table below:

No.	Restart Variable Name	Variable Description	Variable Array Name
1	KRG	Gas relative permeability at the grid blocks gas saturation.	GASKR
2	KRNSW_GO	Gas-oil relative permeability scaling factor array used when the hysteresis option has been activated by the HYSTER variable on the SATOPTS keyword in the RUNSPEC section, to enable restarts.	KRNSW-_GO
3	KRNSW_OW	Oil-water relative permeability scaling factor array used when the hysteresis option has been activated by the HYSTER variable on the SATOPTS keyword in the RUNSPEC section, to enable restarts.	KRNSW_OW
4	KRO	Oil relative permeability at the grid blocks oil saturation.	OILKR
5	PCSWM_GO	Gas-oil capillary pressure scaling factor array used when the hysteresis option has been activated by the HYSTER variable on the SATOPTS keyword in the RUNSPEC section, to enable restarts.	PCSWM_GO
6	PCSWM_OW	Oil-Water capillary pressure scaling factor array used when the hysteresis option has been activated by the HYSTER variable on the SATOPTS keyword in the RUNSPEC section, to enable restarts.	PCSWM_OW
7	POLY	Polymer concentration for each grid block to enable restarts for when the POLYMER option has been activated in the RUNSPEC section	CPOLYMER
8	PRESS	Pressure data for each grid block to enable restarts.	PRESSURE
9	RS	Dissolved gas-oil ratio for each grid block to enable restarts.	RS
10	RV	Vaporized oil-gas ratio for each grid block to enable restarts.	RVS
11	SGAS	Gas saturation for each grid block to enable restarts.	SGAS
12	SOIL	Oil saturation each grid block to enable restarts.	SOIL
12	SOMAX	Maximum oil saturation used in determining the rate of oil vaporization in the presence of undersaturated gas and the rate at which the remaining oil gets "heavier" via the reduction in the solution gas-oil ratio ("Rs").	SOMAX

No.	Restart Variable Name	Variable Description	Variable Array Name
14	SSOL	Solvent saturation for each grid block to enable restarts for when the SOLVENT option has been activated in the RUNSPEC section	SSOL
15	SWAT	Water ratio for each grid block to enable restarts.	SWAT
16	TEMP	Temperature of each grid block, currently not used in this version of OPM Flow.	Not Used
17	TERNARY	Three phase ternary saturation data is data array is calculated by OPM ResInsight when the RESTART file is loaded into OPM ResInsight,	TERNARY (Calculated)
18	KRW	Water relative permeability at the grid blocks water saturation.	WATKR

Notes:

1) Only items (1) to (14) that are necessary to restart a run are written to the restart file, for example if the niether the POLYMER and SOLVENT options have not been invoked in the RUNSPEC section then the CPOLYMER ans SSOL arrays will not be written to the restart file.

Table 10.21: Data Sets Automatically Written to the RESTART File

Examples

The first example request that the standard restart data be written out every month.

```
--
--        RESTART CONTROL BASIC = 4 (YEARLY) 5 (MONTHLY)
--
RPTRST
          BASIC=5                                                    /
```

The next example requests that the standard restart data be written at every report time step until this switch is reset and all the restarts are kept. In addition to the standard the data the gas, oil and water relative permeability data will also be written out at each report time step.

```
--
--        RESTART CONTROL BASIC = 4 (YEARLY) 5 (MONTHLY)
--
RPTRST
          BASIC=2  KRG   KRO   KRW                                   /
```

10.3.66 RPTSOL – DEFINE SOLUTION SECTION REPORTING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data in the SOLUTION section that is to be printed to the output print file in human readable format. The keyword has two distinct forms, the first of which consists of the keyword followed by a series of integers on the next line indicating the data to be printed (see the first example). This is the original formal in the commercial simulator and was subsequently superseded by the second format. The second format consists of the keyword followed by a series of character strings that indicate the data to be printed. In most cases the character string is the keyword used to load the data in the OPM Flow input deck, for example PVDG for the dry gas PVT tables. Its is anticipated that OPM Flow will eventually support the functionality of the second format only, the first format although recognized will be completely ignored.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description	Default
1	DENO	Print the oil reservoir density array	N/A
2	EQUIL	Print the equilibration report.	N/A
3	FIP	Print the fluid in-place report.	N/A
4	FIPRESV	Print the reservoir volumes in-place report.	N/A
….		….	N/A

Notes:

1) The keyword is terminated by "/".

Table 10.22: RPTSOL Keyword Description

Note

Except for non-array like data, FIP etc., this keyword has the potential to produce very large print files that some text editors may have difficulty loading. A more efficient solution for array type data is to load the *.INIT and *.RESTART files into OPM ResInsight to view the data graphically, this also has the benefit of being able to filter the grid based on I, J, K ranges and grid properties.

Examples

The first example shows the original format of this keyword; although the keyword and format are recognized by OPM Flow, the format is ignored and is unlikely to be implemented in in the simulator.

```
--
--        DEFINE SOLUTION SECTION REPORT OPTION (ORIGINAL FORMAT)
-
RPTSOL
          1        2*0      1        3*1                                        /
```

The next example shows the second format of the keyword which may be supported in a future release of OPM Flow.

```
--
--        DEFINE SOLUTION SECTION REPORT OPTIONS
--
RPTSOL
          FIP=2    FIPRESV  RESTART=3                                           /
```

10.3.67 RS – DEFINE THE INITIAL EQUILIBRATION GOR (RS) FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RS keyword defines the initial equilibration gas-oil ratio values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RV, SGAS, SOIL and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if dissolved gas has been activated in the model via the DISGAS keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	RS	RS is an array of real positive numbers assigning the initial equilibration gas-oil ratio values to each cell in the model. Repeat counts may be used, for example 20*1.30.			
		Mscf/stb	sm^3/sm^3	scc/scc	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.23: RS Keyword Description

See also the PBUB, PDEW, PRESSURE, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--      DEFINE INITIAL EQUILIBRATION GOR VALUES FOR ALL CELLS IN THE MODEL
--      BASED ON NX = 100, NY = 100 AND NZ = 3
--
RS
        1000*1.3500   1000*1.3010   1000*1.3000                                /
```

The above example defines the initial equilibration GOR values to be 1.3500 for all the cells in the first layer, 1.3010 for all the cells in the second layer, and finally 1.3000 for all the cells in the third layer.

10.3.68 RSVD – EQUILIBRATION DISSOLVED GAS-OIL RATIO (RS) VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RSVD keyword defines the dissolved gas-oil ratio (Rs) versus depth tables for each equilibration region that should be used when there is dissolved gas in the model (DISGAS has been activated in the RUNSPEC section) and the EQLOPT1 variable has been set to a positive integer on the EQUIL keyword in the SOLUTION section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth values for the corresponding dissolve gas-oil ratio values, RSVALS.			
		feet	m	cm	None
2	RSVALS	A columnar vector of real values that defines the dissolved gas-oil ratio values at the corresponding DEPTH.			
		Mscf/stb	sm^3/sm^3	scc/scc	None

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.24: RSVD Keyword Description

Alternatively, the oil bubble-point pressure versus depth tables may be entered using the PBVD keyword in the SOLUTION section instead of this keyword.

See also the PBVD and EQUIL keywords in the SOLUTION section.

Example

Given NTEQUL equals three and NDRXVD is greater than or equal to two on the EQLDIMS keyword in the RUNSPEC section, then the following example defines the bubble-point versus depth functions.

```
--
--        DEPTH     RS
--                  MSCF/STB
--        ------    --------
RSVD
          3000.0     1.400
          8000.0     1.400                          / RS VS DEPTH EQUIL REGN 01
--        ------    --------
          3000.0     1.400
          8000.0     1.400                          / RS VS DEPTH EQUIL REGN 02
--        ------    --------
          3000.0     1.400
          8000.0     1.400                          / RS VS DEPTH EQUIL REGN 03
```

Here three tables are entered with a constant GOR versus depth relationship.

10.3.69 RTEMP - Define the Initial Reservoir Temperature for the Model

This keyword defines the reservoir temperature for when a temperature option has been activated by the either the TEMP or THERMAL keywords in the RUNSPEC section. The RTEMPA keyword is alias for RTEMP

See *RTEMP - Define the Initial Reservoir Temperature for the Model* in the PROPS section for a full description.

10.3.70 RTEMPA - Define the Initial Reservoir Temperature for the Model

This keyword defines the reservoir temperature for when a temperature option has been activated by the either the TEMP or THERMAL keywords in the RUNSPEC section. The RTEMP keyword is alias for RTEMPA

See *RTEMPA - Define the Initial Reservoir Temperature for the Model* in the PROPS section for a full description.

10.3.71 RTEMPVD - DEFINE THE INITIAL RESERVOIR TEMPERATURE VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the reservoir temperature versus depth tables for when the temperature or thermal options has been activated by either the TEMP or THERMAL keywords in the RUNSPEC section in the commercial simulator. For OPM Flow the THERMAL keyword must be used to invoke the thermal option. The RTEMPVD keyword is an alias for the TEMPVD keyword; however, the latter is ignored by OPM Flow.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth for corresponding reservoir temperature parameter TEMP.			
		feet	m	cm	None
2	TEMP	A columnar vector of real monotonically increasing down the column values that defines the corresponding reservoir temperature for the given depth.			
		°F	°C	°C	None

Notes:

1) The keyword is followed by NTEQUIL tables as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQIDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.25: RTEMPVD Keyword Description

See also the RTEMP keyword in the PROPS section.

Example

```
--
--       INITIAL RESERVOIR TEMPERATURE VERSUS DEPTH TABLE
--
RTEMPVD
--       DEPTH    TEMPERATURE
--       FEET     DEG F
--       ------   ----------
         1000.0     90.000
         2000.0    100.000
         3000.0    130.000
         4000.0    160.000                                  / TABLE N0. 01
--       ------   ----------
         1000.0     90.000
         2000.0    100.000
         3000.0    130.000
         4000.0    160.000                                  / TABLE N0. 02
--       ------   ----------
         1000.0     90.000
         2000.0    100.000
         3000.0    130.000
         4000.0    160.000                                  / TABLE N0. 03
```

The above example defines three identical reservoir depth versus temperature tables for the three NTEQUIL regions defined on the EQLDIMS keyword in the RUNSPEC section.

10.3.72 RV – DEFINE THE INITIAL EQUILIBRATION CGR (RV) FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RV keyword defines the initial equilibration vaporized oil-gas ratio values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, SGAS, SOIL and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if vaporized oil been activated in the model via the VAPOIL keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	RV	RV is an array of real positive numbers assigning the initial equilibration vaporized oil-gas ratio values to each cell in the model. Repeat counts may be used, for example 20*0.00720			
		stb/Mscf	sm^3/sm^3	scc/scc	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.26: RV Keyword Description

See also the PBUB, PDEW, PRESSURE, RS, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION CGR VALUES FOR ALL CELLS IN THE MODEL
--        BASED ON NX = 100, NY = 100 AND NZ = 3
--
RV
          1000*0.00720   1000*0.00725   1000*0.00730                          /
```

The above example defines the initial equilibration GOR values to be 0.00720 for all the cells in the first layer, 0.00725 for all the cells in the second layer, and finally 0.00730 for all the cells in the third layer.

10.3.73 RVVD – EQUILIBRATION VAPORIZED OIL-GAS RATIO (RV) VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RVVD keyword defines the vaporized oil-gas ratio (Rv) versus depth tables for each equilibration region that should be used when there is vaporize oil in the model (VAPOIL has been activated in the RUNSPEC section) and the EQLOPT2 variable has been set to a positive integer on the EQUIL keyword in the SOLUTION section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth values for the corresponding vaporized oil-gas ratio values, RVVALS.			
		feet	m	cm	None
2	RVVALS	A columnar vector of real values that defines the vaporized oil-gas ratio values, values at the corresponding DEPTH.			
		stb/Mscf	sm^3/sm^3	scc/scc	None

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.27: RVVD Keyword Description

Alternatively, the gas dew-point pressure versus depth tables may be entered using the PDVD keyword in the SOLUTION section instead of this keyword.

See also the PDVD and EQUIL keywords in the SOLUTION section.

Example

Given NTEQUL equals three and NDRXVD is greater than or equal to two on the EQLDIMS keyword in the RUNSPEC section, then the following example defines the bubble-point versus depth functions.

```
--
--        DEPTH     RV
--                  STB/MSCF
--        ------    --------
RVVD
          3000.0    0.00725
          8000.0    0.00725                          / RV VS DEPTH EQUIL REGN 01
--        ------    --------
          3000.0    0.00730
          8000.0    0.00730                          / RV VS DEPTH EQUIL REGN 02
--        ------    --------
          3000.0    0.00750
          8000.0    0.00750                          / RV VS DEPTH EQUIL REGN 03
```

Here three tables are entered with a constant CGR versus depth relationship for each equilibration region.

10.3.74 SALT – DEFINE THE INITIAL EQUILIBRATION SALT CONCENTRATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SALT keyword defines the initial equilibration salt concentration values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SGAS and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if the salt (brine) phase has been activated in the model via the BRINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SALT	SALT is an array of real positive numbers that are greater than or equal to zero assigning the initial equilibration salt concentration values to each cell in the model. Repeat counts may be used, for example 20*15.0.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.28: SALT Keyword Description

See also the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--       DEFINE INITIAL EQUILIBRATION SALT VALUES FOR ALL CELLS IN THE MODEL
--       BASED ON NX = 100, NY = 100 AND NZ = 3
--
SALT
         1000*0.0000    1000*0.0000    1000*15.000                              /
```

The above example defines the initial equilibration salt concentration values to be 0.0000 for all the cells in the first and second layers and finally 15.000 for all the cells in the third layer.

10.3.75 SALTREST – DEFINE THE RESTART SALT CONCENTRATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SALTREST keyword defines restart salt concentration values for all grid cells in the model and should be used in runs that are using the RESTART facility, where the initial run has not used the Low Salt or Brine options. This allows for initial runs that have used the standard water PVT properties via the PVTW keyword in the PROPS section, to be restarted with salt dependent water properties. The keyword should only be used if the salt (brine) phase has been activated in the current restart run (not the initial run) via the BRINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SALTREST	SALTREST is an array of real positive numbers that are greater than or equal to zero assigning the restart salt concentration values to each cell in the model. Repeat counts may be used, for example 20*15.0.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.29: SALTREST Keyword Description

See also the PVTWSALT keyword in the PROPS section and the RESTART keyword in the SOLUTION section.

Example

```
--
--        DEFINE RESTART SALTREST VALUES FOR ALL CELLS IN THE MODEL
--        BASED ON NX = 100, NY = 100 AND NZ = 3
--
SALTREST
         1000*0.0000    1000*0.0000    1000*15.000                          /
```

The above example defines the restart salt concentration values to be 0.0000 for all the cells in the first and second layers and finally 15.000 for all the cells in the third layer.

10.3.76 SALTPVD – EQUILIBRATION SALT PRECIPITATED CONCENTRATION VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SALTPVD keyword defines the initial salt precipitated concentration versus depth tables for each equilibration region for when OPM Flow's Salt Precipitation Model has been activated in the input deck via the PRECSALT keyword in the RUNSPEC section. The keyword defines the initial deposited salt as a volume fraction (S_s), that is solid salt saturation.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note

This is an OPM Flow specific keyword for the simulator's Salt Precipitation Model that is activated by the PRECSALT keyword and declaring that vaporized water is present in the run via the VAPWAT in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth for corresponding salt concentrations SALTCON.			
		feet	m	cm	None
2	SALTSAT	A columnar vector of real values that defines the corresponding volume fraction of precipitated salt for the given depth. Note only the standard Brine Model is supported and therefore there should be only one columnar vector of SALTSAT.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) The keyword is followed by NTEQUIL tables as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQIDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.30: SALTPVD Keyword Description

Note

This is the initial precipitated salt concentration contained within the pore space, see SALTVD in the SOLUTION section that defines the initial salt concentration within the water phase.

Example

The example activates the standard Brine Tracking model using the BRINE keyword, OPM Flow's Salt Precipitation model using the PRECSALT keyword, and OPM Flow's vaporized water phase with the VAPWAT keyword; all three keywords are in the RUNSPEC section. The example also sets the number of equilibrium regions to three (NTEQUIL set to three on the EQLDIMS keyword also in the RUNSPEC), that is:

```
-- ==============================================================================
--
-- RUNSPEC SECTION
--
-- ==============================================================================
RUNSPEC
--
--       MAX     MAX     RSVD    TVDP    TVDP
--       EQLNUM  DEPTH   NODES   TABLE   NODES
EQLDIMS
         3       1*      20      1*      1*                                      /
--
--       ACTIVATE STANDARD BRINE MODEL
--
BRINE
--
--       ACTIVATE THE OPM FLOW SALT PRECIPITATION MODEL (OPM FLOW KEYWORD)
--
PRECSALT
--
--       VAPORIZED WATER IN WET GAS IS PRESENT IN THE RUN (OPM FLOW KEYWORD)
--
VAPWAT
```

Then in the SOLUTION section the SALTPVD keyword would be of the form:

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION
--
--       DEPTH    SALTSAT
--       ------   --------
SALTPVD
         3000.0    0.000
         8000.0    0.000                                   / EQUIL REGN 01
--       ------   --------
         3000.0    0.000
         8000.0    0.000                                   / EQUIL REGN 02
--       ------   --------
         3000.0    0.000
         8000.0    0.000                                   / EQUIL REGN 03
```

Here the precipitated salt volume fraction has been set to zero for all three equilibration regions.

10.3.77 SALTVD – EQUILIBRATION SALT CONCENTRATION VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SALTVD keyword defines the initial salt concentration versus depth tables for each equilibration region for when the salt (brine) phase has been activated in the model via the BRINE keyword in the RUNSPEC section, and the EQLOPT1 variable has been set to a positive integer on the EQUIL keyword in the SOLUTION section. Secondly, the keyword should also be used to set the initial salt concentration versus depth if OPM Flow's PRECSALT keyword in the RUNSPEC section has been used to activate the simulators Salt Precipitation model.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth for corresponding salt concentrations SALTCON.			
		feet	m	cm	None
2	SALTCON	A columnar vector of real monotonically increasing down the column values that defines the corresponding salt concentration within the water phase for the given depth. There should be one columnar vector for each type of salt. For the standard Brine Model there is only one salt type and therefore there should be only one columnar vector of SALTCON. However, if the BRINE keyword has been invoked with the ECLMC keyword in the RUNSPEC section, then there should one columnar SALTCON vector for each declared salt type. It is recommended to provide initial salt concentrations less then or equal to values provided by SALTSOL keyword in the PROPS section.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) The keyword is followed by NTEQUIL tables as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQIDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.31: SALTVD Keyword Description

Note

This is the initial salt concentration contained within the water phase, see SALTPVD in the SOLUTION section that defines the initial salt concentration that has been precipitated into the pore space.

Examples

The first example activates the standard Brine Tracking model using the BRINE keyword in the RUNSPEC section and sets the number of equilibrium regions to three (NTEQUIL set to 3 on the EQLDIMS keyword also in the RUNSPEC), that is:

```
-- ==============================================================================
--
-- RUNSPEC SECTION
--
-- ==============================================================================
RUNSPEC
--
--       MAX      MAX      RSVD     TVDP     TVDP
--       EQLNUM   DEPTH    NODES    TABLE    NODES
EQLDIMS
         3        1*       20       1*       1*                                  /
--
--       ACTIVATE STANDARD BRINE MODEL
--
BRINE
```

Then in the SOLUTION section the SALTVD keyword would be of the form:

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION
--
--       DEPTH    SALT-1    SALT-2    SALT-3    SALT-4
--                SALTCON   SALTCON   SALTCON   SALTCON
--       ------   -------   -------   -------   -------
SALTVD
         3000.0    1.200
         8000.0    1.200                                 / EQUIL REGN 01
--       ------   --------
         3000.0    1.300
         8000.0    1.300                                 / EQUIL REGN 02
--       ------   --------
         3000.0    1.400
         8000.0    1.400                                 / EQUIL REGN 03
```

The next example shows how the SALTVD keyword is entered when both the ECLMC and BRINE keywords have activated the Multi-Component Brine model in the RUNSPEC section, that is:

```
-- ==============================================================================
--
-- RUNSPEC SECTION
--
-- ==============================================================================
RUNSPEC
--
--       MAX     MAX     RSVD    TVDP    TVDP
--       EQLNUM  DEPTH   NODES   TABLE   NODES
EQLDIMS
         3       1*      20      1*      1*                                      /
--
--
--       ACTIVATE MULTI-COMPONENT BRINE MODEL
--
ECLMC
--
--       DEFINE WATER PHASE MULTI-COMPONENT BRINE COMPONENTS
--
--       SALT1   SALT2   SALT3   SALT4   SALT5
BRINE
         NACL    CACL    MGC03                                                   /
```

The above example activates the Multi-Component Brine model with three different water salinities for three equilibrium regions. In this case the resulting SALTVD keyword would be of the form:

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION
--
--       DEPTH    SALT-01   SALT-02   SALT-03   SALT-04
--                CONCENTR  CONCENTR  CONCENTR  CONCENTR
--       ------   --------  --------  --------  --------
SALTVD
         3000.0    1.200    0.540     0.020
         7000.0    1.200    0.640     0.040             / EQUIL REGN 01
--       ------   --------  --------  --------
         3000.0    1.300    0.440     0.020
         8000.0    1.300    0.540     0.040             / EQUIL REGN 02
--       ------   --------  --------  --------
         5000.0    1.400    0.640     0.002
         8000.0    1.400    0.640     0.002             / EQUIL REGN 03
```

In this case there are three data sets, on one for each equilibrium region and three SALTCON columnar vectors, one for each salt type (NACL, CACL and MGC03) declared via the BRINE keyword in the RUNSPEC section.

Note that the Multi-Component Brine model is not available in OPM Flow.

10.3.78 SCVD – DEFINE EQUILIBRATION COAL SOLVENT CONCENTRATION VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SCVD keyword defines the initial coal solvent concentration versus depth tables for each equilibration region for when the coal phase has been activated in the run via the COAL keyword in the RUNSPEC section. The keyword may be used in conjunction with the SOLVCONC keyword in the SOLUTION section, to fully describe the initial state of the model. Note both SOLVCONC and SCVD are optional as the simulator will calculate the coal gas concentration based on the equilibrium concentration and the block pressure.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A columnar vector of real monotonically increasing down the column values that defines the depth values for the corresponding coal solvent concentration, SCVALS.			
		feet	m	cm	None
2	SCVALS	A columnar vector of real values that defines the coal solvent concentration values at the corresponding DEPTH.			
		Mscf/ft^3	sm^3/m^3	scc/cc	None

Notes:

1) The keyword is followed by NTEQUL records as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.32: SCVD Keyword Description

See also the SOLVCONC, GCVD, GASCONC and GASSATC keywords in the SOLUTION section.

Example

Given NTEQUL equals three and NDRXVD is greater than or equal to two on the EQLDIMS keyword in the RUNSPEC section, then the following example defines the coal solvent concentration versus depth functions.

```
--
--        DEPTH    SOLVC
--                 MSCF/FT
--        ------   --------
SCVD
           100.0   75.5000
          1000.0   75.5000                          / SC VS DEPTH EQUIL REGN 01
--        ------   --------
           100.0   65.5000
          1000.0   65.5000                          / SC VS DEPTH EQUIL REGN 02
--        ------   --------
           100.0   60.0000
          1000.0   60.0000                          / SC VS DEPTH EQUIL REGN 03
```

Here three tables are entered with a constant coal solvent concentration versus depth relationship for each equilibration region

10.3.79 SFOAM – DEFINE THE INITIAL EQUILIBRATION FOAM CONCENTRATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SFOAM keyword defines the initial equilibration foam concentration values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SGAS and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if the foam phase has been activated in the model via the FOAM keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SFOAM	SFOAM is an array of real positive numbers that are greater than or equal to zero assigning the initial equilibration foam concentration values to each cell in the model. Units are dependent on the transport phase specified via the FOAMOPT1 variable on the FOAMOPTS keyword in the PROPS section. FOAMOPT1 should be set to either GAS or WATER. Repeat counts may be used, for example 20*0.5			
		Gas: lb/Mscf Water: lb/stb	Gas: kg/sm^3 Water: kg/sm^3	Gas: gm/scc Water: gm/scc	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.33: SFOAM Keyword Description

See also the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--      DEFINE INITIAL EQUILIBRATION FOAM VALUES FOR ALL CELLS IN THE MODEL
--      BASED ON NX = 100, NY = 100 AND NZ = 3
--
SFOAM
        1000*0.0000    1000*0.0000    1000*0.500                          /
```

The above example defines the initial equilibration foam concentration values to be 0.0000 for all the cells in the first and second layers and finally 0.500 for all the cells in the third layer.

10.3.80 SGAS – DEFINE THE INITIAL EQUILIBRATION GAS SATURATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SGAS keyword defines the initial equilibration gas saturation values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SOIL and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if the gas phase has been activated in the model via the GAS keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SGAS	SGAS is an array of real positive numbers that are greater than or equal to zero and less than or equal to one assigning the initial equilibration gas saturation values to each cell in the model. Repeat counts may be used, for example 20*0.600.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.34: SGAS Keyword Description

Note for two phase runs it is only necessary to enter one saturation array of one of the phases present in the run (SGAS, SOIL, or SWAT), as the simulator will calculate the other phases by difference. Similarly for three phase runs it is only necessary to enter the array data for two of the phases, as the third saturation will again be calculated by the simulator.

See also the PBUB, PDEW, PRESSURE, RS, RV, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION GAS SAT VALUES FOR ALL CELLS IN THE MODEL
--        BASED ON NX = 100, NY = 100 AND NZ = 3
--
SGAS
          1000*0.7000    1000*0.6500    1000*0.6000                              /
```

The above example defines the initial equilibration gas saturation values to be 0.7000 for all the cells in the first layer, 0.6500 for all the cells in the second layer, and finally 0.6000 for all the cells in the third layer.

10.3.81 SOIL – DEFINE THE INITIAL EQUILIBRATION OIL SATURATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOIL keyword defines the initial equilibration oil saturation values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SGAS and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if the oil phase has been activated in the model via the OIL keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SOIL	SOIL is an array of real positive numbers that are greater than or equal to zero and less than or equal to one assigning the initial equilibration oil saturation values to each cell in the model. Repeat counts may be used, for example 20*0.600.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.35: SOIL Keyword Description

Note for two phase runs it is only necessary to enter one saturation array of one of the phases present in the run (SGAS, SOIL, or SWAT), as the simulator will calculate the other phases by difference. Similarly for three phase runs it is only necessary to enter the array data for two of the phases, as the third saturation will again be calculated by the simulator.

See also the PBUB, PDEW, PRESSURE, RS, RV, SGAS and SWAT keywords to fully define the initial state of the model.

Example

```
--
--       DEFINE INITIAL EQUILIBRATION OIL SAT VALUES FOR ALL CELLS IN THE MODEL
--       BASED ON NX = 100, NY = 100 AND NZ = 3
--
SOIL
         1000*0.7000    1000*0.6500    1000*0.6000                              /
```

The above example defines the initial equilibration oil saturation values to be 0.7000 for all the cells in the first layer, 0.6500 for all the cells in the second layer, and finally 0.6000 for all the cells in the third layer.

10.3.82 SPOLY – DEFINE THE INITIAL EQUILIBRATION POLYMER CONCENTRATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SPOLY keyword defines the initial equilibration polymer concentration values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SGAS and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if the polymer phase has been activated in the model via the POLYMER keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SPOLY	SPOLY is an array of real positive numbers that are greater than or equal to zero assigning the initial equilibration polymer concentration values to each cell in the model. Repeat counts may be used, for example 20*25.0.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.36: SPOLY Keyword Description

See also the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION POLYMER VALUES FOR ALL CELLS IN THE MODEL
--        BASED ON NX = 100, NY = 100 AND NZ = 3
--
SPOLY
          1000*0.0000    1000*0.0000    1000*15.000                              /
```

The above example defines the initial equilibration polymer concentration values to be 0.0000 for all the cells in the first and second layers and finally 15.000 for all the cells in the third layer.

10.3.83 SOLUTION - DEFINE THE START OF THE SOLUTION SECTION OF KEYWORDS

Description

The SOLUTION activation keyword marks the end of the REGIONS section and the start of the SOLUTION section that defines the initialized parameters used to initialized the model, by:

1) defining fluid contacts and pressures, or
2) defining pressures and fluid saturations for all cells in the model, or
3) by restarting from a previously run OPM Flow completed run.

There is no data required for this keyword.

Example

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION
```

The above example marks the end of the REGIONS section and the start of the SOLUTION section in the OPM Flow data input file.

10.3.84 SOLVCONC – DEFINE THE INITIAL COAL SOLVENT CONCENTRATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOLVCONC keyword defines the initial coal solvent concentration values for all matrix grid cells in the model and should be used in conjunction with the SCVD keyword in the SOLUTION section, to fully describe the initial state of the model. The keyword should only be used if the coal phase has been activated in the model via the COAL keyword in the RUNSPEC section. Note both SOLVCONC and SCVD are optional as the simulator will calculate the coal solvent concentration based on the equilibrium concentration and the block pressure.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SOLVCONC	SOLVCONC is an array of real positive numbers that define the initial equilibration coal solvent concentration values to each matrix cell in the model. Repeat counts may be used, for example 20*75.0.			
		Mscf/ft^3	sm^3/m^3	scc/cc	None

Notes:

1) The number of entries should correspond to number of matrix cells in the model, that is (NX x NY x NZ) divided by two, as per the parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.37: SOLVCONC Keyword Description

See also the SCVD keyword in the SOLUTION section to fully define the initial state of the model.

Example

```
--
--       DEFINE INITIAL EQUILIBRATION COAL SOLVENT CONCENTRATION FOR ALL CELLS
--       BASED ON NX = 100, NY = 100 AND NZ = 6
--
SOLVCONC
         1000*75.500    1000*65.500    1000*60.000                          /
```

The above example defines the initial coal solvent concentration values to be 75.500 for all the matrix cells in the first layer, 65.500 for all the cells in the second layer, and finally 60.000 for all the cells in the third layer.

10.3.85 SOLVFRAC – DEFINE THE INITIAL GAS SOLVENT FRACTION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SOLVFRAC keyword defines the initial solvent faction within the gas phase values for all matrix grid cells in the model. The keyword should only be used if the coal phase has been activated in the model via the COAL keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

SOLVFRAC is used with the standard equilibration method to initialize the model via the EQUIL keyword in the RUNSPEC section, as oppose to the non-standard enumeration method.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SOLVFRAC	SOLVFRAC is an array of real positive numbers that define the initial solvent fraction within the gas phase values for each matrix cell in the model. Repeat counts may be used, for example 20*0.075.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to number of matrix cells in the model, that is (NX x NY x NZ) divided by two, as per the parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.38: SOLVFRAC Keyword Description

See also the EQUIL keyword in the SOLUTION section to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION GAS SOLVENT FRACTION FOR ALL CELLS
--        BASED ON NX = 100, NY = 100 AND NZ = 6
--
SOLVFRAC
          1000*0.0250    1000*0.0350    1000*0.0500                          /
```

The above example defines the initial gas solvent fraction values to be 0.250 for all the matrix cells in the first layer, 0.0350 for all the cells in the second layer, and finally 0.0500 for all the cells in the third layer.

10.3.86 SSOL – DEFINE THE INITIAL EQUILIBRATION SOLVENT SATURATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SSOL keyword defines the initial equilibration solvent saturation values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if the solvent phase has been activated in the model via the SOLVENT keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SSOL	SSOL is an array of real positive numbers that are greater than or equal to zero and less than or equal to one assigning the initial equilibration solvent saturation values to each cell in the model. Repeat counts may be used, for example 20*0.000.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.39: SSOL Keyword Description

See also the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SOIL, and SWAT keywords to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION GAS SAT VALUES FOR ALL CELLS IN THE MODEL
--        BASED ON NX = 100, NY = 100 AND NZ = 3
--
SSOL
          1000*0.0000    1000*0.0000    1000*0.0000                              /
```

The above example defines the initial equilibration solvent saturation values to be 0.0 for all the cells in the in the model.

10.3.87 SURF – DEFINE THE INITIAL EQUILIBRATION POLYMER CONCENTRATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SURF keyword defines the initial equilibration surfactant concentration values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SGAS and SWAT keywords etc., to fully describe the initial state of the model. The keyword should only be used if the surfactant phase has been activated in the model via the SURFACT keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SURF	SURF is an array of real positive numbers that are greater than or equal to zero assigning the initial equilibration surfactant concentration values to each cell in the model. Repeat counts may be used, for example 20*25.0.			
		lb/stb	kg/sm^3	gm/scc	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.40: SURF Keyword Description

See also the PBUB, PDEW, PRESSURE, RS, RV, SGAS, SOIL and SWAT keywords to fully define the initial state of the model.

Example

```
--
--       DEFINE INITIAL EQUILIBRATION SURFACTANT VALUES FOR ALL CELLS
--       BASED ON NX = 100, NY = 100 AND NZ = 3
--
SURF
         1000*0.0000    1000*0.0000    1000*0.2500                              /
```

The above example defines the initial equilibration surfactant concentration values to be 0.0000 for all the cells in the first and second layers and finally 0.2500 for all the cells in the third layer.

10.3.88 SWAT – DEFINE THE INITIAL EQUILIBRATION WATER SATURATION FOR ALL GRID BLOCKS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SWAT keyword defines the initial equilibration water saturation values for all grid cells in the model and should be used in conjunction with the PBUB, PDEW, PRESSURE, RS, RV, SGAS and SOIL keywords etc., to fully describe the initial state of the model. The keyword should only be used if the water phase has been activated in the model via the WATER keyword in the RUNSPEC section.

This is the non-standard method to initialize the model via enumeration and is seldom employed in the industry. The standard methodology is for OPM Flow to initialize a model using the parameters on the EQUIL keyword combined with other keywords to fully describe the initial state of the model. The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SWAT	SWAT is an array of real positive numbers that are greater than or equal to zero and less than or equal to one assigning the initial equilibration water saturation values to each cell in the model. Repeat counts may be used, for example 20*0.300.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.41: SWAT Keyword Description

Note for two phase runs it is only necessary to enter one saturation array of one of the phases present in the run (SGAS, SOIL, or SWAT), as the simulator will calculate the other phases by difference. Similarly for three phase runs it is only necessary to enter the array data for two of the phases, as the third saturation will again be calculated by the simulator.
See also the PBUB, PDEW, PRESSURE, RS, RV, SGAS and SOIL keywords to fully define the initial state of the model.

Example

```
--
--        DEFINE INITIAL EQUILIBRATION GAS SAT VALUES FOR ALL CELLS IN THE MODEL
--        BASED ON NX = 100, NY = 100 AND NZ = 3
--
SWAT
          1000*0.2000    1000*0.2500    1000*0.4500                          /
```

The above example defines the initial equilibration water saturation values to be 0.2000 for all the cells in the first layer, 0.2500 for all the cells in the second layer, and finally 0.4500 for all the cells in the third layer.

10.3.89 TBLK – DEFINE TRACER INITIAL GRID BLOCK CONCENTRATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TBLK keyword defines the initial tracer concentration for all or selected cells in the model, for when the TRACERS keyword in the RUNSPEC section has declared the maximum number of tracers for each phase, and the TRACER keyword in the PROPS section has defined the tracer. This keyword is not in the standard keyword format due to the tracer name being concatenated to the keyword TBLK to fully define the tracer being initialized.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NAME	A character string of up to eight characters, consisting of TBLK as the first four characters followed by a four letter character string defining the tracer's name. The fifth character should either be the letter F or the letter S, that indicates the state of the tracer either to be free (F) or in solution (S). For example, TBLKFIGS (free) or TBLKSIGS (solution). The last three characters of NAME (the effective tracer name) must also match an entry on the TRACER keyword's NAME parameter, in the PROPS section. Note it is best to void names beginning with the letters F, S, and T as these names may create naming issues in post-processing software.			None
2	TBLK	TBLK is an array of real numbers greater than or equal to zero, that are assigned the tracer concentration values for each cell in the model or the current input BOX. Repeat counts may be used, for example 200*0.0. The units for the tracer, if required, are set on the TRACER keyword in the PROPS section. This should be the same as the PHASE in the model.			None
		Liquid: TBLK/stb Gas: TBLK/Mscf	Liquid: TBLK/sm^3 Gas: TBLK/sm^3	Liquid: TBLK/scc Gas: TBLK/scc	

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.42: TBLK Keyword Description

See also the TRACERS keyword in the RUNSPEC section to declared the maximum number of tracers for each phase, the TRACER keyword in the PROPS section to define the tracer, and the WTRACER keyword in the SCHEDULE section that defines the wells injecting the tracer.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

The following TRACERS keyword in the RUNSPEC section declares the number of tracers in the model.

```
--
--       NUMBER AND TYPE OF TRACERS
--       NO OIL  NO WAT  NO GAS  NO ENV  DIFF    MAX    MIN    TRACER
--       TRACERS TRACERS TRACERS TRACERS CONTL   NONLIN NONLIN NONLIN
TRACERS
         0       0       1       0      'NODIFF' 1*     1*     1*             /
```

And the TRACER keyword in the PROPS section declares the tracer name and the phase for the tracer.

```
--
--       DEFINE TRACER NAMES
--
--       TRACER   TRACER
--       NAME     PHASE
--       ------   ------
TRACER
        'IGS'     'GAS'                                    / INJECTED GAS
/
```

Finally, the TBLK keyword in the SOLUTION section sets the initial tracer concentrations in both the free and solution states.

```
--
--       INITIALIZATION OF TRACER CONCENTRATIONS BY BLOCK
--
--       ARRAY       CONSTANT     ---------- BOX ---------
--                                I1  I2   J1  J2   K1  K2
EQUALS
         TBLKFIGS    0.0000       1*  1*   1*  1*   1*  1* / TRACER CONCENTRATION
         TBLKSIGS    0.0000       1*  1*   1*  1*   1*  1* / TRACER CONCENTRATION
/
```

Here the initial concentrations are set to zero.

Then in the SCHEDULE section one can us the WTRACER keyword to define the well injecting the tracer and the tracer concentration being injected,.

```
--
--       DEFINE CONCENTRATION OF TRACERS IN THE INJECTION STREAMS,
--       INJECTION TRACER CONCENTRATIONS NOT DEFINED USING THE WTRACER
--       KEYWORD ARE ASSUMED TO BE ZERO.
--
-- WELL  NAME    TRACER  TRACER  TRACER
-- NAME  TRACER  VALUE   CUM     GROUP
WTRACER
'GI01'   'GAS'   1.0                                                    /
/
```

In this case, well GI01 is a gas injection well injecting gas with a tracer concentration of 1.0. The example shows how to track dry gas injection in a gas condensate reservoir, although, the example can be used for any type of gas injection.

10.3.90 TEMPI – DEFINE THE INITIAL TEMPERATURE VALUES FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TEMPI defines the initial temperature for all the cells in the model via an array for when the THERMAL option has been activated in the RUNSPEC section. This keyword is used to explicitly define the initial reservoir temperature via the Enumeration Initialization method rather than using the Equilibration Initialization method that utilizes the EQUIL keyword in the SOLUTION section.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

The keyword can be used with all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TEMPI	TEMPI is an array of real positive numbers assigning the initial temperature to each cell in the model. Repeat counts may be used, for example 20*100.0.			
		°F	°C	°C	None

Notes:

1) The number of entries should correspond to the NX x NY x NZ parameters on the DIMENS keyword in the RUNSPEC section, unless the BOX keyword defines a sub area of the grid, in which case the total number of entries should correspond to the number of cells defined by the BOX statement.

2) The keyword is terminated by "/".

Table 10.43:TEMPI Keyword Description

See also the RTEMP and RTEMPA keywords in the PROPS section and the RTEMPVD in the SOLUTION section for alternative ways to initialize the model's initial temperature.

Example

```
--
--        DEFINE GRID BLOCK TEMPERATURE FOR ALL CELLS
–         (BASED ON NX x NY x NZ = 300)
--
TEMPI
          100*212.0   100*215.0   100*220.0                                  /
```

The above example defines the initial temperature to be 212.0, 215.0, and 220.0 °F for the first, second and third layers in the model for all 300 cells, as defined by the DIMENS keyword in the RUNSPEC section.

10.3.91 TEMPVD - DEFINE THE INITIAL RESERVOIR TEMPERATURE VERSUS DEPTH TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the reservoir temperature versus depth tables for when the temperature or thermal options has been activated by either the TEMP or THERMAL keywords in the RUNSPEC section in the commercial simulator. For OPM Flow the THERMAL keyword must be used to invoke the thermal option.

The TEMPVD keyword is an alias for the RTEMPVD keyword; however, the former is ignored by OPM Flow.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DEPTH	A real monotonically increasing down the column values that defines the depth for corresponding reservoir temperature RTEMP.			
		feet	m	cm	None
2	RTEMP	A real monotonically increasing down the column values that defines the corresponding reservoir temperature for the given depth			
		°F	°C	°C	None

Notes:

1) The keyword is followed by NTEQUIL tables as declared on the EQLDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NDRXVD rows as declared on the EQLDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.44:TEMPVD Keyword Description

See also the RTEMP keyword in the PROPS section and RTEMPVD keyword in the SOLUTION section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
--
--       INITIAL RESERVOIR TEMPERATURE VERSUS DEPTH TABLE
--
RTEMPVD
--       DEPTH    TEMPERATURE
--       FEET     DEG F
--       ------   ----------
         1000.0     90.000
         2000.0    100.000
         3000.0    130.000
         4000.0    160.000                                  / TABLE N0. 01
--       ------   ----------
         1000.0     90.000
         2000.0    100.000
         3000.0    130.000
         4000.0    160.000                                  / TABLE N0. 02
--       ------   ----------
         1000.0     90.000
         2000.0    100.000
         3000.0    130.000
         4000.0    160.000                                  / TABLE N0. 03
```

The above example defines three identical reservoir depth versus temperature tables for the three NTEQUIL regions defined on the EQLDIMS keyword in the RUNSPEC section.

10.3.92 THPRES - DEFINE EQUILIBRATION REGION THRESHOLD PRESSURES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THPRES defines the threshold pressure between various equilibration regions that have been defined by the EQLNUM keyword in the REGIONS section. The threshold pressure defines the potential difference between two regions which must be exceeded before flow can occur between the two regions. Once flow occurs the potential between the two regions is reduced by the threshold pressure.

This option must be activated by THPRES variable on EQLOPTS keyword in the RUNSPEC section in order to utilize this feature. Note that the irreversible option, as defined by IRREVER variable on EQLOPTS keyword in the RUNSPEC section, is not supported.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	EQLNUM1	EQLNUM1 is an a positive integer that is greater or equal to one and less than or equal to NTEQUL on the EQLDIMS keyword in the RUNSPEC section, that defines the "from" equilibration region number.			
		dimensionless	dimensionless	dimensionless	None
2	EQLNUM2	EQLNUM1 is an a positive integer that is greater or equal to one and less than or equal to NTEQUL on the EQLDIMS keyword in the RUNSPEC section, that defines the "to" equilibration region number.			
		dimensionless	dimensionless	dimensionless	None
3	THPRES	THPRES defines the threshold pressure from EQLNUM1 to EQLNUM2 and from EQLNUM2 to EQLNUM1. The default value of 1* sets the threshold pressure to a value that initially prevents flow between the two equilibration regions. Any subsequent production or injection in either of the two equilibration regions will therefore result in flow between the two regions. Thus, this default initially isolates the two equilibration regions. If a equilibration region number pair has not been explicitly defined by this keyword the THPRES is set to zero, for no threshold pressure.			
		psia	barsa	atma	1*

Notes:

1) The keyword is followed by any number of records with each record terminated by "/".
2) The keyword is terminated by "/".

Table 10.45: THPRES Keyword Description

See also the MULTREGT keyword in the GRID section that uses the transmissibility between the MULTNUM, FLUXNUM or OPERNUM region arrays to control the flow between various regions within the model.

Note

Care should be taken that cells in different EQLNUM regions are not in communication, as this will result in an unstable initial equilibration.

Examples

Given NTEQUL is equal to six on the EQLDIMS keyword in the RUNSPEC section,

```
--
--        EQLNUM  EQLNUM  THPRES
--        FROM    TO      VALUE
THPRES
          1       2       0.588031                        / REGN 1 TO REGN 2
          2       1       0.588031                        / REGN 2 TO REGN 1
          1       3       0.787619                        / REGN 1 TO REGN 3
          3       1       0.787619                        / REGN 3 TO REGN 1
          1       4       7.000830                        / REGN 1 TO REGN 4
          4       1       7.000830                        / REGN 4 TO REGN 1
/
```

The above example defines the threshold pressures between equilibration regions one and two, one and three and one and four. As the threshold pressures between regions one and five and one and six (as well as other combinations), have not been explicitly set in the example, the threshold pressures for these combinations are set to zero.

However, as the irreversible option, as defined by IRREVER variable on EQLOPTS keyword in the RUNSPEC section, is not supported, then example can be simplified to:

```
--
--        EQLNUM  EQLNUM  THPRES
--        FROM    TO      VALUE
THPRES
          1       2       0.588031                        / REGN 1 AND REGN 2
          1       3       0.787619                        / REGN 1 AND REGN 3
          1       4       7.000830                        / REGN 1 AND REGN 4
/
```

Again, as the threshold pressures between regions one and five and one and six (as well as other combinations), have not been explicitly set in the example, the threshold pressures for these combinations are set to zero.

10.3.93 TVDP – Define the Initial Equilibration Tracer Saturation versus Depth Functions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the tracer name as the subsequent four characters after TVDP characters of the keyword, and then defines the tracer saturation as a function of depth.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.94 VAPPARS – OIL VAPORIZATION PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

VAPPARS defines the rate of oil vaporization in the presence of undersaturated gas and the rate at which the remaining oil gets "heavier" via the reduction in the solution gas-oil ratio ("Rs"). This keyword should only be used if the OIL, GAS, DISGAS and VAPOIL keywords in the RUNSPEC section have been invoked to allow oil, gas, dissolved gas and vaporized oil to be present in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	VAPPAR1	VAPPAR1 is a real positive dimensionless number that defines the rate at which oil vaporizes into the available undersaturated gas in a grid block. The default value of zero invokes the standard black-oil formulation in which all oil vaporizes into the available undersaturated phase in a grid cell. Increasing this parameter decrease the rate of vaporization. Typical values for VAPPAR1 range from zero and five.			
		dimensionless	dimensionless	dimensionless	0
2	VAPPAR2	VAPPAR2 is a real positive dimensionless number that defines the rate at which the Rs of the remaining oil in a grid cell decreases The default value of zero invokes the standard black-oil formulation in which the remaining oil's Rs does not change as the oil vaporizes into the available undersaturated gas in a grid cell. Increasing this parameter increases the difference between the remaining oil and the vaporized oil Rs values. Typical values for VAPPAR2 are less than one.			
		dimensionless	dimensionless	dimensionless	0

Notes:

1) The keyword is terminated by "/".

Table 10.46: VAPPARS Keyword Description

Note this keyword is normally used in history matching field performance to control the availability of the vaporized oil phase.

See also the DRSDT and DRVDT keywords in the SCHEDULE section that control the rate at which the solution gas-oil ratio and the vaporized oil-gas ratio increase within a grid block, respectively.

Examples

The first example sets the black-oil default parameters

```
--
--       OIL VAPORIZATION PARAMETERS
--
--       OIL-VAP   RS-INCS
--       VAPPAR1   VAPPAR2
VAPPARS
         0         0                                        /
```

And the second example decreases the rate at which the oil vaporizes into the available undersaturated gas and increases the difference between the grid block oil saturation Rs and the vaporized oil Rs within a grid cell.

```
--
--       OIL VAPORIZATION PARAMETERS
--
--       OIL-VAP   RS-INCS
--       VAPPAR1   VAPPAR2
VAPPARS
         1.5       0.150                                    /
```

Again, the keyword is normally used in history matching field performance to control the availability of the vaporized oil phase.

10.3.95 VISDATES – Define External Reservoir Geo-Mechanics VISAGE Stress Dates

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The VISDATES keyword defines External Reservoir Geo-Mechanics VISAGE option stress dates. The keyword should not be used in input decks as the associated data is generated by an external program.

This keyword is ignored by OPM Flow and has no effect on the simulation.

10.3.96 VISOPTS – DEFINE EXTERNAL RESERVOIR GEO-MECHANICS VISAGE OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The VISDATES keyword defines External Reservoir Geo-Mechanics VISAGE option modeling options. The keyword should not be used in input decks as the associated data is generated by an external program.

This keyword is ignored by OPM Flow and has no effect on the simulation.

CHAPTER 11: SUMMARY SECTION

11.1 INTRODUCTION

The SUMMARY section defines the variables to be written to the summary files that are used to generate line graphs of properties such as oil flow rate versus time, grid block pressure versus time, etc. Unlike the other sections, the SUMMARY section has basically two types of keywords, keywords that request a variable to be written out to the summary file as described in section *11.2 Data Requirements*, and the conventional type of keyword described in section *11.3 Keyword Definitions* that perform an action. There are literally hundreds of keywords associated with the former indicating the variety of data that can be written to the summary file. Whereas, for the latter there are less than twenty keywords.

Summary file output consists of three files as outlined Table 11.1, with the raw requested data stored in SUMMARY index and SUMMARY data files, the SUMMARY RSM file is an ASCII file that is generated from the other two files by the simulator at the end of the run.

File Type	Data Type	Description	OPM Flow Status
RSM	Output File	The RSM file contains the variables requested to be written to the SUMMARY file via the keywords described in the *11.2 Data Requirements*, in a tabulated ASCII output format. The format of the file enables the data to be easily loaded into the LibreOffice Calc program for further processing, as each vector represents one column. The report is written at the end of the simulation run by parsing the SUMMARY Index and SUMMARY Data files.	Fully Supported
SUMMARY Index	Dynamic Vector Index	The SUMMARY index file type specifies and defines the format and data type written to the SUMMARY Data file.	Fully Supported
SUMMARY Data	Dynamic Vector Data	The SUMMARY data file contains the variables requested to be written to the file via the keywords described in the *11.2 Data Requirements*. The data consists of vectors that are used to generate line graphs of properties such as oil flow rate versus time, grid block pressure versus time, etc. The properties to be stored on the SUMMARY file are written to the summary file at the end of each successful time step. The data can be used to compare actual production data with the simulation derived results in post processing software like OPM ResInsight.	Fully Supported

Notes:

1) If no summary data is requested then the files will not be created.
2) The SUMMARY files can be loaded or written out in either unified or non-unified formats as well as in binary or ASCII formats.

Table 11.1: OPM Flow Summary Output File Summary

As mentioned in Table 11.1 all files can be written out in either ASCII or binary formats and in addition the SUMMARY file can be loaded or written out in either unified or non-unified formats. The file type (ASCII or binary) and file structure format (unified or non-unified formats) is set via a set of keywords in the RUNSPEC section, as described in Table 11.2 for easy of reference.

Process	RUNSPEC Keyword	Description	Files
Input	FMTIN	The keyword defines the input files to be formatted as ASCII i.e. text files, as oppose to binary files.	*.FSMSPEC *.FUNSMRY

Process	RUNSPEC Keyword	Description	Files
	MULTIN	The keyword defines the input files to be non-unified multiple files, as opposed to unified files.	*.SMSPEC *.S0001
	UNIFIN	UNIFIN defines the input files to be unified files, as opposed to non-unified multiple files.	*.SMSPEC *.UNSMRY
Output	FMTOUT	The keyword sets all output files to be formatted as ASCII i.e. text files, as opposed to binary files.	*.FSMSPEC *.FUNSMRY
	MULTOUT	MULTOUT defines the output files to be non-unified multiple files, as opposed to unified files.	*.SMSPEC *.S0001
	UNIFOUT	UNIFOUT defines the output files to be unified files, as opposed to non-unified multiple files.	*.SMSPEC *.UNSMRY

Notes:

1) A binary file is computer-readable but not human-readable.
2) For unified files if the run terminates unexpectedly, or there is insufficient disk space, then the last reported output is not stored. The main advantage of unified files is that if a number of simulation cases reside in one directory, the number of output files per case is minimum compared to using non-unified multiple files. There is no limit on the number of reporting steps that a unified file can store.

Table 11.2: RUNSPEC Input and Output File Format Keywords

OPM Flow automatically generates the SUMMARY file names based on the input file name and the output options selected via the keywords in the RUNSPEC section as summarized in in Table 11.2. For example, starting OPM Flow using the following command from the terminal:

```
flow CASENAME
```

will start the simulator and run the case specified by CASENAME.DATA. Here CASENAME is the "root" of the filename and DATA is the extension of the filename. OPM Flow will generate the SUMMARY output files based on the CASENAME with the extension based on the type (ASCII or binary) and file structure format (unified or non-unified formats), as outlined in Table 11.3.

File Type	Unformatted Extension	Description	Formatted Extension
RSM	*.RSM	Output RSM file.	*.RSM
SUMMARY Index	*.SMSPEC	The SUMMARY index file for both unified and non-unified formats.	*.FSMSPEC

SUMMARY Data Non-Unified	*.Snnnn	The SUMMARY data files containing the variables requested to be written to the SUMMARY files. For example, the SUMMARY non-unified binary files would be:
		`CASENAME.S0001`
		`CASENAME.S0002`
		`CASENAME.S0003`
		`etc.`
		`CASENAME.SMSPEC`
			*.Annnn

File Type	Unformatted Extension	Description	Formatted Extension
SUMMARY Data Unified	*.UNSMRY	The SUMMARY data file containing the variables requested to be written to the SUMMARY file. For example, the SUMMARY data unified binary files: `CASENAME.UNSMRY` `CASENAME.SMSPEC`	*.FUNSMRY

Notes:

1) The above file naming convention is for Linux type operating systems, as OPM Flow is currently only officially supported for Linux distributions.

Table 11.3: OPM Flow File Naming Conventions

The default behavior is write out the requested variables at each time step. As this can lead to large files, especially for full field simulation models, the *RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File* keyword allows one to write out the data only at a report time step instead.

The SUMMARY section is terminated by the SCHEDULE keyword.

11.2 DATA REQUIREMENTS

To generate a summary vector, the appropriate keyword must be entered in the SUMMARY section of the input data file; only variables explicitly requested will be written to the SUMMARY files. Normally the data is written to the summary file at the end of each successful time step, but as mentioned previously, this can be changed by the *RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File* keyword to write out the data only at report time steps, thus reducing the overall size of the SUMMARY files.

The following sections describe the summary variable mnemonic syntax which defines the type of summary variable object (Aquifer, Field, Group, Well, etc.), the variable format for a given variable object, and the variable names for the various variable objects.

11.2.1 SUMMARY VARIABLE MNEMONIC SYNTAX

As mentioned earlier, there are literally hundreds of variables that can be written to the SUMMARY file, which can make the process of requesting the data rather complex. Fortunately in most cases, but not always, the variable names follow a four or five letter syntax that defines the variable mnemonic used to describe the data to be written out. Table 11.4 outlines the general syntax employed in deriving the variable mnemonic.

Summary Variable Mnemonic Syntax									
First Character Object		**Second Character Object Type**		**Third Character Flow Type**		**Four Character Value Type**		**Fifth Character Special**	
A	**Aquifers**	A	Analytical Aquifer	Q	Influx	R			
		L	Analytical Aquifer List	L	Liquid influx	T			
		N	Numerical Aquifer						
B	**Block (Grid Cell)**	O	Oil	P	Production	R	Rate	L	Liquid
F	**Field**	W	Water	I	Injection	T	Total (cumulative)	H	History
G	**Group**	G	Gas	F	Flow			G	Gas
R	**Region**	V	Volume at reservoir conditions						
W	**Well**	L	Liquid						
C	**Well Connection**	P[1]	Pressure						
S	**Well Segment**	T	Tracer						

Notes:

1) For Field and Region pressures the mnemonic is PR, that is FPR for the field reservoir pressure and RPR for region average pressure. A well's bottom-hole pressure is WBHP and the tubing head pressure is WTHP.

Table 11.4: Summary Variable Mnemonic Syntax

So for example, FOPR would mean Field Oil Production Rate. Also if there is historical data associated with a variable, then the same variable mnemonic is used with the suffix H, that is for the historical field oil production rate the mnemonic would be FOPRH. Table 11.5 shows some examples of variable mnemonics that follow the general syntax.

Summary Variable Mnemonics Examples	
Name	**Description**
BOFT	Block Oil Flow Total
COFR	Connection Oil Flow Rate
FOPR	Field Oil Production Rate
GVPR	Group Volume Production Rate
RTIT	Region Tracer Injection Total
WWPT	Well Water Production Total

Table 11.5: Summary Variable Mnemonics Examples

And Table 11.6 shows some examples that do not follow the general syntax. Where applicable, each of these keywords would also have a history equivalent mnemonics available in history matching runs, that is: FPRH, FWCTH, WBHPH, WTHPH, WWCTH, etc.

Summary Variable Mnemonics Examples Not Following the General	
Name	**Description**
BAPI	Block API
BOSAT	Block Oil Saturation
BPR	Block Pressure
FAQR	Field Aquifer Influx Rate
FPR	Field Average Pressure
FWCT	Field Water Cut
WBHP	Well Bottom-Hole Pressure
WTHP	Well Tubing Head Pressure
WWCT	Well Water Cut

Table 11.6: Summary Variable Mnemonics Examples Not Following the General Syntax

11.2.2 SUMMARY VARIABLE FORMAT

In addition to the general mnemonic syntax, each object type (Field, Group, Region, Well etc.) has additional syntax governing what specific object (group, well, etc.) should be written out to the SUMMARY file as explained in Table 11.7.

Summary Variable Format		
Summary Object	**Format**	**Example**

AQUIFER	Analytical aquifers are identified by the first two characters AA in the variable mnemonic and numerical aquifers are identified by the first two characters of AQ.
	Aquifer variables for a given aquifer can be followed by a list of aquifer numbers and therefore a terminating "/" is required to end the list of aquifers. A blank list requests output for all the aquifers.
		For instance to obtain the aquifer influx rate and cumulative influx for all analytical aquifers in the model, one would use:
		`AAQR`
		`/`
		`AAQT`
		`/`
		or just for numerical aquifers one, two and three:
		`ANQR`
		`1 2 3 /`
		`ANQR`
		`1 2 3 /`
		<u>Note OPM Flow does not currently support Numerical Aquifers</u>

	Analytical aquifers that have been allocated to an analytical aquifer list via the AQUALIST keyword in the SOLUTION section are identified by the first two characters AL in the variable mnemonic.
	Aquifer variables for a given aquifer list can be followed by a list of aquifer names and therefore a terminating "/" is required to end the list of aquifers. A blank list requests output for all the aquifers.
		For instance to obtain the aquifer influx rate and cumulative influx for all two analytical aquifers list, EAST and WEST in the model, one would use:
		`AAQR`
		`'EAST' 'WEST'/`
		`AAQT`
		`'EAST' 'WEST'/`
		<u>Note OPM Flow does not currently support Analytical Aquifer Lists.</u>

BLOCK
(Grid Cells)
	Block variables are followed by a list of cell (I, J, K) indices, with each line terminated by a "/"., and the list terminated with another terminating "/".	To request the oil saturation for a series of grid cells one would use the following:
		`BOSAT`
		`1 1 1 /`
		`10 10 3 /`
		`15 15 10 /`
		`/`

FIELD	Field variables take no additional parameters and therefore do not require a terminating "/".	For example:
		`FOPR`
		`FOPT`
		`FPR`
		Would export the field oil rate and total, plus the field average reservoir pressure to the SUMMARY file.

Summary Variable Format		
Summary Object	**Format**	**Example**

GROUP	Group variables can be followed by a list of group names enclosed in quotes and therefore a terminating "/" is required to end the list of groups. A blank list requests output for all groups.	As an example to get the oil production rates and totals for two groups representing two platforms one would use
		`GOPR`
		`'PLAT1' 'PLAT2' /`
		
		`GOPT`
		`'PLAT1' 'PLAT2' /`
		or
		`GOPR`
		`/`
		`GOPT`
		`/`
		if there are only two groups in the model.

REGION	Region variables for a given region can be followed by a list of region numbers and therefore a terminating "/" is required to end the list of regions. A blank list requests output for all the regions.	For instance to obtain the reservoir pressures and oil totals for all regions:
		`RPR`
		`/`
		`ROPT`
		`/`
		or just for regions one, two and three:
		`RPR`
		`1 2 3 /`
		`ROPT`
		`1 2 3 /`

	Region variables that are based on flows between regions must be followed by a list of region pair numbers, indicating the two regions. Each region pair is terminated by a "/". In addition the variable mnemonic should also be terminated by a terminating "/".	To obtain the oil and water flow between regions one and two, and also three and four, one would use:
		`ROFT`
		`1 2 /`
		`3 4 /`
		`/`
		`RWFT`
		`1 2 /`
		`3 4 /`
		`/`

WELL	Well variables can be followed by a list of well names enclosed in quotes and therefore a terminating "/" is required to end the list of wells. A blank list requests output for all wells.	As an example to get the oil production rates and totals for all oil wells beginning with the letters OP one would use
		`WOPR`
		`'OP*' /`
		
		`WOPT`
		`'OP*' /`

Summary Variable Format		
Summary Object	**Format**	**Example**

WELL CONNECTIONS	Connection variables are followed by a list of well names in quotes and completion I, J, K indices, each terminated by a "/". In addition the list is terminated by a terminating "/".	To request the gas-oil ratio and water cut for the OP01 and OP02 wells for several connections, one would use:
		`CGOR`
		`OP01 1 1 1 /`
		`OP01 1 1 2 /`
		`OP02 10 10 1 /`
		`/`
		
		`CWCT`
		`OP01 1 1 1 /`
		`OP01 1 1 2 /`
		`OP02 10 10 1 /`
		`/`

WELL SEGMENTS	Well variables for multi-segment well segments can be followed by a list of well names enclosed in quotes and the segment number, each terminated by a "/". In addition the list is terminated by a terminating "/".
	A blank list for the segments results in all segments for a well being written out. And a blank list for the well will result in all wells being written to the SUMMARY file.
	Care should be exercised when defaulting the list of wells and segments as there is the potential to generate large volumes of data.
		For example, to get the segment oil production rates for wells OP01 segments two, three, and four and for segment two for OP02 one would use:
		`SOFR`
		`'OP01' 2 /`
		`'OP01' 3 /`
		`'OP01' 4 /`
		`'OP02' 2 /`
		`/`
		or to get all the oil production rates for all the segments for well OP01:
		`SOFR`
		`'OP01' /`
		`/`

Table 11.7: Summary Variable Format

11.2.3 AQUIFER SUMMARY VARIABLES

Table 11.8 outlines the aquifer summary variables based on the type of aquifer: analytical, analytical list and numerical. Note that the analytical list aquifer type is just an analytical aquifer "set" defined using the AQULIST keyword in the SOLUTION section, that assigns an analytic aquifer name to a set of aquifer numbers for greater readability in the output. This type of aquifer is not supported by OPM Flow and neither are numerical aquifers.

Aquifer Summary Variables						
Variable	**Root**	**Field**	**Analytical Aquifer**	**Analytical Aquifer List**	**Numerical Aquifer**	**Comment**
Aquifer Influx Rate (Water Aquifers)	QR	FAQR	AAQR	ALQR	ANQR	
Aquifer Influx Total (Water Aquifers)	QT	FAQT	AAQT	ALQT	ANQT	
Aquifer Influx Rate (Gas Aquifers)	QRG	FAQRG	AAQRG	ALQRG		
Aquifer Influx Total (Gas Aquifers)	QTG	FAQTG	AAQTG	ALQTG		
Aquifer Pressure	QP		AAQP		ANQP	Water pore volume weighted average
Aquifer Carter-Tracy Dimensionless Pressure	QTD		AAQTD			
Aquifer Carter-Tracy Dimensionless Time	QPD		AAQPD			

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available, for example, numerical aquifers are currently not supported by OPM Flow.

Table 11.8: Aquifer Summary Variables

Example

The following example requests the field and analytical aquifer pressure, rate and cumulative water influxes for all analytical aquifers to be written to the SUMMARY file.

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       ANALYTICAL AQUIFERS (FIELD)
--
FAQR
FAQT
--
--       ANALYTICAL AQUIFERS
--
AAQP
/
AAQR
/
AAQT
/
```

11.2.4 Field, Group, Well, Well Connection and Completion Summary Variables

The following table (Table 11.9) lists the field, group, well, well connection and well completion production, injection, pressure and productivity summary variables. Note that not all of these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

See also section *11.2.6 Field, Region and Block Summary Variables* that outlines the field, region and block production and injection data summary variables, and section *11.2.7 Field and Region Summary Recovery Variables* that describes the summary variables for oil recovery efficiency and the oil recovery mechanism.

Field, Group, Well, Well Connection and Completion Summary Variables

Type	Variable	Root	Field	Group	Well	Well Connection	Well Completion	Comment
Flow	Energy Production Rate	EPR	FEPR	GEPR	WEPR			
Flow	Energy Production Total	EPT	FEPT	GEPT	WEPT			
Flow	Gas Consumption Rate	GSCR	FGSCR	GGSCR				
Flow	Gas Consumption Total	GCT	FGCT	GGCT				
Flow	Gas Flow Rate	GFR				CGFR	CGFRL	Positive for production and negative for injection
Flow	Gas Flow Rate (Free)	GFRF				CGFRF		
Flow	Gas Flow Rate (Solution)	GFRS				CGFRS		
Flow	Gas Flow Rate (Upstream)	GFRU				CGFRU		Sum of connection Gas flow rates upstream of, and including, this connection
Flow	Gas Import Rate	GIMR	FGIMR	GGIMR				
Flow	Gas Import Total	GIMT	FGIMT	GGIMT				
Flow	Gas Injection Guide Rate	GIGR		GGIGR	WGIGR			
Flow	Gas Injection Rate	GIR	FGIR	GGIR	WGIR	CGIR	CGIRL	
Flow	Gas Injection Rate History	GIRH	FGIRH	GGIRH	WGIRH			
Flow	Gas Injection Rate Target/Limit	GIRT	FGIRT	GGIRT	WGIRT			
Flow	Gas Injection Total	GIT	FGIT	GGIT	WGIT	CGIT	CGITL	
Flow	Gas Injection Total History	GITH	FGITH	GGITH	WGITH			
Flow	Gas Lift Rate	GLIR	FGLIR	GGLIR	WGLIR			Gas lift gas with group and fields totals based on well efficiency
Flow	Gas Potential Injection Rate	GPI	FGPI	GGPI	WGPI	CGPI		Also WGIP for WGPI
Flow	Gas Potential Injection Rate	GPI2	FGPI2	GGPI2	WGPI2			Including shut and stopped wells.

Field, Group, Well, Well Connection and Completion Summary Variables								
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Well Completion**	**Comment**
Flow	Gas Potential Production Rate	GPP	FGPP	GGPP	WGPP	CGPP		
Flow	Gas Potential Production Rate	GPP2	FGPP2	GGPP2	WGPP2			Including shut and stopped wells.
Flow	Gas Potential Production Rate (Free)	GPPF	FGPPF	GGPPF	WGPPF			
Flow	Gas Potential Production Rate (Free)	GPPF2	FGPPF2	GGPPF2	WGPPF2			Including shut and stopped wells.
Flow	Gas Potential Production Rate (Soln)	GPPS	FGPPS	GGPPS	WGPPS			
Flow	Gas Potential Production Rate (Soln)	GPPS2	FGPPS2	GGPPS2	WGPPS2			Including shut and stopped wells.
Flow	Gas Production Guide Rate	GPGR		GGPGR	WGPGR			
Flow	Gas Production Rate	GPR	FGPR	GGPR	WGPR	CGPR		Produced reservoir gas only, gas lift gas excluded
Flow	Gas Production Rate (Free)	GPRF	FGPRF	GGPRF	WGPRF			
Flow	Gas Production Rate (Solution)	GPRS	FGPRS	GGPRS	WGPRS			
Flow	Gas Production Rate History	GPRH	FGPRH	GGPRH	WGPRH			
Flow	Gas Production Rate Target/Limit	GPRT	FGPRT	GGPRT	WGPRT			
Flow	Gas Production Total	GPT	FGPT	GGPT	WGPT	CGPT	CGPTL	
Flow	Gas Production Total (Free)	GPTF	FGPTF	GGPTF	WGPTF			
Flow	Gas Production Total (Solution)	GPTS	FGPTS	GGPTS	WGPTS			
Flow	Gas Production Total History	GPTH	FGPTH	GGPTH	WGPTH			
Flow	Gas Sales Rate	GSR	FGSR	GGSR				
Flow	Gas Sales Total	GST	FGST	GGST				
Flow	Gas Voidage Injection Rate	GVIR			WGVIR			
Flow	Gas Voidage Production Rate	GVPR			WGVPR			
Flow	Liquid Flow Rate	LFR				CLFR	CLFRL	Positive for production and negative for injection
Flow	Liquid Production Rate	LPR	FLPR	GLPR	WLPR	CLPR		
Flow	Liquid Production Rate History	LPRH	FLPRH	GLPRH	WLPRH			
Flow	Liquid Production Rate Target/Limit	LPRT	FLPRT	GLPRT	WLPRT			
Flow	Liquid Production Total	LPT	FLPT	GLPT	WLPT	CLPT	CLPTL	
Flow	Liquid Production Total History	LPTH	FLPTH	GLPTH	WLPTH			
Flow	Oil Flow Rate	OFR				COFR	COFRL	Positive for production and negative for injection
Flow	Oil Flow Rate (Free)	OFRF				COFRF		
Flow	Oil Flow Rate (Solution)	OFRS				COFRS		

Field, Group, Well, Well Connection and Completion Summary Variables								
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Well Completion**	**Comment**
Flow	Oil Flow Rate (Upstream)	OFRU				COFRU		Sum of connection oil flow rates upstream of, and including, this connection
Flow	Oil Injection Guide Rate	OIGR		GOIGR	WOIGR			
Flow	Oil Injection Rate	OIR	FOIR	GOIR	WOIR	COIR	COIRL	
Flow	Oil Injection Rate History	OIRH	FOIRH	GOIRH	WOIRH			
Flow	Oil Injection Rate Target/Limit	OIRT	FOIRT	GOIRT	WOIRT			
Flow	Oil Injection Total	OIT	FOIT	GOIT	WOIT	COIT	COITL	
Flow	Oil Injection Total History	OITH	FOITH	GOITH	WOITH			
Flow	Oil Potential Injection Rate	OPI	FOPI	GOPI	WOPI			
Flow	Oil Potential Injection Rate	OPI2	FOPI2	GOPI2	WOPI2			Including shut and stopped wells.
Flow	Oil Potential Production Rate	OPP	FOPP	GOPP	WOPP	COPP		
Flow	Oil Potential Production Rate	OPP2	FOPP2	GOPP2	WOPP2			Including shut and stopped wells.
Flow	Oil Production Guide Rate	OPGR		GOPGR	WOPGR			
Flow	Oil Production Rate	OPR	FOPR	GOPR	WOPR	COPR		
Flow	Oil Production Rate (Free)	OPRF	FOPRF	GOPRF	WOPRF			
Flow	Oil Production Rate (Solution)	OPRS	FOPRS	GOPRS	WOPRS			
Flow	Oil Production Rate History	OPRH	FOPRH	GOPRH	WOPRH			
Flow	Oil Production Rate Target/Limit	OPRT	FOPRT	GOPRT	WOPRT			
Flow	Oil Production Total	OPT	FOPT	GOPT	WOPT			
Flow	Oil Production Total (Free)	OPTF	FOPTF	GOPTF	WOPTF			
Flow	Oil Production Total (Solution)	OPTS	FOPTS	GOPTS	WOPTS			
Flow	Oil Production Total History	OPTH	FOPTH	GOPTH	WOPTH			
Flow	Res. Vol. Flow Rate	VFR				CVFR	CVFRL	Positive for production and negative for injection
Flow	Res. Vol. Flow Rate (Free)	VFRF				CVFRF		
Flow	Res. Vol. Injection Guide Rate	VIGR		GVIGR	WVIGR			
Flow	Res. Vol. Injection Rate	VIR	FVIR	GVIR	WVIR	CVIR	CVIRL	
Flow	Res. Vol. Injection Rate Target/Limit	VIRT	FVIRT	GVIRT	WVIRT			
Flow	Res. Vol. Injection Total	VIT	FVIT	GVIT	WVIT	CVIT	CVITL	
Flow	Res. Vol. Potential Injection Rate	VPI	FVPI	GVPI	WVPI			

Field, Group, Well, Well Connection and Completion Summary Variables								
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Well Completion**	**Comment**
Flow	Res. Vol. Potential Injection Rate	VPI2	FVPI2	GVPI2	WVPI2			Including shut and stopped wells.
Flow	Res. Vol. Potential Production Rate	VPP	FVPP	GVPP	WVPP	CVPP		
Flow	Res. Vol. Potential Production Rate	VPP2	FVPP2	GVPP2	WVPP2			Including shut and stopped wells.
Flow	Res. Vol. Production Guide Rate	VPGR		GVPGR	WVPGR			
Flow	Res. Vol. Production Guide Rate	VPGR		GVPGR	WVPGR			
Flow	Res. Vol. Production Rate	VPR	FVPR	GVPR	WVPR	CVPR		
Flow	Res. Vol. Production Rate Target/Limit	VPRT	FVPRT	GVPRT	WVPRT			
Flow	Res. Vol. Production Total	VPT	FVPT	GVPT	WVPT			
Flow	Water Flow Rate	WFR				CWFR	CWFRL	Positive for production and negative for injection
Flow	Water Flow Rate (Upstream)	WFRU				CWFRU		Sum of connection water flow rates upstream of, and including, this connection
Flow	Water Injection Guide Rate	WIGR		GWIGR	WWIGR			
Flow	Water Injection Rate	WIR	FWIR	GWIR	WWIR	CWIR	CWIRL	
Flow	Water Injection Rate History	WIRH	FWIRH	GWIRH	WWIRH			
Flow	Water Injection Rate Target/Limit	WIRT	FWIRT	GWIRT	WWIRT			
Flow	Water Injection Total	WIT	FWIT	GWIT	WWIT	CWIT	CWITL	
Flow	Water Injection Total History	WITH	FWITH	GWITH	WWITH			
Flow	Water Potential Injection Rate	WPI	FWPI	GWPI	WWPI			Also WWIP for WWPI
Flow	Water Potential Injection Rate	WPI2	FWPI2	GWPI2	WWPI2			Including shut and stopped wells.
Flow	Water Potential Production Rate	WPP	FWPP	GWPP	WWPP	CWPP		
Flow	Water Potential Production Rate	WPP2	FWPP2	GWPP2	WWPP2			Including shut and stopped wells.
Flow	Water Produce/Injected Ratio	WPIR	FWPIR	GWPIR	WWPIR			Reported as a percent.
Flow	Water Production Guide Rate	WPGR		GWPGR	WWPGR			
Flow	Water Production Rate	WPR	FWPR	GWPR	WWPR	CWPR		
Flow	Water Production Rate History	WPRH	FWPRH	GWPRH	WWPRH			
Flow	Water Production Rate Target/Limit	WPRT	FWPRT	GWPRT	WWPRT			

Field, Group, Well, Well Connection and Completion Summary Variables								
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Well Completion**	**Comment**
Flow	Water Production Total	WPT	FWPT	GWPT	WWPT	CWPT	CWPTL	
Flow	Water Production Total History	WPTH	FWPTH	GWPTH	WWPTH			
Flow	Water Voidage Injection Guide Rate	WVIR			WWVIR			
Flow	Water Voidage Injection Guide Total	WVIT			WWVIT			
No. Wells	Number of abandoned injection wells	MWIA	FMWIA	GMWIA				
No. Wells	Number of abandoned production wells	MWPA	FMWPA	GMWPA				
No. Wells	Number of drilling events in total	MWDT	FMWDT	GMWDT				
No. Wells	Number of drilling events this timestep	MWDR	FMWDR	GMWDR				
No. Wells	Number of injection wells currently flowing	MWIN	FMWIN	GMWIN				
No. Wells	Number of injectors on group control	MWIG	FMWIG	GMWIG				
No. Wells	Number of injectors on own reservoir volume rate limit control	MWIV	FMWIV	GMWIV				
No. Wells	Number of injectors on own surface rate limit control	MWIS	FMWIS	GMWIS				
No. Wells	Number of injectors on pressure control	MWIP	FMWIP	GMWIP				
No. Wells	Number of producers controlled by own oil rate limit	MWPO	FMWPO	GMWPO				
No. Wells	Number of producers on group control	MWPG	FMWPG	GMWPG				
No. Wells	Number of producers on own reservoir volume rate limit control	MWPV	FMWPV	GMWPV				
No. Wells	Number of producers on own surface rate limit control	MWPS	FMWPS	GMWPS				
No. Wells	Number of producers on pressure control	MWPP	FMWPP	GMWPP				
No. Wells	Number of producers using artificial lift (with ALQ > 0.0)	MWPL	FMWPL	GMWPL				
No. Wells	Number of production wells currently flowing	MWPR	FMWPR	GMWPR				
No. Wells	Number of unused injection wells	MWIU	FMWIU	GMWIU				
No. Wells	Number of unused production wells	MWPU	FMWPU	GMWPU				
No. Wells	Number of workover events in total	MWWT	FMWWT	GMWWT				
No. Wells	Number of workover events this time step.	MWWO	FMWWO	GMWWO				
No. Wells	The number of connections capable of flowing in the well	MCON			WMCON			
No. Wells	Total number of injection wells	MWIT	FMWIT	GMWIT				
No. Wells	Total number of production wells	MWPT	FMWPT	GMWPT				
Pressure	Blocking Factor (GPP)	CDBF				CCDBF		
Pressure	Bottom-Hole Pressure	BHP			WBHP			

Field, Group, Well, Well Connection and Completion Summary Variables								
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Well Completion**	**Comment**
Pressure	Bottom-Hole Pressure (Five Point	BP5			WBP5			
Pressure	Bottom-Hole Pressure (Four Point)	BP4			WBP4			
Pressure	Bottom-Hole Pressure (Nine Point)	BP9			WBP9			
Pressure	Bottom-Hole Pressure (One Point)	BP			WBP			
Pressure	Bottom-Hole Pressure History	BHPH			WBHPH			
Pressure	Bottom-Hole Pressure Target/Limit	BHPT			WBHPT			
Pressure	Connection Pressure	PR				CPR	CPRL	Completion pressure is an average pressure for the completion
Pressure	Connection Transmissibility Factor	TFAC				CTFAC		
Pressure	Productivity (Gas Phase)	PIG			WPIG			
Pressure	Productivity (Liquid Phase)	PIL			WPIL			
Pressure	Productivity (Oil Phase)	PIO			WPIO			
Pressure	Productivity (Preferred Phase – Five Point)	PI5			WPI5			
Pressure	Productivity (Preferred Phase – Four Point)	PI4			WPI4			
Pressure	Productivity (Preferred Phase – Nine Point)	PI9			WPI9			
Pressure	Productivity (Preferred Phase – One Point)	PI1			WPI1			
Pressure	Productivity (Preferred Phase)	PI			WPI	CPI		
Pressure	Productivity (Water Phase)	PIW			WPIW			
Pressure	Tubing Head Pressure	THP			WTHP			
Pressure	Tubing Head Pressure History	THPH			WTHPH			
Ratio	Gas-Liquid Ratio	GLR	FGLR	GGLR	WGLR	CGLR	CGLRL	
Ratio	Gas-Liquid Ratio (Bottom-Hole)	BGLR			WBGLR			
Ratio	Gas-Liquid Ratio History	GLRH	FGLRH	GGLRH	WGLRH			
Ratio	Gas-Oil Ratio	GOR	FGOR	GGOR	WGOR	CGOR	CGORL	
Ratio	Gas-Oil Ratio History	GORH	FGORH	GGORH	WGORH			
Ratio	Oil-Gas Ratio	OGR	FOGR	GOGR	WOGR	COGR	COGRL	
Ratio	Oil-Gas Ratio History	OGRH	FOGRH	GOGRH	WOGRH			
Ratio	Water -Gas Ratio	WGR	FWGR	GWGR	WWGR	CWGR	CWGRL	
Ratio	Water Cut	WCT	FWCT	GWCT	WWCT	CWCT	CWCTL	
Ratio	Water Cut History	WCTH	FWCTH	GWCTH	WWCTH			
Ratio	Water-Gas Ratio History	WGRH	FWGRH	GWGRH	WWGRH			

Field, Group, Well, Well Connection and Completion Summary Variables								
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Well Completion**	**Comment**

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.9: Field, Group, Well, Well Connection and Completion Summary Variables

11.2.5 FIELD, GROUP AND WELL CONTROL MODE SUMMARY VARIABLES

In addition to the production, injection, pressure and productivity summary variables, there are also summary variables that output the control mode at which the field, groups and wells are being controlled. Table 11.10 summarizes the mnemonics for the field and groups together with a description and the values written out to the SUMMARY file.

Field and Group Control Mode Reporting						
Object	**Field**	**Group**	**Field**	**Group**	**Field**	**Group**
Mnemonic	FMCTP	GMCTP	FMCTW	GMCTW	FMCTG	GMCTG
Description	Group production mode of control set to negative if the rate was set by a higher group.		Group water injection mode of control set to negative if the rate was set by a higher group:.		Group gas injection mode of control set to negative if the rate was set by a higher group.	
Values	0.0	None	0.0	None	0.0	None
	1.0	Oil Rate	1.0	Water Rate	1.0	Gas Rate
	2.0	Water Rate	2.0	Reservoir Voidage Rate	2.0	Reservoir Voidage Rate
	3.0	Gas Rate	3.0	Reservoir Re-Injection	3.0	Reservoir Re-Injection
	4.0	Liquid Rate	4.0	Voidage Replacement	4.0	Voidage Replacement
	5.0	Reservoir Voidage Rate	5.0		5.0	
	6.0	Pressure Balance	6.0		6.0	
	7.0	Energy	7.0		7.0	
	8.0		8.0		8.0	
	9.0	Condensate Rate	9.0	Available	9.0	Available
	10.0		10.0		10.0	
	11.0		11.0		11.0	
	12.0	Unused	12.0		12.0	

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.10: Field and Group Control Mode Reporting

Similarly, Table 11.11 shows the control mode reporting variables for wells.

Well Control Mode Reporting				
Object	**Well**		**Well**	
Mnemonic	WSTAT		WMCTL	
Description	Well Status indicator.		Well mode of control.	
Values	0.0	Producer	0.0	Shut or Stopped
	1.0	Injector	1.0	Oil Rate
	2.0	Shut	2.0	Water Rate
	3.0	Stop	3.0	Gas Rate
	4.0	Priority Shut	4.0	Liquid Rate
	5.0	Priority Stop	5.0	Reservoir Voidage Rate
	6.0	Pressure Balance	6.0	THP
			7.0	BHP
			9.0	Condensate Rate
			11.0	GOR Penalty
			12.0	Drawdown
			13.0	NGL
			31.0	Re-injection
			32.0	
			33.0	

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.11: Well Control Mode Reporting

11.2.6 FIELD, REGION AND BLOCK SUMMARY VARIABLES

The next set of summary data is based on the block, field and region summary variables and the variables are tabulated in Table 11.9. Note when the data is for a block variable, like for example the oil saturation, this will be the actual value for the a grid cell (block), whereas, for the field and region items this will be an average value.

See also section *11.2.4 Field, Group, Well, Well Connection and Completion Summary Variables* that outlines the field production data summary variables, and section *11.2.7 Field and Region Summary Recovery Variables* that describes the summary variables for oil recovery efficiency and the oil recovery mechanism.

Block, Field and Region Summary Variables						
Type	**Variable**	**Root**	**Field**	**Region**	**Block**	**Comment**
Flow	Gas Flow (Inter-Block in I+ Direction)	FLOGI			BFLOGI	
Flow	Gas Flow (Inter-Block in J+ Direction)	FLOGJ			BFLOGJ	
Flow	Gas Flow (Inter-Block in K+ Direction)	FLOGK			BFLOGK	
Flow	Gas Flow Total Inter-Region	RGFT		RRGFT		Liquid and gas phases
Flow	Gas Flow Total Inter-Region (Gas Phase)	RGFTG		RRGFTG		
Flow	Gas Flow Total Inter-Region (Liquid Phase)	RGFTL		RRGFTL		
Flow	Gas Injection Rate	GIR		RGIR		
Flow	Gas Injection Total	GIT		RGIT		
Flow	Gas Potential	PPG	FPPG	RPPG	BPPG	
Flow	Gas Production Rate	GPR		RGPR		
Flow	Gas Production Rate (Free)	GPRF		RGPRF		
Flow	Gas Production Rate (Solution)	GPRS		RGPRS		
Flow	Gas Production Total	GPT		RGPT		Liquid and gas phases
Flow	Gas Production Total (Free)	GPTF		RGPTF		
Flow	Gas Production Total (Net From Region)	GP		RGP		Minus injected gas
Flow	Gas Production Total (Solution)	GPTS		RGPTS		
Flow	Gas Velocity (Inter-Block in I+ Direction)	VELGI			BVELGI	
Flow	Gas Velocity (Inter-Block in J+ Direction)	VELGJ			BVELGJ	
Flow	Gas Velocity (Inter-Block in K+ Direction)	VELGK			BVELGK	
Flow	Oil Flow (Inter-Block in I+ Direction)	FLOOI			BFLOOI	
Flow	Oil Flow (Inter-Block in J+ Direction)	FLOOJ			BFLOOJ	
Flow	Oil Flow (Inter-Block in K+ Direction)	FLOOK			BFLOOK	
Flow	Oil Flow Total Inter-Region	ROFT		RROFT		Liquid and gas phases
Flow	Oil Flow Total Inter-Region (Gas Phase)	ROFTG		RROFTG		
Flow	Oil Flow Total Inter-Region (Liquid Phase)	ROFTL		RROFTL		
Flow	Oil Injection Rate	OIR		ROIR		

Block, Field and Region Summary Variables						
Type	**Variable**	**Root**	**Field**	**Region**	**Block**	**Comment**
Flow	Oil Injection Total	OIT		ROIT		
Flow	Oil Potential	PPO	FPPO	RPPO	BPPO	
Flow	Oil Production Rate	OPR		ROPR		
Flow	Oil Production Total	OPT		ROPT		
Flow	Oil Production Total (Net From Region)	OP		ROP		
Flow	Oil Velocity (Inter-Block in I+ Direction)	VELOI			BVELOI	
Flow	Oil Velocity (Inter-Block in J+ Direction)	VELOJ			BVELOJ	
Flow	Oil Velocity (Inter-Block in K+ Direction)	VELOK			BVELOK	
Flow	Water Flow (Inter-Block in I+ Direction)	FLOWI			BFLOWI	
Flow	Water Flow (Inter-Block in J+ Direction)	FLOWJ			BFLOWJ	
Flow	Water Flow (Inter-Block in K+ Direction)	FLOWK			BFLOWK	
Flow	Water Flow Total Inter-Region	RWFT		RRWFT		
Flow	Water Injection Rate	WIR		RWIR		
Flow	Water Injection Total	WIT		RWIT		
Flow	Water Potential	PPW	FPPW	RPPW	BPPW	
Flow	Water Production Rate	WPR		RWPR		
Flow	Water Production Total	WPT		RWPT		
Flow	Water Production Total (Net From Region)	WP		RWP		
Flow	Water Velocity (Inter-Block in I+ Direction)	VELWI			BVELWI	
Flow	Water Velocity (Inter-Block in J+ Direction)	VELWJ			BVELWJ	
Flow	Water Velocity (Inter-Block in K+ Direction)	VELWK			BVELWK	
Pressure	Gas Phase Pressure	GPR			BGPR	
Pressure	Oil Phase Pressure	PR	FPR	RPR	BPR	Field and Region HCPV weighted
Pressure	Oil Phase Pressure	PRH	FPRH	RPRH		Field and Region HCPV weighted
Pressure	Oil Phase Pressure (PV Weighted)	PRP	FPRP	RPRP		Field and Region PV weighted
Pressure	Water Phase Pressure	WPR			BWPR	
Property	Block Hydrocarbon Phase State	STATE			BSTATE	Gas (1), Gas & Oil (2), Oil (3)
Property	Bubble Point Pressure	PBUB			BPBUB	
Property	Capillary Pressure (Gas-Oil)	GPC			BGPC	
Property	Capillary Pressure (Water-Oil)	WPC			BWPC	
Property	Dew Point	PDEW			BPDEW	

Block, Field and Region Summary Variables

Type	Variable	Root	Field	Region	Block	Comment
Property	Gas P/Z	PRGZ	FPRGZ	RPRGZ		
Property	Gas Reservoir Density	GDEN	FGDEN	RGDEN	BGDEN	
Property	Gas Saturation	GSAT	FGSAT	RGSAT	BGSAT	
Property	Gas Saturation (Drainage to Imbibition)	GSHY			BGSHY	Leaving gas saturation for gas capillary pressure hysteresis
Property	Gas Saturation (Dynamically Trapped)	GTPD			BGTPD	WAG Hysteresis only
Property	Gas Saturation (Trapped Critical)	GSTRP			BGSTRP	For gas capillary pressure hysteresis
Property	Gas Saturation (Trapped)	GTRP			BGTRP	WAG Hysteresis only
Property	Gas Viscosity	GVIS	FGVIS	RGVIS	BGVIS	
Property	Gas-Oil Ratio (Saturated)	RSSAT			BRSSAT	
Property	Initial Contact Corrected Potential	PPC	FPPC	RPPC	BPPC	
Property	Oil Reservoir Density	ODEN	FODEN	RODEN	BODEN	
Property	Oil Saturation	OSAT	FOSAT	ROSAT	BOSAT	
Property	Oil Viscosity	OVIS	FOVIS	ROVIS	BOVIS	
Property	Oil-Gas Ratio (Saturated)	RVSAT			BRVSAT	
Property	Relative Permeability (Gas in the R- Direction)	GKRR-			BGKRR-	
Property	Relative Permeability (Gas in the R+ Direction)	GKRR			BGKRR	
Property	Relative Permeability (Gas in the Theta- Direction)	GKRT-			BGKRT-	
Property	Relative Permeability (Gas in the Theta+ Direction)	GKRT			BGKRT	
Property	Relative Permeability (Gas in the X- Direction)	GKRX-			BGKRX-	Also BGKRI-
Property	Relative Permeability (Gas in the X+ Direction)	GKRX			BGKRX	Also BGKRI
Property	Relative Permeability (Gas in the Y- Direction)	GKRY-			BGKRY-	Also BGKRJ-
Property	Relative Permeability (Gas in the Y+ Direction)	GKRY			BGKRY	Also BGKRJ
Property	Relative Permeability (Gas in the Z- Direction)	GKRZ-			BGKRZ-	Also BGKRK-
Property	Relative Permeability (Gas in the Z+ Direction)	GKRZ			BGKRZ	Also BGKRK
Property	Relative Permeability (Gas)	KRG			BKRG	Also BGWR
Property	Relative Permeability (Krw Reduction Factor)	RK			BRK	Due to Polymer
Property	Relative Permeability (Oil Two Phase to Gas)	KROG			BKROG	
Property	Relative Permeability (Oil Two Phase to Water)	KROW			BKROW	
Property	Relative Permeability (Oil in the R- Direction)	OKRR-			BOKRR-	
Property	Relative Permeability (Oil in the R+ Direction)	OKRR			BOKRR	
Property	Relative Permeability (Oil in the Theta- Direction)	OKRT-			BOKRT-	

Block, Field and Region Summary Variables						
Type	**Variable**	**Root**	**Field**	**Region**	**Block**	**Comment**
Property	Relative Permeability (Oil in the Theta+ Direction)	OKRT			BOKRT	
Property	Relative Permeability (Oil in the X- Direction)	OKRX-			BOKRX-	Also BOKRI-
Property	Relative Permeability (Oil in the X+ Direction)	OKRX			BOKRX	Also BOKRI
Property	Relative Permeability (Oil in the Y- Direction)	OKRY-			BOKRY-	Also BOKRJ-
Property	Relative Permeability (Oil in the Y+ Direction)	OKRY			BOKRY	Also BOKRJ
Property	Relative Permeability (Oil in the Z- Direction)	OKRZ-			BOKRZ-	Also BOKRK-
Property	Relative Permeability (Oil in the Z+ Direction)	OKRZ			BOKRZ	Also BOKRK
Property	Relative Permeability (Oil)	KRO			BKRO	Also BOKR
Property	Relative Permeability (Water in the R- Direction)	WKRR-			BWKRR-	
Property	Relative Permeability (Water in the R+ Direction)	WKRR			BWKRR	
Property	Relative Permeability (Water in the Theta- Direction)	WKRT-			BWKRT-	
Property	Relative Permeability (Water in the Theta+ Direction)	WKRT			BWKRT	
Property	Relative Permeability (Water in the X- Direction)	WKRX-			BWKRX-	Also BWKRI-
Property	Relative Permeability (Water in the X+ Direction)	WKRX			BWKRX	Also BWKRI
Property	Relative Permeability (Water in the Y- Direction)	WKRY-			BWKRY-	Also BWKRJ-
Property	Relative Permeability (Water in the Y+ Direction)	WKRY			BWKRY	Also BWKRJ
Property	Relative Permeability (Water in the Z- Direction)	WKRZ-			BWKRZ-	Also BWKRK-
Property	Relative Permeability (Water in the Z+ Direction)	WKRZ			BWKRZ	Also BWKRK
Property	Relative Permeability (Water)	KRW			BKRW	Also BWKR
Property	Water Reservoir Density	WDEN	FWDEN	RWDEN	BWDEN	
Property	Water Saturation	WSAT	FWSAT	RWSAT	BWSAT	
Property	Water Saturation (Drainage to Imbibition)	WSHY			BWSHY	Leaving water saturation for gas capillary pressure hysteresis
Property	Water Saturation (Maximum Wetting)	WSMA			BWSMA	Capillary pressure hysteresis maximum water saturation
Property	Water Viscosity	WVIS	FWVIS	RWVIS	BWVIS	
Ratio	Gas-Oil Ratio	RS	FRS	RRS	BRS	
Ratio	Oil-Gas Ratio	RV	FRV	RRV	BRV	
Volumes	Gas In-Place	GIP	FGIP	RGIP	BGIP	Liquid and gas phases
Volumes	Gas In-Place (Gas Phase)	GIPG	FGIPG	RGIPG	BGIPG	
Volumes	Gas In-Place (Liquid Phase)	GIPL	FGIPL	RGIPL	BGIPL	
Volumes	Oil In-Place	OIP	FOIP	ROIP	BOIP	Liquid and gas phases

Block, Field and Region Summary Variables						
Type	**Variable**	**Root**	**Field**	**Region**	**Block**	**Comment**
Volumes	Oil In-Place (Gas Phase)	OIPG	FOIPG	ROIPG	BOIPG	
Volumes	Oil In-Place (Liquid Phase)	OIPL	FOIPL	ROIPL	BOIPL	
Volumes	Pore Volume (Gas)	GPV	FGPV	RGPV	BGPV	
Volumes	Pore Volume (HCPV)	HPV	FHPV	RHPV	BHPV	Also BHPV
Volumes	Pore Volume (Oil)	OPV	FOPV	ROPV	BOPV	
Volumes	Pore Volume (Reservoir Conditions)	RPV			BRPV	
Volumes	Pore Volume (Water)	WPV	FWPV	RWPV	BWPV	
Volumes	Rock Compaction (Trans. Multiplier X Direction)	PERMMDX			BPERMMDX	Also BPERMOD
Volumes	Rock Compaction (Trans. Multiplier Y Direction)	PERMMDY			BPERMMDY	
Volumes	Rock Compaction (Trans. Multiplier Z Direction)	PERMMDZ			BPERMMDZ	
Volumes	Rock Compaction (Trans. Multiplier)	RTM	FRTM	RRTM	BRTM	
Volumes	Rock Compaction (Dual Porosity SIGMA Multiplier)	SIGMMOD			BSIGMMOD	
Volumes	Rock Compaction (PV Multiplier)	PORVMOD			BPORVMOD	
Volumes	Water In-Place	WIP	FWIP	RWIP	BWIP	

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.12: Block, Field and Region Summary Variables

11.2.7 FIELD AND REGION SUMMARY RECOVERY VARIABLES

Oil recovery factors (or efficiency) may be reported at both the field and the region levels using a variety of parameters as summarized in Table 11.13 and equations (11.1) to (11.6). In addition to the actual recovery factors the simulator can also report the oil volumes produced by various drive mechanisms as described in the table.

See also section *11.2.4 Field, Group, Well, Well Connection and Completion Summary Variables* that outlines the field production data summary variables, and section *11.2.6 Field, Region and Block Summary Variables* that outlines the field, region and block production and injection data summary variables.

Field and Region Summary Recovery Variables

Type	Variable	Root	Field	Region	Comment
Recovery	Oil Recovery Efficiency (STOIIP)	OE	FOE	ROE	Based on STOIIP
Recovery	Oil Recovery Efficiency (Wells)	OEW	FOEW	ROEW	Based on well production and STOIIP
Recovery	Oil Recovery Efficiency (STOIIP Mobile with respect to Water)	OEIW	FOEIW	ROEIW	Based on STOIIP and initial mobile oil saturate with respect to water
Recovery	Oil Recovery Efficiency Wells Mobile with respect to Water)	OEWW	FOEWW	ROEWW	Based on well production and initial mobile oil saturate with respect to water
Recovery	Oil Recovery Efficiency (STOIIP Mobile with respect to Gas)	OEIG	FOEIG	ROEIG	Based on STOIIP and initial mobile oil saturate with respect to gas.
Recovery	Oil Recovery Efficiency (Wells Mobile with respect to Gas)	OEWG	FOEWG	ROEWG	Based on well production and initial mobile oil saturate with respect to gas.
Recovery	Oil Production Total (Free Gas Gas)	OTMF	FOTMF	ROTMF	Volumes reported at stock tank conditions
Recovery	Oil Production Total (Gas Influx)	ORMG	FORMG	RORMG	
Recovery	Oil Production Total (Oil Expansion)	ORME	FORME	RORME	
Recovery	Oil Production Total (Rock Compaction)	ORMR	FORMR	RORMR	
Recovery	Oil Production Total (Solution Gas)	ORMS	FORMS	RORMS	
Recovery	Oil Production Total (Water Influx)	ORMW	FORMW	RORMW	

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.13: Field and Region Summary Recovery Variables

Where:

$$\mathrm{OE} = \frac{\left(STOIIP_{t=0} - STOIIP_{t=i}\right)}{STOIIP_{t=0}} \tag{11.1}$$

$$\mathrm{OEW} = \frac{\left(\text{Well Oil Production}_{t=i}\right)}{STOIIP_{t=0}} \tag{11.2}$$

$$\mathrm{OEIW} = \frac{\left(STOIIP_{t=0} - STOIIP_{t=i}\right)}{\left(\text{Initial Mobile Oil Saturation with respect to Water}_{t=0}\right)} \tag{11.3}$$

$$\mathrm{OEWW} = \frac{\left(\text{Well Oil Production}_{t=i}\right)}{\left(\text{Initial Mobile Oil Saturation with respect to Water}_{t=0}\right)} \tag{11.4}$$

$$\mathrm{OEIG} = \frac{\left(STOIIP_{t=0} - STOIIP_{t=i}\right)}{\left(\text{Initial Mobile Oil Saturation with respect to Gas}_{t=0}\right)} \tag{11.5}$$

$$\mathrm{OEWG} = \frac{\left(\text{Well Oil Production}_{t=i}\right)}{\left(\text{Initial Mobile Oil Saturation with respect to Gas}_{t=0}\right)} \tag{11.6}$$

In addition to all the aforementioned summary variables, there are variables associated with specific features that may have been enabled in the input deck, for instance, the Brine Model, or the Polymer Model. The next set of sections describe the variables associated with these specific options.

11.2.8 Option Specific Summary Variables – Alkaline Model

This feature has not been implemented in OPM Flow.

11.2.9 OPTION SPECIFIC SUMMARY VARIABLES – API AND TRACER TRACKING

The summary variables in this section are for use for when either the API tracking model has be activated by the API keyword in the RUNSPEC section so that the various "oil types" are tracked in the model, or for when the Tracer Model has been requested via the TRACERS keyword in the RUNSPEC section, that defines the number of tracers in the model and the various passive tracer tracking options. Only the Tracer model has been currently implement in OPM Flow.

API and Tracer Tracking Summary Variables								
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Region**	**Block**
Flow	Oil API	API	FAPI	GAPI	WAPI	CAPI	RAPI	BAPI
Flow	Tracer Flow Rate	TFR				CTFR		
Flow	Tracer Flow Total (Free Inter Region)	TFTF					RTFTF	
Flow	Tracer Flow Total (Free Inter Region)	TFTT					RTFTT	
Flow	Tracer Flow Total (Solution Inter Region)	TFTS					RTFTS	
Flow	Tracer Injection Concentration	TIC	FTIC	GTIC	WTIC	CTIC		
Flow	Tracer Injection Rate	TIR	FTIR	GTIR	WTIR	CTIR		
Flow	Tracer Injection Total	TIT	FTIT	GTIT	WTIT	CTIT		
Flow	Tracer Production Concentration	TPC	FTPC	GTPC	WTPC	CTPC		
Flow	Tracer Production Rate	TPR	FTPR	GTPR	WTPR	CTPR		
Flow	Tracer Production Total	TPT	FTPT	GTPT	WTPT	CTPT		
Volume	Tracer Concentration	TCN						BTCN
Volume	Tracer Concentration (Free)	TCNF						BTCNF
Volume	Tracer Concentration (Solution)	TCNS						BTCNS
Volume	Tracer In-Place	TIPT	FTIPT				RTIPT	BTIPT
Volume	Tracer In-Place (Free)	TIPF	FTIPF				RTIPF	BTIPF
Volume	Tracer In-Place (Solution)	TIPS	FTIPS				RTIPS	BTIPS

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.14: API and Tracer Tracking Summary Variables

Note that for the tracer summary variables the mnemonic should be concatenated with the tracer name as defined by the TRACER keyword in the PROPS section. This keyword defines a series of passive tracers that are associated with a phase (oil, water, or gas) in the model, see the example for reference.

Example

In the PROPS section the TRACER keyword defines four passive tracers one for a gas injection well, one for tracking the dissolved gas, and two to track the injected water from two water injection wells.

```
-- ==============================================================================
--
-- PROPS SECTION
--
-- ==============================================================================
PROPS
--
--       DEFINE TRACER NAMES
--
--       TRACER   TRACER
--       NAME     PHASE
--       ------   ------
TRACER
        'IGS'     'GAS'                                        / GAS INJECTOR
        'DGS'     'GAS'                                        / DISOLVED GAS
        'IW1'     'WAT'                                        / WAT INJECTOR 1
        'Iw2'     'WAT'                                        / WAT INJECTOR 2
/
```

If we wish to report the field total amount of the tracers in-place we would use the following in the SUMMARY section:

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY

FTIPTIGS
FTIPTDGS
FTIPIW1
FTIPIW2
```

Notice there are no terminating "/" for field summary variables.

11.2.10 Option Specific Summary Variables – Asphaltene Model

This feature has not been implemented in OPM Flow.

11.2.11 OPTION SPECIFIC SUMMARY VARIABLES – BRINE MODEL

The available Brine model summary keywords are dependent on which form of the Brine model has been invoked in the simulation input deck. In the RUNSPEC section the BRINE keyword activates the standard Brine Tracking model and optionally defines the water phase to have various salinities if the ECLMC keyword in the RUNSPEC section has been used to activate the Multi-Component Brine model. The Multi-Component Brine model allows for the water phase to have multiple water salinities.

Note that the Multi-Component Brine model is currently not supported by OPM Flow.

Brine and Multi-Component Brine Model Summary Variables

Type	Variable	Root	Field	Group	Well	Well Connection	Region	Block	Comment
Flow	Salt Flow Rate	SFR				CSFR			Brine Model
Flow	Salt Injection Rate	SIR	FSIR	GSIR	WSIR	CSIR			
Flow	Salt Injection Total	SIT	FSIT	GSIT	WSIT	CSIT			
Flow	Salt Production Rate	SPR	FSPR	GSPR	WSPR	CSPR			
Flow	Salt Production Total	SPT	FSPT	GSPT	WSPT	CSPT			
Property	Salt Corrected Water Viscosity	EMV_SAL						BEMV_SAL	
Volume	Salt Concentration (Block)	SCN						BSCN	
Volume	Salt Concentration (Injection)	SIC	FSIC	GSIC	WSIC	CSIC			
Volume	Salt Concentration (Production)	SPC	FSPC	GSPC	WSPC	CSPC			
Volume	Salt In-Place	SIP	FSIP				RSIP	BSIP	
Flow	Anion Concentration (Block)	TCNFANI						BTCNFANI	Multi-Component Brine Model
Flow	Anion Flow Rate	TFRANI				CTFRANI			
Flow	Anion Injection Rate	TIRANI	FTIRANI	GTIRANI	WTIRANI				
Flow	Anion Injection Total	TITANI	FTITANI	GTITANI	WTITANI	CTITANI			
Flow	Anion Production Rate	TPRANI	FTPRANI	GTPRANI	WTPRANI				
Flow	Anion Production Total	TPTANI	FTPTANI	GTPTANI	WTPTANI	CTPTANI			
Flow	Cation Flow Rate	TFRCAT				CTFRCAT			
Flow	Cation Injection Rate	TIRCAT	FTIRCAT	GTIRCAT	WTIRCAT				
Flow	Cation Injection Total	TITCAT	FTITCAT	GTITCAT	WTITCAT	CTITCAT			
Flow	Cation Production Rate	TPRCAT	FTPRCAT	GTPRCAT	WTPRCAT				
Flow	Cation Production Total	TPTCAT	FTPTCAT	GTPTCAT	WTPTCAT	CTPTCAT			
Property	Effective Salinity (Polymer)	ESALPLY						BESALPLY	
Property	Effective Salinity (Surfactant)	ESALSUR						BESALSUR	
Volume	Cation Concentration (Block)	TCNFCAT						BTCNFCAT	

Brine and Multi-Component Brine Model Summary Variables									
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Region**	**Block**	**Comment**
Volume	Cation Concentration (Rock Associated)	TRADCAT						BTRADCAT	
Volume	Cation Concentration (Surfactant Associated)	TSADCAT						BTSADCAT	

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.15: Brine and Multi-Component Brine Model Summary Variables

Note that not all these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

11.2.12 Option Specific Summary Variables – Coal Bed Methane Model

The Coal Bed Methane model is not supported by OPM Flow.

11.2.13 Option Specific Summary Variables – Conductive Faults Model

Conductive faults have not been implemented in OPM Flow.

11.2.14 Option Specific Summary Variables – Environmental Tracers

Environmental tracers are not supported by OPM Flow.

11.2.15 OPTION SPECIFIC SUMMARY VARIABLES – FOAM MODEL TRACERS

The Foam phase and model are activated via the FOAM keyword in the RUNSPEC section. Note in the commercial simulator the FOAM phase and model can be used in conjunction with the POLYMER and SURFACT phases; this is not the case for OPM Flow. OPM Flow's FOAM phase and model is a standalone implementation and cannot be used in conjunction with the either the POLYMER or SURFACT phases.

Foam Model Tracers Summary Variables									
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Region**	**Block**	**Comment**
Flow	Foam Flow Rate	TFRFOA				CTFRFOA			
Flow	Foam Injection Rate	TIRFOA	FTIRFOA	GTIRFOA	WTIRFOA				
Flow	Foam Injection Total	TITFOA	FTITFOA	GTITFOA	WTITFOA	CTITFOA			
Flow	Foam Production Rate	TPRFOA	FTPRFOA	GTPRFOA	WTPRFOA				
Flow	Foam Production Total	TPTFOA	FTPTFOA	GTPTFOA	WTPTFOA	CTPTFOA			
Property	Foam Adsorption Total	TADSFOA	FTADSFOA			CTADSFOA	RTADSFOA	BTADSFOA	Block is current value
Property	Foam Capillary Number	TCNMFOA						BTCNMFOA	
Property	Foam Decayed Half Life	THLFFOA						BTHLFFOA	
Property	Foam Decayed Tracer	TDCYFOA	FTDCYFOA				RTDCYFOA	BTDCYFOA	
Property	Foam Gas Mobility Factor	TMOBFOA	FTMOBFOA						Excluding shear
Property	Foam in Solution	TIPTFOA	FTIPTFOA			CTIPTFOA	RTIPTFOA	BTIPTFOA	
Volume	Foam Concentration	TCNFFOA						BTCNFFOA	

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.16: Foam Model Tracers Summary Variables

Note that not all these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

11.2.16 Option Specific Summary Variables – Gas Field Operations Model

The Gas Field Operations model has not been implemented in OPM Flow.

11.2.17 Option Specific Summary Variables – Gas Lift Optimization Model

The Gas Lift Optimization model has not been implemented in OPM Flow.

11.2.18 Option Specific Summary Variables – Gas Calorific Value Reporting

This feature has not been implemented in OPM Flow.

11.2.19 Option Specific Summary Variables – Gi Psuedo-Compositional Model

This feature has not been implemented in OPM Flow.

11.2.20 Option Specific Summary Variables – LGR and Coarsening

Local Grid Refinement ("LGR") and cell coarsening have not been implemented in OPM Flow.

11.2.21 OPTION SPECIFIC SUMMARY VARIABLES – MULTI-SEGMENT WELLS

The summary variables in this section are for use for when multi-segment wells are active in the model, and the variables only apply to the well segments requested for a multi-segment well, not to the well, well connection or well completion.

Note that not all these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

Multi-Segment Wells Summary Variables				
Type	**Variable**	**Root**	**Well Segment**	**Comment**
Flow	Artificial Lift Quantity	ALQ	SALQ	See keyword WSEGTABL
Flow	Brine Flow Rate	FR	SFR	Surfactant and Polymer model
Flow	Gas Flow Rate	GFR	SGFR	
Flow	Gas Flow Rate (Free)	GFRF	SGFRF	
Flow	Gas Flow Rate (Solution)	GFRS	SGFRS	
Flow	Gas Flow Total (Absolute)l	GFTA	SGFTA	
Flow	Gas Flow Total	GFT	SGFT	
Flow	Gas Flow Velocity	GFV	SGFV	
Flow	Gas Holdup Fraction	GHF	SGHF	
Flow	Gas Import Rate	GIMR	SGIMR	See keyword WSEGEXSS
Flow	Gas Import Total	GIMT	SGIMT	See keyword WSEGEXSS
Flow	Oil Absolute Flow Total	OFTA	SOFTA	
Flow	Oil Flow Rate	OFR	SOFR	
Flow	Oil Flow Rate (Free)	OFRF	SOFRF	
Flow	Oil Flow Rate (Solution)	OFRS	SOFRS	
Flow	Oil Flow Total	OFT	SOFT	
Flow	Oil Flow Velocity	OFV	SOFV	
Flow	Oil Holdup Fraction	OHF	SOHF	
Flow	Polymer Flow Rate	CFR	SCFR	Polymer model
Flow	Tracer Flow Rate	TFR	STFR	Tracer model
Flow	Water Flow Rate	WFR	SWFR	
Flow	Water Flow Total	WFT	SWFT	
Flow	Water Flow Total (Absolute)	WFTA	SWFTA	
Flow	Water Flow Velocity	WFV	SWFV	
Flow	Water Holdup Fraction	WHF	SWHF	
Flow	Water Import Rate	WIMR	SWIMR	See keyword WSEGEXSS
Flow	Water Import Total	WIMT	SWIMT	See keyword WSEGEXSS

Multi-Segment Wells Summary Variables				
Type	**Variable**	**Root**	**Well Segment**	**Comment**
Pressure	Pressure	PR	SPR	
Pressure	Pressure Drop	PRD	SPRD	
Pressure	Pressure Drop component due to Friction	PRDF	SPRDF	
Pressure	Pressure Drop component due to Hydrostatic head	PRDH	SPRDH	
Pressure	Pressure drop due to Acceleration head	PRDA	SPRDA	
Pressure	Pressure Drop Frictional Multiplier	PRDM	SPRDM	See keyword WSEGMULT
Property	API	API	SAPI	API model
Property	Fluid Mixture Density (Excludes Exponents)	DENM	SDENM	Excludes exponents of flowing fractions
Property	Fluid Mixture Density (Includes Exponents)	MDEN	SMDEN	Includes exponents of flowing fractions
Property	Fluid Mixture Viscosity (Includes Exponents)	MVIS	SMVIS	Includes exponents of flowing fractions
Property	Fluid Viscosity (Effective Mixture)	EMVIS	SEMVIS	Water/polymer fluid
Property	Gas Density	GDEN	SGDEN	
Property	Gas Viscosity	GVIS	SGVIS	
Property	Gas-Liquid Drift Velocity (Vd)	GLVD	SGLVD	Drift flux slip model
Property	Gas-Liquid Profile Parameter (C0)	GLPP	SGLPP	Drift flux slip model
Property	Oil Density	ODEN	SODEN	
Property	Oil Viscosity	OVI	SOVI	
Property	Oil-Water Drift Velocity (Vd)	OWVD	SOWVD	Drift flux slip model
Property	Oil-Water Profile Parameter (C0)	OWPP	SOWPP	Drift flux slip model
Property	Pump Working Power	PPOW	SPPOW	See keyword WSEGPULL
Property	Scale Deposition Diameter (Karst Conduit Calcite Dissolution)	FD	SFD	Scale Deposition model
Property	Setting of segment	FOPN	SFOPN	See keywords WSEGVALV, WSEGAICD, WSEGSICD, WSEGTABL, WSEGLABY and WSEGFLIM)
Property	Strength of ICD on segment	STR	SSTR	See keywords WSEGVALV, WSEGAICD and WSEGSICD)
Property	Water Density (Pure Water)	WDEN	SWDEN	
Property	Water Viscosity (Pure Water)	WVIS	SWVIS	
Ratio	Gas-Oil Ratio	GOR	SGOR	
Ratio	Oil-Gas Ratio	OGR	SOGR	
Ratio	Water Cut	WCT	SWCT	
Ratio	Water Gas Ratio	WGR	SWGR	
Volume	Brine Concentration	SCN	SSCN	Surfactant and Polymer model

Multi-Segment Wells Summary Variables				
Type	**Variable**	**Root**	**Well Segment**	**Comment**
Volume	Polymer Concentration	CCN	SCCN	Polymer model
Volume	Tracer Concentration	TFC	STFC	Tracer model

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.17: Multi-Segment Wells Summary Variables

Examples

For example, to get the segment oil production rates for well OP01 segments two, three, and four and for segment two for OP02 one would use:

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY

SOFR
'OP01' 2 /
'OP01' 3 /
'OP01' 4 /
'OP02' 2 /
/
```

or to get all the oil production rates for all the segments for well OP01:

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY

SOFR
'OP01' /
/
```

Care should be exercised when defaulting the list of wells and segments as there is the potential to generate large volumes of data.

11.2.22 Option Specific Summary Variables – Network Model

This feature has not been implemented in OPM Flow.

11.2.23 OPTION SPECIFIC SUMMARY VARIABLES – OPM FLOW SIMULATION PERFORMANCE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The following table (Table 11.18) lists the OPM Flow simulation performance summary variables that can be written to the SUMMARY file. Note that not all these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

Cumulative Message Variables		
Variable	**Root**	**Comment**
CPR Solver - Average number of pressure iterations per linear iteration for each time step.	NCPRLINS	Unknown keyword.
CPR Solver - Average number of pressure iterations per Newton iteration per time step.	NLINEARP	Unknown keyword.
CPR Solver - Cumulative number of pressure iterations.	MSUMLINP	Unknown keyword.
CPR Solver - Number of pressure iterations for each time step.	MLINEARP	Unknown keyword.
CPU - CPU time per day (or hour in lab units depending on run units system).	TCPUDAY	No data written to file.
CPU - CPU time per time step for all gradient calculations (Gradient Option).	TCPUTSHT	OPM Flow currently has not implemented the Gradient option.
CPU - CPU time per time step for each gradient calculation (Gradient Option).	TCPUTSH	OPM Flow currently has not implemented the Gradient option.
CPU - CPU time per time step in seconds.	TCPUTS	No data written to file.
CPU - Cumulative CPU time for each gradient calculation (Gradient Option).	TCPUH	OPM Flow currently has not implemented the Gradient option.
CPU - Cumulative CPU time for all gradient calculations (Gradient Option).	TCPUHT	OPM Flow currently has not implemented the Gradient option.
CPU - Cumulative CPU time used in SCHEDULE section.	TCPUSCH	
CPU - Current CPU usage in seconds.	TCPU	Does not consider the time taken by inter-process communications in parallel runs, whereas ELAPSED does. Thus, for parallel jobs, ELAPSED is the most relevant time measurement. Written to file.
Elapsed - Cumulative waiting time per process in seconds.	DTMWAIT	Unknown keyword.
Elapsed - Elapsed time in seconds.	ELAPSED	No data written to file.
Elapsed - Elapsed time per day (or hour in lab units).	TELAPDAY	
Elapsed - Elapsed time per linear iteration in seconds.	TELAPLIN	No data written to file.
Elapsed - Elapsed time per time step in seconds.	TELAPTS	

Cumulative Message Variables		
Variable	**Root**	**Comment**
Iterations - Average number of linear iterations per Newton iteration for each time step.	NLINEARS	For runs with LGRs, LLINEARS will automatically be exported for each LGR.
Iterations - Cumulative number of linear iterations.	MSUMLINS	No data written to file.
Iterations - Cumulative number of Newton iterations.	MSUMNEWT	No data written to file.
Iterations - Maximum number of linear iterations in the Newton iterations per time step.	NLINSMAX	No data written to file.
Iterations - Minimum number of linear iterations in the Newton iterations per time step.	NLINSMIN	No data written to file.
Iterations - Number linear iterations for each time step.	MLINEARS	No data written to file.
Iterations - Number of linear iterations for each gradient calculation (Gradient Option).	HLINEARS	OPM Flow currently has not implemented the Gradient option.
Iterations - Number of Newton iterations used for each time step.	NEWTON	No data written to file.
Iterations - Number of well Newton iterations taken in the last global Newton iteration. A negative value indicates that the well failed to converge.	WNEWTON	
Iterations - Total number of linear iterations for each gradient pressure (Gradient Option).	HSUMLINS	OPM Flow currently has not implemented the Gradient option.
Maximum change in gas saturation for each time step.	MAXDSG	
Maximum change in oil saturation for each time step.	MAXDSO	
Maximum change in pressure for each time step.	MAXDPR	
Maximum change in water saturation for each time step.	MAXDSW	
Memory - Operating system reported maximum current memory usage across processors.	MEMORYTS	
Memory - Peak usage of dynamically allocated memory reported by OPM Flow. For parallel cases this is the maximum across all processors.	NBYTOT	
Messages - Cumulative number of BUG messages.	MSUMBUG	Unknown keyword.
Messages - Cumulative number of COMMENT messages.	MSUMCOMM	Unknown keyword.
Messages - Cumulative number of ERROR messages.	MSUMERR	Unknown keyword.
Messages - Cumulative number of MESSAGES messages.	MSUMMESS	Unknown keyword.
Messages - Cumulative number of PROBLEM messages.	MSUMPROB	Unknown keyword.
Messages - Cumulative number of WARNING messages.	MSUMWARN	Unknown keyword.

Cumulative Message Variables				
Variable			**Root**	**Comment**
Time Step – Criteria used to select the length of the time step, set to one of the following:			STEPTYPE	No data written to file. Note if the RUNSUM keyword has been activated in the SUMMARY section, then the mnemonics are written to the RSM file instead of integer values.
Value	Criteria	Definition		
1	INIT	Initial time step.		
2	TRNC	Controlled via time truncation error.		
3	MINF	Minimum ratio between one time step and the next.		
4	MAXF	Maximum ratio between one time step and the next.		
5	MINS	Minimum permitted time step.		
6	MAXS	Maximum permitted time step.		
7	REPT	Report time step		
8	HALF	Half of the time set to reach the next report time step.		
9	CHOP	Time step chopped due non-convergence of non-linear equations.		
10	SATM	Maximum saturation change.		
11	PCHP	Time step chopped due to maximum pressure change in IMPES formulation.		
12	DIFF	Difficult time step after a time step CHOP.		
13	LGRC	Determined by LGR fluid in-place error targets.		
14	SURF	Set by maximum expected grid block surfactant concentration change.		
15	NETW	Time step determined by network balancing controls.		
16	THRP	Time step controlled by maximum through put ratio.		
17	EMTH	Time step selected to match the end of a month.		
18	MAXP	Set by maximum expected grid block pressure change.		
19	WCYC	Determined by well cycling on/off time.		
20	MAST	Chosen by the master simulation in a reservoir coupling run.		

Cumulative Message Variables				
Variable			Root	Comment
21	SLVR	Selected by a slave simulation to match a slave reporting time step, in a reservoir coupling run.		
22	SLVC	Time step selected by a slave simulation due to a slave's expected flow rate change in a reservoir coupling run.		
23	MAXW	Maximum time step size after a well control event.		
24	EFF+	Selected by ZIPPY optimum time selection algorithm.		
25	EFF-			
26	NLTR			
27	EFFT			
28	DLYA			
29	ACTN			
30	RAIN			
Time Step - Length of time step.			TIMESTEP	
Time Step - Predicted efficiency of the time step (developer use).			ZIPEFF	
Time Step - Predicted efficiency of the time step divided by the actual efficiency (developer use).			ZIPEFFC	

Notes:

1) Cells under the Root column not colored indicate that the summary variable is available in OPM Flow.
2) Cells under the Root column colored in gray indicate that the summary variable is recognized by the parser but the summary variable is not available.
3) Cells under the Root column colored in orange indicate that the summary variable is not recognized by the parser and the summary variable is not available. These summary variables may cause the simulator to abort.

Table 11.18: OPM Flow Simulator Performance Summary Variables

See also the PERFORMA and NMESSAGE keywords in section *11.3 Keyword Definitions* that write out a selection of the variables in Table 11.18.

11.2.24 OPTION SPECIFIC SUMMARY VARIABLES – POLYMER MODEL

The summary variables in this section are associated with Polymer phase and the polymer flood model. The feature is activated by the POLYMER keyword in the RUNSPEC section.

Note that not all these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

Polymer Model Summary Variables									
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Region**	**Block**	**Comment**
Flow	Polymer Flow Rate	CFR				CCFR			
Flow	Polymer Flow Total (Inter-Region)	CFT					RCFT		
Flow	Polymer Injection Rate	CIR	FCIR	GCIR	WCIR	CCIR			
Flow	Polymer Injection Total	CIT	FCIT	GCIT	WCIT	CCIT			
Flow	Polymer Production Rate	CPR	FCPR	GCPR	WCPR	CCPR			
Flow	Polymer Production Total	CPT	FCPT	GCPT	WCPT	CCPT			
Flow	Salt Flow Rate	SFR				CSPR			
Flow	Salt Injection Rate	SIR	FSIR	GSIR	WSIR	CSIR			
Flow	Salt Injection Total	SIT	FSIT	GSIT	WSIT	CSIT			
Flow	Salt Production Rate	SPR	FSPR	GSPR	WSPR	CSPR			
Flow	Salt Production Total	SPT	FSPT	GSPT	WSPT	CSPT			
Property	Polymer Adsorbed (PLYTRRFA)	CABnnn						BCABnnn	By highest temperature band at which residual resistance factor was calculated, see keyword PLYTRRFA. The band number nnn can range from 001 to 999, but must be less than or equal to the argument on the PLYTRRFA keyword.
Property	Polymer Adsorption Total	CAD	FCAD				RCAD	BCAD	Block is concentration
Property	Polymer Solution (Effective Viscosity)	EPVIS						BEPVIS	Also BVPOLY
Property	Polymer Solution Shear Viscosity (Inter-Block I+ Direction)	SHWVISI						BSHWVISI	
Property	Polymer Solution Shear Viscosity (Inter-Block J+ Direction)	SHWVISJ						BSHWVISJ	
Property	Polymer Solution Shear Viscosity (Inter-Block K+ Direction)	SHWVISK						BSHWVISK	

Polymer Model Summary Variables									
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Region**	**Block**	**Comment**
Property	Polymer Thermal Degradation	CDCS						BCDCS	Total mass degraded in previous time step
Property	Polymer Thermal Degradation Rate	CDCR						BCDCR	Total mass degraded in previous time step
Property	Polymer Thermal Degradation Rate (Adsorbed)	CDCA						BCDCA	
Property	Polymer Thermal Degradation Rate (Solution)	CDCP						BCDCP	
Property	Polymer Water (Effective Viscosity)	EMVIS						BEMVIS	Based on block center properties.
Property	Water Flow Rate Times Shear Multiplier (Inter-Block I+ Direction)	FLOW0I						BFLOW0I	Multiplied by the corresponding shear multiplier (PLYSHLOG and PLYSHEAR options only)
Property	Water Flow Rate Times Shear Multiplier (Inter-Block J+ Direction)	FLOW0J						BFLOW0J	
Property	Water Flow Rate Times Shear Multiplier (Inter-Block K+ Direction)	FLOW0K						BFLOW0K	
Property	Water Shear Rate After Shear Effects (Inter-Block I+ Direction)	SRTWI						BSRTWI	
Property	Water Shear Rate After Shear Effects (Inter-Block J+ Direction)	SRTWJ						BSRTWJ	
Property	Water Shear Rate After Shear Effects (Inter-Block K+ Direction)	SRTWK						BSRTWK	
Property	Water Shear Rate Prior to Shear Effects (Inter-Block I+ Direction)	SRTW0I						BSRTW0I	
Property	Water Shear Rate Prior to Shear Effects (Inter-Block J+ Direction)	SRTW0J						BSRTW0J	
Property	Water Shear Rate Prior to Shear Effects (Inter-Block K+ Direction)	SRTW0K						BSRTW0K	
Property	Water Velocity (Inter-Block I+ Direction)	VELW0I						BVELW0I	
Property	Water Velocity (Inter-Block J+ Direction)	VELW0J						BVELW0J	
Property	Water Velocity (Inter-Block K+ Direction)	VELW0K						BVELW0K	
Property	Water Viscosity (Effective)	EWV_POL						BEWV_POL	
Property	Water Viscosity Sheared Factor (Inter-Block I+ Direction)	PSHLZI						BPSHLZI	
Property	Water Viscosity Sheared Factor (Inter-Block J+ Direction)	PSHLZJ						BPSHLZJ	
Property	Water Viscosity Sheared Factor (Inter-Block K+ Direction)	PSHLZK						BPSHLZK	
Volume	Polymer Concentration (Block)	CCN						BCCN	

Polymer Model Summary Variables

Type	Variable	Root	Field	Group	Well	Well Connection	Region	Block	Comment
Volume	Polymer Concentration (Injection)	CIC	FCIC	GCIC	WCIC	CCIC			
Volume	Polymer Concentration (Production)	CPC	FCPC	GCPC	WCPC	CCPC			
Volume	Polymer Solution (In Solution)	CIP	FCIP				RCIP	BCIP	
Volume	Salt Cell Concentration	SCN						BSCN	
Volume	Salt In Place	SIP	FSIP				RSIP	BSIP	
Volume	Salt inter-region Flow Total	SFT					RSFT		

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.19: Polymer Model Summary Variables

11.2.25 Option Specific Summary Variables – Pseudo Steady State

This feature has not been implemented in OPM Flow.

11.2.26 Option Specific Summary Variables – Reservoir Coupling

This feature has not been implemented in OPM Flow.

11.2.27 OPTION SPECIFIC SUMMARY VARIABLES – SOLVENT MODEL

The SOLVENT keyword in the RUNSPEC section activates the solvent phase in the model and activates the four component solvent model for the run. In addition to this keyword, the oil, water and gases phases should also be declared for the run using the OIL, WATER and GAS keywords. The summary variables for this option are outlined in Table 11.20.

Note that not all these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

Solvent Model Summary Variables									
Type	**Variable**	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Region**	**Block**	**Comment**
Flow	Solvent Flow Rate	NFR				CNFR			Field, group and wells gas rates and cumulative volumes include the solvent gas.
Flow	Solvent Flow Total (Inter-Region)	NFT					RNFT		
Flow	Solvent Injection Rate	NIR	FNIR	GNIR	WNIR				
Flow	Solvent Injection Total	NIT	FNIT	GNIT	WNIT	CNIT			
Flow	Solvent Production Rate	NPR	FNPR	GNPR	WNPR				
Flow	Solvent Production Total	NPT	FNPT	GNPT	WNPT	CNPT			
Property	Solvent Relative Permeability	NKR						BNKR	
Volume	Solvent In-Place	NIP	FNIP				RNIP	BNIP	
Volume	Solvent Saturation	BNSAT						BBNSAT	

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.20: Solvent Model Summary Variables

11.2.28 Option Specific Summary Variables – Surfactant Model

This feature has not been implemented in OPM Flow.

11.2.29 OPTION SPECIFIC SUMMARY VARIABLES – THERMAL MODEL

The temperature option (TEMP keyword in the RUNSPEC section) and the thermal option (THERMAL keyword in the RUNSPEC section) are two separate modeling facilities in the commercial simulator, although some keywords can be used by both options. OPM Flow's thermal implementation is based on solving the energy equation fully coupled with the "black-oil" equations so the results are not directly equivalent to the commercial simulator's "black-oil" TEMP or compositional THERMAL formulations. The THERMAL keyword is used to invoke OPM Flow's thermal option. The summary variables for this option are listed in Table 11.21.

Note that not all these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

Thermal Model Summary Variables

Type	Variable	Root	Field	Group	Well	Well Connection	Region	Block	Comment
Flow	Energy Injection Rate	TIRHEA	FTIRHEA	GTIRHEA	WTIRHEA				
Flow	Energy Injection Total	TITHEA	FTITHEA	GTITHEA	WTITHEA				
Flow	Energy Production Rate	TPRHEA	FTPRHEA	GTPRHEA	WTPRHEA				
Flow	Energy Production Total	TPTHEA	FTPTHEA	GTPTHEA	WTPTHEA				
Property	Temperature (Block)	TCNFHEA						BTCNFHEA	
Property	Temperature (Injection)	TICHEA	FTICHEA	GTICHEA	WTICHEA				
Property	Temperature (Production)	TPCHEA	FTPCHEA	GTPCHEA	WTPCHEA			BTPCHEA	
Volume	Energy In-Place Difference	TIPTHEA	FTIPTHEA				RTIPTHEA	BTIPTHEA	Difference in energy in- place from start of run to current time.

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.21: Thermal Model Summary Variables

See the THERMAL keyword in the RUNSPEC section for additional information on this feature.

11.2.30 OPTION SPECIFIC SUMMARY VARIABLES – USER DEFINE QUANTITIES

The UDQ keyword in the SCHEDULE section defines variables and operations used to access the User Defined Quantities features in OPM Flow. UDQ variables can be constants, summary variables, as defined in the SUMMARY section, or a formula using various mathematical functions together with constants and summary variables.

The variable names defined by the UDQ keyword in the SCHEDULE section consist of a character string of length eight, that stipulates the name of the user defined variable based on the type of variable. The variable type is defined by the first two characters of the variable name and must be set to one of the following:

1) CU: For variables that are associated with connections, for example summary variable COFR (Connection Oil Flow Rate).
2) FU: For variables that are associated with field data, for example summary variable FOPR (Field Oil Production Rate).
3) GU: For variables that are associated with groups, for example summary variable GLPR (Group Liquid Production Rate).
4) RU: For variables that are associated with regions, for example summary variable RPR (Region Pressure).
5) SU: For variables that are associated with multi-segment wells, for example summary variable SOFR (Segment Oil Flow Rate).
6) WU: For variables that are associated with wells, for example summary variable WWCT (Well Water Cut).
7) AU: For variables that are associated with aquifers, for example summary variable AAQP (Analytical Aquifer Pressure).
8) BU: For variables that are associated with blocks, for example summary variable BPR (Block oil phase Pressure).

The summary variable format for UDQ defined variables is presented in Table 11.22.

User Define Quantities Summary Variables							
Variable	**Root**	**Field**	**Group**	**Well**	**Well Connection**	**Region**	**Well Segment**
UDQ Variable	XXXXXX	FUXXXXXX	GUXXXXXX	WUXXXXXX	CUXXXXXX	RUXXXXXX	SUXXXXXX
Notes: 1) Where XXXXXX is the variable name defined by the UDQ keyword in the SCHEDULE section. 2) Output of aquifer (AU) and block (BU) summary variables is not supported.							

Table 11.22: User Define Quantities Summary Variables

The following example illustrates the use of this type of summary variable.

Examples

The example shows how to define some constant field variables used for calculating facilities corrected condensate yields in a wet gas model in the SCHEDULE section. The corrected condensate rate is stored as variable named FU_FNGLR.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE
--
-- DEFINE START OF USER DEFINED QUANTITY SECTION
--
UDQ
--
-- OPERATOR VARIABLE  EXPRESSION
--
ASSIGN      FUNGLYLD  1.100000                 / Condensate Yield Correction
--
-- OPERATOR VARIABLE  EXPRESSION
--
DEFINE      FU_FNGLR  FGPR *(FOGR * FUNGLYLD)  / Calculate Condensate Rate Field
UPDATE      FU_FNGLR  ON                       /
UNITS       FU_FNGLR  STBD                     /

/  DEFINE END OF USER DEFINED QUANTITY SECTION
```

In order to report the field corrected condensate values, one would declare FU_FNGLR in the SUMMARY section, as shown below.

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY

FU_FNGLR
```

Note that the normal summary variables syntax rules still apply to groups, regions and wells, etc. So for example, in addition, if the same calculations were performed on two wet gas producers, GP01 and GP02, then one would use:

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY

FU_FNGLR

WU_FNGLR
GP01
GP02
/
```

Assuming of course that WU_FNGLR was defined in the SCHEDULE section.

11.2.31 Option Specific Summary Variables – Wellbore Friction model

This feature has not been implemented in OPM Flow.

11.3 Keyword Definitions

11.3.1 ALL – EXPORT STANDARD SUMMARY VARIABLE VECTORS TO FILE

Description

This keyword activates the writing out of a standard set of summary production and injection data vectors for the field, group and well objects to the SUMMARY (*.SMSPEC and .*UNSMRY) and RSM (*.RSM) files. Table 11.23 lists the production, injection, pressure and volume summary variables written out by the ALL keyword, and Table 11.24 list the aquifer variables.

Standard Production, Injection, and Pressures Summary Variables					
Variable	**Root**	**Field**	**Group**	**Well**	**Comment**
Gas Injection Rate	GIR	FGIR	GGIR	WGIR	
Gas Injection Total	GIT	FGIT	GGIT	WGIT	
Gas Production Rate	GPR	FGPR	GGPR	WGPR	Produced reservoir gas only, gas lift gas is excluded.
Gas Production Total	GPT	FGPT	GGPT	WGPT	
Oil Injection Rate	OIR	FOIR	GOIR	WOIR	
Oil Injection Total	OIT	FOIT	GOIT	WOIT	
Oil Production Rate	OPR	FOPR	GOPR	WOPR	
Oil Production Total	OPT	FOPT	GOPT	WOPT	
Res.Vol. Injection Rate	VIR	FVIR	GVIR	WVIR	
Res.Vol. Injection Total	VIT	FVIT	GVIT	WVIT	
Res.Vol. Production Rate	VPR	FVPR	GVPR	WVPR	
Res.Vol. Production Total	VPT	FVPT	GVPT	WVPT	
Water Injection Rate	WIR	FWIR	GWIR	WWIR	
Water Injection Total	WIT	FWIT	GWIT	WWIT	
Water Production Rate	WPR	FWPR	GWPR	WWPR	
Water Production Total	WPT	FWPT	GWPT	WWPT	
Bottom-Hole Pressure	BHP			WBHP	
Productivity	PI			WPI	Preferred Phase
Tubing Head Pressure	THP			WTHP	
Gas-Oil Ratio	GOR	FGOR	GGOR	WGOR	
Water -Gas Ratio	WGR	FWGR	GWGR	WWGR	
Water Cut	WCT	FWCT	GWCT	WWCT	
Pressures and Volumes					
Variable	**Root**	**Field**	**Group**	**Well**	**Comment**
Oil Phase Pressure	PR	FPR			Field and Region HCPV weighted

Standard Production, Injection, and Pressures Summary Variables					
Gas In-Place	GIP	FGIP			Liquid and gas phases
Gas In-Place (Gas Phase)	GIPG	FGIPG			
Gas In-Place (Liquid Phase)	GIPL	FGIPL			
Oil In-Place	OIP	FOIP			Liquid and gas phases
Oil In-Place (Gas Phase)	OIPG	FOIPG			
Oil In-Place (Liquid Phase)	OIPL	FOIPL			
Water In-Place	WIP	FWIP			

Notes:

1) Cells colored in gray indicate that the summary variable is not available for this combination.
2) Cells colored orange under the Type column indicate that this set of summary variables are not available in OPM Flow because the underlying feature is not available in OPM Flow.

Table 11.23: Standard Production, Injection, and Pressure Summary Variables

Standard Aquifer Summary Variables						
Variable	**Root**	**Field**	**Analytical Aquifer**	**Analytical Aquifer List**	**Numerical Aquifer**	**Comment**
Aquifer Influx Rate (Water Aquifers)	QR	FAQR	AAQR			
Aquifer Influx Total (Water Aquifers)	QT	FAQT	AAQT			
Aquifer Influx Rate (Gas Aquifers)	QRG	FAQRG	AAQRG			
Aquifer Influx Total (Gas Aquifers)	QTG	FAQTG	AAQTG			

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.24: Standard Aquifer Summary Variables

There is no data required for this keyword and there is no terminating "/" for this keyword.

Examples

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       EXPORT STANDARD SUMMARY VARIABLE VECTORS TO FILE
--
ALL
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

Note the SEPARATE keyword is not required for OPM Flow as this is the default behavior; however, it is probably good practice to include it if the same input decks are being run with commercial simulator.

11.3.2 DATE - ACTIVATE THE DATE OPTION FOR THE SUMMARY FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the writing out of the date of each time step to the SUMMARY file. Normally only the time in days and decimal years are written out to the SUMMARY file, activating the DATE option also results in the DATE being written out to the SUMMARY file as well. This option is normally used when the RUNSUM keyword in the SUMMARY section has been activated to produce a RSM file.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

The following example shows an example RSM file output when the DATE option has not been activated.

```
 ------------------------------------------------------------------------------
 SUMMARY OF RUN NO-DATE-KEYWORD
 ------------------------------------------------------------------------------
 TIME          YEARS         FPR           FOEW          FOPR          FOPT
 DAYS          YEARS         PSIA                        STB/DAY       STB



 ------------------------------------------------------------------------------
        0            0      4467.125            0             0             0
 1.000000     0.002738      4466.943     0.000239      3235.662      3235.662
 31.00000     0.084873      4464.476     0.007407      3230.117      100256.4
 60.00000     0.164271      4462.717     0.014291      3193.902      193421.5
 91.00000     0.249144      4460.813     0.021523      3127.557      291306.3
 121.0000     0.331280      4458.909     0.028362      3055.878      383879.7
 152.0000     0.416153      4456.914     0.035262      2982.212      477271.4
.................................................
```

And activating the SUMMARY file DATE option with:

```
--
--        ACTIVATE DATE SUMMARY FILE OPTION
--
DATE
```

Results in the following example RSM file output.

```
 ------------------------------------------------------------------------------
 SUMMARY OF RUN WITH-DATE-KEYWORD
 ------------------------------------------------------------------------------
 DATE          YEARS     DAY  MONTH  YEAR  FPR           FOEW          FOPR
               YEARS                      PSIA                        STB/DAY



 ------------------------------------------------------------------------------
  1-JAN-98           0  19   10     1992  4467.125            0             0
  2-JAN-98     0.002738  20   10     1992  4466.943      0.000239      3235.662
 31-JAN-98     0.084873  21   10     1992  4464.476      0.007407      3230.117
 28-FEB-98     0.164271  24   10     1992  4462.717      0.014291      3193.902
 31-MAR-98     0.249144  28   10     1992  4460.813      0.021523      3127.557
 30-APR-98     0.331280   3   11     1992  4458.909      0.028362      3055.878
 31-MAY-98     0.416153  14   11     1992  4456.914      0.035262      2982.212
.................................................
```

11.3.3 EXCEL - ACTIVATE THE EXCEL OPTION FOR THE SUMMARY FILE

Description

This keyword activates the writing out of the RSM file data in a format that can easily be loaded into Microsoft's EXCEL spreadsheet program or LibreOffice's CALC spreadsheet program. The RSM file output is activated by the RUNSUM keyword in the SUMMARY section.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Examples

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY       --
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE EXCEL SUMMARY FILE OPTION
--
EXCEL
```

The above example activates the SUMMARY file EXCEL option for directly loading the RSM file into either Microsoft's EXCEL or LibreOffice's CALC spreadsheet programs

11.3.4 FMWSET - EXPORT WELL STATUS VECTORS FOR THE FIELD TO FILE

Description

This keyword is similar to the ALL keyword in the SUMMARY section, in that it results in a group of summary variables to be written out to the SUMMARY file. In this case the keyword activates the writing out of a set of data vectors that give the production and injections status of all the wells in the model, as well as the number of wells in the drilling queue and the number of workover events occurring within a time step. Both instantaneous and cumulative well counts and events are written out as listed in Table 11.25.

There is no data required for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Field and Group Well Status Summary Variables				
Variable	**Root**	**Field**	**Group**	**Comment**
Number of abandoned injection wells	MWIA	FMWIA	GMWIA	
Number of abandoned production wells	MWPA	FMWPA	GMWPA	
Number of drilling events in total	MWDT	FMWDT	GMWDT	
Number of drilling events this timestep	MWDR	FMWDR	GMWDR	
Number of injection wells currently flowing	MWIN	FMWIN	GMWIN	
Number of injectors on group control	MWIG	FMWIG	GMWIG	
Number of injectors on own reservoir volume rate limit control	MWIV	FMWIV	GMWIV	
Number of injectors on own surface rate limit control	MWIS	FMWIS	GMWIS	
Number of injectors on pressure control	MWIP	FMWIP	GMWIP	
Number of producers controlled by own oil rate limit	MWPO	FMWPO	GMWPO	
Number of producers on group control	MWPG	FMWPG	GMWPG	
Number of producers on own reservoir volume rate limit control	MWPV	FMWPV	GMWPV	
Number of producers on own surface rate limit control	MWPS	FMWPS	GMWPS	
Number of producers on pressure control	MWPP	FMWPP	GMWPP	
Number of producers using artificial lift (with ALQ > 0.0)	MWPL	FMWPL	GMWPL	
Number of production wells currently flowing	MWPR	FMWPR	GMWPR	
Number of unused injection wells	MWIU	FMWIU	GMWIU	
Number of unused production wells	MWPU	FMWPU	GMWPU	
Number of workover events in total	MWWT	FMWWT	GMWWT	
Number of workover events this time step.	MWWO	FMWWO	GMWWO	
Total number of injection wells	MWIT	FMWIT	GMWIT	
Total number of production wells	MWPT	FMWPT	GMWPT	

Field and Group Well Status Summary Variables				
Variable	**Root**	**Field**	**Group**	**Comment**

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.25: FMWSET - Standard Field and Group Well Status Summary Variables

See also the GMWSET keyword in the SUMMARY schedule that has similar functionality but at a group level.

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY       --
--       EXPORT WELL STATUS VECTORS FOR THE FIELD TO FILE
--
FMWSET
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

The above example exports the field standard well status variables to the SUMMARY file.

11.3.5 GMWSET - EXPORT WELL STATUS VECTORS BY GROUP TO FILE

Description

This keyword is similar to the ALL keyword in the SUMMARY section, in that it results in a group of summary variables to be written out to the SUMMARY file. In this case the keyword activates the writing out of a set of data vectors that give the production and injections status of all the wells in the named groups, as well as the number of wells in the drilling queue and the number of workover events occurring within a time step for the requested groups. Both instantaneous and cumulative well counts and events for the groups are written out as tabulated in Table 11.26.

Note that GMWSET should be followed by a list of group names enclosed in quotes and therefore a terminating "/" is required to end the list of groups. A blank list requests output for all groups.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Field and Group Well Status Summary Variables				
Variable	**Root**	**Field**	**Group**	**Comment**
Number of abandoned injection wells	MWIA	FMWIA	GMWIA	
Number of abandoned production wells	MWPA	FMWPA	GMWPA	
Number of drilling events in total	MWDT	FMWDT	GMWDT	
Number of drilling events this timestep	MWDR	FMWDR	GMWDR	
Number of injection wells currently flowing	MWIN	FMWIN	GMWIN	
Number of injectors on group control	MWIG	FMWIG	GMWIG	
Number of injectors on own reservoir volume rate limit control	MWIV	FMWIV	GMWIV	
Number of injectors on own surface rate limit control	MWIS	FMWIS	GMWIS	
Number of injectors on pressure control	MWIP	FMWIP	GMWIP	
Number of producers controlled by own oil rate limit	MWPO	FMWPO	GMWPO	
Number of producers on group control	MWPG	FMWPG	GMWPG	
Number of producers on own reservoir volume rate limit control	MWPV	FMWPV	GMWPV	
Number of producers on own surface rate limit control	MWPS	FMWPS	GMWPS	
Number of producers on pressure control	MWPP	FMWPP	GMWPP	
Number of producers using artificial lift (with ALQ > 0.0)	MWPL	FMWPL	GMWPL	
Number of production wells currently flowing	MWPR	FMWPR	GMWPR	
Number of unused injection wells	MWIU	FMWIU	GMWIU	
Number of unused production wells	MWPU	FMWPU	GMWPU	
Number of workover events in total	MWWT	FMWWT	GMWWT	
Number of workover events this time step.	MWWO	FMWWO	GMWWO	
Total number of injection wells	MWIT	FMWIT	GMWIT	
Total number of production wells	MWPT	FMWPT	GMWPT	

Field and Group Well Status Summary Variables				
Variable	**Root**	**Field**	**Group**	**Comment**

Notes:

1) Cells colored in gray with a mnemonic indicate that the summary variable is not available in OPM Flow.
2) Cells colored in gray with no mnemonic indicate that the summary variable is not available for this combination.
3) Cells colored orange show combinations that are not available in OPM Flow because the underlying feature is not available.

Table 11.26: GMWSET - Standard Field and Group Well Status Summary Variables

See also the FMWSET keyword in the SUMMARY schedule that has similar functionality but at the field level.

Examples

The first example below exports all the group standard well status variables to the SUMMARY file.

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       EXPORT WELL STATUS VECTORS FOR NAMED GROUPS TO FILE
--
GMWSET
/
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

The second example exports all the group standard well status variables for just the PLAT1 and PLT2 groups only to the SUMMARY file.

```
--
--       EXPORT WELL STATUS VECTORS FOR NAMED GROUPS TO FILE
--
GMWSET
'PLAT1' 'PLAT2'
/
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

11.3.6 NMESSAGE – EXPORT CUMULATIVE MESSAGE SUMMARY VARIABLES TO FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the writing out of a standard set of summary OPM Flow simulation performance summary variables to the SUMMARY (*.SMSPEC and .*UNSMRY) and RSM (*.RSM) files, namely the number of messages written per message class. Table 11.23 lists the summary variables written out by the NMESSAGE keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

OPM Flow Simulator Performance Summary Variables Cumulative Message Variables		
Variable	**Root**	**Comment**
Messages - Cumulative number of BUG messages.	MSUMBUG	Unknown keyword.
Messages - Cumulative number of COMMENT messages.	MSUMCOMM	Unknown keyword.
Messages - Cumulative number of ERROR messages.	MSUMERR	Unknown keyword.
Messages - Cumulative number of MESSAGES messages.	MSUMMESS	Unknown keyword.
Messages - Cumulative number of PROBLEM messages.	MSUMPROB	Unknown keyword.
Messages - Cumulative number of WARNING messages.	MSUMWARN	Unknown keyword.

Notes:

1) Cells under the Root column not colored indicate that the summary variable is available in OPM Flow.
2) Cells under the Root column colored in gray indicate that the summary variable is recognized by the parser but the summary variable is not available.
3) Cells under the Root column colored in orange indicate that the summary variable is not recognized by the parser and the summary variable is not available. These summary variables may cause the simulator to abort.

Table 11.27: Simulator Performance Summary Variables (Cumulative Messages)

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       EXPORT PERFORMANCE CUMULATIVE MESSAGE VARIABLE VECTORS TO FILE
--
NMESSAGE
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

Note the SEPARATE keyword is not required for OPM Flow as this is the default behavior; however, it is probably good practice to include it if the same input decks are being run with the commercial simulator.

11.3.7 MONITOR – Activate Output of the Monitoring Data and File

The MONITOR keyword activates the writing out of the run time monitoring information used by post-processing graphics software to display run time information, for example the simulated production and injection rates and cumulative values. OPM Flow does not have this functionality.

See *MONITOR – Activate Output of the Monitoring Data and File* in the RUNSPEC section for a full description.

11.3.8 NARROW – ACTIVATE RUN SUMMARY NARROW COLUMN OUTPUT OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NARROW keyword activates the Run Summary Narrow Column Output option, for when printed SUMMARY data has been requested by the RUNSUM keyword in the SUMMARY section. The option increases the number of columns "printed on the page".

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

11.3.9 NEWTON – ACTIVATE NEWTON ITERATION SUMMARY OUTPUT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the writing out of the Newtonian iteration vector (the number of non-linear iterations per time step) to the SUMMARY file, and the RSM file if the RSM file option has been requested by the RUNSUM keyword in the SUMMARY section,

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE       --
--       ACTIVATE NEWTON ITERATION SUMMARY OUTPUT
--
NEWTON
```

The above example actives the writing out of the Newtonian iteration vector to the SUMMARY file.

11.3.10 NOMONITO – Deactivate Output of the Monitoring Data and File

The NOMONITO keyword deactivates the writing out of the run time monitoring information used by post-processing graphics software to display run time information, for example the simulated production and injection rates and cumulative values. OPM Flow does not have this functionality.

See *NOMONITO – Deactivate Output of the Monitoring Data and File* in the RUNSPEC section for a full description.

11.3.11 OFM – Activate OFM File Output of the SUMMARY Data

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the writing out of the SUMMARY file data in the Oil Field Manager ("OFM") file format to enable the simulated data to be directly loaded into OFM.

There is no data required for this keyword and there is no terminating "/" for this keyword.

See also the EXCEL, RPTONLY, RUNSUM and SEPARATE keywords in the SUMMARY section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

11.3.12 PERFORMA – EXPORT STANDARD SIMULATOR PERFORMANCE SUMMARY VARIABLES TO FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PERFORMA keyword activates the writing out of a standard set of summary OPM Flow simulation numerical performance summary variables to the SUMMARY (*.SMSPEC and .*UNSMRY) and RSM (*.RSM) files. Table 11.23 lists the summary variables written out by the keyword.

Note that not all these variables are available in OPM Flow; however, the simulator will issue a warning messages if this is indeed the case. It is anticipated that the number of recognized summary variables will increase in future releases of OPM Flow.

OPM Flow Simulator Performance Summary Variables **Numerical Performance Variables**		
Variable	**Root**	**Comment**
CPU - CPU time per day (or hour in lab units depending on run units system).	TCPUDAY	No data written to file.
CPU - CPU time per time step for all gradient calculations (Gradient Option).	TCPUTSHT	OPM Flow currently has not implemented the Gradient option.
CPU - Cumulative CPU time for each gradient calculation (Gradient Option).	TCPUH	OPM Flow currently has not implemented the Gradient option.
Elapsed - Elapsed time in seconds.	ELAPSED	No data written to file.
Elapsed - Elapsed time per linear iteration in seconds.	TELAPLIN	No data written to file.
Iterations - Average number of linear iterations per Newton iteration for each time step.	NLINEARS	For runs with LGRs, LLINEARS will automatically be exported for each LGR.
Iterations - Cumulative number of linear iterations.	MSUMLINS	No data written to file.
Iterations - Cumulative number of Newton iterations.	MSUMNEWT	No data written to file.
Iterations - Maximum number of linear iterations in the Newton iterations per time step.	NLINSMAX	No data written to file.
Iterations - Minimum number of linear iterations in the Newton iterations per time step.	NLINSMIN	No data written to file.
Iterations - Number linear iterations for each time step.	MLINEARS	No data written to file.
Iterations - Number of Newton iterations used for each time step.	NEWTON	No data written to file.
Time Step – Criteria used to select the length of the time step. See section *11.2.23 Option Specific Summary Variables – OPM Flow Simulation Performance* for the definition	STEPTYPE	No data written to file.

OPM Flow Simulator Performance Summary Variables Numerical Performance Variables		
Variable	**Root**	**Comment**
of of the STEPTYPE mnemonics.		

Notes:

1) Cells under the Root column not colored indicate that the summary variable is available in OPM Flow.
2) Cells under the Root column colored in gray indicate that the summary variable is recognized by the parser but the summary variable is not available.
3) Cells under the Root column colored in orange indicate that the summary variable is not recognized by the parser and the summary variable is not available. These summary variables may cause the simulator to abort.

Table 11.28: Simulator Performance Summary Variables (Numerical Performance)

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       EXPORT NUMERICAL PERFORMANCE SUMMARY VARIABLES TO FILE
--
PERFORMA
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

Note the SEPARATE keyword is not required for OPM Flow as this is the default behavior; however, it is probably good practice to include it if the same input decks are being run with commercial simulator.

11.3.13 PYEND – END THE DEFINITION OF A PYINPUT SECTION

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords. A PYINPUT Definition Section is terminated by a PYEND keyword on a separate single line.

See *PYEND – End the Definition of a PYINPUT Section* in the GRID section for a full description.

11.3.14 PYINPUT – DEFINE THE START OF A PYINPUT SECTION

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords used by the simulator. PYINPUT declares the start of a PYINPUT Definition Section on a single separate line, which is then followed by various standard Python commands, with one command per line.

See *PYINPUT – Define the Start of a PYINPUT Section* in the GRID section for a full description.

11.3.15 RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the writing out of the SUMMARY file and the RSM file data, if the RSM file option has been requested by the RUNSUM keyword in the SUMMARY section, at report time steps only. The default is for the data to be written out for all time steps to the SUMMARY files. This keyword reduces the file size at the expense of lower resolution in the time domain.

There is no data required for this keyword and there is no terminating "/" for this keyword.

The option can be deactivated by the RPTONLYO keyword in the SUMMARY section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       EXPORT STANDARD SUMMARY VARIABLE VECTORS TO FILE
--
ALL
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE --
--       ACTIVATE REPORT TIME STEPS ONLY SUMMARY FILE OPTION
--
RPTONLY
```

The above example activates the writing out of the SUMMARY file at report time steps only.

11.3.16 RPTONLYO - Deactivate the Report Time Steps Only Option for the SUMMARY File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword deactivates the writing out of the SUMMARY file and the RSM file data, if the RSM file option has been requested by the RUNSUM keyword in the SUMMARY section, at report time steps only, and switches on writing out all the time steps to the files. This option is the default behavior for when RPTONLY has not been activated.

There is no data required for this keyword and there is no terminating "/" for this keyword.

The option can be activated by the RPTONLY keyword in the SUMMARY section that will switch on writing the data at every report time step instead of every time step..

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       EXPORT STANDARD SUMMARY VARIABLE VECTORS TO FILE
--
ALL
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE --
--       DEACTIVATE REPORT TIME STEPS ONLY SUMMARY FILE OPTION
--
RPTONLYO
```

The above example deactivates the writing out of the SUMMARY file at report time steps only, and switches on writing out all the time steps to the file.

11.3.17 RPTSMRY - ACTIVATE OR DEACTIVATE SUMMARY LIST REPORT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates or deactivates a listing of all the summary variables that are going to be written to the SUMMARY file and the RSM file, if the RSM file option has been requested by the RUNSUM keyword in the SUMMARY section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	RPTSMRY	An integer value set to zero for no report, or one to produce the report.	0

Notes:

1) The keyword is terminated by "/".

Table 11.29: RPTSMRY Keyword Description

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--        EXPORT STANDARD SUMMARY VARIABLE VECTORS TO FILE
--
ALL
--
--        ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--        ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
--
--        ACTIVATE OR DEACTIVATE SUMMARY LIST REPORT
--
RPTSMRY
          1                                                    /
```

The example switches on the summary list report.

11.3.18 RUNSUM – ACTIVATE RSM FILE OUTPUT OF THE SUMMARY DATA

Description

This keyword activates the writing out of the SUMMARY file data in a columnar format to the PRT file. Normally the SEPARATE keyword in the SUMMARY section is invoked in the same run to direct the data stream to a separate RSM file for easy loading into other programs, for example, Microsoft's EXCEL or LibreOffice's CALC spreadsheet programs.

There is no data required for this keyword and there is no terminating "/" for this keyword.

See also the EXCEL, RPTONLY and SEPARATE keywords in the SUMMARY section.

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

Note unlike the commercial simulator, OPM Flow always writes out the data to a separate file.

11.3.19 SEPARATE – ACTIVATE THE SEPARATE RSM FILE OUTPUT OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates the writing out of the SUMMARY file date in a columnar format to the RSM file, if the RUNSUM keyword has also been activated in the SUMMARY section. Both the SEPARATE and the RUNSUM keywords need to be invoked. If the SEPARATE option is not activated then the RSM output is directed to the end of the PRT file. Normally the both the SEPARATE and RUNSUM keywords are invoked in the same run to enable easy loading of the data into Microsoft's EXCEL or LibreOffice's CALC spreadsheet programs.

There is no data required for this keyword and there is no terminating "/" for this keyword.

See also the EXCEL, RPTONLY and RUNSUM keywords in the SUMMARY section.

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

Note unlike the commercial simulator, OPM Flow always writes out the data to a separate file; however, it is probably good practice to include it if the same input decks are being run with commercial simulator.

11.3.20 SUMMARY - Define the Start of the SUMMARY Section of Keywords

Description

The SUMMARY activation keyword marks the end of the SOLUTION section and the start of the SUMMARY section that defines the variables to be written out to the SUMMARY file for reporting and plotting of grid block data, production data, etc.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

```
-- ==============================================================================
--
-- SUMMARY SECTION
--
-- ==============================================================================
SUMMARY
```

The above example marks the end of the SOLUTION section and the start of the SUMMARY section in the OPM Flow data input file.

11.3.21 SUMTHIN – DEFINE SUMMARY DATA REPORTING TIME STEPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines a time interval for writing out the SUMMARY data to the SUMMARY file and the RSM file, if the RUNSUM keyword has also been activated in the SUMMARY section. Only the data for the first time step in the time interval is written out and the other time steps are skipped until the next time interval. This enables the size of the SUMMARY files to be reduced depending on the size of the time interval. However, the keyword will produce irregular time steps reports of the SUMMARY data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SUMSTEP	SUMSTEP is a real positive number that defines the time interval for which the first time step of data will be written to the SUMMARY file (and the RSM file if RSM output has been activated). For example, if SUMSTEP is set to 30 days, and if the simulator takes time steps of 0, 5, 10, 16, 24, 30, 40, 45, 60, 90 days. Then the SUMMARY data will be written out at time steps 0, 30, 40 and 60 days.			
		days	days	hours	None

Notes:

1) The keyword is terminated by "/".

Table 11.30: SUMTHIN Keyword Description

See also the RPTONLY keyword in the SUMMARY section that forces the SUMMARY data to be only written out at report time steps, as oppose to all time steps or SUMSTEPS time intervals.

Example

```
--
--        DEFINE SUMMARY DATA REPORTING TIME STEP INTERVAL
--
--        SUMSTEP
SUMTHIN
          30.0                                                /
/
```

The above example defines the SUMMARY file time step interval to be 30 days for both field and metric units.

CHAPTER 12: SCHEDULE SECTION

12.1 INTRODUCTION

The SCHEDULE section is used to specify the production and injection targets and constraints for the entire model, advance the model through time, and stipulate any other data that depends on time. For example, drilling wells at a particular time, incorporating production and/or injection rate changes as the model progresses through time, and opening and shutting wells and well connections/completions at particular times during the history of the reservoir. Field development and operating strategy are also incorporated in the SCHEDULE section, for example the timing and effect of upgrading of the field facilities liquid and water handling capacities. All these actions must be specified in the SCHEDULE section at the time they occur, that is all the events in the SCHEDULE section are time dependent. This is different to the other sections of the input deck were the order of keywords is largely unimportant; in the SCHEDULE section it is essential because the order in which events take place in the field have to be preserved. For instance, the keyword defining wellhead locations via the WELSPECS keyword must precede the keyword defining the locations and properties of the well connections using the COMPDAT keyword. The rules on keyword order generally follow the same sequence as the order of events in a production plan, that is we drill wells first (WELSPECS), then complete them (COMPDAT), and put them on production (WCONHIST, WCONPROD or WCONINJE).

In most cases a significant part of the contents of the SCHEDULE section is often imported from other applications. For instance, the Vertical Lift Performance ("VLP") tables used to convert from Bottom-Hole Pressure ("BHP") to Tubing Head Pressure ("THP") and entered via the VFPPROD keyword, are always generated by an external Nodal Analysis application. These tables are then included in the input deck via the INCLUDE keyword. Note as the VFP tables are assigned to a well via the WCONHIST, WCONPROD or WCONINJE keywords, then the tables need to have been previously entered prior to assigning them to a well, that is the data is order dependent. Well historical production data is also normally "included" from an external source, typically the production data base, and may have to be edited to ensure that the correct connections/completions are opened and shut at the appropriate time.

Note

The term well connection is used to describe individual connections from the wellbore to the reservoir grid cell, as opposed to a well completion. A well completion is used to describe a set of connections that are "grouped" into well completions using the COMPLUMP keyword in the SCHEDULE section. For instance, a well may consist of several completions with each completion consisting of multiple connections.

The reservoir management flexibility offered in the SCHEDULE section is indicated by over 300 keywords available in the section and thus makes quality assurance of the data challenging. This means that one should not assume that the data included from third party applications are error free and therefore suitable error checking should be performed.

The majority of the keywords are related to controlling how wells and groups are operated, by applying production/injection targets and constraints, economic criteria and associated actions if a criteria is violated, drilling of additional wells to meet production targets or constraints, as well as the relationship between the different wells and groups in the model. In addition, the DATES, TIME and TSTEP keywords that are used to progress the simulation through time and the TUNING series of keywords control the numerical parameters in defining numerical convergence of each time step. Note that OPM Flow can be instructed to read the first record of the TUNING keyword if the appropriate command line parameter has been activated (see section *2.2 Running OPM Flow 2020-04 From The Command Line*).

Note

When the DATES, TIME and TSTEP keywords are used to advanced the simulation through time this "new" time step is known as a "report time step", as either an action (open a well for example) or a report request will be made. This is different to a simulator's automatic time step used to advance the simulator to the next "reporting time step".

For instance, if the simulation is currently at January 1, 2020 and the next reporting time step is January 1, 2021, then the simulator may not be able to advance directly in one time step to January 1, 2021. Instead, a series of time steps of various duration will be automatically selected by the simulator based on the current set of numerical convergence controls until the required "report time step" is reached.

The next section summarizes the data requirements for the SCHEDULE section and offers some guidance on structuring the format of the keywords in order to increase readability of the input deck and to minimize potential input errors.

12.2 DATA REQUIREMENTS

Apart from the keywords that advance the simulator through time (the DATES, TIME and TSTEP keywords), the minimum required data is associated with defining a well (WELSPECS), defining a well's connection to the reservoir (COMPDAT), and the operating and production targets and constraints for the well (WCONHIST, WCONPROD or WCONINJE). Well connections can be "grouped" into completions using the COMPLUMP keyword to represent actual physical well completions in the model. Well's can either operate independently or under group control. That is when a well is allocated to a group, then the group can dictate how the wells in the group under group control are operated. For example, a group may have production targets and constraints and all wells under group control within the group will be operated in such a manner as to satisfy the group's targets and constraints. Note that wells can belong to a group but do not necessary have to be under group control. The top level group, level one, has the name FIELD and under this level can be wells, groups and sub groups to the higher level groups. By default three group levels are defined that sets the wells as level three, reporting directly to defined groups at level two, and the level two groups reporting to the FIELD group at level one. If a different configuration is required, then the GRUPTREE keyword should be used to define the group hierarchy by defining a lower level group that reports directly to a higher level group.

The major well specification keywords are summarized in Table 12.1 for easy of reference.

Major Well Specification Keywords		
Purpose	**Keywords**	**Description**
Vertical Flow Tubing Performance Table Specification	VFPPROD	The VFPPROD keyword defines production Vertical Flow Performance ("VFP") tables that are used to determine the outflow or downstream pressure based on the inlet or upstream pressure and the phases flowing through the system. For a well this means the table relates the flowing bottom-hole pressure ("FBHP") to the well's tubing head pressure ("THP") based on the oil, gas and water rates (and any artificial lift quantities like gas lift gas), or phases ratios, flowing up the wellbore.
	VFPINJ	VFPINJ declares similar data but for injection wells.
Well Specification	WELSPECS	The WELSPECS keyword defines the general well specification data for all well types, and must be used for all wells before any other well specification keywords are used in the input file. The keyword declares the name of well, the initial group the well belongs to, the wellhead location and other key parameters.

Major Well Specification Keywords		
Purpose	**Keywords**	**Description**
Well Completion Data	COMPDAT	COMPDAT defines how a well is connected to the reservoir by defining or modifying existing well connections.
	COMPLUMP	The COMPLUMP keyword assigns connections, as defined by the COMPDAT keyword, to completion intervals. This "lumping" or "grouping" of the connections to various completion intervals allows automatic workovers and economic criteria to be applied to the completions (that is a set of connections) as opposed to the individual connections.
Historical Production and Injection Data	WCONHIST	WCONHIST defines production rates and pressures for wells that have been declared history matching wells by the use of this keyword. History matching wells are handled differently than ordinary wells that use the WCONPROD keyword for controlling their production targets and constraints.
	WCONINJH	WCONINJH declares similar data as the WCONHIST keyword but for injection wells.
Predictive Production and Injection Data	WCONPROD	The WCONPROD keyword defines production targets and constraints for wells that have previously been defined by the WELSPECS keyword.
	WCONINJE	WCONINJE declares similar data as the WCONPROD keyword but for injection wells.
Well Control	WELCNTL	The WELCNTL keyword modifies a wells' target control and value, both rates and pressures, for previously defined wells without having to define all the variables on the well control keywords: WCONPROD, WCONHIST, WCONDINJE, or WCONDINJH keywords. See also the WELTARG keyword below.
	WECON	WECON defines the economic criteria for production wells that have previously been defined by the WELSPECS and WCONPROD keywords.
	WEFAC	WEFAC defines a well's efficiency or up-time as opposed to setting the efficient factors at the group level.
	WHISCTL	The WHISCTL keyword changes the target control phase for wells declared as history match wells via the WCONHIST keyword. The target phase is set on the WCONHIST keyword and WHISCTL overrides this value for all subsequent entries on the WCONHIST keyword
	WELOPEN	WELOPEN defines the status of wells and the well connections, and is used to open and shut previously defined well and well connections without having to re-specify all the data on the well control keywords: WCONPROD, WCONHIST, WCONINJE, or WCONINJH keywords.
	WELTARG	The WELTARG keyword modifies the target and constraints values of both rates and pressures for previously defined wells without having to define all the variables on the well control keywords: WCONPROD, WCONHIST, WCONINJE, or WCONINJH keywords. See also the WELCNTL keyword above.
Well Productivity Adjustments (Normally used in History Matching)	WELPI	WELPI is used to define a well's productivity or injectivity index and the values enter on this keyword for a given well will override any previously calculated values, or values previously entered values using this keyword.

Major Well Specification Keywords		
Purpose	**Keywords**	**Description**
	WPIMULT	The WPIMULT keyword defines a well connection multiplier factor that scales the existing well connection values. The resulting effect is to scale the well's productivity at the reporting time step the keyword is entered.

Table 12.1: Major Well Specification Keywords

Wells are initially allocated to groups via the WELSPECS keyword and groups have similar set of keywords as for wells, as outlined in Table 12.2. However only a limited set of keywords have been implemented in OPM Flow compared with the commercial simulator's set of keywords.

Major Group Specification Keywords		
Purpose	**Keywords**	**Description**
Group Specification	GRUPTREE	GRUPTREE defines the group hierarchy of groups that have been created by having wells assigned to them via the WELSPECS keyword. By default three group levels are defined that sets the wells as level three, reporting directly to defined groups at level two, and the level two groups reporting to the FIELD group at level one.
Predictive Production and Injection Data	GCONPROD	The GCONPROD keyword defines production targets and constraints for groups, including the top most group in the group hierarchy known as the FIELD group.
	GCONINJE	GCONINJE declares similar data as for GCONPROD but for group injection targets and constraints.
Group Control	GECON	The GECON keyword defines economic criteria for production groups, including the field level group FIELD, that have previously been defined by the GCONPROD keyword.
	GEFAC	GEFAC defines a group's efficiency or up-time as opposed to setting the efficient factors for individual wells.
	GRUPTARG	GRUPTARG keyword modifies the target and constraints values of both rates and pressures for previously defined groups without having to define all the variables on the group control keywords: GCONPROD or GCONPRI keywords.

Table 12.2: Major Group Specification Keywords

The final set of keywords define various controls for the model, the keywords available to advance the simulator through time, and the available reporting keywords, as illustrated in Table 12.3.

Schedule Advancement, Control And Reporting Keywords		
Purpose	**Keywords**	**Description**
Control RS and RV Behavior	DRSDT	DRSDT defines the maximum rate at which the solution gas-oil ratio (Rs) can be increased in a grid cell. The keyword is similar in functionality to the DRSDTR keyword, that defines the maximum rate at which Rs can be increased in a grid cell by region.
	DRSDTR	DRSDTR defines the maximum rate at which the solution gas-oil ratio (Rs) can be increased in a grid cell for various regions in the model. The keyword is similar in functionality to the DRSDT keyword, that defines the maximum rate at which Rs can be increased in a grid cell for all cells in the model.
	DRVDT	DRVDT defines the maximum rate at which the solution oil-gas ratio or condensate-gas ratio (Rv) can be increased in a grid cell. The keyword is similar in functionality to the DRVDTR keyword, that defines the maximum rate at which Rv can be increased in a grid cell by region.
	DRVDTR	DRVDTR defines the maximum rate at which the solution oil-gas ratio or condensate-gas ratio (Rv) can be increased in a grid cell for various regions in the model. The keyword is similar in functionality to the DRVDT keyword, that defines the maximum rate at which Rv can be increased in a grid cell for all cells in the model.
Schedule Advancement	DATES	DATES advances the simulation to a given report date after which additional keywords may be entered to instruct OPM Flow to perform additional functions via the SCHEDULE section keywords, or further DATES keywords may be entered to advance the simulator to the next report date.
	TIME	TIME advances the simulation to a given cumulative report time after which additional keywords may be entered to instruct OPM Flow to perform additional functions via the SCHEDULE section keywords, or further TIME keywords may be entered to advance the simulator to the next report time.
	TSTEP	TSTEP keyword advances the simulation to a given report time after which additional keywords may be entered to instruct OPM Flow to perform additional functions via the SCHEDULE section keywords, or further TSTEP keywords may be entered to advance the simulator to the next report time
Schedule Advancement Control	TUNING	TUNING defines the parameters used for controlling the commercial simulator's numerical convergence parameters for the global grid. The keyword is mostly ignored by OPM Flow; however, the simulator can be instructed to read the first record of the TUNING keyword if the appropriate command line parameter has been activated (see section *2.2 Running OPM Flow 2020-04 From The Command Line*).
	NEXTSTEP	NEXTSTEP defines the maximum time step size the simulator should take for the next time step. This keyword can be used to reset the time step for when known large changes to the model are taking place that may result in time step chops.
Reporting	RPTSCHED	RPTSCHED keyword defines the data in the SCHEDULE section that is to be printed to the output print file in human readable format.
	RPTRST	RPTRST keyword defines the data and frequency of the data to be written to the RESTART file at each requested restart point. In addition to the solution data arrays required to restart a run, the user may request additional data to be written to the restart file for visualization in OPM ResInsight.

Table 12.3: Schedule Advancement, Control and Reporting Keywords

In terms of structuring the format of the keywords in the SCHEDULE section it is advisable to declared all the VLP tables, wells and groups at the start of SCHEDULE section as oppose to declaring the items as they are needed, or when they come on stream at various times during the simulation. This produces a cleaner input deck and tends to limit unforeseen errors, as all items are declared upfront and only the operational changes (opening wells, changing group and well targets, etc.) are needed. The example SCHEDULE section given on the following pages illustrates a typical SCHEDULE based on this philosophy.

The first segment of the example shows the start of the SCHEDULE section and the group definitions and controls. Here there are controls on the group level only at the FIELD level and there is both production and injection rate targets, as well as water and liquid handling constraints applied on the FIELD level. These keywords are activated from the start of the simulation as set by the START keyword in the RUNSPEC section, in this case January 1, 2020.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE

-- ------------------------------------------------------------------------------
-- GROUP PRODUCTION AND INJECTION CONTROLS
-- ------------------------------------------------------------------------------
--
--       DEFINE GROUP TREE HIERARCHY
--
--       LOWER     HIGHER
--       GROUP     GROUP
GRUPTREE
         FLTBLK1  FIELD                                                        /
         FLTBLK2  FIELD                                                        /
         FLTBLK3  FLTBK2                                                       /
/
--
--       GROUP PRODUCTION CONTROLS
--
-- GRUP  CNTL  OIL    WAT    GAS    LIQ    CNTL  GRUP  GUIDE  GUIDE  CNTL
-- NAME  MODE  RATE   RATE   RATE   RATE   OPT   CNTL  RATE   DEF    WAT
GCONPROD
FIELD    GRAT  1*     8E3   125E3   10E3   1*     1*    1*     1*     1*       /
/
--
--       GROUP INJECTION TARGETS AND CONSTRAINTS
--
-- GRUP  FLUID CNTL   SURF   RESV   REINJ  VOID  GRUP  GUIDE  GUIDE GRUP  GRUP
-- NAME  TYPE  MODE   RATE   RATE   FRAC   FRAC  CNTL  RATE   DEF   REINJ RESV
GCONINJE
FIELD    GAS   RATE  100E3   1*     1*     1.0   YES   1*     1*    1*    1*   /
/
```

The next segment covers the well specification and includes the loading of the VFP tables via include files, declaring the wells using the WELSPECS keyword, and connecting the wells to the reservoir using the COMPDAT keyword. In addition, the COMPLUMP keyword is invoked to assign the well connections to well completions.

In multi-stacked reservoirs it is a good idea to associate the completion number with a given reservoir for all the wells. So for example completion number one is always associated with the Lower Talang Akar Formation Unit A, completion number two with the Lower Talang Akar Formation Unit B, and completion number three with the Upper Talang Akar Formation Unit C, etc. In this way one can easily identify which zone a well is producing from or completed in.

Finally, the WCONPROD keyword is used to define the operating conditions for the gas producers(GP01 and GP02) and to assign the VFP tables to the producing wells. Whereas the WCONINJE keyword performs a similar function for the single gas injector, GI01.

```
-- ------------------------------------------------------------------------------
-- WELL SPECIFICATIONS AND COMPLETIONS
-- ------------------------------------------------------------------------------
--
--       LOAD INCLUDE FILES WITH VLP TABLES
--
INCLUDE
         'WEL-P50-VLP01.inc'     / VFP TABLE #1 5 1/2 inch tubing

INCLUDE
         'WEL-P50-VLP02.inc'     / VFP TABLE #2 4 1/2 inch tubing
--
--       WELL SPECIFICATION DATA
--
-- WELL  GROUP     LOCATION  BHP    PHASE  DRAIN  INFLOW  OPEN  CROSS  PVT
-- NAME  NAME        I    J  DEPTH  FLUID  AREA   EQUANS  SHUT  FLOW   TABLE
WELSPECS
GI01     FIELD      14   13   1*     GAS    1*     GPP    SHUT   NO     1*     /
GP01     FLTBLK1    64   80   1*     GAS    1*     GPP    SHUT   NO     1*     /
GP02     FLTBLK1    24  110   1*     GAS    1*     GPP    SHUT   NO     1*     /
/
--
--       WELL CONNECTION DATA
--
-- WELL  --- LOCATION ---  OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME   II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
GI01      1*  1*   1  60   SHUT   1*    1*    0.708  1*    0.0    1*    'Z'   /
GP01      1*  1*   1  60   SHUT   1*    1*    0.708  1*    0.0    1*    'Z'   /
GP01      1*  1*   1  60   SHUT   1*    1*    0.708  1*    0.0    1*    'Z'   /
/
--
--       ASSIGN WELL CONNECTIONS TO COMPLETIONS
--
-- WELL  --- LOCATION ---  COMPL
-- NAME   II  JJ  K1  K2   NO.
COMPLUMP
GI01      14  13   1  20    1                                / COMPLETION NO. 01
GI01      14  13  35  60    2                                / COMPLETION NO. 02
GP01      64  80   1  20    1                                / COMPLETION NO. 01
GP01      64  80  20  60    1                                / COMPLETION NO. 02
GP02      24 110   1  20    1                                / COMPLETION NO. 01
GP02      24 110  25  60    1                                / COMPLETION NO. 02
/
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS   LIQ    RES    BHP   THP   VFP    VFP
-- NAME  SHUT   MODE   RATE   RATE   RATE  RATE   RATE   PRES  PRES  TABLE  ALFQ
WCONPROD
GP01     SHUT   GRUP   1*     1*     70E3  1*     1*     500.0 120.0 1         /
GP02     SHUT   GRUP   1*     1*     70E3  1*     1*     500.0 120.0 2         /
/
--
--       WELL INJECTION CONTROLS
--
-- WELL  FLUID  OPEN/  CNTL  SURF   RESV   BHP   THP   VFP
-- NAME  TYPE   SHUT   MODE  RATE   RATE   PRSES PRES  TABLE
WCONINJE
GI01     GAS    SHUT   RATE 125E3  1*     10E3  1*    1*                     /
/
```

Notice also the well naming nomenclature that easily identifies the type of well: the letter G for a gas well, O for an oil well and W for a water well, and the function of the well, P for a producer and I for an injector.

The final part of the well specification segment is shown below and sets the well efficiency for the wells via the WEFAC keyword, the producing wells economic limits via the WECON keyword, and then advances the simulation to June 25, 2020. Thus, there is no production up to January 25, 2020 as all the wells are shut-in.

```
--
--       WELL EFFICIENCY FACTORS
--
-- WELL  EFF    NETWK
-- NAME  FACT   OPTN
WEFAC
'GI*'    0.950                                                          /
'GP*'    0.950                                                          /
/
--
--       WELL ECONOMIC CRITERIA FOR PRODUCTION WELLS
-- WELL  MIN    MIN    MAX    MAX    MAX    CNTL    END   WELL
-- NAME  ORAT   GRAT   WCUT   GOR    WGR    MODE    RUN   NAME
WECON
'GP*'    1*     5.0E3  1*     1*     1*    'WELL'  'NO'                  /
/
DATES
 25 JAN   2020            /
/
```

At January 25, 2020 yearly restarts are requested (RPTRST) together with various printed reports (RPTSCHED), as well as the maximum time step size of 31 days being set via the TUNING keyword. More importantly, well GP01 is opened together with completion number one to put the well on production. Note that one needs to open both the well and the completion; hence, the two lines in the WELOPEN keyword.

```
-- ---------------------------------------------------------------------------
-- SCHEDULE SECTION FOR PHASE 1 DEVELOPMENT
-- ---------------------------------------------------------------------------
--
--       RESTART CONTROL BASIC = 4 (ALL=2, YEARLY=4, MONTHLY=5, TSTEP=6)
--
RPTRST
         BASIC=4                                                        /
--
--       DEFINE SCHEDULE SECTION REPORT OPTION
--
RPTSCHED
         'WELLS=2'    'WELSPECS'    'CPU=2'     'FIP=2'                 /
--
-- DEFAULT TUNING PARAMETERS (SET MAX TSTEP = 31 days)
--
TUNING
1.0      31.0     0.1     0.15     3     0.3     0.1     1.25     0.75  /
                                                                        /
/
--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
GP01     OPEN                                                           /
GP01     OPEN     0   0    0     1     1                                /
/

DATES
 1  FEB   2020  /
/
```

At February 1, 2020 further SCHEDULE keywords are processed. The first keyword is the RPTSCHED keyword that in this case switches off all reports printed to the *.PRT file, as only annual reports are required for this particular model.

Next the gas producer GP02 is put on production using two statements in the WELOPEN keyword, and the simulator is requested to advance to report time step of March 1, 2020.

```
--
--       DEFINE SCHEDULE SECTION REPORT OPTION
--
RPTSCHED
'NOTHING'                                                                    /
--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
GP02     OPEN                                                                /
GP02     OPEN     0   0    0     1     1                                     /
/
DATES
 1  MAR   2020  /
/
```

Then finally at March 1, 2020 the gas injector is place on stream and the simulation advances on a monthly report basis to the end of the year.

```
--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
GI01     OPEN                                                                /
GI01     OPEN     0   0    0     1     1                                     /
/
DATES
 1  APR   2020  /
 1  MAY   2020  /
 1  JUN   2020  /
 1  JLY   2020  /
 1  AUG   2020  /
 1  SEP   2020  /
 1  OCT   2020  /
 1  NOV   2020  /
 1  DEC   2020  /
/
```

Next a detailed report is produced as of January 1, 2021, and reporting is then switch off and the simulation continues to the end of the run.

```
-- ---------------------------------------------------------------------------
-- SCHEDULE SECTION - 2021-01-01
-- ---------------------------------------------------------------------------
RPTSCHED
'WELLS=2'    'WELSPECS'    'CPU=2'     'FIP=2'                                /

DATES
 1  JAN   2021  /
/

RPTSCHED
'NOTHING'                                                                    /

DATES
 1  FEB   2021  /
 1  MAR   2021  /
 1  APR   2021  /
 ...............................................................
/
```

12.2.1 HISTORY MATCHING RUNS

History matching is the process of matching actual historical production data versus the model's production performance. During history matching the engineer specifies the actual field measured production and injection rates for a reservoir which has been producing for a period of time. Although other reservoir characteristics such as permeability, layering structure, aquifer strength and individual well performance are specified as normal in the remainder of the data file, they are in only one realization out of possibly thousands of realizations. There is therefore significant uncertainty associated with the data set. Thus in most cases, the simulated past performance of the reservoir, that is the well rates calculated by OPM Flow up to the present day, will not in general correspond to the measured rates specified by the user. History matching then becomes an exercise in identifying those reservoir properties subject to the greatest uncertainty and adjusting them to bring the simulated and measured rates to an acceptable degree of agreement.

Prior to beginning the matching process the production data should be reviewed and quality checked. This step is needed mainly to:

- Allocate production data areally and vertically to the pertinent areas and zones, as well as ensuring that the correct well completions have been implemented into the model's schedule section. Particular care should be taken with multiple completed wells to ensure that the wells produce from the correct zones at the correct times. Wells that are completed across fault planes also need be checked so that the completions are on the right side of the fault plane.
- Correct field production data to separator conditions consistent with model conditions, or vice versa.
- Correct reported pressures for simulation use (e.g., Peaceman correction), or use the weighted areal average well bottom-hole pressures from the simulator to match against actual data.

Note also that not all production volumes have the same level of quality assurance. Product streams that are sold are going have a higher level of quality assurance because they have value, compared with production streams that are disposed off or re-injected, as they have no value. Thus, in an oil field field selling the produced oil but flaring or re-injecting the produced gas, the oil volumes will be back allocated based on "ticketed sales", and thus the field volumes are reasonable certain. However, even here there are uncertainties associated with allocating production volumes back to the individual wells and well completions. As the gas volumes are not sold they have no value and thus have greater uncertainty than the oil volumes, especially when back allocating back to the wells.

History matching is an iterative process, in which steps are repeated a number of times with variations in reservoir characterization (permeability, pore volume, relative permeability modifications, etc.), until a reasonable match is obtained. There are no precise rules for conducting a history match but the methodology is well established. Generally one first matches pressures globally, then overall saturations (and well rates) and repeat until an overall match is achieved, as the process of matching pressures also effects the saturations and vice versa. Which is why this is an iterative process. This methodology is then repeated on a regional level until the process is complete and reasonable matches have been obtained at the field, region and well levels.

Generally, group control, targets and constraints are not utilized in the history matching part of a simulation study. Instead, the WCONHIST keyword is used to enter the well production (oil, gas and water rates), pressure data (BHP and THP when available) and VFP table assignment, on a well by well basis and on discrete time intervals, normally monthly. WCONHIST allows one to set the "target" phase and rate the well will attempt to produce at, if possible, and to produce the other phases that come with the target rate. That is there is no constraints applied to the other phases, unlike when using the WCONPROD keyword. If well productivity has been matched then the target phase rates will be satisfied and the quality of the history match is determined by the accuracy of the other phases, together with the pressure match. Thus, in an oil field the target phase will normally be the oil phase and the oil rate, and the quality of the history would be determined by the produced gas and water volumes plus the pressure match at various levels (field, region, reservoir and well). If water breakthrough has not occurred and the field is producing above the saturation pressure then there is very little to match, as the gas production in this case is a direct function of the oil rate.

The WCONHIST keyword also has a RESV target phase where the target is set to the in situ reservoir volume rate which is calculated by the simulator using the oil, water, gas and liquid rates declared on the keyword. This is useful in the initial part of the history matching study where one is trying to match the overall pressure behavior, as the option forces the simulator to produce the correct number of reservoir barrels (or m^3), although the actual oil, gas and water rates will most likely not match at this stage of the study. Note that it is not necessary to edit the WCONHIST keywords for a run to change the target phase, as the WHISTCNTL keyword can be used do this from the time this keyword is invoked, thus avoiding changing the control mode on all subsequent WCONHIST keywords.

As mentioned above, the rates and volumes of product streams that are sold are more reliable then those that are being re-injected, flared or otherwise disposed of, and therefore in an oil field the preferred target phase is oil and not liquid, which some engineers prefer to use.

The WCONINJH keyword has similar functionality as the WCONHIST keyword, but is used for history matching injection wells instead.

More recent developments in history matching incorporate Assisted History Matching ("AHM") techniques [139, 140, 141, 142, 143, 144 and 145] in which various statistical techniques are applied in specialized software to match the field data by the user supplying the parameters to vary, the range of the parameters values, and the objective function to minimize. This type of software can also generate a range of "reasonable" history match models that can then be used to quantify the uncertainty range in the prediction phase.

[139] *History Matching and Uncertainty Quantification: Multi-objective Particle Swarm Optimisation Approach (SPE 143067), L. Mohamed, M. Christie, V. Demyanov, Vienna, Austria, 23–26 May 2011.*

[140] *Field-Scale Assisted History Matching Using a Systematic, Massively Parallel Ensemble Kalman Smoother Procedure (SPE00182617), Binghuai Lin, Paul I Crumpton, and Ali H. Dogru, Society of Petroleum Engineers (February 2017).*

[141] *Enhancing the Geological Models Consistency in Ensemble-Based History Matching - An Integrated Approach (SPE00186049), A. Perrone, F Pennadoro, A Tiani, E Della Rossa, and J. Saetrom, Society of Petroleum Engineers (May, 2017).*

[142] *Correlation-Based Adaptive Localization for Ensemble-Based History Matching - Applied to the Norne Field Case Study (SPE00191305), Xiaodong Luo, Rolf Lorentzen, Randi Valestrand, and Geir Evensen, , Society of Petroleum Engineers (April, 2018).*

[143] *Rapid Forecast Calibration Using Nonlinear Simulation Regression with Localization (SPE-193845-MS), Jincong He, Wenyue Sun, and Xian-Huan Wen, SPE Reservoir Simulation Conference held in Galveston, Texas, USA, 10–11 April 2019.*

[144] *Multilevel Strategies and Geological Parameterizations for History Matching Complex Reservoir Models (SPE-193895-MS), Yimin Liu and Louis J. Durlofsky, SPE Reservoir Simulation Conference held in Galveston, Texas, USA, 10–11 April 2019.*

[145] *Improved Estimation and Forecast Through Model Error Estimation – Norne Field Example (IPTC-19142-MS), Minjie Lu and Yan Chen, International Petroleum Technology Conference held in Beijing, China, 26 – 28 March 2019.*

12.2.2 PREDICTION RUNS

Prediction runs are used to optimize future production from the field and can take two forms:

- Prediction runs may follow directly from a history match case using the reservoir description estimated during the history matching phase. The history matching and prediction runs are frequently in separate data files, with the prediction cases "restarting" from the final history match run, as the history match restart file contains sufficient data to continue the simulation into the future. Therefore, the prediction data set contains the same reservoir description as the history match but is initialized using the restart file output from the history match case. In general, the base case scenario is the No Further Activity ("NFA") scenario. This is just a continuation of the history match into the future using the well controls in force at the end of the history matching period. This is the simplest way to run the field since the surface facilities remain unchanged and no workovers take place. However, the switch from history matching mode to prediction mode should be treated with care in order to ensure a smooth transition between the two phases. Subsequent cases will then be based on the NFA scenario, and will attempt to optimize recovery by examining the impact of drilling infill wells, modifying facilities constraints, varying the reservoir management strategy, etc.
- Prediction cases may also be based on predicting production from structures that have not been put on production at the time of the study, that is there is no historical production available. In this case, the reservoir description is based on the best available data set and interpretation, although there may be various variations of the models to cover the range of uncertainties in the static earth modeling. Typically, Low, Best and High models are generated to capture the range of uncertainty in the static modeling, although full uncertainty analysis is becoming more common as computational computer power becomes more available. Additional dynamic sensitivities are then run to determine the Low, Best and High models that address both the static and dynamic uncertainties. These models then form the basis of the supplementary predictions using a variety of different production strategies that are used to improve the petroleum recovery and reduce production costs. For each prediction case, an aspect of the surface facilities or well management policy is changed and the case is compared to the base prediction. Most simulators, including OPM Flow, have a wide range of well, group and surface facility modeling features and it is likely that several will be invoked during recovery optimization to model events such as drilling infill wells, modifying facilities constraints, investigating various depletion strategies, etc.

In both scenarios more recent developments within the industry apply a full uncertainty analysis to the models, in which multiple cases are run under various parameter changes to derive a distribution of recoverable volumes, which in turn are used to select the Low, Best and High scenarios. This can result in hundreds of cases being run and is computationally expensive.

As mentioned above, the switch from history matching mode to prediction mode should be treated with care in order to ensure a smooth transition between the two phases. History matching of a well's BHP has always been somewhat problematic, as the field measured data consists of shutting-in the well for a specific period for the BHP to build backup to a well's average drainage pressure (usually assumed to be the reservoir pressure in the surrounding area). History matching time steps are normally based on monthly time steps to coincide with the monthly back allocated field reported production volumes. Thus, to correctly match the measured Shut-in Bottom-Hole Pressure ("SBHP") data in the model, one would have to shut-in the well in the model as per the field, and then open up the well back up at the end of the BHP survey. One would also have to re-adjust the well rates to match the cumulative volumes produced for the time the well was shut-in. These steps are impracticable and engineers originally handled the problem by assigning the wells a high productivity index, so that the difference between the Flowing Bottom-Hole Pressure ("FBHP") and the SBHP was small.

This would lead to a mismatch in rates when switching from history matching mode to prediction mode as shown in Figure 12.1. Thus, the final step in history matching was to calibrate the well rates based on adjusting the Productivity Indices ("PI") of the wells, in order to get a smooth transition between the two modes of operating the wells.

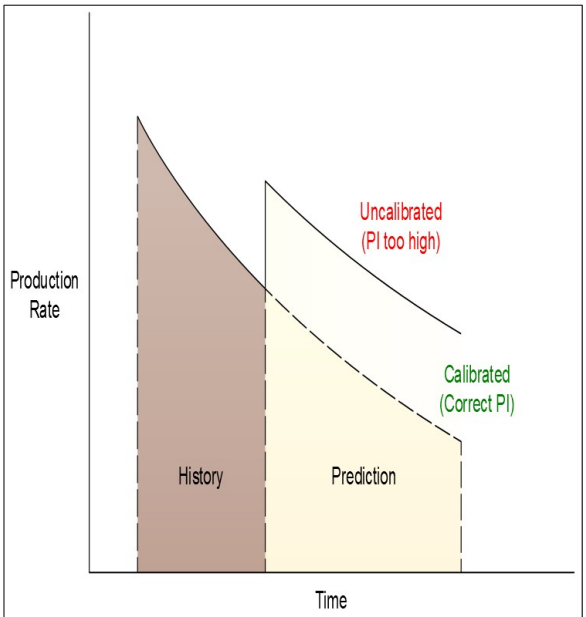


Figure 12.1: Calibration of Well Productivity Index

Calibration is achieved by running the model at the back pressures held against the wells at one or several time-steps. The well PIs and/or wellbore flow parameters are adjusted to duplicate field-observed rates. Although the calibration step was usually done after the history-matching step, there are times when it must be done beforehand (e.g., when modeling multi-layer flow into a well). This is because in stratified reservoirs the correct allocation of rates among layers is dependent on the absolute value of the well's PI (and not solely on the ratios of PIs of the various layers).

Although well PI matching is still performed as part of the general history matching methodology, it is no longer necessary to set a well's PI to a high value in order to mimic the field measured SBHP. This is because most simulators are now capable of reporting an "average" bottom-hole pressure around the well, including one, four, five and nine grid cell averaging, as well as alternative averaging schemes. Thus, the engineer now matches the field measured SBHP with one of the simulator's average grid cell BHPs, normally either the five or nine grid cell average BHP values.

This leaves the question on what controls should be used when moving from history matching mode to prediction mode and ensuring a smooth transition between the two, and at the same time ensuring the resulting predictive forecast is reasonable. There are basically three approaches to this problem:

1) set the well's prediction constraint to the last observed rate,
2) set the well's prediction constraint to the average FBHP and adjusting a well's PI, and thirdly,
3) set the well's prediction constraint to the last FBHP or THP.

The next three sections discusses these options in some detail.

(1) Prediction Constraint Based on a Well's Last Observed Rate

In the history matching mode the wells are controlled by a rate target, so using the last observed well rate would seem a sensible approach. Thus, this approach uses the last observed well rates as well constraints in the prediction run. The typical approach is to constrain production based on a preferred phase (oil rate, gas rate or liquid rate), and then set a reasonable flowing BHP value as a limit for when the well can no longer meet the rate target set. The main requirement for using this approach is therefore that the history-matched model reproduces the rates and flowing bottom-hole pressures fairly exactly.

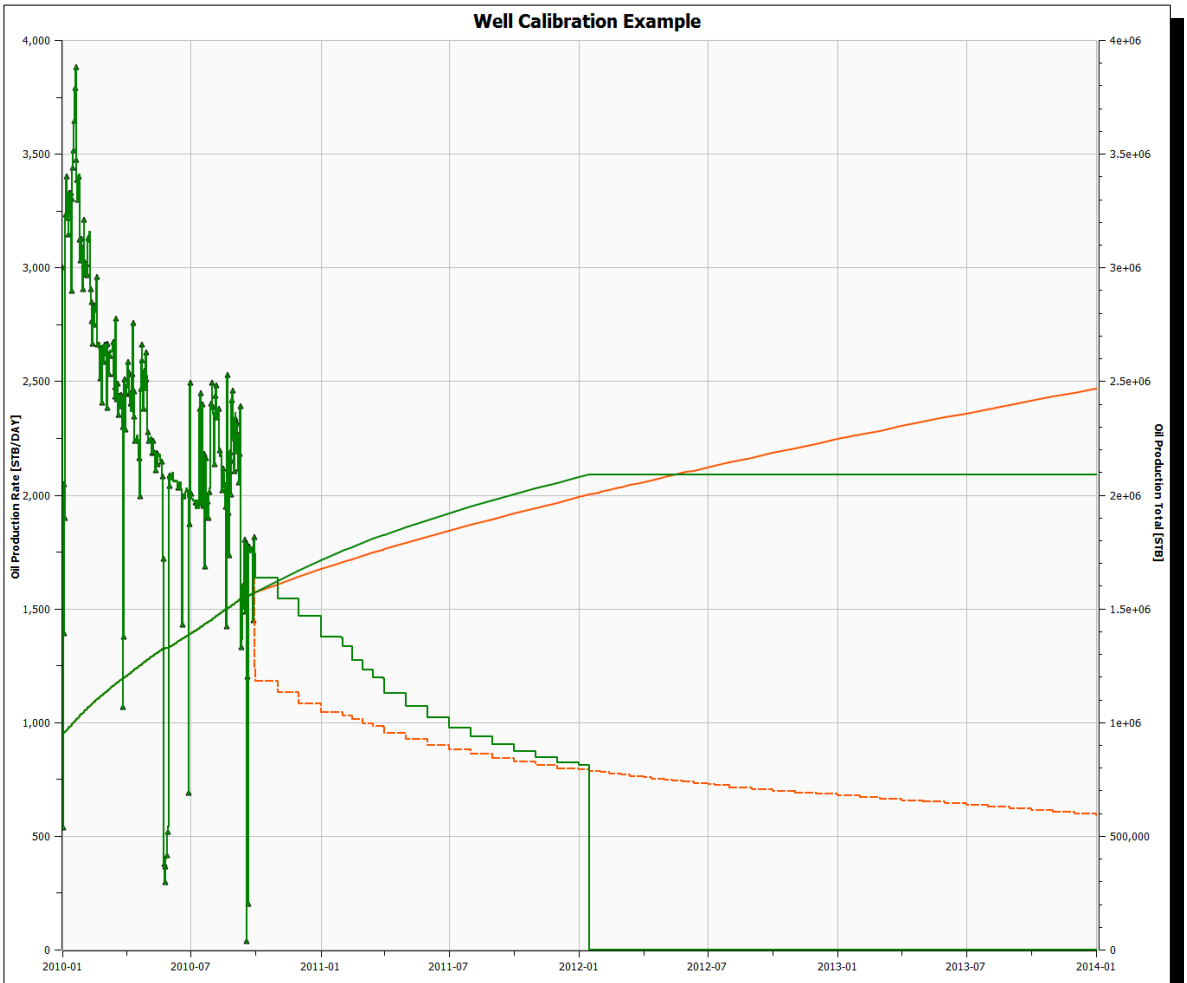


Figure 12.2: Well Calibration Example

However, the are some drawbacks to this approach as one can observe in Figure 12.2, which shows the oil rate and cumulative oil for a well, the symbols on the plot are the actual historical oil production rates. If the last period of production history were not matched successfully, a smooth transition from the history simulation to prediction phase will not be achieved, as shown by the orange lines in Figure 12.2.

A second drawback to this approach, is that the well and field production rate profiles will tend have a flat trend for a few months (or even years) when the well can still deliver the rate target. In real field management such rate profiles can be optimistic if the specified boundary conditions are not representative of actual operating conditions in the field.

(2) Prediction Constraint Based on a Well's Average FBHP and Adjusting a Well's PI

This approach has been adopted by some reservoir engineers as a result of the issues mentioned for the first approach.

Here, an average FBHP of each well, based on most recent production history, is used as a target to control the wells during the prediction phase. Usually, this will lead to abrupt changes in rate and pressure profiles during the transition. The next step is therefore to dampen these abrupt changes in the well rate profiles by applying well PI multipliers (at the well and/or completion level) until a smooth transition is obtained in the rate profiles, similar to that shown in Figure 12.1 previously.

The problem with this approach is that it is synonymous to re-calibrating a supposedly history-matched simulation model (with a given permeability distribution based on a certain geological characterization), and thus this approach is rather questionable and is not recommended.

(3) Prediction Constraint Based on a Well's Last Flowing BHP or THP

This methodology is the recommended approach for switching between historical and prediction controls in a reservoir model. It involves automatically applying the last flowing bottom-hole pressure at the instant the transition takes place as the production target, and therefore setting the latest flow rates to be constraints. This ensures a smooth transition between history and prediction phases without having to resort to unreasonable changes to the model. In OPM Flow this is accomplished by using the WELTARG keyword to specify that all the wells should use the bottom-hole pressure as the target at the beginning of the restart run, and defaulting the actual value for the BHP. By defaulting the BHP value the simulator will use the current value of FBHP for a well as the constraint. Note that the WELTARG keyword only defines the variable to be changed, it does not change how a well is controlled. However, by setting the BHP to equal to the current FBHP this has a similar effect as changing the operating target.

Using this approach, all wells will continue flowing at the last flowing bottom-hole pressure from the previous time step, using this value of FBHP as the effective target while the last historical rates are kept as limits (if BHP is requested as shown in the example). This approach achieves two important objectives, firstly it results in a smooth transition from the history-match phase to prediction phase in well and field production profiles And secondly, it gives a smooth decline in well production rate, as is expected of real wells in the field.

Although this discussion has been based on using the BHP as the effective control mechanism, one could also use THP, and to a lesser extent, liquid rate, instead.

The following example below shows how to apply the recommended method to obtain a smooth transition to the predictive phase using the BHP as the controlling mechanism.

Example

In the example, December 2019 is the last month of historical data and therefore the predication phase starts from January 1, 2020.

```
DATES
01 DEC 2019 /
/
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.5E3  100.0  1550   10      1*   900.0 1*     /
OP02     OPEN   ORAT  10.3E3  500.0  1550   10      1*   700.0 1*     /
OP03     OPEN   ORAT   5.4E3 2100.0  1550   10      1*   500.0 1*     /
/
-- ------------------------------------------------------------------------------
-- 01 JAN 2020 START OF PREDICTION SCHEDULE SECTION
-- ------------------------------------------------------------------------------
DATES
01 JAN 2020 /
/
--
--       WELL PRODUCTION AND INJECTION TARGETS
--
--  WELL WELL   TARGET
--  NAME TARG   VALUE
WELTARG
 OP*     BHP                                                  /
/
```

From December 1, 2019 to January 1, 2020 the three oil producing wells will be under history matching control with the oil rate being the target rate for the wells. On January 1, 2020 the wells will be converted to normal producers as the WELTARG keyword changes a well status from a history match well to a regular well. At the same time the WELTARG keyword sets all the wells to have their current FBHP as a constraint, by setting the target BHP values to the default values, which effectively makes the FBHP a target as it is now the "active" constraint.

The alternative keyword for implementing the same approach is the WELCNTL keyword, but unfortunately this is currently not implemented in OPM Flow.

12.2.3 WELL PRODUCTIVITY

Throughout this section the equations are presented in terms of oil production, - or liquid flow, i.e., oil and water. Note that similar equations exists for gas flow in terms of p^2 and pseudo pressure formulations ($\psi(p)$).

Under the assumption of (1) one-dimensional, radial flow into the wellbore, (2) steady-state pressure behavior, and (3) single-phase flow, it can be shown that the flow rate of a well is given by:

$$q = (0.001127)(2\pi)\frac{kh}{\mu}\left[\frac{p_e - p_w}{\left(\ln\left(\frac{r_e}{r_w}\right) + S\right)}\right] \tag{12.1}$$

Where:

q	= production rate, res.bbl./day
p_e	= pressure at the drainage radius of the well, psia
p_w	= bottom-hole well pressure, psia
r_e	= drainage radius, ft.
r_w	= wellbore radius, ft.
S	= skin factor, dimensionless
kh	= effective permeability thickness, md-ft.

This is extended to multi-phase flow by introduction of relative permeabilities and adjusted to surface conditions by use of the formation volume factor resulting in the following expression for oil production rate:

$$q_o = (0.001127)(2\pi)\frac{kk_{ro}h}{B_o\mu_o}\left[\frac{p_e - p_w}{\left(\ln\left(\frac{r_e}{r_w}\right) + S\right)}\right] \tag{12.2}$$

If the modified radial flow equation is written for each perforated interval and summed over all intervals, the resulting equation is the one used to calculate oil production rates in the simulator. One way to specify the flow capacities of wells is to enter r_e, r_w, s and p_w values for the well, with the kh values for each perforated interval. The simulator then determines the other parameter values from calculated pressure and saturation distributions.

Because the pressure at the drainage radius is not readily determined in the simulator, it substitutes p_b (a representative pressure of each perforation grid block) for p. That is readily accommodated by replacing the drainage radius by a probe radius as defined by Peaceman[146]

$$r_b = 0.28\frac{\left[\sqrt{\frac{K_y}{K_x}}\Delta x^2 + \sqrt{\frac{K_x}{K_y}}\Delta y^2\right]^{0.5}}{\left(\frac{K_y}{K_x}\right)^{0.25} + \left(\frac{K_x}{K_y}\right)^{0.25}} \tag{12.3}$$

Where:

K_x and K_y	= x- and y- direction absolute permeabilities
Δx and Δy	= grid block sizes (feet)

[146] *Peaceman, D.W. "Interpretation of Well-Block Pressures in Numerical Reservoir Simulation with Nonsquare Grid Blocks and Anisotropic Permeability." SPE 10528 presented at the Sixth SPE Symposium on Reservoir Simulation, New Orleans, (February 1982), pp. 553-569.*

The simulator then uses the modified radial flow equation, written for each connection:

$$q_o = \frac{(0.001127)\ (2\pi)}{\left(\ln\left(\frac{r_b}{r_w}\right) + S\right)}\left(\frac{k\,k_{ro}\,h}{B_o\ \mu_o}\ \left(p_b - p_w\right)\right) \tag{12.4}$$

The connection term on the COMPDAT keyword in the SCHEDULE section, CONFACT, is simply the transmissibility portion of equation (12.4) for a given connection that is:

$$T_{xy} = \frac{(0.001127)\ (2\pi)(kh)}{\left(\ln\left(\frac{r_b}{r_w}\right) + S\right)} \tag{12.5}$$

And the oil phase mobility term is defined as:

$$M_o = \left(\frac{k_{ro}}{B_o\ \mu_o}\right) \tag{12.6}$$

Substituting (12.5) and (12.6) into (12.4) and summing all the connections for the well to obtain the oil rate for the well gives:

$$q_o = \sum_1^N \left(T_{xy}\, M_o\left(p_b - p_w\right)\right) \tag{12.7}$$

Note in the case of partially completed wells, the effective permeability thickness of a perforated interval may be substantially greater than the average permeability thickness of the formation opposite the perforation.

Engineers commonly use the Productivity Index ("PI") as a parameter to defined an oil well's deliverability, as it is derived relatively easy from field measurements, that is:

$$q_o = \frac{PI}{\left(p_e - p_w\right)} \tag{12.8}$$

or in terms of the productivity index:

$$PI = \frac{q_o}{\left(p_e - p_w\right)} \tag{12.9}$$

It is significant that this equation is written in terms of the pressure at the drainage radius, p_e, rather than grid block pressure, p_b. It must be written this way since PI is a property that is determined by field production tests. One can also relate the above equation to the multilayered extension of the steady-state radial flow equation (12.7), that is

$$PI = \frac{q_o}{\left(p_b - p_w\right)} = \sum_1^N \left(T_{xy}\, M_o\right) \tag{12.10}$$

On very important point to note is that the productivity index is, in general, not constant for a given well since both relative permeability and drainage radius can be time dependent. This makes PI an inappropriate

quantity for computer prediction of production rates, but it is often the only type of data available on well performance. To overcome this limitation, most simulators accept PI data as input, and then immediately convert this assuming steady state radial flow with a uniform mobility throughout the drainage area, resulting in the following equation.

$$PI = \sum_{n=1}^{N} \left(T_{xy} \, M_o \left(\frac{\ln\left(\frac{r_e}{r_w}\right) + S}{\ln\left(\frac{r_b}{r_w}\right) + S} \right) \right)_n \tag{12.11}$$

Since the drainage radius, r_e, is generally different from the grid block radius, r_b, the ratio of logarithms may be significant; hence, the use of the PI option normally requires specification of both r_e and r_b.

Equation is (12.11) is used to calculate the PI for the well and is used to print the PI on the WELLS production report requested via the RPTSCHED keyword in the SCHEDULE section. Note that gas wells with non-zero D-factors, the non-Darcy skin factor is added to to the skin (S) in equation (12.11) in both the nominator and the denominator. Secondly, r_e is often undetermined or unknown and it is common to default the DRADIUS parameter on the WELSPECS keyword, in the SCHEDULE section. If the well drainage radius (DRADIUS) is defaulted then equation (12.11) simplifies to:

$$PI = \sum_{n=1}^{N} \left(T_{xy} \, M_o \right)_n \tag{12.12}$$

In this case the PI should be considered a grid block productivity index and not a well drainage area productivity index. Note also that if DRADIUS is set to a negative number, then this results in a well's potential being written out to the WELLS production report instead of the productivity index. In this instance this is the rate based on only applying the BHP and THP constraints only, all other constraints are ignored.

12.3 Keyword Definitions

12.3.1 ACTION – Define Action Conditions and Command Processing (Field)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

The ACTION keyword defines a series of conditions that invoke run time processing of ACTION functions and is similar to executing a run time script for conditions and variables at the field level.

This keyword is ignored by OPM Flow and has no effect on the simulation; use the ACTIONX keyword instead.

12.3.2 ACTIONG – Define Action Conditions and Command Processing (Groups)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

The ACTIONG keyword defines a series of conditions that invoke run time processing of ACTION functions and is similar to executing a run time script for conditions and variables at the group level

This keyword is ignored by OPM Flow and has no effect on the simulation; use the ACTIONX keyword instead.

12.3.3 ACTIONR – Define Action Conditions and Command Processing (Regions)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

The ACTIONR keyword defines a series of conditions that invoke run time processing of ACTION functions and is similar to executing a run time script for conditions and variables at the region level.

This keyword is ignored by OPM Flow and has no effect on the simulation; use the ACTIONX keyword instead.

12.3.4 ACTIONS – Define Action Conditions and Command Processing (Well Segments)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

The ACTIONS keyword defines a series of conditions that invoke run time processing of ACTION functions and is similar to executing a run time script for conditions and variables associated with well segments.

This keyword is ignored by OPM Flow and has no effect on the simulation; use the ACTIONX keyword instead.

12.3.5 ACTIONW – Define Action Conditions and Command Processing (Wells)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

The ACTIONW keyword defines a series of conditions that invoke run time processing of ACTION functions and is similar to executing a run time script for conditions and variables at the well level.

This keyword is ignored by OPM Flow and has no effect on the simulation; use the ACTIONX keyword instead.

12.3.6 ACTIONX – DEFINE ACTION CONDITIONS AND COMMAND PROCESSING

Description

The ACTIONX keyword defines a series of conditions that invoke run time processing of ACTION functions and is similar to executing a run time script. This is the general purpose version of the ACTION series of keywords that can apply Boolean conditional tests to variables at the field, group, region, well segment and well levels. The ACTION, ACTIONG, ACTIONR, ACTIONS and ACTIONW keywords are not implemented in OPM Flow and are unlikely to be so, as the ACTIONX keyword implements their functionality with greater flexibility.

This keyword starts the definition of a ACTIONX section that stipulates the Boolean conditions to test and the resulting SCHEDULE keywords to be executed if the Boolean condition evaluates to true. An ACTIONX Definition Section is terminated by an ENDACTIO keyword on a separate single line.

Although this keyword is read by OPM Flow and the ACTION and UDQ computational logic and calculations have been implemented, one should used caution using this facility as it may result in OPM Flow aborting. This is because the ACTIONX keyword enables the user to implement complex functionality and therefore it is advisable to start with simple expressions before adding the desired complexity.

See also the PYACTION keyword, also in the SCHEDULE, that implements OPM Flow's Python scripting facility using the Python scripting language.

No.	Name	Description	Default
ACTIONX		Define the start of ACTIONX Definition Section. This is then followed on a new line by any number of ACTIONX records that define the conditions for which the defined action will be executed and the various operations to be performed if the conditions are satisfied.	
1-1	ACTNAME	ACTNAME is a character sting of up to length eight that defines the name of this action definition.	None
1-2	ACTNSTEP	ACTNSTEP is a positive integer that defines the number times that the ACTNAME definition is executed. ACTIONX definitions are activated at the end of a time step and this parameter is used to set how many time steps the ACTNAME definition will be invoked. The default value of one means that the definition will be executed only once. Use a large value, for example 10,000 for the definition to be executed at every time step. Noted that the counter only affects successful evaluations; i.e. if ACTNSTEP is set equal to one (the default), then the simulator will test the action at the end of every time step until it evaluates to true.	1
1-3	ACTDELTA	ACTDELTA is a real positive value that stipulates the duration of time that the conditions defined on the second record to be satisfied before the ACTIONX action are executed. For example, if ACTDELTA is defaulted the actions will be executed at the end of the time step for which the conditions are met. If set to say 30, then a minimum of 30 days will pass before the actions are executed (assuming field or metric units). days | days | hours	0.0
1-4	/	Record terminated by a "/"	Not Applicable

No.	Name	Description	Default
2-1	ACTLHS	ACTLHS is a series of character strings, each up to eight characters in length, that defines a constant, UDQ defined value, or a SUMMARY variable on the left hand side of a Boolean conditional test. The format for ACTLHS is dependent on the SUMMARY variable type: Aquifer, Block, Field, Group, Region, Time, Well, Well Connection, Well Local Grid Refinement Connection, or a Well Segment. In addition to SUMMARY variables, an UDQ defined value or a Constant variable can be used. The format for the various data types is given in Table 12.5.	Not Applicable

2-2	ACTTEST	ACTTEST is a defined character string that the states the Boolean operator and must be set to one of the following Boolean conditionals:
		1) >: Greater than.
		2) <: Less than.
		3) >=: Greater than or equal to.
		4) <=: Less than or equal to.
		5) =: Equals to.
		6) !=: Not equal to
		For example to test if the field's gas production rate is less than 600 MMscf/d then one would use:
		`ACTIONX`
		`PHASE2 1 /`
		`GGPR 'FIELD' < 600E3 /`
		`/`
		`….. .`
		`ENDACTIO`
			Not Applicable

2-3	ACTRHS	ACTRHS is a numeric value or a series of character strings, each up to eight characters in length, that defines a constant, an UDQ defined value, or a SUMMARY variable on the right hand side of a Boolean conditional test, as outlined in Table 12.5 (see also ACTLHS).
		In the case of well quantities on the right hand side the set of matching wells is captured and can be used as a general "well list" with the symbol '?' in subsequent well keywords. For example, to shut-in all oil producing wells ('OP*') with a water cut greater than 90% for every time the field water production rate exceeds 60,000 stb/d one would use:
		`ACTIONX`
		`MXWATER 10000 /`
		`GWPR 'FIELD' > 60E3 AND /`
		`WCUT > 'OP*' > 0.90 /`
		`/`
		`-- WELL PRODUCTION STATUS`
		`--`
		`-- WELL WELL --LOCATION-- COMPLETION`
		`-- NAME STAT I J K FIRST LAST`
		`WELOPEN`
		`'?' SHUT /`
		`/`
		`ENDACTIO`
			Not Applicable

No.	Name	Description	Default

2-4	ANDOR	An optional defined character string that stipulates a Boolean operator that must be set to either AND or OR if included on this record, that links this record with additional records of this type. For example, to test if the field's gas production rate is less than 600 MMscf/d after 2020 then one would use:
		`ACTIONX`
		`PHASE2 1 /`
		`GGPR 'FIELD' < 600E3 AND /`
		`YEAR > 2020 /`
		`/`
		`……..`
		`ENDACTIO`
		This item should be left blank if not required.
			Not Applicable

2.5	/	Termination of an ACTIONX Boolean condition record. Note that multiple numbers of records of this type can be entered with each record terminated by a "/", as illustrated above.	Not Applicable
3-1	/	The Boolean condition section of the ACTIONX keyword is terminated by an empty line with a single "/".	Not Applicable

		The next section contains any number of standard SCHEDULE keywords that will be executed if the Boolean expression evaluates to true. For example, to test if the field's gas production rate is less than 600 MMscf/d after 2020 and to open up additional wells if this occurs, then one would use:
		`ACTIONX`
		`PHASE2 1 /`
		`GGPR 'FIELD' < 600E3 AND /`
		`YEAR > 2020 /`
		`/`
		`-- WELL PRODUCTION STATUS`
		`--`
		`-- WELL WELL --LOCATION-- COMPLETION`
		`-- NAME STAT I J K FIRST LAST`
		`WELOPEN`
		`GP10 OPEN /`
		`GP11 OPEN /`
		`/`
		`ENDACTIO`
		Most SCHEDULE keyword can used in an ACTIONX Define Section here, except for the time stepping keywords, i.e, TSTEP and DATES.
		
		Note only the WELOPEN keyword is currently supported by OPM Flow.
			Not Applicable

ENDACTIO		Define the end of ACTIONX Definition Section.	Not Applicable

Notes:

1) There is no terminating "/" for this keyword, instead the ENDACTIO keyword terminates the keyword.

Table 12.4: ACTIONX Keyword Description

The variable types and the associated definitions that are available for use with Boolean conditionals are outlined in Table 12.5.

Variable Type	Description
AQUIFER	AQUIFER variable consists of two parameters the: 1) Aquifer SUMMARY variable; for example, Analytical Aquifer Influx Rate, AAQR, and the 2) Aquifer number consisting of a positive integer greater than zero that defines the aquifer to be used.
BLOCK	BLOCK variable consists of four parameters: 1) Block SUMMARY variable; for example Block Oil Saturation, BOSAT. 2) Block I location which should be a positive integer greater than or equal to zero and less than or equal to NX that defines the connection location in the I-direction. 3) Block J location which should be a positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction. 4) Block K location which should be a positive integer greater than or equal to one and less than or equal to NZ that defines the connection location in the K-direction. The NX, NY, and NZ parameters are defined on the DIMENS keyword in the RUNSPEC section.
CONSTANTS	CONSTANTS can be any numerical value and can also include an integer constant as a counter secondary variable. This type of variable has the following form: 1) Any numerical value. 2) ACTIONX counter as defined by ACTNSTEP in the ACTIONX Definition Section. The default value is zero, but this parameter can be any integer value. For example, if one wanted to activate the action after the third time the Boolean condition was passed then setting ACTNSTEP to one and this parameter to -2 would accomplish this.

FIELD	The FIELD variable consists of any field SUMMARY variable; for example the Field average Pressure, as shown below:
	`ACTIONX`
	`  WIPHASE  1  /`
	`  FPR < 2500  /`
	`/`
	`…...`
	`ENDACTIO`
	The above would action a set of SCHEDULE keywords if the field average pressure fell below 2,500 psia for a run using FIELD units.

GROUP	GROUP variable definition consists of:
	1) Group SUMMARY variable; for example, Group Oil Production Rate, GOPR.
	2) Group Name which is a character string of up to eight characters in length that defines an existing group, note that the group named FIELD is the top most group.
	To enable an action for when the field's oil production rate drops below 20,000 stb/d then one could use.
	`ACTIONX`
	`  OILMIN  1  /`
	`  GOPR  'FIELD' < 20.0E3  /`
	`/`
	`…...`
	`ENDACTIO`

Variable Type	Description
REGION	REGION variable definition consists of: 1) Region SUMMARY variable; selected from one of the following only: RPR, RGSAT, ROSAT, RWSAT, RGIP, ROIP, and RWIP. No other region summary fields are permitted in the expressions. 2) Fluid In-Place region number which is a positive integer greater than or equal to zero that defines the region number. The value should less than or equal to the NTFIP variable on either REGDIMS or TABDIMS keywords in the RUNSPEC section. Note that a zero value indicates the whole model. 3) Fluid In-Place region family (not used by OPM Flow).

TIME	TIME variables consists of one parameter that can have three values:
	1) DAY for the current simulation day of the month, MNTH for the current simulation month, and YEAR for the current simulation year.
	Thus to set an action for January 1, 2025 one would: use
	`ACTIONX`
	`  DAY  = 1  AND  /`
	`  MNTH ='JAN'  AND  /`
	`  YEAR = 2025  /`
	`/`
	`……..`
	`ENDACTIO`

WELL	WELL variable definition consists of:
	1) Well SUMMARY variable; for example, Well Oil Production Rate, WOPR.
	2) Well Name which is a character string of up to eight characters in length that defines the well, which must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.
	To reduce the tubing head pressure constraint for when any of the oil producers' oil rate drop below 100 stb/d then one could use.
	`ACTIONX`
	`  WOILMIN  1  /`
	`  WOPR  'OP*'  < 100.0  /`
	`/`
	`--`
	`-- FLOW WELLS THROUGH LOW PRESSURE SEPARATOR`
	`--`
	`--  WELL  WELL  TARGET`
	`--  NAME  TARG  VALUE`
	`WELTARG`
	`'OP*  '  THP  150  /`
	`/`
	`ENDACTIO`

Variable Type	Description
WELL CONNECTION	WELL CONNECTION variable definition is comprised of: 1) Well connection SUMMARY variable; for example, Connection Oil Flow Rate, COFR. 2) Well Name which is a character string of up to eight characters in length that defines the well, which must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur. 3) I- Connection: A positive integer greater than or equal to zero and less than or equal to NX that defines the connection location in the I-direction 4) J-Connection: A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction. 5) K- Connection: A positive integer greater than or equal to one and less than or equal to NZ that defines the connection location in the K-direction. The NX, NY, and NZ parameters are defined on the DIMENS keyword in the RUNSPEC section.
WELL LOCAL GRID REFINEMENT CONNECTION	WELL LOCAL GRID REFINEMENT CONNECTION variable definition is comprised of: 1) Well local grid refinement connection SUMMARY variable; for example, the Local Grid Refinement Connection Oil Flow Rate, LCOFR. 2) Well Name which is a character string of up to eight characters in length that defines the well, which must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur. 3) Local Grid Refinement Name which is a character string of up to eight characters in length that defines the Local Grid Refinement ("LGR"), which must have been declared previously using the CARFIN or RADFIN keywords in the GRID section, otherwise an error may occur. 4) I- Connection: A positive integer greater than or equal to zero and less than or equal to NX that defines the connection location in the I-direction within the LGR. 5) J-Connection: A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction within the LGR. 6) K- Connection: A positive integer greater than or equal to one and less than or equal to NZ that defines the connection location in the K-direction within the LGR. The NX, NY, and NZ parameters are defined on either the CARFIN or RADFIN keywords in the GRID section depending upon whether a Cartesian or radial local grid refinement is being utilized. **Note Local Grid Refinements are currently not implemented in OPM Flow.**
WELL SEGMENT	WELL SEGMENT variable definition consists of: 1) Well Segment SUMMARY variable; for example, Segment Oil Flow Rate, SOFR. 2) Multi-Segment Well which is a character string of up to eight characters in length that defines the well name which must have been declared previously using the WELSPECS and WELSEGS keywords in the SCHEDULE section, otherwise an error may occur. 3) Segment Number, which is a positive integer greater than or equal to two and less than or equal to MXSEGS on WSEGDIMS keyword in the RUNSPEC section that defines the segment. Note that the total number of wells should be defined via the WELLSDIMS keyword and the number of multi-segment wells should be declared on the WSEGDIMS keyword, both keywords are in the RUNSPEC section.

Table 12.5: ACTIONX Variable Definitions

See also the ACTDIMS and UDADIMS keyword in the RUNSPEC section to define the dimensions for the ACTIONX keyword and associated variables. In addition, the EXIT keyword in the SCHEDULE that allows for terminating the simulation for when a condition within an ACTIONX definition is satisfied.

Examples

The first example users the UDQ keyword to sort the oil wells from high water cut to low, via the WU_WLIST variable, and then use the ACTIONX keyword to shut-in the worst offending well when the field's water production is greater than 30,000 stb/d.

```
--
-- DEFINE START OF USER DEFINED QUANTITY SECTION
--
UDQ
--
-- OPERATOR VARIABLE  EXPRESSION
--
DEFINE      WU_WCUT   1/(WWCT 'OP*')                    / WELL WWCT LIST
DEFINE      WU_LIST   SORT(WU_WCUT)                     / WELL WWCT LIST SORTED
/                                                         END OF UDQ SECTION
--
-- DEFINE START OF ACTIONX SECTION
--
ACTIONX
WSHUTIN         10                                                          /
        GWPR  'FIELD' > 30E3  AND                                           /
        WU_LIST 'OP*' > 1     AND                                           /
/

--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
'?'      SHUT                                                               /
'?'      SHUT     0   0    0     0     0                                    /
/

ENDACTIO
```

Apart from checking that the field's water production rate is greater than 30,000 stb/d the Boolean conditional also checks that there is more than one well in the sorted well list. Notice also the use of '?' symbol as a substitution of the well name and that the ACTIONX WSHUTIN series of commands will be executed a total of ten times.

The second example checks to see if the field's gas rates is below 600 MMscf/d and if the simulation time is greater that January 1, 2030. If it is, then compression is installed by re-setting all the gas producing well's THP and BHP pressures to 450 psia and 300 psia respectively. In addition all gas wells currently shut-in are tested to see if they can be opened up under the new THP and BHP constraints.

```
--
-- START ACTIONX FIELD PHASE-3 AUTOMATIC COMPRESSION
--
ACTIONX
PHASE-3         1                                                       /
        GGPR  'FIELD' < 600E3 AND                                       /
        DAY           = 1     AND                                       /
        MNTH          ='JAN'  AND                                       /
        YEAR          = 2030                                            /
/

--
-- INSTALL COMPRESSION AND RESET WELL THP AND BHPS
--
--  WELL    WELL   TARGET
--  NAME    TARG   VALUE
WELTARG
'GP*     '  THP     450                                                 /
'GP*     '  BHP     300                                                 /
/

--
-- TEST AND OPEN ALL WELLS UNDER COMPRESSION CONSTRAINTS
--
--  WELL    TEST   CLOSE   NO.     START
--  NAME    INTV   CHECK   CHECK   TIME
WTEST
'GP*     '  1.0    PE      1       3                                   /
/

--
-- END OF ACTIONX FIELD PHASE-3 AUTOMATIC COMPRESSION DEFINITION
--
ENDACTIO
```

12.3.7 AITS – Activate Intelligent Time Stepping

Turns on the commercial simulator's intelligent time stepping.

See *AITS – Activate Intelligent Time Stepping* in the RUNSPEC section.

12.3.8 AITSOFF – Deactivate Intelligent Time Stepping

Turns off the commercial simulator's intelligent time stepping.

See *AITSOFF – Deactivate Intelligent Time Stepping* in the RUNSPEC Section

12.3.9 APILIM – DEFINE API TRACKING GRID BLOCK LIMITS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The APILIM keyword defines API Tracking grid block limits for when API Tracking has been activated via the API keyword in the RUNSPEC section. The keyword enables the simulator to monitor the grid blocks outside the limits defined on the keyword, as well as to optionally contrain the values within a given range.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.10 AQUCHGAS – Define Constant Pressure Gas Analytical Aquifer Properties

The AQUCHGAS keyword defines the properties of constant pressure gas analytical aquifers.

See *AQUCHGAS – Define Constant Pressure Gas Analytical Aquifer Properties* in the SOLUTION section for a full description.

12.3.11 AQUCHWAT – Define Constant Pressure Water Analytical Aquifer Properties

The AQUCHWAT keyword defines the properties of constant pressure water analytical aquifers.

See *AQUCHWAT – Define Constant Pressure Water Analytical Aquifer Properties* in the SOLUTION section for a full description.

12.3.12 AQUCWFAC – Modify Constant Pressure Water Analytical Aquifer Properties

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The AQUCWFAC keyword modifies the datum depth and pressure for all aquifers specified by the AQUCHWAT keyword in the SOLUTION or SCHEDULE sections.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.13 AQUFETP – DEFINE FETKOVICH ANALYTICAL AQUIFERS

The AQUFETP keyword defines Fetkovich Analytical aquifers and the aquifer properties. Each row entry in the AQUFETP keyword defines one Fetkovich Analytical aquifer. In order to fully define this type of aquifer, the aquifer must be connected to the reservoir using the AQUANCON keyword in the GRID or SOLUTION sections.

See *AQUFETP – Define Fetkovich Analytical Aquifers* in the SOLUTION section for a full description.

12.3.14 AQUFLUX - DEFINE CONSTANT FLUX ANALYTICAL AQUIFER

The AQUFLUX keword defines the properties of Constant Flux Analytical Aquifers.

See *AQUFLUX - Define Constant Flux Analytical Aquifer* in the SOLUTION section for a full description.

12.3.15 BOUNDARY – DEFINE A BOUNDARY BOX FOR PRINTING

The BOUNDARY keyword defines a a rectangular grid for printing various arrays to the output print file (*.PRT); thus, avoiding printing all the elements in the selected array.

See *BOUNDARY – Define a Boundary Box for Printing* in the GRID section for a full description.

12.3.16 BOX - DEFINE A RANGE OF GRID BLOCKS TO ENTER PROPERTY DATA

BOX defines a range of grid blocks for which subsequent data is assigned for all the cells in the defined BOX. Note that the BOX grid is reset by the keyword ENDBOX by resetting the current defined BOX to be the whole grid. The keyword can be used for any array and for all grid types.

See *BOX - Define a Range of Grid Blocks to Enter Property Data* in the GRID section for a full description.

12.3.17 BRANPROP – DEFINE NETWORK BRANCH PROPERTIES FOR EXTENDED NETWORK OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

BRANPROP defines network branch properties for the extended network option for when the Extended Network option has been activated by the NETWORK keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.18 CALTRAC – Define a Gas Calorfic Value Tracer

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The CALTRAC keyword is used to assign a gas calorfic value to a tracer, for when the Tracer option has been invoked by the TRACER keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.19 CECON – Define Well Connections Economic Limit Criteria

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

CECON sets the economic cut-off criteria for a well's connection to the simulation grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.20 CECONT – Define Well Connections Tracer Economic Limit Criteria

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, CECONT, sets the tracer economic cut-off criteria for a well's connection to the simulation grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.21 COMPDAT – DEFINE WELL CONNECTIONS TO THE GRID

Description

The COMPDAT keyword defines how a well is connected to the reservoir by defining or modifying existing well connections. Ideally the connections should be declared in the correct sequence, starting with the connection nearest the well head and then working along the wellbore towards the bottom or toe of the well, however this may not be possible or convenient, for example when connections are added or removed from a well during the simulation (see COMPORD in the SCHEDULE section for options regarding connection ordering).

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	I	A positive integer greater than or equal to zero and less than or equal to NX that defines the connection location in the I-direction. If set to zero or defaulted with 1* the location is taken from the wellhead location I-direction value on the WELSPECS keyword in the SCHEDULE section.			0
3	J	A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction. If set to zero or defaulted with 1* the location is taken from the wellhead location J-direction value on the WELSPECS keyword in the SCHEDULE section.			0
4	K1	A positive integer greater than or equal to one and less than or equal to NZ that defines the UPPER connection location in the K-direction.			None
5	K2	A positive integer greater than or equal to K1 and less than or equal to NZ that defines the LOWER connection location in the K-direction.			None
6	STATUS	A character string of length four that defines the connections' operational status, STATUS should be set to one of the following character strings: 1) OPEN: the connections are open to flow. 2) SHUT: the connections are closed to flow (shut-in). 3) AUTO: the connection are initially closed, but may be opened automatically if an economic limit is violated. Currently this option is not supported by OPM Flow			OPEN

No.	Name	Description			Default
		Field	Metric	Laboratory	
7	SATNUM	An integer greater than or equal to zero and less than NTSFUN as declared on the TABDIMS keyword in the RUNSPEC, that defines the saturation table number to be used for flow between the reservoir gird block and the well connections. If SATNUM is set to zero or defaulted with 1* then: • The saturation table allocated to the grid block that the connections are located within is used. • If the hysteresis option has been activated via the HYSTER variable on the SATOPTS keyword in the RUNSPEC section, then both the imbibition and drainage saturation tables allocated to the grid block that the connections are located within are used. The imbibition table allocation can be changed by the COMPIMB keyword in the RUNSPEC section, provided it is entered after the COMPDAT keyword.			0
8	CONFACT	A real value greater than or equal to zero that defines the transmissibility connection factor between the well bore and the reservoir grid block. If set to zero or defaulted with 1* then items (9) through (13) are used to calculate CONFACT.			
		cP.rb/day/psia 0	cP.rm^3/day/bars 0	cP.rcc/hr/atm 0	Defined
9	RW	A real positive value that defines the well bore diameter of the connections for the well. RW is used in calculating a well's productivity or injectivity index; however the value will be ignored in calculating the connections CONFACT value if CONFAC has been directly entered.			
		feet	m	cm	None
10	KH	A real value that defines the effective KH (permeability x length) for the connections. If less than or equal to zero or defaulted by 1* then KH is calculated from the connected grid blocks. KH is ignored if CONFAC has been directly entered.			
		mD.ft	mD.m	mD.cm	Calculated from connected grid blocks
11	SKIN	A real value that defines the connections dimensionless skin factor. SKIN is used in calculating a well's productivity or injectivity index; however, the value will be ignored in calculating the connections CONFACT value if CONFAC has been directly entered.			
		dimensionless	dimensionless	dimensionless	0.0
12	DFACT	A real value that defines the non-Darcy D factor coefficient for gas wells. This value should be defaulted with 1* and the non-Darcy D factor coefficient for gas wells defined via the WDFAC keyword in the SCHEDULE section. Currently this option is not supported by OPM Flow.			
		day/Mscf	day/m^3	hour/sc	1*

No.	Name	Description			Default
		Field	Metric	Laboratory	
13	DIRECT	A one letter character string that defines the orientation of the connections and should be set to either X, Y, or Z. The direction of connections also determines the length of the connection used to calculate the connection factor if CONFAC has not been entered directly. The default value is for a vertical connection, that is DIRECT is defaulted to Z.			Z

Notes:

1) The keyword is followed by up to MXCONS records as declared on the WELLDIMS keyword in the RUNSPEC section.
2) Each record is terminated by a "/" and the keyword should be terminated by a "/".

Table 12.6: COMPDAT Keyword Description

Multiple grid block connections can be defined on one record for vertical wells by assigning different values to K1 and K2, for deviated and horizontal wells this may not be possible and therefore each grid block connection must be separately defined by using one record per connection, setting K1 equal to K2 in each record.
See also the WELSPECS keyword to define wells, the COMPIMB to reset the imbibition relative permeability table allocation, and the COMPORD to re-order the completions along the well trajectory. In addition, the COMPLUMP keyword groups well connections together to form well completions for a well. All the aforementioned keywords are described in the SCHEDULE section.

Note

The term well connection is used to describe individual connections from the wellbore to the reservoir grid, as opposed to well completions. A well completion is used to describe a set of connections, for example, a well may consist of several completions with each completion consisting of multiple connections.

Example

The following example defines two vertical oil wells using the WELSPECS keyword and their associated connection data.

```
--
--       WELL SPECIFICATION DATA
--
-- WELL  GROUP     LOCATION  BHP    PHASE  DRAIN  INFLOW  OPEN  CROSS  PRESS
-- NAME  NAME        I    J  DEPTH  FLUID  AREA   EQUANS  SHUT  FLOW   TABLE
WELSPECS
OP01     PLATFORM   14   13   1*     OIL    1*     STD    SHUT   NO     1*  /
OP02     PLATFORM   28   96   1*     OIL    1*     STD    SHUT   NO     1*  /
/
--
--       WELL CONNECTION DATA
--
-- WELL  --- LOCATION ---  OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME   II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
OP01      1*  1*  20  56   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
OP01      1*  1*  75 100   SHUT   1*    1*    0.708  1*    0.0    1*    'Z' /
OP02      35  96  75 100   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
```

Well OP01 has two sets of connections; the first one connects grid cells (14, 13, 20) to (14, 13, 56) to the well and is open to flow and the second connecting grid cells (14, 13, 75) to (14, 13, 100) is shut. Well OP02 has only one open connection from cells (35, 96, 75) to cells (35, 96, 100).

12.3.22 COMPDATL – DEFINE WELL CONNECTIONS TO A LGR GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPDATL keyword defines how a well in a Local Grid Refinement ("LGR") is connected to the reservoir by declaring the LGR and defining or modifying existing well connections. Ideally the connections should be declared in the correct sequence, starting with the connection nearest the well head and then working along the wellbore towards the bottom or toe of the well, however this may not be possible or convenient, for example when connections are added or removed from a well during the simulation (see the COMPORD keyword in the SCHEDULE section for options regarding connection ordering).

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which the well LGR connection data are being defined. Note that the well name (LGRNAME) must have been declared previously using the WELSPECL keyword in the SCHEDULE section, otherwise an error may occur. If defaulted with 1* the LGR on the WELSPECL keyword will be utilized.			Defined
3	I	A positive integer greater than or equal to zero and less than or equal to NX that defines the connection location in the I-direction. If set to zero or defaulted with 1* the location is taken from the wellhead location I-direction value on the WELSPECS keyword in the SCHEDULE section.			0
4	J	A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction. If set to zero or defaulted with 1* the location is taken from the wellhead location J-direction value on the WELSPECS keyword in the SCHEDULE section.			0
5	K1	A positive integer greater than or equal to one and less than or equal to NZ that defines the UPPER connection location in the K-direction.			None
6	K2	A positive integer greater than or equal to K1 and less than or equal to NZ that defines the LOWER connection location in the K-direction.			None
7	STATUS	A character string of length four that defines the connections' operational status, STATUS should be set to one of the following character strings: 1) OPEN: the connections are open to flow. 2) SHUT: the connections are closed to flow (shut-in). 3) AUTO: the connection are initially closed, but may be opened automatically if an economic limit is violated. Currently this option is not supported by OPM Flow			OPEN

No.	Name	Description			Default
		Field	Metric	Laboratory	
8	SATNUM	An integer greater than or equal to zero and less than NTSFUN as declared on the TABDIMS keyword in the RUNSPEC, that defines the saturation table number to be used for flow between the reservoir gird block and the well connections. If SATNUM is set to zero or defaulted with 1* then: • The saturation table allocated to the grid block that the connections are located within is used. • If the hysteresis option has been activated via the HYSTER variable on the SATOPTS keyword in the RUNSPEC section, then both the imbibition and drainage saturation tables allocated to the grid block that the connections are located within are used. The imbibition table allocation can be changed by the COMPIMB keyword in the RUNSPEC section, provided it is entered after the COMPDAT keyword.			0
9	CONFACT	A real value greater than or equal to zero that defines the transmissibility connection factor between the well bore and the reservoir grid block. If set to zero or defaulted with 1* then items (9) through (13) are used to calculate CONFACT.			
		cP.rb/day/psia 0	cP.rm^3/day/bars 0	cP.rcc/hr/atm 0	Defined
10	RW	A real positive value that defines the well bore diameter of the connections for the well. RW is used in calculating a well's productivity or injectivity index; however the value will be ignored in calculating the connections CONFACT value if CONFAC has been directly entered.			
		feet	m	cm	None
11	KH	A real value that defines the effective KH (permeability x length) for the connections. If less than or equal to zero or defaulted by 1* then KH is calculated from the connected grid blocks. KH is ignored if CONFAC has been directly entered.			
		mD.ft	mD.m	mD.cm	Calculated from connected grid blocks
12	SKIN	A real value that defines the connections dimensionless skin factor. SKIN is used in calculating a well's productivity or injectivity index; however, the value will be ignored in calculating the connections CONFACT value if CONFAC has been directly entered.			
		dimensionless	dimensionless	dimensionless	0.0
13	DFACT	A real value that defines the non-Darcy D factor coefficient for gas wells. This value should be defaulted with 1* and the non-Darcy D factor coefficient for gas wells defined via the WDFAC keyword in the SCHEDULE section. Currently this option is not supported by OPM Flow.			
		day/Mscf	day/m^3	hour/sc	1*

No.	Name	Description			Default
		Field	Metric	Laboratory	
14	DIRECT	A one letter character string that defines the orientation of the connections and should be set to either X, Y, or Z. The direction of connections also determines the length of the connection used to calculate the connection factor if CONFAC has not been entered directly. The default value is for a vertical connection, that is DIRECT is defaulted to Z.			Z

Notes:

1) The keyword is followed by up to MXCONS records as declared on the WELLDIMS keyword in the RUNSPEC section.
2) Each record is terminated by a "/" and the keyword should be terminated by a "/".

Table 12.7: COMPDATL Keyword Description

Multiple grid block connections can be defined on one record for vertical wells by assigning different values to K1 and K2, for deviated and horizontal wells this may not be possible and therefore each grid block connection must be separately defined by using one record per connection, setting K1 equal to K2 in each record.
See also the WELSPECS keyword to define wells, the COMPIMB to reset the imbibition relative permeability table allocation, and the COMPORD to re-order the completions along the well trajectory. In addition, the COMPLUMP keyword groups well connections together to form well completions for a well. All the aforementioned keywords are described in the SCHEDULE section.

Note

The term well connection is used to describe individual connections from the wellbore to the reservoir grid, as opposed to well completions. A well completion is used to describe a set of connections, for example, a well may consist of several completions with each completion consisting of multiple connections.

Example

The following example defines two vertical oil wells using the WELSPECS keyword and their associated connection data.

```
--
--       WELL LGR SPECIFICATION DATA
--
--       WELL GROUP  LGR    -LOCATION- BHP    PHASE DRAIN INFLOW SHUT CROSS PVT
--       NAME NAME   NAME     I    J   DEPTH  FLUID AREA  EQUA.  IN   FLOW  TABLE
WELSPECL
         OP01  PLAT OP01LGR  14   13   1*     OIL   1*    STD    SHUT  NO   1*  /
         OP02  PLAT OP02LGR  28   96   1*     OIL   1*    STD    SHUT  NO   1*  /
/
--
--       WELL LGR CONNECTION DATA
--
--       WELL  LGR   ---LOCATION---   OPEN   SAT CONN  WELL KH   SKIN  D    DIR
--       NAME  NAME   II  JJ  K1  K2  SHUT   TAB FACT  DIA  FACT FACT  FACT PEN
COMPDATL
         OP01 OP01LGR 1*  1*  20  56  OPEN   1*  1*  0.708   1*   1*   1*   Z /
         OP01 OP01LGR 1*  1*  75 100  SHUT   1*  1*  0.708   1*   1*   1*   Z /
   OP02 OP02LGR 35  96  75 100  OPEN   1*  1*  0.708   1*   1*   1*   Z /
/
```

Well OP01 has two sets of connections; the first one connects grid cells (14, 13, 20) to (14, 13, 56) to the well and is open to flow and the second connecting grid cells (14, 13, 75) to (14, 13, 100) is shut. Well OP02 has only one open connection from cells (35, 96, 75) to cells (35, 96, 100).

12.3.23 COMPDATM – DEFINE WELL CONNECTIONS TO AN AMALGAMATED LGR GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPDATM keyword is an alias for the COMPDATL keyword. COMPDATM defines how a well in an amalgamated Local Grid Refinement ("LGR") is connected to the reservoir by declaring the LGR and defining or modifying existing well connections. Ideally the connections should be declared in the correct sequence, starting with the connection nearest the well head and then working along the wellbore towards the bottom or toe of the well, however this may not be possible or convenient, for example when connections are added or removed from a well during the simulation (see the COMPORD keyword in the SCHEDULE section for options regarding connection ordering).

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.24 COMPIMB – ASSIGN IMBIBITION SATURATION TABLES TO WELL CONNECTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPIMB keyword assigns imbibition saturation tables to well connections. The COMPDAT keyword in the SCHEDULE section also assigns imbibition saturation tables to connections, but in this case the table number is the same as for the drainage curve. If this is not the required assignment then the COMPIMB keyword can be used to reset the imbibition saturation table number. For this to be effective the COMPIMB keyword must precede the COMPDAT keyword, otherwise it will have no effect.

The COMPIMB keyword should only be used if the hysteresis option has been activated via the HYSTER variable on the SATOPTS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	I	A positive integer greater than or equal to zero and less than or equal to NX that defines the connection location in the I-direction. If set to zero or defaulted with 1* then all connections in the I-direction that also satisfy J, K1 and K2 criteria are assigned the IMBNUM imbibition table number.			0
3	J	A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction. If set to zero or defaulted with 1* then all connections in the J-direction that also satisfy I, K1 and K2 criteria are assigned the IMBNUM imbibition table number.			0
4	K1	A positive integer greater than or equal to one and less than or equal to NZ that defines the UPPER connection location in the K-direction. If set to zero or defaulted with 1* then the upper most connection in the well is used.			0
5	K2	A positive integer greater than or equal to K1 and less than or equal to NZ that defines the LOWER connection location in the K-direction. If set to zero or defaulted with 1* then the lowest most connection in the well is used.			0
6	IMBNUM	An integer greater than or equal to zero and less than NTSFUN as declared on the TABDIMS keyword in the RUNSPEC, that defines the imbibition saturation table number to be used for flow between the reservoir gird block and the well connections. If IMBNUM is set to zero or defaulted with 1* then the inhibition saturation table allocated to the grid block that the connections are located within is used. If I, J, K1, K2 are all set to zero or defaulted to 1*, then IMBNUM is allocated to all connections in the well.			0

No.	Name	Description			Default
		Field	Metric	Laboratory	

Notes:

1) The keyword is followed by up to MXCONS records as declared on the WELLDIMS keyword in the RUNSPEC section.
2) Each record is terminated by a "/" and the keyword should be terminated by a "/".

Table 12.8: COMPIMB Keyword Description

Multiple grid block connections can be defined on one record for vertical wells by assigning different values to K1 and K2, for deviated and horizontal wells this may not be possible and therefore each grid block connection must be separately defines by setting K1 equal to K2.
See also the COMPDAT keyword in the SCHEDULE section.
This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

The following example defines the connections for two vertical oil wells using the COMPDAT keyword and then re-sets the imbibition saturation functions using the COMPIMP keyword.

```
--
--       WELL CONNECTION DATA
--
-- WELL   --- LOCATION ---   OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME    II   JJ   K1   K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
OP01       1*   1*   20   56   OPEN   1     1*    0.708   1*    0.0    1*    'Z' /
OP01       1*   1*   75  100   SHUT   2     1*    0.708   1*    0.0    1*    'Z' /
OP02       35   96   75  100   OPEN   1     1*    0.708   1*    0.0    1*    'Z' /
--
-- ASSIGN IMBIBITION SATURATION TABLES TO CONNECTIONS
--
-- WELL      ---LOCATION---    SAT
-- NAME      II   JJ   K1   K2   TAB
COMPIMB
OP01         1*   1*   20   56   11                    /
OP01         1*   1*   75  100   12                    /
OP02         1*   1*   1*   1*   11                    /
/
```

Well OP01 has two sets of COMPIMB records to overwrite the imbibition saturation tables, one for connections (14, 13, 20) to (14, 13, 56) resetting the imbibition saturation table number from one to 11 and one for connections (14, 13, 75) to (14, 13, 100) that resets the imbibition table number from 2 to 12. Well OP02 has only one connection from cells (35, 96, 75) to cells (35, 96, 100), so all the default values for I, J, K1, and K2 can be used to set the imbibition table numbers from 2 to 11. Note in all cases the drainage saturation table retains the value as specified by the COMPDAT keyword, that is one, two and one.

12.3.25 COMPINJK – Assign Injection well Relative Permeability Values

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPINJK keyword assigns injection well relative permeability values to well connections.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.26 COMPLMPL – ASSIGN WELL LGR CONNECTIONS TO COMPLETIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPLMPL keyword assigns well connections in a LGR, as defined by the COMPDATL keyword in the SCHEDULE section, to completion intervals. This "lumping" of the connections to various completion intervals allows automatic workovers and economic criteria to be applied to the completions (that is a set of connections) as opposed to the connections. This allows for a more realistic approach for workovers operations.

For example, if the water cut criteria for working over a well was set to 95%, and the average grid block connection thickness was one meter, then once a well's water cut reached 95% the worst offending one meter connection would be shut-in. If the well's actual perforation interval was 10 meters and the 10 connections were lumped as one completion, then when the water cut limit of 95% is reach, the completion would be shut-in, that is all of the 10 connections within the completion would be shut-in.

As the keyword is used to lump connections into a completions, the simulator adds together the contribution from all connections in the completion and uses the total values to test the economic limits. Note that a connection can only belong to one completion. In addition, completions can be used instead of connections in the WELOPEN and WPIMULT keywords if the completions have been defined by COMPLUMP for a well.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which the well LGR connection data are being defined. Note that the well name (LGRNAME) must have been declared previously using the WELSPECL keyword in the SCHEDULE section, otherwise an error may occur. If defaulted with 1* the LGR on the WELSPECL keyword will be utilized.			Defined
3	I	A positive integer greater than or equal to zero and less than or equal to NX that defines the connection location in the I-direction. If set to zero or defaulted with 1* then all connections in the I-direction that also satisfy J, K1 and K2 criteria are assigned the ICOMP completion number.			0
4	J	A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction. If set to zero or defaulted with 1* then all connections in the J-direction that also satisfy I, K1 and K2 criteria are assigned the ICOMP completion number.			0

No.	Name	Description			Default
		Field	Metric	Laboratory	
5	K1	A positive integer greater than or equal to one and less than or equal to NZ that defines the UPPER connection location in the K-direction. If set to zero or defaulted with 1* then the upper most connection in the well is used.			0
6	K2	A positive integer greater than or equal to K1 and less than or equal to NZ that defines the LOWER connection location in the K-direction. If set to zero or defaulted with 1* then the low most connection in the well is used.			0
7	ICOMP	An integer greater than or equal to one and less than or equal to MXCONS as defined on the WELLDIMS keyword in the RUNSPEC section, that defines the completion number of the currently defined set of connections. If I, J, K1, K2 are all set to zero or defaulted to 1*, then all connections in the well have the same completion number of ICOMP.			None

Notes:

1) The keyword is followed by any number of records.
2) Each record is terminated by a "/" and the keyword should be terminated by a "/".

Table 12.9: COMPLUPL Keyword Description

Multiple grid block connections can be defined on one record for vertical wells by assigning different values to K1 and K2, for deviated and horizontal wells this may not be possible and therefore each grid block connection must be separately defined by setting K1 equal to K2.

See also the COMPDATL keyword in the SCHEDULE section.

Example

The following example defines the connections for two vertical oil wells using the COMPDATL keyword and the re-allocation of the connections to completions intervals using the COMPLMPL keyword.

```
--
--       WELL CONNECTION DATA FOR LGR WELLS
--
--       WELL    LGR      --- LOCATION ---  OPEN   SAT   CONN   WELL   D     DIR
--       NAME    NAME      II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  PEN
COMPDATL
         OP01    OP01LGR    1*  1*  20  56  OPEN   1*    1*    0.708   3*     Z /
         OP01    OP01LGR    1*  1*  75 100  SHUT   1*    1*    0.708   3*     Z /
         OP02    OP02LGR    35  96  75 100  OPEN   1*    1*    0.708   3*     Z /
/
--
--       ASSIGN WELL CONNECTIONS TO COMPLETIONS
--
--       WELL    LGR      --- LOCATION ---  COMPL
--       NAME    NAME      II  JJ  K1  K2   NO.
COMPLMPL
         OP01    OP01LGR   1*  1*  20  56    1          / COMPLETION NO. 01
         OP01    OP01LGR   1*  1*  75 100    2          / COMPLETION NO. 02
         OP02    OP02LGR   1*  1*  75  85    1          / COMPLETION NO. 01
         OP02    OP21LGR   1*  1*  86 100    2          / COMPLETION NO. 02
/
```

Here the well OP01 connections (14, 13, 20) to (14, 13, 56) are assigned to completion number one and connections (14, 13, 75) to (14, 13, 100) are assigned to completion number two. Well OP02 has only one set of connection data from cells (35, 96, 75) to cells (35, 96, 100), but they have split into two separate completion intervals, with connections (35. 96, 75) to (35. 96, 85) assigned to completion interval number one and (35, 96, 86) to (35, 96, 100) to completion number two.

12.3.27 COMPLUMP – ASSIGN WELL CONNECTIONS TO COMPLETIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPLUMP keyword assigns connections, as defined by the COMPDAT keyword in the SCHEDULE section, to completion intervals. This "lumping" of the connections to various completion intervals allows automatic workovers and economic criteria to be applied to the completions (that is a set of connections) as opposed to the connections. This allows for a more realistic approach for workovers operations.

For example, if the water cut criteria for working over a well was set to 95%, and the average grid block connection thickness was one meter, then once a well's water cut reached 95% the worst offending one meter connection would be shut-in. If the well's actual perforation interval was 10 meters and the 10 connections were lumped as one completion, then when the water cut limit of 95% is reach, the completion would be shut-in, that is all of the 10 connections within the completion would be shut-in.

As the keyword is used to lump connections into a completions, the simulator adds together the contribution from all connections in the completion and uses the total values to test the economic limits. Note that a connection can only belong to one completion. In addition, completions can be used instead of connections in the WELOPEN and WPIMULT keywords if the completions have been defined by COMPLUMP for a well.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	I	A positive integer greater than or equal to zero and less than or equal to NX that defines the connection location in the I-direction. If set to zero or defaulted with 1* then all connections in the I-direction that also satisfy J, K1 and K2 criteria are assigned the ICOMP completion number.			0
3	J	A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction. If set to zero or defaulted with 1* then all connections in the J-direction that also satisfy I, K1 and K2 criteria are assigned the ICOMP completion number.			0
4	K1	A positive integer greater than or equal to one and less than or equal to NZ that defines the UPPER connection location in the K-direction. If set to zero or defaulted with 1* then the upper most connection in the well is used.			0
5	K2	A positive integer greater than or equal to K1 and less than or equal to NZ that defines the LOWER connection location in the K-direction. If set to zero or defaulted with 1* then the low most connection in the well is used.			0

No.	Name	Description			Default
		Field	Metric	Laboratory	
6	ICOMP	An integer greater than or equal to one and less than or equal to MXCONS as defined on the WELLDIMS keyword in the RUNSPEC section, that defines the completion number of the currently defined set of connections. If I, J, K1, K2 are all set to zero or defaulted to 1*, then all connections in the well have the same completion number of ICOMP.			None

Notes:

1) The keyword is followed by any number of records.
2) Each record is terminated by a "/" and the keyword should be terminated by a "/".

Table 12.10: COMPLUMP Keyword Description

Multiple grid block connections can be defined on one record for vertical wells by assigning different values to K1 and K2, for deviated and horizontal wells this may not be possible and therefore each grid block connection must be separately defined by setting K1 equal to K2.
See also the COMPDAT keyword in the SCHEDULE section.

Example

The following example defines the connections for two vertical oil wells using the COMPDAT keyword and the re-allocation of the connections to completions intervals using the COMPLUMP keyword.

```
--
--       WELL CONNECTION DATA
--
-- WELL  --- LOCATION ---  OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME   II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
OP01      1*  1*  20  56   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
OP01      1*  1*  75 100   SHUT   1*    1*    0.708  1*    0.0    1*    'Z' /
OP02      35  96  75 100   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
/
--
--       ASSIGN WELL CONNECTIONS TO COMPLETIONS
--
-- WELL  --- LOCATION ---  COMPL
-- NAME   II  JJ  K1  K2   NO.
COMPLUMP
OP01      1*  1*  20  56    1                                / COMPLETION NO. 01
OP01      1*  1*  75 100    2                                / COMPLETION NO. 02
OP02      1*  1*  75  85    1                                / COMPLETION NO. 01
OP02      1*  1*  86 100    2                                / COMPLETION NO. 02
/
```

Here the well OP01 connections (14, 13, 20) to (14, 13, 56) are assigned to completion number one and connections (14, 13, 75) to (14, 13, 100) are assigned to completion number two. Well OP02 has only one set of connection data from cells (35, 96, 75) to cells (35, 96, 100), but they have split into two separate completion intervals, with connections (35. 96, 75) to (35. 96, 85) assigned to completion interval number one and (35, 96, 86) to (35, 96, 100) to completion number two.

12.3.28 COMPOFF – Deactivate Network Automatic Compressors

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPOFF keyword deactivates network automatic compressors defined via the GASFCOMP keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.29 COMPORD - DEFINE WELL CONNECTION ORDERING

Description

The COMPORD keyword defines how the well connection data entered on the COMPDAT keyword in the SCHEDULE section are to be ordered for a well.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	COMPORD	A character string that defines the method for ordering the well connections given on the COMPDAT keyword, and should be set to DEPTH, INPUT, or TRACK. 1) DEPTH: The connections are ordered by a connection's true vertical depth from the shallowest to the deepest. If multiple connections are at the same depth then these connections are sub ordered by the sequence they were entered on the COMPDAT keyword. 2) INPUT: This option results in the connections being ordered in the same sequence as entered via the COMPDAT keyword. In this case the connections should be declared in the correct sequence, starting with the connection nearest the well head and then working along the wellbore towards the bottom or toe of the well. 3) TRACK: This option enables OPM Flow to trace the well connections through the grid to obtain the correct order for the connections. If the supplied COMPDAT indicates the well is vertical (via the DIRECT variable being equal to Z on the COMPDAT keyword) then the DEPTH option will be applied instead.			TRACK
Notes: 1) The keyword is followed by any number of records. 2) Each record is terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.11: COMPORD Keyword Description

See also the COMPDAT keyword in the SCHEDULE section.

Note

If visual inspection of the well trajectories in the model indicate problematic or unrealistic well connections, the options on this keyword may be useful in correcting the issue.

Example

The following example defines the connections for two vertical oil wells using the COMPDAT keyword and the COMPORD to defined the connection ordering for the wells.

```
---
--       WELL CONNECTION DATA
--
-- WELL  --- LOCATION ---  OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME   II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
OP01      1*  1*  20  56   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
OP01      1*  1*  75 100   SHUT   1*    1*    0.708  1*    0.0    1*    'Z' /
OP02      35  96  75 100   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
--
--       DEFINE WELL CONNECTION ORDERING
--
-- WELL  COMPL
-- NAME  ORDER
COMPORD
OP01     DEPTH                                                  /
OP02     DEPTH                                                  /
/
```

The DEPTH option has been chosen because both wells are vertical. Also one could use the following format instead for the COMPORD:

```
--
--       DEFINE WELL CONNECTION ORDERING
--
-- WELL  COMPL
-- NAME  ORDER
COMPORD
*        DEPTH                                                  /
/
```

as both wells should utilize the DEPTH option. This version would set all wells in the model to DEPTH connection ordering.

12.3.30 COMPRIV – Define Grid Cell Connections to a River

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPRIV keyword defines grid cell connections to a river, for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.31 COMPRP – Re-Scale Fluid Saturations of Well Connections

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COPMPRP keyword re-scales the fluid saturations of a well's connection to the grid block.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.32 COMPRPL – Re-Scale Fluid Saturations of Well LGR Connections

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COPMPRPL keyword re-scales the fluid saturations of a well's connection to an LGR grid block, for when the Local Grid Refinement ("LGR") option has been activated by the LGR keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.33 COMPSEGL – DEFINE WELL CONNECTIONS FOR MULTI-SEGMENT WELLS IN A LGR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMSEGSL keyword defines how a multi-segment well is connected to the reservoir by defining or modifying existing well connections in an LGR. Note that well must have been previously define by the WELSPECL keyword in the SCHEDULE section and the well connections must have been previously defined via the COMPDATL keyword in the SCHEDULE section. The COMPSEGL keyword should be repeated for each multi-segment well in the model.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	WELNAME	A character string of up to eight characters in length that defines the well name for which a multi-segment well is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECL keyword in the SCHEDULE section, otherwise an error may occur.			None
1-2	/	Record terminated by a "/"			Not Applicable
2-1	LGRNAME	A character string of up to eight characters in length that defines the name of the local grid refinement for which the well is assigned to.			None
2-2	I	A positive integer greater than or equal to one and less than or equal to NX that defines the connection location in the I-direction.			None
2-3	J	A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction.			None
2-4	K	A positive integer greater than or equal to zero and less than or equal to NZ that defines the connection location in the K-direction.			None
2-5	IBRANCH	A positive integer greater than or equal to one and less than or equal to MXBRAN on WSEGDIMS keyword in the RUNSPEC section that defines the branch number of the defined I, J and K connection.			None
2.6	DEPTH1	DEPTH1 is a real positive value that defines the length of the tubing from the tubing head or wellhead at the surface to the start of the connection in the I, J, K cell.			
		feet	m	cm	None
2-7	DEPTH2	DEPTH2 is a real positive value that defines the length of the tubing from the tubing head or wellhead at the surface to the end of the connection in the I, J, K cell.			
		feet	m	cm	None
2-8	DIRECT	A one letter character string that defines the orientation of the connections and should be set to either X, Y, or Z. The direction of connections also determines the length of the connection The default value is for a vertical connection, that is DIRECT is defaulted to Z.			Z

No.	Name	Description			Default
		Field	Metric	Laboratory	
2-9	IEND	IEND is positive or negative integer, that is not equal to zero that is set to one of the following: 1) a value between -NX and +NX that is not equal to zero that defines the last connection location in the I-direction, 2) a value between -NY and +NY that is not equal to zero that defines the last connection location in the J-direction, or 3) a value between -NZ and +NZ that is not equal to zero that defines the last connection location in the K-direction, that defines the end of the range of the connections depending on the value of DIRECT. For example, if DIRECT is equal to Y or J then the IEND will be associated with the J-direction. The value may be positive or negative but must be calculated to remain within the grid. For example for NY is set 100 on the DIMENS keyword in the RUNSPEC section and J on this record set to 50, then IEND most range between -49 to +50. Currently this option is not supported by OPM Flow.			None
2-10	DEPTH3	DEPTH3 is a real positive value that defines the datum depth for this set of connection, normally taken as the mid-point of the perforations associated with this set of connections. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
2-11	LENGTH	LENGTH is a real positive value that defines the length of the well for this set of completions that is used in thermal calculations.. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
2-12	ISEG	A real positive values equal to or greater than zero that defines the coordinate in the x-direction of the nodal point of this segment that is used for display purposes only. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
2-13	/	Record terminated by a "/"			Not Applicable

Notes:

1) Each multi-segment wells must be defined by a separate COMPSEGL keyword that consists of two records, with entries 1-1 to 1-2 representing record one items and 2-1 to 2-13 representing record number two items in the "No." column in this table.
2) Record number two of the keyword, items 2-1 to 2-13 is followed by up to MXCONS records as declared on the WSEGDIMS keyword in the RUNSPEC section.
3) Each of the records are terminated by a "/" and is explicitly shown in the above rows and the keyword should be terminated by a "/".

Table 12.12: COMPSEGL Keyword Description

The total number of wells and completions should be defined via the WELLSDIMS keyword and the number of multi-segment wells and completions should be declared on the WSEGDIMS keyword, both keywords are in the RUNSPEC section.

See also the WELSPECL keyword to define wells in an LGR, the COMPDATL keyword to define the well connections for both ordinary wells and multi-segment wells with an LGR, and the COMPSEGS keyword to define a multi-segment connections in the global grid. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the completions for two oil producing segment oil wells (OP01 and OP02) using the COMPSEGS keywords.

```
--       COMPLETION SEGMENT SPECIFICATION DATA
--
-- WELL
-- NAME
COMPSEGS
OP01                                                                    /
--      LGR  --LOCATION--  BRAN  TUBING  NODAL   DIR  LOC    MID    COMP    ISEG
--      NAME  II  JJ  K1   NO    LENGTH  DEPTH   PEN  I,J,K  PERFS  LENGTH
        LGR01 10  10   1    1    2512.5  2525.0                              /
        LGR01 10  10   2    1    2525.0  2550.0                              /
        LGR01 10  10   3    1    2550.0  2575.0                              /
        LGR01 10  10   4    1    2575.0  2600.0                              /
        LGR01 10  10   5    1    2600.0  2625.0                              /
        LGR01 10  10   6    1    2625.0  2650.0                              /

        LGR01  9  10   2    2    2637.5  2837.5                              /
        LGR01  8  10   2    2    2837.5  3037.5                              /
        LGR01  7  10   2    2    3037.5  3237.5                              /
        LGR01  6  10   2    2    3237.5  3437.5                              /
        LGR01  5  10   2    2    3437.5  3637.5                              /
/
```

Note that the COMPDATL keyword in the SCHEDULE section must also be defines for this well.

12.3.34 COMPSEGS – DEFINE WELL CONNECTIONS FOR MULTI-SEGMENT WELLS

Description

The COMSEGS keyword defines how a multi-segment well is connected to the reservoir by defining or modifying existing well connections. Note that well must have been previously define by the WELSPECS keyword in the SCHEDULE section and the well connections must have been previously defined via the COMPDAT keyword in the SCHEDULE section

The COMPSEGS keyword should be repeated for each multi-segment well in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	WELNAME	A character string of up to eight characters in length that defines the well name for which a multi-segment well is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
1-2	/	Record terminated by a "/"			Not Applicable
2-1	I	A positive integer greater than or equal to one and less than or equal to NX that defines the connection location in the I-direction.			None
2-2	J	A positive integer greater than or equal to zero and less than or equal to NY that defines the connection location in the J-direction.			None
2-3	K	A positive integer greater than or equal to zero and less than or equal to NZ that defines the connection location in the K-direction.			None
2-4	IBRANCH	A positive integer greater than or equal to one and less than or equal to MXBRAN on WSEGDIMS keyword in the RUNSPEC section that defines the branch number of the defined I, J and K connection.			None
2-5	DEPTH1	DEPTH1 is a real positive value that defines the length of the tubing from the tubing head or wellhead at the surface to the start of the connection in the I, J, K cell.			
		feet	m	cm	None
2-6	DEPTH2	DEPTH2 is a real positive value that defines the length of the tubing from the tubing head or wellhead at the surface to the end of the connection in the I, J, K cell.			
		feet	m	cm	None
2-7	DIRECT	A one letter character string that defines the orientation of the connections and should be set to either X, Y, or Z. The direction of connections also determines the length of the connection The default value is for a vertical connection, that is DIRECT is defaulted to Z. Currently this option is not supported by OPM Flow.			Z

No.	Name	Description			Default
		Field	Metric	Laboratory	
2-8	IEND	IEND is positive or negative integer, that is not equal to zero that is set to one of the following: 1) a value between -NX and +NX that is not equal to zero that defines the last connection location in the I-direction, 2) a value between -NY and +NY that is not equal to zero that defines the last connection location in the J-direction, or 3) a value between -NZ and +NZ that is not equal to zero that defines the last connection location in the K-direction, that defines the end of the range of the connections depending on the value of DIRECT. For example, if DIRECT is equal to Y or J then the IEND will be associated with the J-direction. The value may be positive or negative but must be calculated to remain within the grid. For example for NY is set 100 on the DIMENS keyword in the RUNSPEC section and J on this record set to 50, then IEND most range between -49 to +50. Currently this option is not supported by OPM Flow.			None
2-9	DEPTH3	DEPTH3 is a real positive value that defines the datum depth for this set of connection, normally taken as the mid-point of the perforations associated with this set of connections. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
2-10	LENGTH	LENGTH is a real positive value that defines the length of the well for this set of completions that is used in thermal calculations.. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
2-11	ISEG	A real positive values equal to or greater than zero that defines the coordinate in the x-direction of the nodal point of this segment that is used for display purposes only. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
2-12	/	Record terminated by a "/"			Not Applicable

Notes:

1) Each multi-segment wells must be defined by a separate COMPSEGS keyword that consists of two records, with entries 1-1 to 1-2 representing record one items and 2-1 to 2-12 representing record number two items in the "No." column in this table.
2) Record number two of the keyword, items 2-1 to 2-12 is followed by up to MXCONS records as declared on the WSEGDIMS keyword in the RUNSPEC section.
3) Each of the records are terminated by a "/" and is explicitly shown in the above rows and the keyword should be terminated by a "/".

Table 12.13: COMPSEGS Keyword Description

The total number of wells and completions should be defined via the WELLSDIMS keyword and the number of multi-segment wells and completions should be declared on the WSEGDIMS keyword, both keywords are in the RUNSPEC section.

See also the WELSPECS keyword to define wells, the COMPDAT keyword to define the well connections for both ordinary wells and multi-segment wells, and the COMPSEGL keyword to define a multi-segment connections in a LGR. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the completions for two oil producing segment oil wells (OP01 and OP02) using the COMPSEGS keywords.

```
--       COMPLETION SEGMENT SPECIFICATION DATA
--
-- WELL
-- NAME
COMPSEGS
OP01                                                                                  /
--      --LOCATION--  BRAN  TUBING  NODAL   DIR  LOC    MID    COMP    ISEG
--       II  JJ  K1   NO    LENGTH  DEPTH   PEN  I,J,K  PERFS  LENGTH
         10  10   1    1    2512.5  2525.0                                          /
         10  10   2    1    2525.0  2550.0                                          /
         10  10   3    1    2550.0  2575.0                                          /
         10  10   4    1    2575.0  2600.0                                          /
         10  10   5    1    2600.0  2625.0                                          /
         10  10   6    1    2625.0  2650.0                                          /

          9  10   2    2    2637.5  2837.5                                          /
          8  10   2    2    2837.5  3037.5                                          /
          7  10   2    2    3037.5  3237.5                                          /
          6  10   2    2    3237.5  3437.5                                          /
          5  10   2    2    3437.5  3637.5                                          /
/
--       COMPLETION SEGMENT SPECIFICATION DATA
--
-- WELL
-- NAME
COMPSEGS
OP02                                                                                  /
--      --LOCATION--  BRAN  TUBING  NODAL   DIR  LOC    MID
--       II  JJ  K1   NO    LENGTH  DEPTH   PEN  I,J,K  PERFS
          1   9   3    1    2662.5  2862.5                                          /
          1   8   3    1    2862.5  3062.5                                          /
          1   7   3    1    3062.5  3262.5                                          /
          1   6   3    1    3262.5  3462.5                                          /
          1   5   3    1    3462.5  3662.5                                          /

          2  10   5    2    2712.5  2912.5                                          /
          2  10   5    2    2912.5  3112.5                                          /
          4  10   5    2    3112.5  3312.5                                          /
          5  10   5    2    3312.5  3512.5                                          /
          6  10   5    2    3512.5  3712.5                                          /

          1   9   6    3    2737.5  2937.5                                          /
          1   8   6    3    2937.5  3137.5                                          /
          1   7   6    3    3137.5  3337.5                                          /
          1   6   6    3    3337.5  3537.5                                          /
          1   5   6    3    3537.5  3737.5                                          /
/
```

Note that the COMPDAT keyword in the SCHEDULE section must also be defines for these two wells.

12.3.35 COMPVE – Re-Define Well Connection Depths

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPVE keyword is used to re-define the well connection depths in the global grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.36 COMPVEL – Re-Define Well LGR Connection Depths

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The COMPVEL keyword is used to re-define the well connection depths in a Local Grid Refinement ("LGR") grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.37 CPIFACT – Define Well Connection Transmissibility Multipliers

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The CPIFACT keyword is used to define well connection transmissibility multipliers for well connections to the global grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.38 CPIFACTL – DEFINE WELL CONNECTION TRANSMISSIBILITY MULTIPLIERS IN A LGR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The CPIFACT keyword is used to define well Local Grid Refinement ("LGR") connection transmissibility multipliers for well connections to a LGR, for when the LGR option has been invoked by the LGR keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.39 CSKIN – Re-Define Well Connection Skin Factors

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, CSKIN, is used to re-define a well's connection skin factors and as such will result in the well's connection transmissibility factors being updated accordingly.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.40 DATES – ADVANCE SIMULATION BY REPORTING DATE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword advances the simulation to a given report date after which additional keywords may be entered to instruct OPM Flow to perform additional functions via the SCHEDULE section keywords, or further DATES data sets or keywords may be entered to advance the simulator to the next report date.

If the DATES keyword is to be used during the simulation, then the START keyword in the RUNSPEC section must be declared to set the start date for the run.

No.	Name	Description	Default
1	DAY	A positive integer that defines the day of the month for the data set, the value should be greater than or equal to one and less than or equal to 31.	None
2	MONTH	Character string for the month for the data set and should be one of the following 'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL' (or 'JLY'), 'AUG', 'SEP', 'OCT', 'NOV', or 'DEC'	None
3	YEAR	A positive four digit integer value representing the year for the data set, which must be specified fully by four digits, that is 1986.	None
4	TIME	A numeric character string that defines the time for the data set in the form of: HH;MM:SS:SSSS The default value means in most cases this parameter can be defaulted. TIME is normally used when detailed DST matching is performed to enable the pressures and rates to be stated at specific dates and times.	00:00:00

Notes:

1) The keyword is followed by a number of data sets (or rows) representing one DATE record per row.
2) Each record (or row) is terminated by "/" and the keyword is terminated by a "/".

Table 12.14: DATES Keyword Description

Note that since OPM Flow uses the standard Gregorian calendar and therefore leap years are accounted for in the DATES keyword. Thus, it is more accurate to use the DATES keyword to progress the simulator through time if one is matching actual production data.

See also the TIME and TSTEP keywords in the SCHEDULE section.

Whenever possible it is a good idea to always set the start date to be at the beginning of the year, as like most simulators, OPM Flow reports are always stated at the number of days from the start date (and sometimes at a given date). If the start date is at the beginning of the year, then calculating the actual date is relatively straight forward and simple.

Examples

Given a start date of January 1, 2020 set via the START keyword in the RUNSPEC section, the following example advances the simulator from the start date of January 1, 2020 to January 1, 2021, using quarterly reporting time steps.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE

-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2020-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
          'WELLS=2'    'WELSPECS'    'CPU=2'     FIP=2'                        /

DATES
          2  JAN   2020  /
/

RPTSCHED
          'NOTHING'                                                            /

DATES
          1  APR   2020  /
          1  JLY   2020  /
          1  OCT   2020  /
/
-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2021-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
          'WELLS=2'    'WELSPECS'    'CPU=2'     FIP=2'                        /

DATES
          1  JAN   2021  /
/
RPTSCHED
          'NOTHING'                                                            /

DATES
          1  APR   2021  /
          1  JLY   2021  /
          1  OCT   2021  /
/
```

The above example writes out a series of report at the start of the run and then advances the simulation one day to January 2, 2020 and switches off the reporting. The simulation then advances to April 1, July 1 and October 1, 2020 with no further changes to the run. After October 1, 2020 reporting is switched on again to enable a report on January 1, 2021, which is then subsequently switched off after the January 1, 2021 report time step has been completed.

Note if one wishes to terminate the run at the end of year (as opposes to the beginning of the year and get a final report for the year, then the next example demonstrates the keyword sequence to enable this.

```
-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2021-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
          'WELLS=2'    'WELSPECS'    'CPU=2'     FIP=2'                        /

DATES
          2  JAN   2021  /
/

RPTSCHED
         'NOTHING'                                                            /

DATES
          1  FEB   2021  /
          1  MAR   2021  /
          1  APR   2021  /
          1  MAY   2021  /
          1  JUN   2021  /
          1  JLY   2021  /
          1  AUG   2021  /
          1  SEP   2021  /
          1  OCT   2021  /
          1  NOV   2021  /
          1  DEC   2021  /
/
--
-- FINAL REPORT AND RESTART AT YEAR END
--
RPTSCHED
          'WELLS=2'    'WELSPECS'    'CPU=2'     FIP=2'                        /

RPTRST
          'BASIC=2'                                                            /

DATES
           31 DEC   2021  /
/
```

In the above example monthly reporting time steps have been used instead of quarterly and report is requested after the December 1, 2021 time step and is therefore written out on December 31, 2021.

12.3.41 DCQDEFN – Define Gas DCQ Units as Rate or Energy

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DCQDEFN keyword defines the DCQ units to be rate or energy (calorific value) when using the Gas Field Operation model and the Gas Calorific Value control option. The gas DCQ rates are controlled by the GASYEAR, GASPERIO, GDCQ, GASFTARG or GASFDECR keywords in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.42 DELAYACT - Define Delayed Action Keywords

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The DELAYACT keyword defines a series of keywords that should be executed after an ACTION keyword has been triggered by the ACTION, ACTIONG, ACTIONR, ACTIONW, ACTIONS, or ACTIONX keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.43 DIFFMMF – DEFINE DIFFUSIVITY MULTIPLIERS FOR MATRIX-FRACTURES

This keyword, DIFFMMF, defines the diffusivity multipliers for matrix-fractures for when the Dual Porosity option has be activated by either the DUALPORO or DUALPERM keywords, or the Coal Bed Methane option is selected by the COAL keyword, and the Diffusivity option has been activated by the DIFFUSE keywords; all four keywords are in the RUNSPEC section.

See *DIFFMMF – Define Diffusivity Multipliers for Matrix-Fractures* in the GRID section for a full description.

12.3.44 DIMPES – DEFINE IMPES DYNAMIC SOLUTION PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DIMPES, defines the Implicit in Pressure Explicit Saturation ("IMPES") dynamic solution parameters and results in the simulator switching from the current solution formulation to the IMPES formulation. OPM Flow users a different numerical scheme which makes this keyword redundant; hence, OPM Flow ignores this keyword. It is documented here for completeness.

There is no data required for this keyword.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

Example

```
--
--        ACTIVATE THE IMPES SOLUTION OPTION
--
DIMPES
```

The above example switches on the IMPES solution option; however, this has no effect in OPM Flow input decks.

12.3.45 DIMPLICT – ACTIVATE FULLY IMPLICIT DYNAMIC SOLUTION FORMULATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DIMPLICT, activates the Fully Implicit Formulation and results in the simulator switching from the current solution formulation to the fully implicit formulation. OPM Flow users a different numerical scheme which makes this keyword redundant; hence, OPM Flow ignores this keyword. It is documented here for completeness.

There is no data required for this keyword.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

Example

```
--
--       ACTIVATES THE FULLY IMPLICIT SOLUTION OPTION
--
DIMPLICT
```

The above example switches on the fully implicit solution option; however, this has no effect in OPM Flow input decks.

12.3.46 DRILPRI – Define Prioritized Drilling Queue Priority Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DRILPRI, defines the prioritized drilling queue priority parameters used in the priority formulae for this type of drilling queue.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.47 DRSDT – SOLUTION GAS (RS) MAXIMUM RATE OF INCREASE PARAMETERS

Description

DRSDT defines the maximum rate at which the solution gas-oil ratio (Rs) can be increased in a grid cell. The keyword is similar in functionality to the DRSDTR keyword, that defines the maximum rate at which Rs can be increased in a grid cell by region. Both keywords should only be used if the OIL, GAS, and DISGAS keywords in the RUNSPEC section have been invoked to allow oil, gas and dissolved gas to be present in the model. The keyword only affects the behavior of an increasing Rs, for example when gas is being injected into an oil reservoir, and is subject to the availability of free gas and the ability of the undersaturated oil to adsorb this gas.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DRSDT1	DRSDT1 is a real positive number that defines the maximum rate at which the solution gas-oil ratio is allowed to increase in a grid cell, that is the maximum rate the gas can dissolve into the available undersaturated oil. A value of zero means that Rs cannot increase and free gas cannot dissolve into the unsaturated oil in a grid cell. Alternatively a very large value of DRSDT1 allows Rs to increase rapidly until there is no free gas or the oil within the grid block is fully saturated. Note if the keyword is not present in the input deck then DRSDT1 is assumed to be a very large number resulting in complete re-solution of the gas into the available undersaturated oil.			
		Mscf/stb/day	$sm^3/sm^3/day$	scc/scc/day	None
2	DRSDT2	DRSDT2 is a defined character string that defines whether the DRSDT1 is applied to either all grid blocks or just those grid blocks containing free gas: 1) ALL: means the DRSDT1 maximum rate at which Rs is allowed to increase in a grid cell is applied to all grid blocks. 2) FREE: means the DRSDT1 maximum rate at which Rs is allowed to increase in a grid cell is applied to grid blocks only containing free gas. Note if the keyword is not present in the input deck then DRSDT2 is set to the default value of ALL.			ALL

Notes:

1) The keyword is terminated by "/".

Table 12.15: DRSDT Keyword Description

Note this keyword can be used in history matching field performance to control the availability of the movable gas phase.

See also the VAPPAR keyword in the SOLUTION section and the DRSDTR, DRVDT and DRVDTR keywords in the SCHEDULE section that controls how vaporized oil is treated and the rate at which the dissolved phase ratio increases within a grid block.

Examples

The first example prevents the solution gas-oil ratio from increasing and applies this to all grid cells.

```
--
--       SOLUTION GAS (RS) MAXIMUM RATE OF INCREASE FOR MODEL
--
DRSDT
--       MAX RS    ALL/FREE
--       DRSDT1    DRSDT2
--       -------   --------
         0.000     ALL                                    /
```

And the second example below applies 0.005 Mscf/stb/day as the maximum rate at which the solution gas-oil ratio is allowed to increase in a grid cell, and applies this to only cells containing free gas.

```
--
--       SOLUTION GAS (RS) MAXIMUM RATE OF INCREASE FOR MODEL
--
DRSDT
--       MAX RS    ALL/FREE
--       DRSDT1    DRSDT2
--       -------   --------
         0.0005    FREE                                   /
```

Again, the keyword parameters when applied are subject to the availability of free gas and the ability of the undersaturated oil to adsorb this gas.

12.3.48 DRSDTR – SOLUTION GAS (RS) MAXIMUM RATE OF INCREASE PARAMETERS BY REGION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DRSDTR defines the maximum rate at which the solution gas-oil ratio (Rs) can be increased in a grid cell for various regions in the model. The keyword is similar in functionality to the DRSDT keyword, that defines the maximum rate at which Rs can be increased in a grid cell for all cells in the model. The number of DRSDTR vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the DRSDTR records to different grid blocks in the model is done via the PVTNUM keyword in the REGION section. One data set consists of one record or line which is terminated by a "/".

DRSDTR should only be used if the OIL, GAS, and DISGAS keywords in the RUNSPEC section have been invoked to allow oil, gas and dissolved gas to be present in the model. The keyword only affects the behavior of an increasing Rs, for example when gas is being injected into an oil reservoir, and is subject to the availability of free gas and the ability of the undersaturated oil to adsorb this gas.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DRSDT1	DRSDT1 is a real positive number that defines the maximum rate at which the solution gas-oil ratio is allowed to increase in a grid cell, that is the maximum rate the gas can dissolve into the available undersaturated oil. A value of zero means that Rs cannot increase and free gas cannot dissolve into the unsaturated oil in a grid cell. Alternatively a very large value of DRSDT1 allows Rs to increase rapidly until there is no free gas or the oil within the grid block is fully saturated. Note if the keyword is not present in the input deck then DRSDT1 is assumed to be a very large number resulting in complete re-solution of the gas into the available undersaturated oil.			
		Mscf/stb/day	$sm^3/sm^3/day$	scc/scc/day	None
2	DRSDT2	DRSDT2 is a defined character string that defines whether the DRSDT1 is applied to either all grid blocks or just those grid blocks containing free gas: 1) ALL: means the DRSDT1 maximum rate at which Rs is allowed to increase in a grid cell is applied to all grid blocks. 2) FREE: means the DRSDT1 maximum rate at which Rs is allowed to increase in a grid cell is applied to grid blocks only containing free gas. Note if the keyword is not present in the input deck then DRSDT2 is set to the default value of ALL.			ALL

Notes:

1) The keyword is followed by NTPVT records as declared on the TABDIMS keyword in the RUNSPEC section.
1) Each record is terminated by "/" and there is no "/" terminator for the keyword.

Table 12.16: DRSDTR Keyword Description

Note this keyword can be used in history matching field performance to control the availability of the movable gas phase.

See also the VAPPAR keyword in the SOLUTION section and the DRSDT, DRVDT and DRVDTR keywords in the SCHEDULE section that controls how vaporized oil is treated and the rate at which the dissolved phase ratio increases within a grid block.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness, as it is expected to be available in the next release of OPM Flow.

Examples

The first example prevents the solution gas-oil ratio from increasing and applies this to all regions for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to three.

```
--
--       SOLUTION GAS (RS) MAXIMUM RATE OF INCREASE BY REGION
--
DRSDTR
--       MAX RS    ALL/FREE
--       DRSDT1    DRSDT2
--       -------   --------
         0.0000    ALL                                    /
         0.0000    ALL                                    /
         0.0000    ALL                                    /
```

The second example below prevents the solution gas-oil ratio from increasing and applies this to all grid cells in PVTNUM region one. For PVTNUM regions one and two the keyword applies 0.005 Mscf/stb/day as the maximum rate at which the solution gas-oil ratio is allowed to increase in a grid cell, and applies this to only cells containing free gas.

```
--
--       SOLUTION GAS (RS) MAXIMUM RATE OF INCREASE BY REGION
--
DRSDTR
--       MAX RS    ALL/FREE
--       DRSDT1    DRSDT2
--       -------   --------
         0.0000    ALL                                    /
         0.0005    FREE                                   /
         0.0005    FREE                                   /
```

Again, the keyword parameters when applied are subject to the availability of free gas and the ability of the undersaturated oil to adsorb this gas.

12.3.49 DRVDT – SOLUTION OIL (RV) MAXIMUM RATE OF INCREASE PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DRVDT defines the maximum rate at which the solution oil-gas ratio or condensate-gas ratio (Rv) can be increased in a grid cell. The keyword is similar in functionality to the DRVDTR keyword, that defines the maximum rate at which Rv can be increased in a grid cell by region. Both keywords should only be used if the OIL, GAS, and VAPOIL (condensate) keywords in the RUNSPEC section have been invoked to allow oil, gas and condensate to be present in the model. The keyword only affects the behavior of an increasing Rv, for example when gas is being injected into a gas condensate reservoir as part of as gas re-cycling scheme, and is subject to the availability of free oil (condensate) and the ability of the undersaturated gas to adsorb this condensate.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DRVDT1	DRVDT1 is a real positive number that defines the maximum rate at which the solution oil-gas ratio is allowed to increase in a grid cell, that is the maximum rate at which the oil can dissolve into the available undersaturated gas. A value of zero means that Rv cannot increase and free oil cannot dissolve into the unsaturated gas in a grid cell. Alternatively a very large value of DRVDT1 allows Rv to increase rapidly until there is no free oil or the gas within the grid block is fully saturated. Note if the keyword is not present in the input deck then DRVDT1 is assumed to be a very large number resulting in complete re-solution of the oil into the available undersaturated gas.			
		stb/Mscf/day	$sm^3/sm^3/day$	scc/scc/day	None

Notes:

1) The keyword is terminated by "/".

Table 12.17: DRVDT Keyword Description

Note this keyword can be used in history matching field performance to control the availability of the movable gas phase.

See also the VAPPARS keyword in the SOLUTION section and the DRVDTR, DRSDT and DRSDTR keywords in the SCHEDULE section that controls how vaporized oil is treated and the rate at which the dissolved phase ratio increases within a grid block.

Example

The example prevents the solution oil-gas ratio from increasing.

```
--
--        SOLUTION OIL (RV) MAXIMUM RATE OF INCREASE FOR MODEL
--
DRVDT
--        MAX RV
--        DRVDT1
--        -------
          0.000                                                /
```

Again, the keyword parameters when applied are subject to the availability of free oil and the ability of the undersaturated gas to adsorb this oil.

12.3.50 DRVDTR – SOLUTION OIL (RV) MAXIMUM RATE OF INCREASE PARAMETERS BY REGION

Description

DRVDTR defines the maximum rate at which the solution oil-gas ratio or condensate-gas ratio (Rv) can be increased in a grid cell for various regions in the model. The keyword is similar in functionality to the DRVDT keyword, that defines the maximum rate at which Rv can be increased in a grid cell for all cells in the model. The number of DRVDTR vector data sets is defined by the NTPVT parameter on the TABDIMS keyword in the RUNSPEC section and the allocation of the DRVDTR records to different grid blocks in the model is done via the PVTNUM keyword in the REGION section. One data set consists of one record or line which is terminated by a "/".

This keyword should only be used if the OIL, GAS, and VAPOIL (condensate) keywords in the RUNSPEC section have been invoked to allow oil, gas and condensate to be present in the model. The keyword only affects the behavior of an increasing Rv, for example when gas is being injected into a gas condensate reservoir as part of as gas re-cycling scheme, and is subject to the availability of free oil (condensate) and the ability of the undersaturated gas to adsorb this condensate.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	DRVDT1	DRVDT1 is a real positive number that defines the maximum rate at which the solution oil-gas ratio is allowed to increase in a grid cell, that is the maximum rate at which the oil can dissolve into the available undersaturated gas. A value of zero means that Rv cannot increase and free oil cannot dissolve into the unsaturated gas in a grid cell. Alternatively a very large value of DRVDT1 allows Rv to increase rapidly until there is no free oil or the gas within the grid block is fully saturated. Note if the keyword is not present in the input deck then DRVDT1 is assumed to be a very large number resulting in complete re-solution of the oil into the available undersaturated gas.			
		stb/Mscf/day	sm^3/sm^3/day	scc/scc/day	None

Notes:

1) The keyword is followed by NTPVT records as declared on the TABDIMS keyword in the RUNSPEC section.
1) Each record is terminated by "/" and there is no "/" terminator for the keyword.

Table 12.18: DRVDTR Keyword Description

Note this keyword can be used in history matching field performance to control the availability of the movable gas phase.

See also the VAPPARS keyword in the SOLUTION section and DRVD, DRSDT, and DRSDTR keywords in the SCHEDULE section that controls how vaporized oil is treated and the rate at which the dissolved phase ratio increases within a grid block.

Examples

The first example prevents the solution oil-gas ratio from increasing and applies this to all regions for when NTPVT on the TABDIMS keyword in the RUNSPEC section is set to three.

```
--
--        SOLUTION OIL (RV) MAXIMUM RATE OF INCREASE PARAMETERS BY REGION
--
DRVDTR
--        MAX RV
--        DRVDT1
--        -------          -
          0.000                                          /
          0.000                                          /
          0.000                                          /
```

The second example below prevents the solution oil-gas ratio from increasing and applies this to all grid cells in PVTNUM region one. For PVTNUM regions one and two the keyword applies 0.005 stb//Mscf/day as the maximum rate at which the solution oil-gas ratio is allowed to increase in a grid cell,

```
--
--        SOLUTION OIL (RV) MAXIMUM RATE OF INCREASE PARAMETERS BY REGION
--
DRVDTR
--        MAX RV
--        DRVDT1
--        -------
          0.0000                                         /
          0.0005                                         /
          0.0005                                         /
```

Again, the keyword parameters when applied are subject to the availability of free oil and the ability of the undersaturated gas to adsorb this oil.

12.3.51 DUMPCUPL – Activate Output to the Reservoir Coupling File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, DUMPCUPL, activates output to the Reservoir Coupling file from the reservoir coupling file in the master run for when reservoir coupling is invoked by the GRUPMAST and SLAVES keywords in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.52 DYNAMICR – DEFINE DYNAMIC REGION PARAMETERS

The DYNAMICR keyword marks the start of a Dynamic Region section and defines the parameters used for Dynamic Regions that allows for property and reporting regions to vary as the run progresses, based on the parameters and logic defined by this keyword and section. A Dynamic Region section is terminated by the ENDDYN keyword in the SOLUTION or SCHEDULE sections.

See *DYNAMICR – Start of Dynamic Region Parameter Definition* in the SOLUTION section for a full description.

12.3.53 ENDACTIO – END THE DEFINITION OF ACTION COMMANDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

The ENDACTIO keyword defines the end of a series of conditions that invoke run time processing of the ACTION series of keywords, namely: ACTION, ACTIONG, ACTIONR, ACTIONS, ACTIONW and ACTIONX. Only the ACTIONX keyword is implemented in OPM Flow as this keyword implements the ACTION, ACTIONG, ACTIONR, ACTIONS, ACTIONW functionality with greater flexibility. See the ACTIONX keyword in the SCHEDULE section for a full description of the ACTION facility.

There is no data required for this keyword and there is no terminating "/" for this keyword.

Example

The example shows the use of the ACTIONX and ENDACTIO keywords to test if the field's gas production rate is less than 600 MMscf/d after 2020 and to open up additional wells if this occurs.

```
--
-- START OF ACTIONX FIELD PHASE-2 DEVELOPMENT DEFINITION
--
ACTIONX
     PHASE2       1               /
     GGPR  'FIELD' < 600E3 AND    /
     YEAR > 2020                  /
/
-- WELL PRODUCTION STATUS
--
--  WELL    WELL   --LOCATION--  COMPLETION
--  NAME    STAT     I   J    K  FIRST LAST
WELOPEN
GP10        OPEN                          /
GP11        OPEN                          /
/
--
-- END OF ACTIONX FIELD PHASE-2 DEVELOPMENT DEFINITION
--
ENDACTIO
```

12.3.54 ENDBOX – DEFINE THE END OF THE BOX DEFINED GRID

This keyword marks the end of a previously defined BOX sub-grid as defined by a previously entered BOX keyword. The keyword resets the input grid to be the full grid as defined by the NX, NY, and NZ variables on the DIMENS keyword in the RUNSPEC section.

See *ENDBOX – Define the End of the BOX Defined Grid* in the GRID section for a full description.

12.3.55 ENDDYN– END OF DYNAMIC REGION PARAMETER DEFINITION

The ENDDYN keyword marks the end of a Dynamic Region section that was started with the DYNAMICR keyword in the SOLUTION or SCHEDULE sections. Dynamic Regions allow for property and reporting regions to vary as the run progresses, based on the parameters and logic defined within the section.

See *ENDDYN– End of Dynamic Region Parameter Definition* in the SOLUTION for a full description.

12.3.56 ENDFIN – END THE DEFINITION OF A LOCAL GRID REFINEMENT

ENDFIN defines the end of a Cartesian or radial local grid refinement ("LGR") definition and a LGR property definition data set.

See *ENDFIN – End the Definition of a Local Grid Refinement* in the GRID section for a full description.

12.3.57 EPSDBGS – WRITE END-POINT DEBUG DATA TO THE DEBUG FILE (MULTIPLE)

This keyword, EPSDBGS, defines the end-point debug data for multiple grid blocks that should be written to the DEBUG file (*.DBG) for when the End-Point Scaling option has been activated by the ENDSCALE keyword in the RONSPEC section.

See *EPSDBGS - Write End-Point Debug Data to the DEBUG File (Multiple)* in the PROPS section for afull description.

12.3.58 EPSDEBUG - WRITE END-POINT DEBUG DATA TO THE DEBUG FILE (INDIVIDUAL)

This keyword, EPSDEBUG, defines the end-point debug data for individual grid blocks that should be written to the DEBUG file (*.DBG) for when the End-Point Scaling option has been activated by the ENDSCALE keyword in the RONSPEC section.

See *EPSDEBUG - Write End-Point Debug Data to the DEBUG File (Individual)*n the PROPS section for afull description.

12.3.59 EXCAVATE - Set the Status of a Grid Block To Active or Excavate

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, EXCAVATE, sets the status of global and LGR grid blocks to active or excavate. Excavated grid blocks have all the transmissibilities set to zero thus disabling flow between the surrounding grid blocks.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.60 EXIT – EXIT SIMULATION FROM WITHIN AN ACTION SECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The EXIT keyword is part of OPM Flow's ACTION facility that allows for terminating the simulation for when a condition within an ACTIONX definition is satisfied. Invoking the keyword within an ACTIONX definition will result in the simulation terminating with an exit status code. The ACTION facility allows the user to enter computational logic to the simulation run based on the how the simulation run is proceeding – see the ACTIONX keyword in the SCHEDULE section.

Note

This is an OPM Flow specific keyword for the simulator's ACTION facility and will therefore cause an error if used in the commercial simulator.

No.	Name	Description	Default
1	EXITCODE	An optional integer that sets the exit code printed to the *.PRT file, if not not defined the default value of zero will be used.	0
Notes: 1) The keyword is terminated by "/".			

Table 12.19: EXIT Keyword Description

The EXIT keyword should only be used as part of an ACTIONX block, if found elsewhere in the input deck it will be ignored.

Examples

The first example users the ACTIONX keyword to define a condition for when the Field Oil Production Rate ("FOPR) falls below 1,000 stb/d (or 1,000 m^3) using the default value for the EXITCODE.

```
--
--        DEFINE START OF ACTIONX SECTION
--
ACTIONX
          'CHECK_FOPR' 100000            /
          FOPR < 1000                    /
/
--
--        TERMINATE AND EXIT SIMULATION
--
EXIT
                                         /

ENDACTIO
```

The next example terminates the simulation with EXITCODE one when the Field Pressure ("FPR") falls below 200 psia (or 200 barsa).

```
--
--       DEFINE START OF ACTIONX SECTION
--
ACTIONX
         'CHECK_FPR'  100000             /
          FPR < 200                      /
/
--
--       TERMINATE AND EXIT SIMULATION
--
EXIT
         1                               /

ENDACTIO
```

Note is is probably good practice to always set the EXITCODE to be able to identify the reason for the simulation stopping.

12.3.61 FBHPDEF – DEFINE WELL DEFAULT BHP TARGET AND CONSTRAINTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, FBHPDEF, defines the default well BHP target for production wells and the default BHP constraint for injection wells.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.62 FILEUNIT – ACTIVATE UNIT CONSISTENCY VERIFICATION

The FILEUNIT keyword defines the units of the of the data set, and is used to verify that the units in the input deck and any associated include files are consistent grid data. The keyword does not provide for the conversion between different sets of units.

See *FILEUNIT – Activate Unit Consistency Checking* in the GRID section for a full description.

12.3.63 GASBEGIN – DEFINE START OF ANNUAL SCHEDULING SECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GASBEGIN, defines the start of an Annual Scheduling section set of keywords used when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section. An Annual Scheduling section starts with the GASBEGIN keyword and is terminated by the GASEND keyword, with keywords in between used to control and write reports at selected times between the start and end of a contract period. Only one Annual Scheduling section is activate at a time, that is, a subsequent Annual Scheduling section overwrites the previous set of entries. To clear the current Annual Schedule section enter the GASBEGIN keyword followed by the GASEND keyword word with no other keywords in between.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.64 GASEND – DEFINE END OF ANNUAL SCHEDULING SECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GASEND, defines the end of an Annual Scheduling section set of keywords used when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section. An Annual Scheduling section starts with the GASBEGIN keyword and is terminated by the GASEND keyword, with keywords in between used to control and write reports at selected times between the start and end of a contract period. Only one Annual Scheduling section is activate at a time, that is, a subsequent Annual Scheduling section overwrites the previous set of entries. To clear the current Annual Schedule section enter the GASBEGIN keyword followed by the GASEND keyword word with no other keywords in between.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.65 GASFCOMP – DEFINE AUTOMATIC GAS COMPRESSORS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GASFCOMP, defines automatic gas compressors for when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section and the Standard Network option has been specified by the GRUPTREE, GRUPNET and GNETINJE series of keywords in the SCHEDULE section. Automatic gas compressors are automatically switch on for a group if a group's gas production target cannot be satisfied. In addition, if a group's gas target is reduced then the automatic compressors are initially switch off to test that the reduced gas rate target can be met without compression, if not, compression is switched back on. Note that all automatic compressors are "switch on" when calculating a field's gas deliverability.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.66 GASFDECR – DEFINE FIELD GAS SALES CONTRACT MONTHLY REDUCTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GASFDECR, defines the field's monthly reduction in the gas sales contract quantity for when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section. Gas contracts are commonly based on a Daily Contract Quantity ("DCQ") that determines the gas rate that the field should be produced at, which is normally expressed as a multiple of the DCQ, for example 1.33, and is often referred to as the "swing factor". Some gas contracts also define a maximum DCQ ("Max DCQ") and/or a minimum take or pay DCQ ("Min DCQ"), as well as seasonal demand characteristics. For example, gas rates may be set higher in the winter months in order to meet heating demand compared with summer months in colder climates, and the opposite in warmer climates where air conditioning demand is high.

Thus, the DCQ must be calculated first over a contract period, where the contract period is commonly contract years, or in some instances contract quarters. This is performed by the simulator using the current DCQ and checking to see if the (DCQ x Swing Factor) can be satisfied throughout the current contract period, if not the DCQ is re-calculated so that the (DCQ x Swing Factor) condition is satisfied. Once this condition is met, the second and final pass uses the calculated DCQ in conjunction with the monthly scaling profile data to set the monthly gas rate for the field:

$$Q_{month} = DCQ \times SWINGFAC_{month} \tag{12.13}$$

Where:

Q_{month} = the monthly gas production target
DCQ = Daily Contract Quantity
$SWINGFAC_{month}$ = monthly rate scaling factor that takes into account seasonal demand, etc.

Here the GASFDECR keyword allows for a reduction in the calculated final pass monthly gas rates and thus equation (12.13) become:

$$Q_{month} = \left(DCQ \times SWINGFAC_{month}\right) - GASFDECR_{month} \tag{12.14}$$

Where:

Q_{month} = the monthly gas production target
DCQ = Daily Contract Quantity
$SWINGFAC_{month}$ = monthly rate scaling factor that takes into account seasonal demand, etc.
$GASFDECR_{month}$ = monthly gas rate reduction.

Since the simulator must make two passes to calculate the final rates this will naturally decrease computational efficiency.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.67 GASFDELC – DEFINE GAS DELIVERABILITY CALCULATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GASFDELC keyword defines how the field's gas deliverability calculation should be performed for when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.68 GASFTARG – DEFINE FIELD GAS SALES CONTRACT MONTHLY TARGET

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GASFTARG, defines the field's monthly gas sales contract quantity for when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section. Gas contracts are commonly based on a Daily Contract Quantity ("DCQ") that determines the gas rate that the field should be produced at, which is normally expressed as a multiple of the DCQ, for example 1.33, and is often referred to as the "swing factor". Some gas contracts also define a maximum DCQ ("Max DCQ") and/or a minimum take or pay DCQ ("Min DCQ"), as well as seasonal demand characteristics. For example, gas rates may be set higher in the winter months in order to meet heating demand compared with summer months in colder climates, and the opposite in warmer climates where air conditioning demand is high.

Thus, the DCQ must be calculated first over a contract period, where the contract period is commonly contract years, or in some instances contract quarters. This is performed by the simulator using the current DCQ and checking to see if the (DCQ x Swing Factor) can be satisfied throughout the current contract period, if not the DCQ is re-calculated so that the (DCQ x Swing Factor) condition is satisfied. Once this condition is met, the second and final pass uses the calculated DCQ in conjunction with the monthly scaling profile data to set the monthly gas rate for the field:

$$Q_{month} = DCQ \times SWINGFAC_{month} \tag{12.15}$$

Where:

Q_{month} = the monthly gas production target
DCQ = Daily Contract Quantity
$SWINGFAC_{month}$ = monthly rate scaling factor that takes into account seasonal demand, etc.

Here the GASFTARG keyword sets a minimum target rate in the calculated final pass monthly gas rates and thus equation (12.15) become:

$$Q_{month} = Minimum\left(\left(DCQ \times SWINGFAC_{month}\right),\ GASFTARG_{month}\right) \tag{12.16}$$

Where:

Q_{month} = the monthly gas production target
DCQ = Daily Contract Quantity
$SWINGFAC_{month}$ = monthly rate scaling factor that takes into account seasonal demand, etc.
$GASFTARG_{month}$ = minimum monthly gas rate target.

Since the simulator must make two passes to calculate the final rates this will naturally decrease computational efficiency.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.69 GASMONTH – Define Start of Annual Scheduling Event

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GASMONTH, states the month for which subsequent scheduling events take place within an Annual Schedule section for when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section. The keyword must lie in between the GASBEGIN, that defines the start of an Annual Scheduling section and the GASEND keyword that ends the section. Optionally, the keyword can be used to write a report to the print file (*.PRT) at the requested month.

See also the GASBEGIN and GASEND keywords in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.70 GASPERIO – ADVANCE SIMULATION BY GAS CONTRACT PERIOD

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword advances the simulation over one or more gas contract periods for when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section. A contract period in this case is the period over which the Daily Contract Quantity is fixed, this can a be year or one or more months. If the contract period is a year then the GASYEAR keyword in the SCHEDULE section can be used instead of GASPERIOD.

GASPERIO is an alternative to the DATES, TIME and TSTEP keywords in the SCHEDULE section that advances the simulation to a given report time after which additional keywords may be entered to instruct OPM Flow to perform additional functions via the SCHEDULE section keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.71 GASYEAR – ADVANCE SIMULATION BY GAS CONTRACT YEAR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword advances the simulation over one or more gas contract years for when the Gas Field Operations option has been activated by the GASFIELD keyword in the RUNSPEC section. A contract year in this case is the period over which the Daily Contract Quantity is fixed, this can a be year, this keyword or the GASPERIO keyword in the SCHEDULE section, or one or more months. If the contract period is over one or more months then the GASPERIO keyword in the SCHEDULE section can be used instead of GASYEAR.

GASYEAR is an alternative to the DATES, TIME and TSTEP keywords in the SCHEDULE section that advances the simulation to a given report time after which additional keywords may be entered to instruct OPM Flow to perform additional functions via the SCHEDULE section keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.72 GCALECON – GROUP ECONOMIC CRITERIA FOR PRODUCTION CALORIFIC GROUPS

Description

The GCALECON keyword defines economic criteria for production groups, including the field level group FIELD, that have previously been defined by the GCONPROD keyword in the SCHEDULE section and have had their rate targets and constraints set by calorific value via the GCONVAL keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note that wells are allocated to a group when they are specified by the WELSPECS keyword and wells can also have economic controls. Wells under group control are therefore subject to the economic criteria set via the GCONPROD and CECON keywords in the SCHEDULE section and the controls specified by the WECON keyword.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group target and constraints are being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	ENEVAL	A real positive value that defines the minimum economic surface energy production rate, below which an economic action of shutting in or stopping all the wells in the group, as requested by item (9) of the WELSPECS keyword. A value less than or equal to zero switches of this criteria.			
		BTU/day	kJ/day	J/hour	0.0
3	CALVAL	A real positive value that defines the minimum economic surface calorific value, below which an economic action of shutting in or stopping all the wells in the group, as requested by item (9) of the WELSPECS keyword. A value less than or equal to zero switches of this criteria,			
		Btu/Mscf	kJ/sm^3	J/hour	0.0
8	END	A defined character string that defines if the simulation should terminate if all the producing wells in the group, including the FIELD group, are shut or stopped. END should be set to one of the following character strings: 1) NO: no action is taken and the run continues. 2) YES: terminate the run at the next report time step.			NO

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.20: GCALECON Keyword Description

See also the WELSPECS keyword to define a wells shut-in or stop options, GCONPROD, GCONCAL,

GCONENG for group controls, and WECON for setting a well's economic criteria. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the economic criteria for the field with a minimum economic surface energy production rate of 5 x 10^9 BTU/day and a minimum economic surface calorific value of900 Btu/Mscf

```
--
--       GROUP ECONOMIC CRITERIA FOR PRODUCTION GROUPS UNDER CALORIFIC CONTROL
--
-- GRUP  ENERGY  CALORIFIC  END
-- NAME  RATE    VALUE      RUN
GCALECON
FIELD    5E9     900.0     'YES'                                                /
/
```

If the economic limits are violated then the run will stop at the next report time step.

12.3.73 GCONCAL – GROUP PRODUCTION CALORIFIC TARGETS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GCONCAL keyword defines calorific production targets and constraints for groups, including the top most group in the group hierarchy known as the FIELD group. Wells are allocated to groups when the wells are specified by the WELSPECS keyword in the SCHEDULE section. Wells defined to be under group control will have their production rates controlled by the group to which they belong, in addition to any well constraints defined for the wells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group's target calorific value is being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	CALVAL	A real positive value that defines the target surface calorific value of the produced gas. The default value of 1×10^{20} switches off calorific control for the group.			
		Btu/Mscf	kJ/sm^3	J/hour	1.0×10^{20}
3	ACTION	A defined character string that defines the action to be taken if the CALVAL is violated. ACTION should be set to one of the following character strings: 1) NONE: no action is taken and the group's produced calorific value will therefore no longer meet CALVAL. 2) RATE: scale back the gas rate of various wells under the group by the value of FACTOR until the calorific target (CALVAL) is satisfied. The corrective action takes places at the end of the time step in which the constraint is violated.			None
4	FACTOR	A real positive value that is less than or equal to one that defines the amount wells can be scaled back in order to satisfy CALVAL. Note this assumes that there are wells within the group that are producing with higher and lower calorific values, and the simulator is thus able to fine a combination of wells that satisfy the group's CALVAL target.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.21: GCONCAL Keyword Description

See also the GRUPTREE keyword to define the hierarchy of the groups below the FIELD level, the GCONPROD and GCONINJ keywords to define a group's production and injection rate targets and constraints, the WCONPROD keyword to define a production well's targets and constraints, and the WCONINEJ keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the calorific production target for the field.

```
---
--       GROUP CALORIFIC PRODUCTION CONTROLS
--
-- GRUP  CALORIFIC  ACTION  CUT
-- NAME  VALUE              BACK
GCONCAL
FIELD    1010E3     RATE    0.95                                        /
/
```

Here the calorific production target has been set to 1,010 x 10^3 Btu/Mscf for the field and if the target cannot be met then the well rates are reduced by 0.95 at each iteration until the target is satisfied.

12.3.74 GCONENG – GROUP PRODUCTION ENERGY TARGETS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GCONCAL keyword defines energy production targets and constraints for groups, including the top most group in the group hierarchy known as the FIELD group. Wells are allocated to groups when the wells are specified by the WELSPECS keyword in the SCHEDULE section. Wells defined to be under group control will have their production rates controlled by the group to which they belong, in addition to any well constraints defined for the wells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group's target calorific value is being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	ENGVAL	A real positive value that defines the surface energy target for the group. The default value of 1×10^{20} switches off the energy target for the group.			
		BTU/day	kJ/day	J/hour	1.0×10^{20}

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.22: GCONENG Keyword Description

See also the GRUPTREE keyword to define the hierarchy of the groups below the FIELD level, the GCONPROD and GCONINJ keywords to define a group's production and injection rate targets and constraints, the WCONPROD keyword to define a production well's targets and constraints, and the WCONINEJ keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the energy production target for the field.

```
--
--        GROUP ENERGY PRODUCTION CONTROLS
--
-- GRUP   ENERGY
-- NAME   VALUE
GCONENG
FIELD     1010E9                                                    /
/
```

Here the energy production target has been set to $1{,}010 \times 10^9$ Btu/day for the field.

12.3.75 GCONINJE – GROUP INJECTION TARGETS AND CONSTRAINTS

Description

The GCONINJE keyword defines injection targets and constraints for groups, including the top most group in the group hierarchy known as the FIELD group. Wells are allocated to groups when the wells are specified by the WELSPECS keyword in the SCHEDULE section. Wells defined to be under group control will have their injection rates controlled by the group to which they belong, in addition to any well constraints defined for the wells.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group target and constraints are being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the whole field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	TYPE	A defined character string that defines the type of injection fluid. TYPE should be set to one of the following character strings: 1) GAS: for a gas injection well. 2) OIL: for a water injection well. 3) WAT: for a water injection well.			None
3	TARGET	A defined character string that sets the target injection control for the group, all the other phases will therefore act as constraints. The simulator will attempt to meet the TARGET based on the phase rate stated in items (4) to (7) on this keyword. TARGET should be set to one of the following character strings: 1) NONE: the group has no target phase, but if entered, constraints are still defined and active. 2) FLD: this group is controlled from a higher level group, including the FIELD group. 3) RATE: the injection phase will be control by the surface fluid rate for the phase defined by the TYPE variable. For example, if TYPE has been set to WAT then this would mean the water injection rate as defined by item (4). 4) RESV: the target is set to the in situ reservoir volume rate as defined by item (5). 5) REIN: the target is set to groups production of the phase defined by TYPE multiplied by the value on item (6). For example, if TYPE has been set to WAT then this would mean the groups water production multiplied by item (6). 6) VREP: the target is set to the groups voidage replacement ratio as defined by item (7).			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
4	RATE	A real positive value that defines the maximum surface injection rate target or constraint for the phase declared by the TYPE variable/			
		Liquid stb/d Gas Mscf/d	Liquid sm^3/day Gas sm^3/day	Liquid scc/hour Gas scc/hour	None
5	RESV	A real positive value that defines the maximum reservoir volume injection rate target or constraint.			
		rtb/d	rm^3/day	rcc/hour	None
6	REIN	A real positive value that defines the target or constraint re-injection fraction for the produced phase defined by the TYPE variable. For example, if TYPE is equal to GAS and REINJ is equal to 0.85, then 85% of the produced gas will be re-injected.			
		dimensionless	dimensionless	dimensionless	None
7	VREP	A real positive value that defines the target or constraint of the voidage replacement ratio based on all the produced fluids. For example, if TYPE is equal to WAT and VREP is equal to 1.00, then 100% of the produced reservoir volume will be re-inject as an equivalent water volume.			
		dimensionless	dimensionless	dimensionless	None
8	GRPCNTL	A defined character string that determines if this group is subject to higher level group control. 1) YES: then this group is subject to a higher level group's control and the flow rates for this group will be adjusted accordingly. 2) NO: then this group is NOT subject to a higher level group's control and the flow rates for this group will only be control by the parameters for this group. This variable is ignored if GRPNAME is equal to FIELD. This option is currently not supported by OPM Flow.			YES
9	GRPGUIDE	A real positive value that defines a group's injection guide rate expressed as a dimensionless number. A group requires a value for GRPGUIDE only if it is required to produce a specified proportion of a higher level group's rate This feature is not supported by OPM Flow and should be defaulted with 1*.			
		dimensionless	dimensionless	dimensionless	None
10	GUIPHASE	A defined character string that sets the guide phase to which the guide rate in item (9) applies. GUIPHASE should be set to one of the following character strings: 1) RATE: the guide phase is set to the surface injection rate. 2) RESV: the guide phase is set to the in situ reservoir volume rate. 3) VOID: the guide rate is calculated at the beginning of each time step based on the group's net voidage rate. This feature is not supported by OPM Flow and should be defaulted with 1*.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
11	GRPREIN	A character string of up to eight characters in length that defines the group name whose production rate should be used for applying the REIN quantity to be injected into GRPNAME. This variable is used to re-inject the REIN production faction from another group (GRPREIN) via this group (GRPNAME). If GRPREIN is defaulted then the re-injection quantity for GRPNAME will be based on the production from GRPNAME.			GRPNAME
12	GRPVREP	A character string of up to eight characters in length that defines the group name whose production rate should be used for applying the VREP quantity to be injected into GRPNAME. This variable is used to re-inject the VREP production faction from another group (GRPVREP) via this group (GRPNAME). If GRPVREP is defaulted then the voidage quantity for GRPNAME will be based on the production from GRPNAME.			GRPNAME
13		Not used should be defaulted with 1*.			

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.23: GCONINJE Keyword Description

See also the GRUPTREE keyword to define the hierarchy of the groups below the FIELD level, the GCONPROD keyword to define a group's production targets and constraints, the WCONPROD keyword to define a production well's targets and constraints, and the WCONINJE keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the injection targets and constraints for the field and two groups that are one level below the field group, since the GRUPTREE keyword has not been entered to define the group hierarchy.

```
--
--        GROUP INJECTION TARGETS AND CONSTRAINTS
--
-- GRUP   FLUID CNTL   SURF   RESV   REINJ  VOID  GRUP  GUIDE  GUIDE GRUP  GRUP
-- NAME   TYPE  MODE   RATE   RATE   FRAC   FRAC  CNTL  RATE   DEF   REINJ RESV
GCONINJE
FIELD     WAT   VREP   35E3   1*     1*     1*     NO   1*     1*    1*    1*   /
GRP01     WAT   VREP   1*     1*     1*     1.0    YES  1*     1*    1*    1*   /
GRPO2     WAT   VREP   1*     1*     1*     1.0    YES  1*     1*    1*    1*   /
/
```

In this example, group GRP01 and GRP02 are injecting water via voidage replacement with a voidage replacement of one and are under the control on the field group, that imposes a 35,000 m^3/day total water injection limit.

12.3.76 GCONPRI – GROUP PRODUCTION PRIORITY TARGETS AND CONSTRAINTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GCONPRI keyword defines production targets and constraints for groups, including the top most group in the group hierarchy known as the FIELD group, for when groups and their associated wells are operating under priority control as oppose to guide rate control. Priority control is activated by the PRIORITY keyword in the SCHEDULE section. Wells are allocated to groups when the wells are specified by the WELSPECS keyword in the SCHEDULE section. Wells defined to be under group control will have their production rates controlled by the group to which they belong, in addition to any well constraints defined for the wells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group target and constraints are being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	ORAT	A real positive value that defines the maximum surface oil production rate constraint.			None
		stb/d	sm^3/day	scc/hour	
3	OILACT	A defined character string that defines the action to be taken if ORAT is exceeded. OILACT should be set to one of the following character strings: 1) NONE: no action is taken. 2) CON: close the worst offending connection in the worst offending well. If connections have been grouped as completions then the worst offending completion in the worst offending well will be closed. 3) +CON: close the worst offending connection and all below it in the worst offending well. If connections have been grouped as completions then the worst offending completion and all below it in the worst offending well will be closed. 4) WELL: close the worst offending well. 5) PLUG: plug back the worst offending well based on the plug back length and options defined on the WPLUG keyword in the SCHEDULE. 6) PRI: control the group production rate using the first priority formulae defined by the PRIORITY keyword in the SCHEDULE section. 7) PR2: control the group production rate using the second priority formulae defined by the PRIORITY keyword in the SCHEDULE section.			"NONE"

No.	Name	Description			Default
		Field	Metric	Laboratory	
4	WRAT	A real positive value that defines the maximum surface water production rate constraint.			
		stb/d	sm^3/day	scc/hour	None
5	WATACT	A defined character string that defines the action to be taken if WRAT is exceeded. WATACT should be set to a character string described by the OILACT parameter on this record.			None
6	GRAT	A real positive value that defines the maximum surface gas production rate constraint			
		Mscf/d	sm^3/day	scc/hour	None
7	GASACT	A defined character string that defines the action to be taken if GRAT is exceeded. GASACT should be set to a character string described by the OILACT parameter on this record.			None
8	LRAT	A real positive value that defines the maximum surface liquid (oil plus water) production rate constraint.			
		stb/d	sm^3/day	scc/hour	None
9	LIQRAT	A defined character string that defines the action to be taken if LRAT is exceeded. LIQACT should be set to a character string described by the OILACT parameter on this record.			None
10	RESV	A real positive value that defines the maximum reservoir volume production rate constraint.			
		rb/day	rm^3/day	rcc/hour	None
11	RESVFRAC	A real positive value that defines a group's maximum production balancing fraction constraint.			
		dimensionless	dimensionless	dimensionless	None
12		Not used should be defaulted with 1*.			1*
13		Not used should be defaulted with 1*.			1*
14		Not used should be defaulted with 1*.			1*
15		Not used should be defaulted with 1*.			1*
16	LINCOMB	A real positive value that defines the linearly combined maximum surface target rate or constraint, as per the LINCOM keyword in the SCHEDULE section.			1*
17	LINACT	A defined character string that defines the action to be taken if LINCOMB is exceeded. LINACT should be set to a character string described by the OILACT parameter on this record.			None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.24: GCONPRI Keyword Description

See also the GRUPTREE keyword to define the hierarchy of the groups below the FIELD level, the GCONPROD keyword to define a group's production targets and constraints, the GCONINJ keyword to define a group's injection targets and constraints, the WCONPROD keyword to define a production well's targets and constraints, and the WCONINEJ keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the production targets and constraints for the field and two groups that are one level below the field group, since the GRUPTREE keyword has not been entered to define the group hierarchy.

```
--
--       GROUP PRIORITY PRODUCTION CONTROLS
--
-- GRUP  ORAT   ORAT   WRAT   WRAT   GRAT   GRAT   LRAT   LRAT   RVOL   RVOL
-- NAME  LIMT   ACTN   LIMT   ACTN   LIMT   ACTN   LIMT   ACTN   LIMT   ACTN
GCONPRI
FIELD    40E3   PRI    30E3   +CON   125E3  PRI    1*     1*     1*     1*     /
GRP01    25E3   PRI    1*     1*     1*     1*     1*     1*     1*     1*     /
GRP02    25E3   PRI    1*     1*     1*     1*     1*     1*     1*     1*     /
/
```

All groups are controlled by oil constraints, but only the field level has water and gas constraints to reflect the actual production facility constraints. The oil production constraint of 40,000, 25,000 and 25,000 stb/d are defined for the field, GRP01 and GRP02 groups, respectively. If the oil rate constraint is exceeded then the wells will be controlled using the priority formulae one, as defined on the PRIORITY keyword in the SCHEDULE section. Similarly for the field, for when the gas constraint is exceeded. Finally, if the field water constraint is surpassed then the worst offending connection and below in the worst offending well are shut.

12.3.77 GCONPROD – GROUP PRODUCTION TARGETS AND CONSTRAINTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GCONPROD keyword defines production targets and constraints for groups, including the top most group in the group hierarchy known as the FIELD group. Wells are allocated to groups when the wells are specified by the WELSPECS keyword in the SCHEDULE section. Wells defined to be under group control will have their production rates controlled by the group to which they belong, in addition to any well constraints defined for the wells.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group target and constraints are being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	TARGET	A defined character string that sets the target production phase for the group, all the other phases will therefore act as constraints. The simulator will attempt to meet the TARGET based on the phase rate stated in items (3) to (6) on this keyword. TARGET should be set to one of the following character strings: 1) NONE: the group has no target phase, but if entered, constraints are still defined and active. 2) FLD: this group is controlled from a higher level group, including the FIELD group. 3) ORAT: the target is set to the surface oil production rate as defined by item (3). 4) WRAT: the target is set to the surface water production rate as defined by item (4). 5) GRAT: the target is set to the surface gas production rate as defined by item (5). 6) LRAT: the target is set to the surface liquid (oil plus water) production rate as defined by item (6). 7) RESV: the target is set to the in situ reservoir volume rate as defined by item (14).			None
3	ORAT	A real positive value that defines the maximum surface oil production rate target or constraint.			
		stb/d	sm^3/day	scc/hour	None
4	WRAT	A real positive value that defines the maximum surface water production rate target or constraint.			
		stb/d	sm^3/day	scc/hour	None
5	GAS	A real positive value that defines the maximum surface gas production rate target or constraint			
		Mscf/d	sm^3/day	scc/hour	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
6	LRAT	A real positive value that defines the maximum surface liquid (oil plus water) production rate target or constraint.			
		stb/d	sm^3/day	scc/hour	None
7	ACTION	A defined character string that defines the action to be taken if the constraints in (3) to (6) are violated. ACTION should be set to one of the following character strings: 1) NONE: no action is taken. 2) CON: close the worst offending connection in the worst offending well. If connections have been grouped as completions then the worst offending completion in the worst offending well will be closed. 3) +CON: close the worst offending connection and all below it in the worst offending well. If connections have been grouped as completions then the worst offending completion and all below it in the worst offending well will be closed. 4) WELL: close the worst offending well. 5) RATE: control the group production rate to equal the upper limit. This effectively changes the TARGET to be the violated phase constraint. The corrective action takes places at the end of the time step in which the constraint is violated.			None
8	GRPCNTL	A defined character string that determines if this group is subject to higher level group control. 1) YES: then this group is subject to a higher level group's control and the flow rates for this group will be adjusted accordingly. 2) NO: then this group is NOT subject to a higher level group's control and the flow rates for this group will only be control by the parameters for this group. This feature is currently not supported by OPM Flow.			None
9	GRPGUIDE	A real positive value that defines a group's production guide rate expressed as a dimensionless number. A group requires a value for GRPGUIDE only if it is required to produce a specified proportion of a higher level group's rate This feature is not supported by OPM Flow and should be defaulted with 1*.			
		dimensionless	dimensionless	dimensionless	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
10	GUIPHASE	A defined character string that sets the guide phase to which the guide rate in item (9) applies. GUIPHASE should be set to one of the following character strings: 1) ORAT: the guide phase is set to the surface oil production rate. 2) WRAT: the guide phase is set to the surface water production rate. 3) GRAT: the guide phase is set to the surface gas production rate. 4) LRAT: the guide phase is set to the surface liquid (oil plus water) production rate. 5) RESV: the guide phase is set to the in situ reservoir volume rate. This feature is not supported by OPM Flow and should be defaulted with 1*.			1*
11		Not used should be defaulted with 1*.			1*
12		Not used should be defaulted with 1*.			1*
13		Not used should be defaulted with 1*.			1*
14	RESV	A real positive value that defines the maximum reservoir volume production rate target or constraint.			
		rtb/d	rm^3/day	rcc/hour	None
15		Not used should be defaulted with 1*.			1*
16		Not used should be defaulted with 1*.			1*
17		Not used should be defaulted with 1*.			1*
18		Not used should be defaulted with 1*.			1*
19		Not used should be defaulted with 1*.			1*
20		Not used should be defaulted with 1*.			1*
21		Not used should be defaulted with 1*.			1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.25: GCONPROD Keyword Description

See also the GRUPTREE keyword to define the hierarchy of the groups below the FIELD level, the GCONINJ keyword to define a group's injection targets and constraints, the WCONPROD keyword to define a production well's targets and constraints, and the WCONINEJ keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the production targets and constraints for the field and two groups that are one level below the field group, since the GRUPTREE keyword has not been entered to define the group hierarchy.

```
--
--       GROUP PRODUCTION CONTROLS
--
-- GRUP  CNTL  OIL    WAT    GAS    LIQ    CNTL  GRUP  GUIDE  GUIDE  CNTL
-- NAME  MODE  RATE   RATE   RATE   RATE   OPT   CNTL  RATE   DEF    WAT
GCONPROD
FIELD    ORAT  40E3   60E3   300E3  60E3   1*     1*    1*     1*     1*      /
GRP01    FLD   25E3   1*     1*     1*     1*     1*    1*     1*     1*      /
GRP02    FLD   25E3   1*     1*     1*     1*     1*    1*     1*     1*      /
/
```

All groups are controlled by oil rate targets or constraints, but only the field level has water, gas and liquid constraints to reflect the actual production facility constraints. The wells under group control will be produced based on oil potential of each of the wells under group control, such that the field oil production target of 40,000 stb/d is honored and subject to the other phase fluid constraints. In addition, GRP01 and GRP02 oil rate values of 25,000 stb/d are constraints as these two groups are subject to the FIELD level targets and constraints.

12.3.78 GCONSALE – DEFINE GROUP SALES GAS PRODUCTION TARGETS AND CONSTRAINTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

GCONSALE defines the group sales gas production targets and constraints for when the gas production from an oil field group is exported under a Gas Sales Agreement ("GSA") and the oil field group also has oil production targets and constraints.

The keyword should not be used to control sales gas for a gas field group, as the gas injection rate is used to control the sales gas production, that is:

$$\begin{aligned}\text{Gas Sales Rate} = {} & \text{Total Group Gas Production Rate} \\ & - \text{Group Gas Injection Rate} \\ & + \text{Total Group Gas Import Rate} \\ & - \text{Total Group Gas Consumption}\end{aligned} \tag{12.17}$$

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.79 GCONSUMP – DEFINE GROUP GAS CONSUMPTION AND GAS IMPORT TARGETS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

GCONSUMP defines the group gas consumption rate either as an actual rate or as a percentage of the group's production. In both oil and gas fields produced gas is commonly used as fuel to support the processing and utility facilities needed to run the plant.

In addition to defining gas consumption, the keyword also sets the group gas import rate, if required. This is used to import gas into the model from other sources (fields, reservoirs etc.) that are not defined in the current run. For example, if a several fields are supplying gas to a power plant (field A, B and C), but only one is being modeled in the current import deck (A), then production from the other two fields (B and C) can be incorporated into model in order to meet the plant demand. Note in this case the import gas rates from fields B and C are fixed, and therefore field A acts like a "swing" producer to match the gas demand target.

If the group is acting under Group Gas Sales control via the GCONSALE keyword in the SCHEDULE section, then the sales gas is calculated by:

$$\begin{aligned}\text{Gas Sales Rate} = {} & \text{Total Group Gas Production Rate} \\ & - \text{Group Gas Injection Rate} \\ & + \text{Total Group Gas Import Rate} \\ & - \text{Total Group Gas Consumption}\end{aligned} \tag{12.18}$$

If the group is acting under Group Gas Re-Injection control via the GCONINJE keyword in the SCHEDULE section, then the group gas injection rate calculated by:

$$\begin{aligned}\text{Group Gas Injection Rate} = {} & \text{Group Gas Injection Rate} \times \text{Group Re-Injection Fraction} \\ & + \text{Total Group Gas Import Rate} \\ & - \text{Total Group Gas Consumption}\end{aligned} \tag{12.19}$$

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.80 GCONTOL – DEFINE GROUP CONSTRAINT TOLERANCE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GCONTOL keyword defines the tolerance and parameters used to control the accuracy of group targets and constraints. The keyword sets the tolerance and number of Newtonian iterations for each time step so that the wells under group control can match the desired group targets and constraints. See also the WLIMTOL keyword in the SCHEDULE section that controls the tolerance for wells.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.81 GCUTBACK – DEFINE GROUP CUTBACK LIMITS AND PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GCUTBACK, defines a production group's cutback limits and parameters. See also the WCUTBACK keyword in the SCHEDULE section that provides similar functionality for wells.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.82 GCUTBACT – DEFINE GROUP TRACER CUTBACK LIMITS AND PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GCUTBACT, defines a production group's cutback limits and parameters based on the named produced tracer from the group. See also the WCUTBACT keyword in the SCHEDULE section that provides similar functionality for groups.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.83 GDCQ – DEFINE GROUP MULTIPLE DAILY CONTRACT QUANTITIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GDCQ keyword defines the Daily Contract Quantities ("DCQ") for when multiple group contracts are required when the Gas Field Operations model has been activated by the GASFIELD keyword in the RUNSPEC section, or the GWSINGF has been invoked to define multiple group contracts in the SCHEDULE section. The group contracts must first be defined by the GSWINGF keyword, followed by the GCDQ keyword, and then the GASYEAR or GASPERIO keywords. GCDQ may be repeated in the SCHEDULE section to reset group DCQs.

See also the SWINGFAC keyword that set a single group DCQ at the field level, as opposed to having multiple DCQ group contracts using the GDCQ keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.84 GDCQECON – GROUP ECONOMIC CRITERIA FOR DCQ PRODUCTION GROUPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GDCQECON keyword defines economic criteria for DCQ production groups, including the field level group FIELD, that have previously been defined by the GCONPROD keywords in the SCHEDULE section. Note that wells are allocated to a group when they are specified by the WELSPECS keyword and wells can also have economic controls. Wells under group control are therefore subject to the economic criteria set via the GCONPROD and CECON keywords in the SCHEDULE section and the controls specified by the WECON keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group target and constraints are being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	DCQ	A real positive value that defines the minimum economic DCQ gas production rate, below which an economic action of shutting in or stopping all the wells in the group, as requested by item (9) of the WELSPECS keyword. Note if GRPNAME is equal to FIELD then the run will be terminated. A value less than or equal to zero switches of this criteria.			
		Mscf/d	sm^3/day	scc/hour	0.0

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.26: GDCQECON Keyword Description

See also the WELSPECS keyword to define a wells shut-in or stop options, GCONPROD for group controls, and WECON for setting a well's economic criteria. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the minimum DCQ for the field to be 10 MMscf/d.

```
--
--       GROUP ECONOMIC CRITERIA FOR DCQ PRODUCTION GROUPS
--
-- GRUP  GAS
-- NAME  DCQ
GDCQECON
FIELD    10E3                                                    /
/
```

12.3.85 GDRILPOT – Define Group Potential Rates for Automatic Drilling

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GDRILPOT, defines the minimum group potential rate that will result in a well from the one of the automatic drilling queues, as defined by either the QDRILL or WDRILPRI keywords in the SCHEDULE section, to be drilled and placed on production. The advantage of using a group's potential, as oppose to a minimum rate limit, is that setting the potential greater than the group's minimum flow rate, will result in well being drilled in time to support the desired production rate.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.86 GECON – GROUP ECONOMIC CRITERIA FOR PRODUCTION GROUPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GECON keyword defines economic criteria for production groups, including the field level group FIELD, that have previously been defined by the GCONPROD keywords in the SCHEDULE section.

Note that wells are allocated to a group when they are specified by the WELSPECS keyword and wells can also have economic controls. Wells under group control are therefore subject to the economic criteria set via the GCONPROD and CECON keywords in the SCHEDULE section and the controls specified by the WECON keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group target and constraints are being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	ORAT	A real positive value that defines the minimum economic surface oil production rate, below which an economic action of shutting in or stopping all the wells in the group, as requested by item (9) of the WELSPECS keyword. A value less than or equal to zero switches of this criteria.			
		stb/day	sm^3/day	scc/hour	0.0
3	GAS	A real positive value that defines the minimum economic surface gas production rate, below which an economic action of shutting in or stopping all the wells in the group, as requested by item (9) of the WELSPECS keyword. A value less than or equal to zero switches of this criteria,			
		Mscf/day	sm^3/day	scc/hour	0.0
4	WCUT	A real positive value that defines the maximum economic surface water cut, above which an economic action will take place. Water cut is defined as: $f_w = \frac{q_w}{q_w + q_o}$, and the various actions that are available if the water cut limit is exceeded are described in item (7). A value less than or equal to zero switches of this criteria.			
		dimensionless	dimensionless	dimensionless	0.0
5	GOR	A real positive value that defines the maximum economic surface gas-oil ratio, above which an economic action will take place, as defined by item (7). A value less than or equal to zero switches of this criteria.			0.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
		Mscf/stb	sm^3/sm^3	scc/scc	
6	WGR	A real positive value that defines the maximum economic surface water-gas ratio, above which an economic action will take place, as defined by item (7). A value less than or equal to zero switches of this criteria.			
		stb/Mscf	sm^3/sm^3	scc/scc	0.0
7	ACTION	A defined character string that defines the action to be taken if the economic WCUT, GOR, or WGR limits are violated. ACTION should be set to one of the following character strings: 1) NONE: no action is taken. 2) CON: close the worst offending connection in the worst offending. If connections have been grouped as completions then the worst offending completion will be closed. 3) +CON: close the worst offending connection and all below it in the worst offending well. If connections have been grouped as completions then the worst offending completion and all below it in the worst offending well will be closed. 4) WELL: shut or stop the well as per the AUTO variable on the WELSPECS keyword. 5) PLUG: plug back the worst offending well based on the plug back length and options defined on the WPLUG keyword in the SCHEDULE. The corrective action takes places at the end of the time step in which the constraint is violated.			None
8	END	A defined character string that defines if the simulation should terminate if all the producing wells in the group, including the FIELD group, are shut or stopped. END should be set to one of the following character strings: 1) NO: no action is taken and the run continues. 2) YES: terminate the run at the next report time step.			NO
9	MXWELS	A positive integer defining the maximum number of producing and injecting wells for this this group and any subordinate groups. The default value of zero implies that there is no limit to the number of wells.			0

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.27: GECON Keyword Description

See also the WELSPECS keyword to define a wells shut-in or stop options, GCONPROD for group controls, and WECON for setting a well's economic criteria. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the economic criteria for the field with a minimum oil rate of 2,000 m^3/day and a maximum water cut of 95%.

```
--
--       GROUP ECONOMIC CRITERIA FOR PRODUCTION GROUPS
--
-- GRUP  OIL   GAS    WCT    GOR    WGR    WORK   END   MAX
-- NAME  MIN   MIN    MAX    MAX    MAX    OVER   RUN   WELLS
GECON
FIELD    2E3   1*     0.95     1*    1*     CON   'YES'  1*                    /
/
```

If the economic limits are violated then the run will stop at the next report time step.

12.3.87 GECONT – GROUP TRACER ECONOMIC CRITERIA FOR PRODUCTION GROUPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GECONT keyword defines tracer economic criteria for production groups, including the field level group FIELD, that have previously been defined by the GCONPROD keywords in the SCHEDULE section, for tracers define by the TRACER keyword in the PROPS section.

Note that wells are allocated to a group when they are specified by the WELSPECS keyword and wells can also have economic controls. Wells under group control are therefore subject to the economic criteria set via the GCONPROD and CECON keywords in the SCHEDULE section and the controls specified by the WECON keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group target and constraints are being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
1-2	ACTION	A defined character string that defines the action to be taken if the economic WCUT, GOR, or WGR limits are violated. ACTION should be set to one of the following character strings: 1) NONE: no action is taken. 2) CON: close the worst offending connection in the worst offending. If connections have been grouped as completions then the worst offending completion will be closed. 3) +CON: close the worst offending connection and all below it in the worst offending well. If connections have been grouped as completions then the worst offending completion and all below it in the worst offending well will be closed. 4) WELL: shut or stop the well as per the AUTO variable on the WELSPECS keyword. 5) PLUG: plug back the worst offending well based on the plug back length and options defined on the WPLUG keyword in the SCHEDULE. The corrective action takes places at the end of the time step in which the constraint is violated.			None
1-3	END	A defined character string that defines if the simulation should terminate if all the producing wells in the group, including the FIELD group, are shut or stopped. END should be set to one of the following character strings: 1) NO: no action is taken and the run continues. 2) YES: terminate the run at the next report time step.			NO

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-4	MXWELS	A positive integer defining the maximum number of producing and injecting wells for this group and any subordinate groups. The default value of zero implies that there is no limit to the number of wells.			0
1-5	/	Record one terminated by a "/"			Not Applicable
2-1	Name	A three letter character string defining the tracer's name. Note it is best to void names beginning with the letters F, S, and T as these names may create naming issues in post-processing software.			None
2-2		A real positive value that defines the maximum total (free plus solution) tracer rate. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-3		A real positive value that defines the maximum total (free plus solution) tracer concentration. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-4		A real positive value that defines the maximum free tracer rate. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-5		A real positive value that defines the maximum free tracer concentration. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-6		A real positive value that defines the maximum solution rate. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-7		A real positive value that defines the maximum solution concentration. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-8	/	Record two terminated by a "/"			Not Applicable
3-1	/	Group terminated by a "/"			Not Applicable

Notes:

1) GECONT keyword consists of two records, with entries 1-1 to 1-5 representing record one items and 2-1 to 2-8 representing record number two items, in the "No." column in this table. A maximum of three type two records can be entered following a type one record.
2) Each type one and type two records are terminate by a "/" as indicated in the table, and a group data set is terminated by a further "/", after which additional group data sets can be entered stating with a record of type one followed by type two.
3) The keyword the keyword should be terminated by an additional "/" after the group data set termination "/" character.

Table 12.28: GECONT Keyword Description

See also the WELSPECS keyword to define a wells shut-in or stop options, GCONPROD for group controls, and WECON for setting a well's economic criteria. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the tracer economic criteria for the field and two groups, FLTBLK1 and FLTBLK,.

```
--
--       GROUP TRACER ECONOMIC CRITERIA FOR PRODUCTION GROUPS
--
-- GRUP  WORK    END    MAX
-- NAME  OVER    RUN    WELLS
GECONT
FIELD    +CON   'YES'   1*                                    / START OF GROUP
--
--       TRACER  TRACER  TRACER  TRACER  TRACER  TRACER  TRACER
--       NAME    TOTAL   TOTAL   FREE    FREE    SOLN    SOLN
--               RATE    CONCEN  RATE    CONCEN  RATE    CONCEN
         PLY     1000.0                                       /
         BRI     1000.0                                       /
         TR1     1*      0.7500                               /
                                                              /
FLTBLK1  +CON   'YES'   1*                                    / START OF GROUP
--
--       TRACER  TRACER  TRACER  TRACER  TRACER  TRACER  TRACER
--       NAME    TOTAL   TOTAL   FREE    FREE    SOLN    SOLN
--               RATE    CONCEN  RATE    CONCEN  RATE    CONCEN
         PLY     800.0                                        /
         BRI     800.0                                        /
                                                              /
FLTBLK2  +CON   'YES'   1*                                    / START OF GROUP
--
--       TRACER  TRACER  TRACER  TRACER  TRACER  TRACER  TRACER
--       NAME    TOTAL   TOTAL   FREE    FREE    SOLN    SOLN
--               RATE    CONCEN  RATE    CONCEN  RATE    CONCEN
         PLY     800.0                                        /
         BRI     800.0                                        / END OF GROUP
                                                              / END OF KEYWORD
```

If the economic limits are violated then the worst offending connection and all below it in the worst offending well will be closed, If connections have been grouped as completions then the worst offending completion and all below it in the worst offending well will be closed.

12.3.88 GEFAC – DEFINE GROUP EFFICIENCY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Defines a group's efficiency or up-time as opposed to setting the efficient factors for individual wells.

Note that wells are allocated to a group when they are specified by the WELSPECS keyword and wells can also have efficient factors.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group efficient factor is being defined. The group named FIELD is the top most group and cannot have an efficiency factor set. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	FACTOR	A real positive value that is less than or equal to one that defines the efficiency factor for the group. If a group's down time is 5% then FACTOR should be set to 0.95 (1.0 – 0.05).			
		dimensionless	dimensionless	dimensionless	1.0
3	NETOPTN	Not used			1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.29: GEFAC Keyword Description

See also the WEFAC keyword in the SCHEDULE section to define a well's' efficiency factor.

Example

```
--
--        GROUP EFFICIENCY FACTORS
--
-- GRUP   EFF       NETWK
-- NAME   FACT      OPTN
--       ------    ------
GEFAC
PLATFORM 0.950                                                          /
SUBSEA1  0.860                                                          /
/
```

In the above example the group PLATFORM has it's efficiency factor (up time) set to 0.95 and the subsea group SUBSEA1 has an up time of 0.860.

12.3.89 GLIFTLIM – GROUP ARTIFICIAL LIFT CONSTRAINTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GLIFTLIM keyword defines the maximum number of wells on artificial lift and the maximum amount of the artificial lift resources available for groups, including the top most group in the group hierarchy known as the FIELD group. Wells are allocated to groups when the wells are specified by the WELSPECS keyword in the SCHEDULE section. Wells defined to be under group control will have their production rates controlled by the group to which they belong, in addition to any well constraints defined for the wells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group's target calorific value is being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	MXLIFT	A real positive value that defines the total amount of artificial lift available for this group and any subordinate groups. The units for MXLIFT are the same as that defined by the ALQ parameter on the VFPPROD keyword in the SCHEDULE section. For example, if ALQ has been set to GRAT on the VFPPROD keyword, then MXLIFT would be the maximum amount of gas lift gas available for this group and any subordinate groups, and the units would Mscf, assuming FIELD units had been activated in the RUNSPEC section. The default value of zero implies that there is no limit applied to the group and its subordinate groups.			
		See VFPPROD (ALQ)	See VFPPROD (ALQ)	See VFPPROD (ALQ)	0
3	MXWELS	A positive integer defining the maximum number of producing wells on artificial lift for this group and any subordinate groups. The default value of zero implies that there is no limit to the number of wells.			
		dimensionless	dimensionless	dimensionless	0

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.30: GCONENG Keyword Description

See also the GRUPTREE keyword to define the hierarchy of the groups below the FIELD level, the GCONPROD and GCONINJ keywords to define a group's production and injection rate targets and constraints, the WCONPROD keyword to define a production well's targets and constraints, and the WCONINEJ keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the artificial lift constraints for the field, assuming all the well are on gas lift.

```
---
--       GROUP ARTIFICIAL LIFT CONSTRAINTS
--
-- GRUP  MAX   MAX
-- NAME  ALQ   WELLS
GLIFTLIM
FIELD    20E3  20                                                    /
/
```

Here the maximum amount of gas lift gas for the field is set to 20.0 MMscf/f and a maximum of 20 wells can utilize gas lift at a time.

12.3.90 GLIFTOPT – DEFINE GROUP GAS OPTIMIZATION LIMITS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

GLIFTOPT defines a group's gas rate limits for when gas lift optimization has been activated via the LIFTOPT keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.91 GNETDP – Group Network Pressure and Rate Controls

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GNETDP keyword sets a group's minimum and maximum network pressure and rate controls for when the either the Standard Network or the Extended Network options have been activated, and the group is part of a network. The keywords allows for the pressure of the group to vary in order to satisfy the rate conditions declared by this keyword. The Standard Network option is invoked if the GRUPTREE, GRUPNET, GNETINJE, GNETPUMP, etc. series of keywords have been used in the SCHEDULE section. Whereas, the Extended Network option is activated by the NETWORK keyword in the RUNSPEC section. Several keywords, including, GNETDP, can be used by both network options.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.92 GNETINJE – Define Group Injection Network Configuration

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GNETINJE keyword defines the configuration of a group injection network for when the either the Standard Network or the Extended Network options have been activated. The Standard Network option is invoked if the GRUPTREE, GRUPNET, GNETINJE, GNETPUMP, etc. series of keywords have been used in the SCHEDULE section. Whereas, the Extended Network option is activated by the NETWORK keyword in the RUNSPEC section. Several keywords, including, GNETINJE, can be used by both network options.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.93 GNETPUMP – STANDARD NETWORK AUTOMATIC COMPRESSOR AND PUMPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GNETPUMP keyword defines the configuration of automatic compressors and pumps in a production Standard Network, for when the Standard Network option is invoked by the GRUPTREE, GRUPNET, GNETINJE, GNETPUMP, etc., series of keywords in the SCHEDULE section. Although several keywords can be used by both the Standard and Extended Network options, GNETPUMP can only be used with the Standard Network option. The equivalent keyword for the Extended Network option is the NETCOMPA keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.94 GPMAINT – Define Group Pressure Maintenance Targets and Controls

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GPMAINT keyword defines the groups under pressure maintenance control, the associated flow rate and pressure targets, and fluid in-place regions associated with pressure maintenance, as well as various pressure maintenance controls.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.95 GRADGRUP – Define Group History Match Gradient File Output

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRADGRUP keyword defines the SUMMARY field and group vectors that should be written to the History Match Gradient output file, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.96 GRADRESV – Define Solution Derivative History Match Gradient Output

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRADRESV keyword defines the SOLUTION derivative arrays that should be written to the History Match Gradient output file, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.97 GRADRFT – Define RFT Derivative History Match Gradient Output

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRADRFT keyword defines the derivative well RFT data, the SOLUTION pressure and saturations at a well's connected grid block, that should be written to the History Match Gradient output file, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.98 GRADWELL – Define Well History Match Gradient File Output

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRADWELL keyword defines the SUMMARY well vectors that should be written to the History Match Gradient output file, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.99 GRDREACH – Define River and Grid Block Connections

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRDREACH keyword defines the location of grid blocks connecting to a previously defined river, for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.100 GRUPMAST – DEFINE MASTER AND SLAVE GROUPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRUPMAST keyword defines master groups and their associated slave groups for when the Reservoir Coupling option as been activated by the GRUPMAST and SLAVES keywords in the SCHEDULE section. Reservoir coupling allows for independent reservoir simulation decks (SLAVES) to be controlled by a separate master run file. For example, if there are five separate reservoir models each representing one field, one of the four would be used as the master and the other four would be the subordinate SLAVES.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.101 GRUPNET – DEFINE GROUP STANDARD NETWORK PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRUPNET keyword defines the standard group network parameters used to model the flow and pressures behavior within the network. The group hierarchy is defined by the GRUPTREE keyword and wells are assigned to groups using the WELSPECS keyword, both keywords are in the SCHEDULE section.

Group pressure values are optionally entered for each group in the network together with a vertical lift performance ("VFP") table that the determines the pipeline pressure behavior from the LOWER group to the HIGHER given the current flowing conditions; the group relationship is defined by the GRUPTREE keyword. The VPP table is entered via the VFPPROD keyword for production pipelines and VFPINJ for injection pipelines. Although these keywords are the same as used for well modeling, they are also used for pipeline modeling as well; however, the manner in which they are generated by an external software is completely different.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the network parameters are being defined. The group named FIELD is the top most group and may be used as a GRUPNAME.			None
2	PRES	A real value that defines the fixed pressure for this group when the group is a terminating group. If the group is not a terminating group then PRES should be defaulted with 1* or set to a negative number.			
		psia	barsa	atma	1*
3	VFPTAB	A positive integer greater than or equal to zero that defines the VFPPROD or VFPINJ vertical lift performance table to be used for calculating the pipeline pressures connecting the LOWER and HIGHER group in the network. Note that: 1) The default value of zero implies that there is no pipeline connecting the LOWER and HIGHER groups. 2) If PRES is set to a real positive number then VFPTAB should be set to zero as this implies that GRPNAME is a terminating group and therefore there is no pipeline connecting GRPNAME to a HIGHER group. 3) If PRES and VFPTAB are defaulted with 1* or zero, then GRPNAME is not part of the networf. 4) IF VFPTAB is set equal to 9999 then this implies that there is no pressure change between the LOWER and HIGHER group. If a non-zero value is entered then the vertical lift performance tables must be entered via the VFPPROD or VFPINJ keyword in the SCHEDULE section.			0

No.	Name	Description			Default
		Field	Metric	Laboratory	
4	ALQ-PIPE	A real positive value that defines the artificial lift quantity to be used in conjunction with the VFPPROD assigned to the group via VPFTAB variable. VFPTAB vertical lift performance table and the artificial lift quantity ALQ-WELL are used with the pipeline fluid rates to calculate the pipeline pressures between the LOWER and HIFGHER groups. Note that the units for ALQ-PIPE is dependent on the associated variable on the VFPPROD keyword and may represent a pump or a compressor depending how the VFPPROD table was generated was generated by an external program.			0.0
5	OPTION1	A defined character string that defines if a group's production target should be achieved by adjusting the tubing pressure of the wells within the group or by the adjusting the well rates by their guide rate. OPTION1 should be set to one of the following character strings: 1) YES: the group production target is achieved by adjusting the tubing pressure of the wells within the group, so that all wells flow at the same tubing head pressure. This is normally used for wells that flow into a common manifold, for example a sub-sea completion manifold. If a group is using this option and has a higher group with production targets or constraints, than this group should have have it's guide rate set via the GCONPROD keyword in the SCHEDULE section, to ensure that the well's within this group operate at the same tubing head pressure. 2) NO: the group production target is achieved by adjusting the guide rates of the wells within the group. This is the standard method in matching group targets and may result with the wells within the having different tubing head pressures. Only groups containing wells can use OPTION1 equal to YES or NO, a group without wells should set OPTION1 to NO. Numerical convergence controls and iteration limits for wells using OPTION1 set equal to YES are defined via the NETBALAN keyword in the SCHEDULE section.			NO

No.	Name	Description			Default
		Field	Metric	Laboratory	
6	OPTION2	A defined character string that defines if how gas lift gas flows through the group's pipeline. OPTION2 should be set to one of the following character strings: 1) NO: no gas lift gas is allowed to flow through the pipeline only produced reservoir gas is allowed to flow through the pipeline. 2) FLO: both gas lift gas and produced reservoir gas are allowed to flow through the pipeline. Gas lift gas is calculated from summing the calculated gas lift values of all the subordinate wells. Here the summed well gas lift gas (ALQ-WELL), the pipeline gas lift gas (ALQ-PIPE), and the reservoir produced gas are added to the gas flow rate along the pipeline. 3) ALQ: both gas lift gas and produced reservoir gas are allowed to flow through the pipeline. Gas lift gas is calculated from summing the calculated gas lift values of all the subordinate wells. Here the summed ALQ-WELL gas lift gas is added to the reservoir produced gas flow rate along the pipeline. This means that ALQ-PIPE gas lift gas value declared on item (4) is ignored. If either FLO or ALQ have been selected then artificial lift quantity for the pipeline (ALQ-PIPE) and the wells (ALQ-WELL) must be defined as gas lift gas on the VFPPROD tables. A well's specific gas lift gas quantity is set via the ALQ-WELL variable on the WCONPROD keyword in the SCHEDULE section.			NO
7	OPTION3	A defined character string that defines if the ALQ-PIPE variable should be reset to an equivalent surface oil or gas density flowing along the pipeline. OPTION3 should be set to one of the following character strings: 1) DENO: set ALQ-PIPE to the average surface density of the oil flowing along the pipeline. 2) DENG: set ALQ-PIPE to the average surface density of the gas flowing along the pipeline. 3) NONE: the group production target is achieved by adjusting the guide rates of the wells within the group. This is the standard method in matching group targets and may result with the wells within the having different tubing head pressures. If either DENO or DENG have been selected then artificial lift quantity on the VFPPROD tables must be based on the same density parameter. These options are normally used when a mixture of oil or gas with different surface densities flows into the network.			NONE

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.31: GRUPNET Keyword Description

See also the WELSPECS keyword to define wells, the VFPPROD and VFPINJ keywords that the define vertical lift performance table to be used for calculating the pipeline pressures connecting the LOWER and HIGHER group in the network. All the aforementioned keywords are described in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Examples

The following example defines a network based on two groups

```
--
--       DEFINE GROUP STANDARD NETWORK PARAMETERS
--
-- GRUP  CNTL   VFP    PUMP   MANIFOLD  INCLUDE   ALQ
-- NAME  PRES   TABLE  POWER  GROUP     LIFT GAS  DENS
GRUPNET
PROD-A   1200.  1*                                                  /
PROD-B   1*     1      1*    'YES'      1*        1*                /
/
```

The next example is more complex and is taken form the Norne model.

```
--
--       DEFINE GROUP STANDARD NETWORK PARAMETERS
--
-- GRUP  CNTL   VFP    PUMP   MANIFOLD  INCLUDE   ALQ
-- NAME  PRES   TABLE  POWER  GROUP     LIFT GAS  DENS
GRUPNET
FIELD    20.0   5*                                                  /
PROD     20.0   5*                                                  /
MANI-B2  1*     8      1*      NO       2*                          /
MANI-B1  1*     8      1*      NO       2*                          /
MANI-K1  1*    9999    4*                                          /
B1-DUMMY 1*    9999    4*                                          /
MANI-D1  1*     8      1*      NO       2*                          /
MANI-D2  1*     8      1*      NO       2*                          /
MANI-K2  1*    9999    4*                                          /
D2-DUMMY 1*    9999    4*                                          /
MANI-E1  1*     9      1*      NO       2*                          /
MANI-E2  1*     9      4*                                          /
/
```

Here the FIELD controlling pressure is set at 20 barsa and the same limit is used for group PROD which sits directly under the FIELD group (see Figure 12.3)

12.3.102 GRUPRIG – Group Drilling and Workover Rig Specifications

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Defines a groups drilling and workover specifications.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.103 GRUPSLAV – DEFINE SLAVE GROUPS IN SLAVE RESERVOIRS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRUPSLAV keyword defines slave groups in a slave input deck and their associated master groups in the master run, for when the Reservoir Coupling option as been activated by the GRUPMAST and SLAVES keywords in the SCHEDULE section. This keyword is required for every slave input deck. Reservoir coupling allows for independent reservoir simulation decks (SLAVES) to be controlled by a separate master run file. For example, if there are five separate reservoir models each representing one field, one of the four would be used as the master and the other four would be the subordinate SLAVES.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.104 GRUPTARG – MODIFY GROUP TARGETS AND CONSTRAINTS VALUES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GRUPTARG keyword modifies the target and constraints values of both rates and pressures for previously defined groups without having to define all the variables on the group control keywords: GCONPROD or GCONPRI keywords. Variables not changed by the GRUPTARG keyword remain the same as those previously entered via the group control keywords or previously entered GRUPTARG keywords. Note that the group must still be initially be fully defined using the GCONPROD or GCONPRI keywords. All the aforementioned keywords are described in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Note that wells are allocated to groups when the wells are specified by the WELSPECS keyword in the SCHEDULE section. Wells defined to be under group control will have their production rates controlled by the group to which they belong, in addition to any well constraints defined for the wells.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRPNAME	A character string of up to eight characters in length that defines the group name for which the group target and constraints are being defined. The group named FIELD is the top most group and should be used to set targets and constraints for the field. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
2	TARGET	A defined character string that sets the item to be changed for the group the value of the item is set by item (3). 1) ORAT: reset the surface oil production rate value as defined by item (3). 2) WRAT: reset the surface water production rate value as defined by item (3). 3) GRAT: reset the surface gas production rate value as defined by item (3). 4) LRAT: reset the surface liquid (oil plus water) production rate value as defined by (3). 5) RESV: reset the in situ reservoir volume rate value as defined by (3). 6) GUID: reset the guide rate value for wells operating under group control. Note TARGET only defines the variable to be changed, it does not change how a group is controlled. For example, if a group is operating on ORAT control, as defined by the previously entered GCONPROD keyword, entering TARGET equal to LRAT with a value, changes the liquid constraint but the group still remains on ORAT control. Use the GCONPROD or GCONPRI keywords in the SCHEDULE section to change the control mode of a well.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
3	VALUE	A real positive value that defines the value of the variable declared by TARGET			
	Liquid	stb/d	sm^3/day	scc/hour	
	Gas	Mscf/d	sm^3/day	scc/hour	
	Res Vol	rb/d	rm^3/day	rcc/hour	
	Pressure	psia	barsa	atma	None

Notes:

1) The keyword is followed by any number records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.32: GRUPTARG Keyword Description

See also the WELTARG and WELCNTL keyword, in the SCHEDULE section that can be used to reset a well's control mode, as well as a well's target and constraints of both rates and pressures.

Example

The following example below shows the oil rates for the field at the start of the schedule section (January 1, 2000).

```
-- ------------------------------------------------------------------------------
-- 01 JAN 2000 START OF SCHEDULE SECTION
-- ------------------------------------------------------------------------------
--
--       GROUP PRODUCTION CONTROLS
--
-- GRUP  CNTL  OIL    WAT    GAS    LIQ    CNTL  GRUP  GUIDE  GUIDE  CNTL
-- NAME  MODE  RATE   RATE   RATE   RATE   OPT   CNTL  RATE   DEF    WAT
GCONPROD
FIELD    ORAT  40E3   60E3   30E3   65E3   1*     1*    1*     1*     1*      /
/
DATES
01 FEB 2000 /
/
--
--       GROUP PRODUCTION AND INJECTION TARGETS
--
--       GROUP    GROUP  TARGET
--       NAME     TARG   VALUE
GRUPTARG
         FIELD    ORAT   45E3                                                  /
         FIELD    LIQ    75E3                                                  /
/
```

From January 1, 2000 to February 1, 2000 the field is on oil rate control and has a target oil rate of 40,000 stb/d, a maximum water handling capacity of 60,000 stb/d, a maximum liquid capacity of 65,000 stb/d, and a maximum gas constraint of 30 MMscf/d. After February 1, 2000 the field's target oil rate is increased to 45,000 stb/d and the maximum liquid constraint is increased to 75,000 stb/s; all the other parameters remain unchanged.

12.3.105 GRUPTREE – DEFINE GROUP TREE HIERARCHY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

GRUPTREE defines the group hierarchy of groups that have been created by having wells assigned to them via the WELSPECS keyword in the SCHEDULE section, By default three group levels are defined that sets the wells as level three, reporting directly to defined groups at level two, and the level two groups reporting to the FIELD group at level one. If a different configuration is required then the GRUPTREE keyword should be used to define the group hierarchy by defining a lower level group that reports directly to a higher level group.

No.	Name	Description	Default
1	LOWER	A character string of up to eight characters in length that defines the group name which belongs to the HIGHER group. The group named FIELD is the top most group and should NOT be used as as a group name for the LOWER group name. Undefined group relationships are automatically assigned to the FIELD group.	None
2	HIGHER	A character string of up to eight characters in length that defines the HIGHER group name that the LOWER group belongs to. The group named FIELD is the top most group and can be used as as the HIGHER group name. Undefined group relationships are automatically assigned to the FIELD group.	None
Notes: 1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".			

Table 12.33: GRUPTREE Keyword Description

A group hierarchy can have any number of levels but groups that have other groups as LOWER groups cannot also have wells for the HIGHER group. Thus, a group either contains wells or has LOWER groups

See also the GCONPROD and GCONINJE for defining group production and injection volumes, and the WELSPECS keywords to allocate wells to groups. All the aforementioned keywords are described in the SCHEDULE section.

Examples

The first example defines PLAT01 and PLAT03 reporting to the FIELD level (default if these records are omitted) and PLAT02 reporting to PLAT01.

```
--
--        DEFINE GROUP TREE HIERARCHY
--
--        LOWER     HIGHER
--        GROUP     GROUP
GRUPTREE
          PLAT01    FIELD                                                  /
          PLAT02    PLAT01                                                 /
          PLAT03    FIELD                                                  /
/
```

The next example is more complex and is taken form the Norne model.

```
--
--       DEFINE GROUP TREE HIERARCHY
--
--       LOWER      HIGHER
--       GROUP      GROUP
GRUPTREE
        'INJE'     'FIELD'                                                  /
        'PROD'     'FIELD'                                                  /
        'MANI-B2'  'PROD'                                                   /
        'MANI-B1'  'PROD'                                                   /
        'MANI-D1'  'PROD'                                                   /
        'MANI-D2'  'PROD'                                                   /
        'MANI-E1'  'PROD'                                                   /
        'MANI-E2'  'PROD'                                                   /
        'MANI-K1'  'MANI-B1'                                                /
        'MANI-K2'  'MANI-D2'                                                /
        'MANI-C'   'INJE'                                                   /
        'MANI-F'   'INJE'                                                   /
        'WI-GSEG'  'INJE'                                                   /
        'B1-DUMMY' 'MANI-B1'                                                /
        'D2-DUMMY' 'MANI-D2'                                                /
/
```

The group hierarchy for this example is shown below.

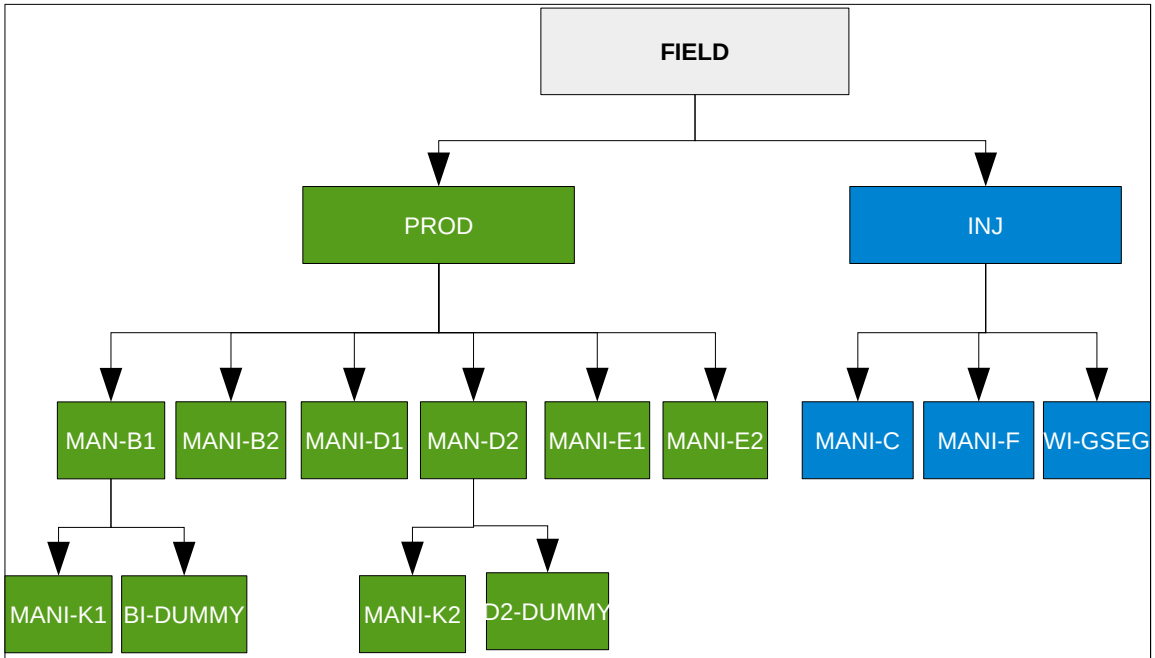


Figure 12.3: Norne Group Tree Hierarchy Example

Here groups PROD, INJ, MAN-B1, and MAN-D2 report to higher level groups and the other remaining groups all have individual wells allocated to them instead.

12.3.106 GSATINJE – DEFINE GROUP SATELLITE INJECTION RATES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GSATINJE keyword defines a satellite group's oil, gas and water injection rates in the model. Satellite groups are not connected to the reservoir model and therefore have no wells or subordinate groups associated with them, they are nevertheless connected to other higher level groups and higher level groups within a network model (if activated). They thus provide a means to "add-in" outside injection and production to the model without modeling the "add-in" reservoir model.

The keyword is used to define injection rates into the model from other sources (fields, reservoirs etc.) that are not defined in the current run. For example, if a several fields are supplying gas to a power plant (field A, B and C), but only one is being modeled in the current import deck (A), then injection and production from the other two fields (B and C) can be incorporated into model in order to meet the plant demand. Note in this case the import gas rates from fields B and C are fixed, and therefore field A acts like a "swing" producer to match the gas demand target. See the GSATPROD keyword in the SCHEDULE section to define satellite production rates.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.107 GSATPROD – DEFINE GROUP SATELLITE PRODUCTION RATES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GSATPROD keyword defines a satellite group's oil, gas and water production rates in the model. Satellite groups are not connected to the reservoir model and therefore have no wells or subordinate groups associated with them, they are nevertheless connected to other higher level groups and higher level groups within a network model (if activated). They thus provide a means to "add-in" outside injection and production to the model without modeling the "add-in" reservoir model.

The keyword is used to import gas into the model from other sources (fields, reservoirs etc.) that are not defined in the current run. For example, if a several fields are supplying gas to a power plant (field A, B and C), but only one is being modeled in the current import deck (A), then production from the other two fields (B and C) can be incorporated into model in order to meet the plant demand. Note in this case the import gas rates from fields B and C are fixed, and therefore field A acts like a "swing" producer to match the gas demand target. See the GSATINJE keyword in the SCHEDULE section to define satellite injection rates.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.108 GSEPCOND – ASSIGN GROUP SEPARATORS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GSEPCOND keyword assigns previously defined separators to a group. Group separators are specified by the SEPVALS keyword in the SCHEDULE section. The facility is used in "black-oil" modeling to re-scale the PVT data entered via the PROPS section, based on the saturation point oil formation volume factor (B_{ob}) and the initial saturated gas-oil ratio (R_{si}) entered on the SEVPALS keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.109 GSSCPTST – Perform Sustainable Capacity Test

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GSSCPTST keyword instructs the simulator to perform a sustainable capacity test. This causes the model to be saved in it's current state via the RESTART file, and the test performed by running the simulation under the current conditions combine with the parameters on this keyword. After the test is perform, the simulator will restart from the point prior to the test by loading in the RESTART file. This type of testing is normally applied to gas fields for which the gas sales contracts stipulate that the gas sales rates are based on a sustainable capacity rate over a fixed period of time.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.110 GSWINGF – DEFINE GROUP MULTIPLE GAS CONTRACT PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GSWINGF, defines the gas contract parameters, swing factor and the monthly seasonal profile factor, for when there are multiple gas contracts being used in the model. The keyword is used with the Gas Field Operations option which is activated by the GASFIELD keyword in the RUNSPEC section. Gas contracts are commonly based on a Daily Contract Quantity ("DCQ") that determines the gas rate that the field should be produced at, which is normally expressed as a multiple of the DCQ, for example 1.33, and is often referred to as the "swing factor". Some gas contracts also define a maximum DCQ ("Max DCQ") and/ or a minimum take or pay DCQ ("Min DCQ"), as well as seasonal demand characteristics. For example, gas rates may be set higher in the winter months in order to meet heating demand compared with summer months in colder climates, and the opposite in warmer climates where air conditioning demand is high.

Thus, the DCQ must be calculated first over a contract period, where the contract period is commonly contract years, or in some instances contract quarters. This is performed by the simulator using the current DCQ and checking to see if the (DCQ x Swing Factor) can be satisfied throughout the current contract period, if not the DCQ is re-calculated so that the (DCQ x Swing Factor) condition is satisfied. Once this condition is met, the second and final pass uses the calculated DCQ in conjunction with the monthly scaling profile data to set the monthly gas rate for the field:

$$Q_{month} = DCQ \times SWINGFAC_{month} \tag{12.20}$$

Where:

Q_{month} = the monthly gas production target
DCQ = Daily Contract Quantity
$SWINGFAC_{month}$ = monthly rate scaling factor that takes into account seasonal demand, etc.

Here the GSWINGF keyword allows for different gas contract parameters to be assign to different groups and is mutually exclusive to the SWINGFAC keyword in the SCHEDULE section, that sets the gas contract parameters for a single contract at the FIELD group level.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.111 GTADD – ADD A CONSTANT TO A GROUP TARGET OR CONSTRAINT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GTADD, adds a numerical constant to a group's target or constraint value. The group must have been initially fully defined using the GCONPROD or GCONPRI keywords for producers or GCONINJE for injectors. Variables not changed by the GTADD keyword remain the same as those previously entered via the group control keywords or previously entered GTADD keywords. See also the GRUPTARG keyword that sets the values for a group's target and constraints and the GTMULT keyword that multiplies a group target or constraint by a constant. All the aforementioned keywords are described in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.112 GTMULT – MULTIPLY GROUP TARGET OR CONSTRAINT BY A CONSTANT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, GTMULT, multiplies a group's target or constraint value by a numerical constant. The group must have been initially fully defined using the GCONPROD or GCONPRI keywords for producers or GCONINJE for injectors. Variables not changed by the GTMULT keyword remain the same as those previously entered via the group control keywords or previously entered GTMULT keywords. See also the GRUPTARG keyword that sets the values for a group's target and constraints, and the GTADD keyword that adds a constant to a group's target or constraint. All the aforementioned keywords are described in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.113 GUIDECAL – Scale Guide Rates Based on Gas Calorific Value

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GUIDECAL keyword defines a well or group's guide rate as a function of their calorific values, for when the individual wells and groups are under guide rate control. Group and well guide rates that have not been directly defined are set equal to their production potentials at the start of each time step. In this case the GUIDECAL keyword can be used to specify the coefficients of a function that takes into account the calorific value of the produced gas, effectively scaling the guide rates based on the calorific value of the gas being produced.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.114 GUIDERAT – Define Group Guide Rate Formula

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines a general formulae used to define a groups guide rate as a function of the group potential.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.115 GUPFREQ – INSTANTANEOUS GRADIENT OPTION UPDATE FREQUENCY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GUPFREQ keyword sets the update frequency of the Instantaneous Gradient option for when this option has been activated by the GDIMS keyword in the RUNSPEC section. The Instantaneous Gradient option calculates derivatives of solution quantities at the current time step with respect to variations in the variables at the current time step. This is different to Gradient option that calculates the derivatives of solution quantities at the current time step with respect to variations in the variables at the initial time step, that is a time equal to zero. Consequently, the Instantaneous Gradient option can be switched on and off by the GUPFREQ keyword in the SCHEDULE section, whereas the Gradient option cannot.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.116 GWRTWCV – INSTANTANEOUS GRADIENT OPTION WELL VARIABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The GWRTWCV keyword defines the wells and instantaneous gradient parameters to be calculated and exported as SUMMARY vectors to the summary file, for when the Instantaneous Gradient option has been activated by the GDIMS keyword in the RUNSPEC section. The Instantaneous Gradient option calculates derivatives of solution quantities at the current time step with respect to variations in the variables at the current time step. This is different to Gradient option that calculates the derivatives of solution quantities at the current time step with respect to variations in the variables at the initial time step, that is a time equal to zero. Consequently, the Instantaneous Gradient option can be switched on and off by the GUPFREQ keyword in the SCHEDULE section, whereas the Gradient option cannot.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.117 HMWPIMLT – HISTORY MATCH WELL PRODUCTIVITY INDEX PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, HMWPIMLT, defines the history match gradient parameters for well productiviity indices, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. Wells must be specified using the WELPSECS keyword in the SCHEDULE section and their connections defined by the COMPDAT and/or COMPDATL keywords, also in the SCHEDULE section

See also the HMDIMS keyword in the RUNSPEC section that specifies the dimensions for the gradient option, including the maximum number of gradient wellss that can be used with the History Match Gradient option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.118 LGRFREE – ACTIVATE LOCAL GRID REFINEMENT INDEPENDENT TIME STEPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LGRFREE keyword activates the Local Grid Refinement ("LGR") Independent Time Step option that allows the LGR to have solution time steps independent of the host grid for the stated LGR, and for when LGRs have been declared by the LGR keyword in the RUNSPEC section, and defined by the CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) keywords in the GRID section. LGR independent solution time stepping can be deactivated by the LGRLOCK keyword in the SCHEDULE section.

Currently, OPM Flow does not support the local grid refinement feature and therefore this keyword is ignored by the simulator.

No.	Name	Description	Default
1	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which independent solution time stepping is to be activated. The LGR must have been previously defined by the CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) keywords in the GRID section.	None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.34: LGRFREE Keyword Description

Example

The example below defines three oil LGRs(LGR-OP01,-OP02, and -OP03) and all the gas well LGRs (LGR-GP*) that should use independent solution time steps.

```
--
--        ACTIVATE LOCAL GRID REFINEMENT INDEPENDENT TIME STEPS
--
--        LGRNAME
LGRFREE
          LGR-OP01                                                    /
          LGR-OP02                                                    /
          LGR-OP03                                                    /
          LGR-GP*                                                     /
/
```

12.3.119 LGRLOCK – DEACTIVATE LOCAL GRID REFINEMENT INDEPENDENT TIME STEPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LGRLOCK keyword deactivates the Local Grid Refinement ("LGR") Independent Time Step option that allows the LGR to have solution time steps independent of the host grid for the stated LGR, that is the LGR will now follow the global grid solution time steps. LGRs must have declared by the LGR keyword in the RUNSPEC section, and defined by the CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) keywords in the GRID section. LGR independent solution time stepping can be activated by the LGRFREE keyword in the SCHEDULE section.

Currently, OPM Flow does not support the local grid refinement feature and therefore this keyword is ignored by the simulator.

No.	Name	Description	Default
1	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which independent solution time stepping is to be deactivated. The LGR must have been previously defined by the CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) keywords in the GRID section.	None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.35: LGRLOCK Keyword Description

Example

The example below defines three oil LGRs(LGR-OP01,-OP02, and -OP03) and all the gas well LGRs (LGR-GP*) that should have their independent solution time steps deactivated.

```
--
--        DEACTIVATE LOCAL GRID REFINEMENT INDEPENDENT TIME STEPS
--
--        LGRNAME
LGRLOCK
          LGR-OP01                                                    /
          LGR-OP02                                                    /
          LGR-OP03                                                    /
          LGR-GP*                                                     /
/
```

12.3.120 LGROFF – DEACTIVATE A LOCAL GRID REFINEMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LGROFF keyword deactivates a stated Local Grid Refinement ("LGR") and optionally sets the minimum number of wells below which the LGR will be automatically deactivated. LGRs must have declared by the LGR keyword in the RUNSPEC section, and defined by the CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) keywords in the GRID section. LGRs can subsequently be activated by the LGRON keyword in the SCHEDULE section.

Currently, OPM Flow does not support the local grid refinement feature and therefore this keyword is ignored by the simulator.

No.	Name	Description	Default
1	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which the LGR is being deactivated. The LGR must have been previously defined by the CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) keywords in the GRID section.	None
2	MNWELLS	A positive integer greater than or equal to zero that defines the minimum number of active wells, below which the LGR will be automatically deactivated. The default value of zero implies that there is no limit to the number of wells and results in the LGR being unconditionally being deactivated.	0

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.36: LGROFF Keyword Description

Example

The example below unconditionally deactivates LGR-OP01, and sets the minimum number of active wells for deactivating LGR-OP02 and LGR-OP03 to one. For all the gas well LGRs (LGR-GP*) the minimum number of wells for deactivation is set to two.

```
--
--        DEACTIVATE LOCAL GRID REFINEMENTS
--
--        LGRNAME   MNWELLS
LGROFF
          LGR-OP01                                                    /
          LGR-OP02  1                                                 /
          LGR-OP03  1                                                 /
          LGR-GP*   2                                                 /
/
```

12.3.121 LGRON – ACTIVATE A LOCAL GRID REFINEMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LGRON keyword activates a stated Local Grid Refinement ("LGR") and optionally sets the minimum number of wells above which the LGR will remain active. LGRs must have declared by the LGR keyword in the RUNSPEC section, and defined by the CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) keywords in the GRID section. LGRs can subsequently be deactivated by the LGROFF keyword in the SCHEDULE section.

Currently, OPM Flow does not support the local grid refinement feature and therefore this keyword is ignored by the simulator.

No.	Name	Description	Default
1	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which the LGR is being activated. The LGR must have been previously defined by the CARFIN (Cartesian LGR grid) or RADIN/RADIN4 (radial LGR grid) keywords in the GRID section.	None
2	MNWELLS	A positive integer greater than or equal to zero that defines the minimum number of active wells, below which the LGR will be automatically deactivated. The default value of zero implies that there is no limit to the number of wells and results in the LGR being unconditionally being activated.	0

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.37: LGRON Keyword Description

Example

The example below unconditionally activates LGR-OP01, and sets the minimum number of active wells for activating LGR-OP02 and LGR-OP03 to one. For all the gas well LGRs (LGR-GP*) the minimum number of wells for activating these LGRs is set to two.

```
--
--        ACTIVATE LOCAL GRID REFINEMENTS
--
--        LGRNAME   MNWELLS
LGRON
          LGR-OP01                                                    /
          LGR-OP02  1                                                 /
          LGR-OP03  1                                                 /
          LGR-GP*   2                                                 /
/
```

12.3.122 LIFTOPT – Activate Gas Lift Optimization

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LIPTOPT keyword actives the gas lift optimization option.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.123 LINCOM – DEFINE LINEAR COMBINATION COEFFICIENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The LINCOM keyword defines the oil, gas and water coefficients for the Linear Combination facility which allows for a linear combination of the aforementioned phase rates and volumes to be used as targets and constraints in controlling group and well production and injection data. See also the LCUNIT in the PROPS section that defines the units for linear combination equation.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.124 MATCORR – Activate the Material Balance Correction Option

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The MATCORR keyword activates the Material Balance Correction option used to adjust the accumulated material balance error in the simulation.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.125 MESSOPTS – Reset Severity Level for Forced Time Steps

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, MESSOPTS, resets the severity level for time steps that are forced to be accepted by the simulator. The normal severity level for this type of simulator generated message is PROBLEM and this can result in the run stopping depending on the parameters entered on the MESSAGES keyword. MESSOPTS can be used to reset the severity level to MESSAGE, COMMENT, WARNING, or PROBLEM; for example, to avoid the run terminating due to too many PROBLEM messages.

Note that the MESSAGES keyword is a global keyword can therefore be used in any section; however, only the last instance of the keywords is active. The MESSOPTS keyword can only be used in the SCHEDULE section but can be used multiple times to change the severity level for forced time steps. Again, only the last occurrence of the keyword is active.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.126 MULSGGD – Multiply Matrix-Fracture Coupling for Oil-Gas Gravity Drainage for All Cells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, MULSGGD, defines a constant multiplier to modify the matrix-fracture coupling transmissibility for dual porosity and dual permeability models, for when the alternative matrix-fracture coupling transmissibilities for oil-gas gravity drainage has been selected. The alternative matrix-fracture coupling transmissibilities for oil-gas gravity drainage option is activated via the SIGMAGD or SIGMAGDV keywords in the GRID section, and the dual porosity or dual permeability models are activated by the DUALPORO or DUALPERM keywords in the RUNSPEC section, respectively.

This keyword applies the multiplier for all cells in model; whereas, the MULSGGDV keyword in the SCHEDULE section applies the multiplier to individual grid blocks.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.127 MULSGGDV – Multiply Matrix-Fracture Coupling for Oil-Gas Gravity Drainage for Individual Cells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, MULSGGDV, defines a constant multiplier to modify the matrix-fracture coupling transmissibility for dual porosity and dual permeability models, for when the alternative matrix-fracture coupling transmissibilities for oil-gas gravity drainage has been selected. The alternative matrix-fracture coupling transmissibilities for oil-gas gravity drainage option is activated via the SIGMAGD or SIGMAGDV keywords in the GRID section, and the dual porosity or dual permeability models are activated by the DUALPORO or DUALPERM keywords in the RUNSPEC section, respectively.

This keyword applies the multiplier for individual cells in model; whereas, the MULSGGD keyword in the SCHEDULE section applies the multiplier to all grid blocks.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.128 MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant

MULTFLT enables the transmissibilities across defined faults, as declared by the FAULTS keyword, to be modified. They keyword allows for the re-scaling of the existing fault transmissibilities calculated by OPM Flow, for example setting a fault to be completely sealing by setting the multiplier to zero..

See *MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant* in the GRID section for a full description.

12.3.129 MULTPV – Multiply Cell Pore Volumes by a Constant

MULTPV multiples the pore volumes of a cell by a real positive constant for all the cells in the model via an array. An alternative to defining the complete array is to use the BOX keyword to define an area of the grid and then use the MULTPV keyword to set the multipliers just for the area defined by the BOX keyword (see the example).

See *MULTPV – Multiply Cell Pore Volumes by a Constant*in the GRID section for a full description.

12.3.130 MULTR - Multiply Cell Transmissibility in the +R Direction

MULTR multiples the transmissibility between two cell faces in the +R direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I+I, J, K). The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

See *MULTR - Multiply Cell Transmissibility in the +R Direction* in the GRID section for a full description.

12.3.131 MULTR- - Multiply Cell Transmissibility in the -R Direction

MULTX- multiples the transmissibility between two cell faces in the -X direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I-1, J, K) and (I, J, K). The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

See *MULTR- - Multiply Cell Transmissibility in the -R Direction* in the GRID section for a full description.

12.3.132 MULTSIG – MULTIPLY MATRIX-FRACTURE COUPLING FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, MULTSIG, defines a constant multiplier to modify the matrix-fracture coupling transmissibility for dual porosity and dual permeability models, for when the matrix-fracture coupling transmissibilities have been specified via the SIGMAGD or SIGMAGDV keywords in the GRID section, and the dual porosity or dual permeability models have been activated by the DUALPORO or DUALPERM keywords in the RUNSPEC section, respectively.

This keyword applies the multiplier for all cells in model; whereas, the MULTSIGV keyword in the SCHEDULE section applies the multiplier to individual grid blocks.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.133 MULTSIGV – Multiply Matrix-Fracture Coupling for Individual Cells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, MULTSIGV, defines a constant multiplier to modify the matrix-fracture coupling transmissibility for dual porosity and dual permeability models, for when the matrix-fracture coupling transmissibilities have been specified via the SIGMAGD or SIGMAGDV keywords in the GRID section, and the dual porosity or dual permeability models have activated by the DUALPORO or DUALPERM keywords in the RUNSPEC section, respectively.

This keyword applies the multiplier for individual cells in model; whereas, the MULTSIG keyword in the SCHEDULE section applies the multiplier to all grid blocks.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.134 MULTTHT - Multiply Cell Transmissibility in the +Theta Direction

MULTTHT multiples the transmissibility between two cell faces in the +Theta direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J+1, K). The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

See *MULTTHT - Multiply Cell Transmissibility in the +Theta Direction* in the GRID section for a full description.

12.3.135 MULTTHT- - Multiply Cell Transmissibility in the -Theta Direction

MULTTHT- multiples the transmissibility between two cell faces in the -Theta direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J-1, K) and (I, J, K). The keyword should only be used with radial grids, as declared by the RADIAL keyword in the RUNSPEC section.

See *MULTTHT- - Multiply Cell Transmissibility in the -Theta Direction* in the GRID section for a full description.

12.3.136 MULTX - Multiply Cell Transmissibility in the +X Direction

MULTX multiples the transmissibility between two cell faces in the +X direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I+1, J, K).

See *MULTX - Multiply Cell Transmissibility in the +X Direction* in the GRID section for a full description.

12.3.137 MULTX- - Multiply Cell Transmissibility in the -X Direction

MULTX- multiples the transmissibility between two cell faces in the -X direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I-1, J, K) and (I, J, K).

See *MULTX- - Multiply Cell Transmissibility in the -X Direction* in the GRID section for a full description.

12.3.138 MULTY - Multiply Cell Transmissibility in the +Y Direction

MULTY multiples the transmissibility between two cell faces in the +Y direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J+1, K).

See *MULTY - Multiply Cell Transmissibility in the +Y Direction* in the GRID section for a full description.

12.3.139 MULTY- - Multiply Cell Transmissibility in the -Y Direction

MULTY- multiples the transmissibility between two cell faces in the -Y direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J-1, K) and (I, J, K).

See *MULTY- - Multiply Cell Transmissibility in the -Y Direction* in the GRID section for a full description.

12.3.140 MULTZ - Multiply Cell Transmissibility in the +Z Direction

MULTZ multiples the transmissibility between two cell faces in the +Z direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K) and (I, J, K+1).

See *MULTZ - Multiply Cell Transmissibility in the +Z Direction* in the GRID section for a full description.

12.3.141 MULTZ- - Multiply Cell Transmissibility in the -Z Direction

MULTZ- multiples the transmissibility between two cell faces in the -Z direction for all the cells in the model via an array, that is the keyword sets the transmissibility multiplier of block (I, J, K) between the cells (I, J, K-1) and (I, J, K).

See *MULTZ- - Multiply Cell Transmissibility in the -Z Direction* in the GRID section for a full description.

12.3.142 NCONSUMP - Node Gas Consumption (Extended Network)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NCONSUMP keyword defines an extended network node's gas consumption rate, for when the Extended Network option has been activated by the NETWORK keyword in the RUNSPEC section. The keyword can also be used to attribute the gas consumption to a previously defined group. See also the GCONSUMP keyword in the SCHEDULE section that overs more flexibility and can also be used with the Extended Network option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.143 NEFAC - Node Efficiency Factors (Extended Network)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NEFAC keyword defines an extended network node's efficiency factor, for when the Extended Network option has been activated by the NETWORK keyword in the RUNSPEC section. See also the GEFAC keyword in the SCHEDULE section that can also be used with the Extended Network option.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.144 NETBALAN – NETWORK BALANCING PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the network balancing parameters used to control how network balancing is perform on a network.

OPM Flow does not have this feature and hence this keyword is ignored by OPM Flow and the NETBALAN keyword has no effect on the simulation.

12.3.145 NETCOMPA – Define Automatic Compressors (Extended Network)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NETCOMPA keyword defines automatic compressors in an extended network, for when the Extended Network option has been activated by the NETWORK keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.146 NEXT – MAXIMUM NEXT TIME STEP SIZE (ALIAS FOR NEXTSTEP)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the maximum time step size the simulator should take for the next time step. This keyword can be used to reset the time step for when known large changes to the model are taking place that may result in time step chops. For example, if the reporting time size is using monthly reporting steps via the DATES keyword in the SCHEDULE section, then if for example, a group of wells start production at a given date, then the NEXT keyword can be used to shorten the next step in order to avoid a time step chop.

Time steps chops are computationally expensive as the simulator cannot solve the current time step at the given tolerance, and therefore has to reduce the time step size. For example, if the previous completed time step was at day 365 and the current time step ending at 396 days cannot be solved, then the simulator will reduce the current time step to perhaps end at day 370, if this still cannot solved then the time step will be chopped back again to perhaps to less then one day. Using the NEXT or NEXTSTEP keyword, the simulator is instructed to take a small time step in the anticipation that this will avoid time step chops and thus improve computational performance.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NSTEP1	NSTEP1 is a real positive value that defines the maximum length of the next time step.			
		days	days	hours	None
2	NSTEP2	NSTEP2 is a character string that should be set to either NO or YES to state if the NSTEP1 should be applied to future reporting time steps. 1) NO: Means that NSTEP1 should not be applied to subsequent reporting time steps. 2) YES: means that STEP1 should be applied to subsequent reporting time steps. The default value of NO means that NSTEP1 will only be applied once.			NO
Notes: 1) The keyword is terminated by "/".					

Table 12.38: NEXT Keyword Description

See also the DATES and TSTEP keywords in the RUNSPEC section that are used to advance the simulation through time.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness. See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to control time stepping for OPM Flow.

Example

```
--        NEXT   ALL
--        STEP   TIME
--        ----   ----
NEXT
          1     'NO'                                    /
```

Here the next step size is set to one day and should only be used once.

12.3.147 NEXTSTEP – MAXIMUM NEXT TIME STEP SIZE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the maximum time step size the simulator should take for the next time step. This keyword can be used to reset the time step for when known large changes to the model are taking place that may result in time step chops. For example, if the reporting time size is using monthly reporting steps via the DATES keyword in the SCHEDULE section, then if for example, a group of wells start production at a given date, then the NEXTSTEP keyword can be used to shorten the next step in order to avoid a time step chop.

Time steps chops are computationally expensive as the simulator cannot solve the current time step at the given tolerance, and therefore has to reduce the time step size. For example, if the previous completed time step was at day 365 and the current time step ending at 396 days cannot be solved, then the simulator will reduce the current time step to perhaps end at day 370, if this still cannot solved then the time step will be chopped back again to perhaps to less then one day. Using the NEXT or NEXTSTEP keyword, the simulator is instructed to take a small time step in the anticipation that this will avoid time step chops and thus improve computational performance.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NSTEP1	NSTEP1 is a real positive value that defines the maximum length of the next time step.			
		days	days	hours	None
2	NSTEP2	NSTEP2 is a character string that should be set to either NO or YES to state if the NSTEP1 should be applied to future reporting time steps. 3) NO: Means that NSTEP1 should not be applied to subsequent reporting time steps. 4) YES: means that STEP1 should be applied to subsequent reporting time steps. The default value of NO means that NSTEP1 will only be applied once.			NO
Notes: 1) The keyword is terminated by "/".					

Table 12.39: NEXTSTEP Keyword Description

See also the DATES and TSTEP keywords in the RUNSPEC section that are used to advance the simulation through time.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness. See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to control time stepping for OPM Flow.

Examples

The first example shows the direct use of the NEXTSTEP keyword:,

```
--        NEXT   ALL
--        STEP   TIME
--        ----   ----
NEXTSTEP
          1     'NO'                                        /
```

Here the next step size is set to one day and should only be used once.

The next example shows a more complete use of the keyword for when the field oil production has increased dramatically from 10,000 stb/d to 50,000 stb/d as indicated by the two GCONPROD keywords.

```
-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2021-01-01
-- ------------------------------------------------------------------------------
--
-- GROUP PRODUCTION CONTROLS
--
-- GRUP    CNTL  OIL    WAT    GAS    LIQ    CNTL  GRUP  GUIDE  GUIDE  CNTL
-- NAME    MODE  RATE   RATE   RATE   RATE   OPT   CNTL  RATE   DEF    WAT
GCONPROD
'FIELD'   'ORAT' 10E3   60E3   300E3  60E3   1*     1*    1*     1*     1*     /
/
RPTSCHED
'WELLS=2'    'WELSPECS'    'CPU=2'     'FIP=2'                                  /

DATES
 2  JAN   2021  /
/
RPTSCHED
'NOTHING'                                                                      /

DATES
 1  FEB   2021  /
 1  MAR   2021  /
/
-- GROUP PRODUCTION CONTROLS
--
-- GRUP    CNTL  OIL    WAT    GAS    LIQ    CNTL  GRUP  GUIDE  GUIDE  CNTL
-- NAME    MODE  RATE   RATE   RATE   RATE   OPT   CNTL  RATE   DEF    WAT
GCONPROD
'FIELD'   'ORAT' 50E3   90E3   300E3  90E3   1*     1*    1*     1*     1*     /
/
--
--        NEXT   ALL
--        STEP   TIME
--        ----   ----
NEXTSTEP
          1     'NO'   /
DATES
 1  APR   2021  /
 1  MAY   2021  /
 1  JUN   2021  /
 1  JLY   2021  /
 1  AUG   2021  /
 1  SEP   2021  /
 1  OCT   2021  /
 1  NOV   2021  /
 1  DEC   2021  /
/
```

Given a start date of January 1, 2020 set via the START keyword in the RUNSPEC section, the above example shows the initial oil production of 10,000 stb/d starting in January 1, 2020, and continuing up to March 1, 2021. At the March 1, 2021 time step the field oil production rate is increased to 50,000 stb/d and the maximum next time step is set to one day. After the one day time step is completed (March 2, 2012), the simulator will progressively in increase the time step size until a maximum of 31 days is reached. The 31 day maximum is a result of requesting monthly time steps via the DATES keyword. The intent of using the NEXTSTEP keyword in this case is to prevent time step chops occurring due to the "shock" to the system caused by the large increase in oil production.

12.3.148 NEXTSTPL – MAXIMUM NEXT TIME STEP SIZE (LGR)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the maximum time step size the simulator should take for the next time step for all Local Grid Refinements (LGR"). This keyword can be used to reset the time step for when known large changes to the model are taking place that may result in time step chops. For example, if the reporting time size is using monthly reporting steps via the DATES keyword in the SCHEDULE section, then if for example, a group of wells start production at a given date, then the NEXTSTPL keyword can be used to shorten the next step in all the LGRs in order to avoid a time step chop.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NSTEP1	NSTEP1 is a real positive value that defines the maximum length of the next time step.			
		days	days	hours	None
2	NSTEP2	NSTEP2 is a character string that should be set to either NO or YES to state if the NSTEP1 should be applied to future reporting time steps. 5) NO: Means that NSTEP1 should not be applied to subsequent reporting time steps. 6) YES: means that STEP1 should be applied to subsequent reporting time steps. The default value of NO means that NSTEP1 will only be applied once.			NO
Notes: 1) The keyword is terminated by "/".					

Table 12.40: NEXTSTPL Keyword Description

See also the NEXT and NEXTSTEP keywords in the SCHEDULE section that are used to control the global grid's next time step.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness. See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to control time stepping for OPM Flow.

Example

```
--
--        NEXT    ALL
--        STEP    TIME
--        ----    ----
NEXTSTEP
          1     'NO'                                    /
```

Here the next step size for all LGRs is set to one day and should only be used once.

12.3.149 NODEPROP – Define Network Node Properties for Extended Network

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the network node properties for the extended network option for when the Extended Network option has been invoked by the NETWORK keyword in the RUNSPEC secction.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.150 NOHMD – DEACTIVATE HISTORY MATCH GRADIENT DERIVATIVE CALCULATIONS

The NOHMD deactivates various history match gradient derivative calculations for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The keyword consists of a series of character strings that define which derivative should be switch off based on the keyword that requested the derivatives to be calculated, for example HMFAULTS keyword in the GRID section. If an empty list is entered then all the gradient derivative calculations previously requested are switch off. The keyword is useful for changing from history matching runs to predication cases, as the prediction cases will be more computationally efficient without the burden of the gradient derivative calculations.

See *NOHMD – Deactivate History Match Gradient Derivative Calculations* in the SOLUTION section for a full description.

12.3.151 NOHMO – DEACTIVATE HISTORY MATCH GRADIENT DERIVATIVE CALCULATIONS (ALIAS)

The NOHMO deactivates various history match gradient derivative calculations for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section. The keyword consists of a series of character strings that define which derivative should be switch off based on the keyword that requested the derivatives to be calculated, for example HMFAULTS keyword in the GRID section. If an empty list is entered then all the gradient derivative calculations previously requested are switch off. The keyword is useful for changing from history matching runs to predication cases, as the prediction cases will be more computationally efficient without the burden of the gradient derivative calculations.

See *NOHMO – Deactivate History Match Gradient Derivative Calculations (Alias)* in the SOLUTION section for a full description.

12.3.152 NOSIM – ACTIVATE THE NO SIMULATION MODE FOR DATA FILE CHECKING

NOSIM switches the mode of OFM Flow to data input checking mode. In this mode the input file is read and all messages and print instructions are sent to the respective output files. The SCHEDULE section is read but the simulation is not performed.

See *NOSIM – Activate the No Simulation Mode for Data File Checking* in the RUNSPEC section for a full description

12.3.153 NUPCOL – DEFINE THE NUMBER OF NEWTONIAN ITERATIONS USED TO UPDATE WELL TARGETS

The NUPOL keyword defines the maximum number of Newtonian iterations within a time step that may be used to update the well production and injection targets, after which the well targets will be frozen until the time step calculations have converged and the time step is complete.

See *NUPCOL – Define the Number of Newtonian Iterations Used to Update Well Targets* in the RUNSPEC section for a full description and also section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to set various other numerical control parameters for OPM Flow.

12.3.154 NWATREM – Node Water Removal (Extended Network)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The NWATREM keyword defines an extended network node as a point where water is removed from the network, for when the Extended Network option has been activated by the NETWORK keyword in the RUNSPEC section. The water to be removed can be specified as a rate or as a fraction of the total volume passing through the node.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.155 OUTSOL – Define Data to be Written to the RESTART File (Retired)

This keyword defines the data and frequency of the data to be written to the RESTART file at each requested restart point. The keyword has been replaced by the RPTRST keyword in the SOLUTION and SCHEDULE sections and is therefore considered retired.

See *OUTSOL – Define Data to be Written to the RESTART File (Retired)* in the SOLUTION section for a full description.

12.3.156 PICOND – DEFINE THE GENERALIZED PSEUDO PRESSURE PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PICOND keyword defines the Generalized Pseudo Pressure ("GPP")[147] and [148] parameters used in a gas condensate well connection inflow equations. GPP accounts for both the impact of condensate drop out and compressibility in the mobility inflow term . If the keyword is absent from the input deck then the default values are applied.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[147] *Whitson, C. H. and Fevang, Ø. "Generalised Pseudopressure Well Treatment in Reservoir Simulation," Presented at the IBC Technical Services Conference on Optimisation of Gas Condensate Fields, Aberdeen, UK (June 26-27, 1997)*

[148] *Whitson, C. H. and Fevang, Ø. "Modeling Gas Condensate Well Deliverability," paper SPE 30714, SPE Reservoir Engineering (1996) 11, No. 4, 221-230; also presented at the SPE Annual Technical Conference and Exhibition, Dallas, Texas, USA (October 22-25, 1995).*

12.3.157 PIMULTAB – DEFINE WELL PRODUCTIVITY INDEX VERSUS WATER CUT TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PIMULTAB defines productivity index multiplier versus water cut tables that are used to scaled a well's connection factors based on connection's current producing water cut. The tables are used for modeling the productivity decline due to increasing water cut. Allocation of the tables to a well is via the WPITAB keyword in the SCHEDULE section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WCUT	A real monotonically increasing positive columnar vector that defines the maximum surface water cut for the corresponding PIMULT vector. Water cut is defined as $f_w = \frac{q_w}{q_w + q_o}$.			
		dimensionless	dimensionless	dimensionless	None
2	PIMULT	A real positive decreasing columnar vector that defines the productivity index multiplier used to scale a well's connection factors, for the corresponding WCUT vector.			
		dimensionless	dimensionless	dimensionless	None

Notes:

1) The keyword is followed by NTPIMT tables as stated on the PIMTDIMS keyword in the RUNSPEC section.
2) Each table must contain a minimum of two rows and a maximum of NRPIMT rows as declared on the PIMTDIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 12.41: PIMULTAB Keyword Description

See also the WPITAB keyword that allocates the tables to the wells, and also the WPIMULT keyword that scales a well's productivity index by a constant value, both of which are in the SCHEDULE section.
This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Examples

Given NTPIMT equals two and NRPIMT equals four on PIMTDIMS keyword in the RUNSPEC section, then:

```
--
--        DEFINE WELL PRODUCTIVITY INDEX VERSUS WATER CUT TABLES
--
--        MAX       PI
--        WCUT      MULT
--        ------    ------
PIMULTAB
          0.0000    1.0000
          0.2500    0.9500
          0.5000    0.8500
          0.7500    0.7500                                  /
--
          0.0000    1.0000
          0.2500    0.9500
          0.5000    0.8500
          0.7500    0.7500                                  /
```

The next example is summarized from the Norne model with NTPIMT equals one and NRPIMT equals to 51 on the PIMTDIMS keyword in the RUNSPEC section.

```
--
--       DEFINE WELL PRODUCTIVITY INDEX VERSUS WATER CUT TABLES
--       The following is the reviewed model in Aug-2006, low-high case
--       a=0.25, b=0.1; PIMULT=(1-a)/exp(fw/b)+a
--
--       MAX      PI
--       WCUT     MULT
--       ------   ------
PIMULTAB
         0.000    1.0000
         0.025    0.8341
         0.050    0.7049
         0.075    0.6043
         0.100    0.5259
         0.125    0.4649
         0.150    0.4173
         0.175    0.3803
         0.200    0.3515
         0.225    0.3290
         0.250    0.3116
         0.275    0.2979
         0.300    0.2873
         0.325    0.2791
         0.350    0.2726
         0.375    0.2676
         0.400    0.2637
         0.425    0.2607
         0.450    0.2583
         0.475    0.2565
         0.500    0.2551
         0.525    0.2539
         0.550    0.2531
         0.575    0.2524
         0.600    0.2519
         0.625    0.2514
         0.650    0.2511
         0.675    0.2509
         0.700    0.2507
         0.725    0.2505
         0.750    0.2504
         0.775    0.2503
         0.800    0.2503
         0.825    0.2502
         0.850    0.2502
         0.875    0.2501
         0.900    0.2501
         0.925    0.2501
         0.950    0.2501
         0.975    0.2500
         1.000    0.2500 /
```

12.3.158 PLYADS - Define Polymer Rock Adsorption Tables

The PLYADS keyword defines the rock polymer adsorption tables for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section. Alternatively, the functions can be entered via the PLYADSS keyword in the PROPS section for when salt sensitivity is to be considered.

See *PLYADS - Define Polymer Rock Adsorption Tables* in the PROPS section for a full description.

12.3.159 PLYDHFLF - Define Polymer Thermal Degradation Half-Life Tables

The PLYDHFLF keyword defines the polymer thermal degradation half-life with respect to temperature functions for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

See *PLYDHFLF - Define Polymer Thermal Degradation Half-Life Tables* in the PROPS section for a full description.

12.3.160 PLYMAX - Define Polymer-Salt Viscosity Mixing Concentrations

The PLYMAX keyword defines maximum polymer and salt concentrations that are to be used in the mixing parameter calculation of the fluid component viscosities, for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

See *PLYMAX - Define Polymer-Salt Viscosity Mixing Concentrations* in the PROPS section for a full description.

12.3.161 PLYROCKM - Modify Polymer-Rock Properties

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PLYROCKM keyword modifies rock properties entered via the PLYCAMAX, PLYKRRF, PLYRMDEN, and PLYROCK keywords in the PROPS section, for when the Polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.162 PLYSHEAR – ACTIVATE AND DEFINE POLYMER SHEARING PARAMETERS

The PLYSHEAR keyword activates and the defines the polymer shear thinning-thickening option for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

See *PLYSHEAR – Activate and Define Polymer Shearing Parameters* in the PROPS section for a full description.

12.3.163 PLYSHLOG - ACTIVATE AND DEFINE THE POLYMER SHEARING LOGARITHMIC PARAMETERS

This keyword activates and defines the parameters for the logarithm-based polymer shear thinning/thickening option.

See *PLYSHLOG - Activate and Define the Polymer Shearing Logarithmic Parameters* in the PROPS section for a full description.

12.3.164 PLYVISC – DEFINE POLYMER VISCOSITY SCALING FACT

PLYSVISC defines the polymer viscosity scaling factors used to determine the relationship of pure water viscosity with respect to increasing polymer saturation within a grid block. The polymer option must be activated by the POLYMER keyword in the RUNSPEC section in order to use this keyword.

See *PLYVISC – Define Polymer Viscosity Scaling Factors* in the PROPS section for a full description.

12.3.165 PLYVISCS – DEFINE POLYMER-SALT VISCOSITY SCALING FACTORS

PLYSVISCS defines the polymer-salt viscosity scaling factor tables applied to pure water that are used to determine the viscosity of a polymer-salt mixture with respect to increasing polymer saturation within a grid block. The polymer option must be activated by the POLYMER keyword, as well as the brine phase declared by the BRINE keyword in the RUNSPEC section in order to use this keyword. However the ECLM keyword in the RUNSPEC must not be used with this keyword.

See *PLYVISCS – Define Polymer-Salt Viscosity Scaling Factors* in the PROPS section for a full description.

12.3.166 PLYVISCT – DEFINE POLYMER-TEMPERATURE VISCOSITY SCALING FACTORS

PLYSVISCT defines the polymer-temperature viscosity scaling factor tables applied to pure water that are used to determine the viscosity of the polymer at a given temperature with respect to increasing polymer saturation within a grid block. Both the polymer option must be activated by the POLYMER keyword and the temperature option invoked by the TEMP keyword in the RUNSPEC section in order to use this keyword. However the BRINE keyword in the RUNSPEC must not be used with this keyword, that is the salt sensitivity options should be deactivated.

See *PLYVISCT – Define Polymer-Temperature Viscosity Scaling Factors* in the PROPS section for a full description.

12.3.167 PLYVSCST – Define Polymer-Salt-Temperature Viscosity Scaling Factors

PLYVSCST defines the polymer-salt-temperature viscosity scaling factor tables applied to pure water that are used to determine the viscosity of the polymer at a given salt concentration and for a given temperature, with respect to increasing polymer saturation within a grid block. Both the polymer option must be activated by the POLYMER keyword and the temperature option invoked by the TEMP keyword in the RUNSPEC section in order to use this keyword. In addition, the BRINE keyword in the RUNSPEC must also be invoked. The keyword is used in conjunction with the SALTNODE keyword to define the various salt concentrations and the TEMPNODE keyword to define the various reservoir temperatures. Both keywords are in the PROPS section.

See *PLYVSCST – Define Polymer-Salt-Temperature Viscosity Scaling Factors* in the PROPS section for a full description.

12.3.168 PRIORITY – ACTIVATE AND DEFINE WELL PRIORITIZATION COEFFICIENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The PRIORITY keyword activates the Well Priority option and defines the coefficients in the well priority equation. Wells under group control are ranked based on their well potential in order to satisfy group controls. For example if a group's oil target is exceeded, then the group may shut-in the lease productive oil wells based on their well potential. The Priority option is an alternative form of ranking the wells based on the following equation:

$$\text{Priority} = \frac{a_1 + a_2 Q_{oil} + a_3 Q_{water} + a_4 Q_{gas}}{b_1 + b_2 Q_{oil} + b_3 Q_{water} + b_4 Q_{gas}} \qquad (12.21)$$

Where:

Q_{oil} = well oil potential
Q_{water} = well water potential
Q_{gas} = well gas potential
$a_{1\text{-}4}$ = priority coefficients supplied by this keyword
$b_{1\text{-}4}$ = priority coefficients supplied by this keyword

This keyword is ignored by OPM Flow and has no effect on the simulation.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TIME	A real positive integer that defines the minimum time interval between executing the well priority calculation. The calculation is performed at the beginning of the time step that exceeds the previous calculation (t_0) by a minimum of TIME, that is for when $t_n \geq (t_0 + \text{TIME})$. Note that the default value of zero means that the calculation is performed at each time step. As a consequence, this may result in some oscillation as well wells are switched on/off at subsequent time steps.			0
		days	days	hours	
2	A1	A real positive integer greater than or equal to zero that defines a_1 priority coefficient in equation (12.21).			0
3	A2	A real positive integer greater than or equal to zero that defines a_2 priority coefficient in equation (12.21).			0
4	A3	A real positive integer greater than or equal to zero that defines a_3 priority coefficient in equation (12.21).			0
5	A4	A real positive integer greater than or equal to zero that defines a_4 priority coefficient in equation (12.21).			0
6	B1	A real positive integer greater than or equal to zero that defines b_1 priority coefficient in equation (12.21).			0
7	B2	A real positive integer greater than or equal to zero that defines b_2 priority coefficient in equation (12.21).			0

No.	Name	Description			Default
		Field	Metric	Laboratory	
8	B3	A real positive integer greater than or equal to zero that defines b_3 priority coefficient in equation (12.21).			0
9	B4	A real positive integer greater than or equal to zero that defines b_4 priority coefficient in equation (12.21).			0

Notes:

1) The keyword is terminated by "/".

Table 12.42: PRIORITY Keyword Description

Example

```
--
--        SETS COEFFICIENTS FOR WELL PRIORITIZATION OPTION
--
--        TIME    A     B     C     D     E     F     G     H
--        STEP          Qo    Qw    Qg          Qo    Qw    Qg
PRIORITY
          0.0     0.0   1.0   0.0   0.0   1.0   0.0   0.0   0.0 / High Oil Pot
--        0.0     0.0   1.0   1.0   0.0   0.0   0.0   1.0   0.0 / Low Water Cut Pot
--        0.0     0.0   1.0   0.0   0.0   0.0   0.0   0.0   1.0 / Low GOR Pot
```

The above example defines the well priority calculation to be based on a well's oil potential, with calculation to be performed at each time step. Note that the low water cut and low GOR options are given for reference but are commented out and therefore ignored by the simulator.

12.3.169 PRORDER – Define a Group Production Rules Sequence

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PRORDER defines the order of group production rules to be implemented fore when a group's target is not satisfied.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.170 PYACTION – DEFINE PYTHON BASED ACTION CONDITIONS AND COMMAND PROCESSING

Description

The PYACTION keyword is part of OPM Flow's Python scripting facility that loads a standard Python script file that can be used to define a series of conditions and actions as the simulation proceeds through time. The "included" Python script file is executed by the standard Python interpreter. Thus, OPM Flow's Python scripting facility offers greater flexibility compared to the commercial simulator's ACTION series of keywords (ACTION, ACTIONG, ACTIONR, ACTIONS, ACTIONW and ACTIONX) that can apply Boolean conditional tests to variables at the field, group, region, well segment and well levels. Note that OPM Flow has also implemented the commercial simulator's ACTIONX keyword, but not the ACTION, ACTIONG, ACTIONR, ACTIONS and ACTIONW keywords, as the ACTIONX keyword implements their functionality with greater flexibility.

This keyword starts the definition of a PYACTION section that stipulates the name of the action and a string indicating the number of times the action should be run; this is then followed file containing the Python script. Noted that unlike the commercial simulator's ACTIONX keyword there is no terminating keyword like the commercial simulator's ENDACTIO keyword.

Although this keyword is read by OPM Flow and the script processing has been implemented, one should use caution when using this facility as it may result in OPM Flow aborting. This is because the PYACTION facility allows the user to implement complex functionality and the implementation is new for the 2020-04 release. Users should therefore use caution when using this facility.

Note

This is an OPM Flow specific keyword for the simulator's scripting facility using the standard Python interpreter, as such it gives more flexibility than the commercial simulator's ACTIONX keyword, although OPM Flow also supports this as well.

The keyword should be considered experimental as details of the OPM Flow - Python interface might change for future releases. In particular, the current implementation is quite minimal; however, future releases are expected to add more entry points in the Schedule class which can be used to manipulate the reservoir model as the simulation progresses. As a user you are encouraged to come with wishes in this regard.

The PYACTION keyword is a very powerful keyword and allows for any piece of Python code to be included and run, including potentially malicious code. The important point is to scrutinize any PYACTION keyword in a deck you receive from other parties.

No.	Name	Description	Default
PYACTION		PYACTION declares the start of a PYACTION Definition Section. This is then followed by one record that defines the name of the action and a string indicating the number of times the action should be run; this is then followed by a second record indicating the file containing the Python script.	Not Applicable
1-1	ACTNAME	ACTNAME is a character sting of any length enclose in quotes that defines the name of this action definition.	Not Applicable

No.	Name	Description	Default
1-2	ACTNSTEP	ACTNSTEP is a defined character string enclosed in quotes that indicates the number of times the action should be performed, and should be set to one of the following: 1) FIRST_TRUE: This option forces the action to be run at the end of every time step until the script returns a value of True. 2) SINGLE: Here the action script is run only once. 3) UNLIMITED: If this option is selected then the action is run at the end of every time step.	Not Applicable
1-4	/	Record terminated by a "/"	Not Applicable
2-1	FILENAME	A character string enclosed in quotes that defines the Python module/script file to read in and to be processed by OPM Flow.	None
2-2	/	Record terminated by a "/"	Not Applicable
Notes: 1) There is no terminating "/" for this keyword.			

Table 12.43: PYACTION Keyword Description

The PYACTION keyword is a result of combining two programming languages, the interactive Python interpreter and OPM Flow's source code language C++. When combing two languages one extends and embeds one into the other. When extending Python with C++ the functionality implemented in C++ is made available to Python applications, when embedding Python in C++ one can call Python functions from within C++. The PYACTION keyword is based on embedding a Python interpreter in the C++ OPM Flow simulator, but the Python code actually runs as part of the PYACTION keyword is based on wrapping C++ objects in Python, that is extending Python.

In order to fully benefit from the power of the PYACTION keyword one should familiarize oneself with the Python wrapper classes for the various OPM Flow C++ classes. These classes are essential to share the simulator state with the PYACTION run() function. That is, the function provides the interface between the two programming languages.

To learn more about these classes you can use the pydoc utility, for example, to learn more about the SummaryState class, in a Linux terminal one would issue the following bash command:

```
bash% pydoc opm.io.sim.SummaryState
```

The Python script file (FILENAME in the PYACTION keyword) should be a standard Python module[149] that defines the run() function with a pre-defined augment definition and should consist of 100% pure Python. The PYACTION Python module (FILENAME) is imported during processing of the input deck and as such this implies:

1) Basic Python syntax checking is performed during reading the FILENAME script file.
2) It is verified that the module has the required run() function with the correct format.
3) Code which is at module level, that is outside of any function call is run immediately at the time import time – this is probably not one wants and should therefore be avoided.

The syntax of the run() command is given in Table 12.44 together with a description of the function's call variables.

[149] *A Python module is a file containing Python definitions and statements. The file name is the module name with the suffix .py appended. Within a module, the module's name (as a string) is available as the value of the global variable __name__.*

RUN() Function Definition		

		`def run(ecl_state, schedule, report_step, summary_state):`
		`#`
		`# OPM Flow PYACTION Module Script`
		`#`
		……
		……
		`return`

No.	**Name**	**Description**
1	ecl_state	The ecl_state augment is a opm.io.ecl_state.EclipseState instance which is initialized with all the static information in the simulation, for example the 3D grid properties and the PVT and saturation tables This object is read by the run() function and the available data should not be modified as any updates will not be passed back to the simulator.
2	schedule	The schedule argument is a opm.io.sched.Schedule instance which has all the SCHEDULE information internalized (Schedule object). Currently, there are only a few call points in opm.io.sched.Schedule which can be used to update the state of the simulation, most notably: `schedule.shut_well(well_name, report_step)` Which can be used to shut a well at a particular report step. Having additional call points to the opm.io.ecl_state.EclipseState instance in order to update the Schedule object in more ways is an obvious candidate for improving the PYACTION functionality.
3	report_step	The current report step.

4	summary_state	The summary_state argument is an instance of the opm.io.sim.SummaryState class, the purpose of this class is to serve as a container for SUMMARY variables that contain the simulation results; for example, the Field Oil Rate (FOPR) or a well's Water CuT (WWCT). See the *SUMMARY SECTION* for a detailed description of the variables available.
		The summary_state variable will typically be the variable one will use to access the state of the simulation. For example, to check if the water cut in well OP01exceeds 0.50 one would use the following statement:
		`if summary_state["WWCT:OPO1"] > 0.50:`
		`...`
		The summary_state variable can also be use to update variables including UDQ variables, i.e:
		`summary_state.update_well_var("OP01", "WUXX", 0.25)`
		The above assigns a value of 0.25 to the well UDQ variable WUXX for well OP01.

Table 12.44: PYACTION Module Script Definition

See also the PYINPUT and PYEND keywords in the GRID[150] section which are also part of OPM Flow's Python scripting facility, that process standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords.

[150] *Note PYINPUT and PYEND can be used in the GRID, EDIT, PROPS, SOLUTION, SUMMARY and SCHEDULE sections, but is described in the GRID section.*

Examples

The first example checks if well OP01 has a water cut greater than 0.80 and if so then the well is just in. In the input deck we would have:

```
--
--       START OF PYACTION SECTION
--
--       ACTNAME       ACTNSTEP
PYACTION
         'MAXWCUT'     'FIRST_TRUE'                        /
         'pthon/script/MAXWCUT.py'                         /
--
--       END OF PYACTION SECTION
--
```

And then in the Python module file 'pthon/script/MAXWCUT.py' one would have:

```
#
# OPM Flow PYACTION Module Script
#
def run(ecl_state, schedule, report_step, summary_state):
    if summary_state.get_well_var("OP1", "WWCT") > 0.80:
        schedule.shut_well("OP1", report_step)
        print("Well OP01 has been shut-in due to WWCT > 0.80")
        return
```

The next example is based on the first example from the ACTIONX keyword (*Examples*). The Python script first checks if the field's water production is greater than 30,000 stb/d, and if not returns control back to the simulator. If the field water production is greater than 30, 000 stb/d then the script users a Python variable *count* to keep track of the number of times the script has been executed, and then sorts the wells from high water cut to low, via the *wct_list* variable, and then shuts in the worst offending well. If a well is shut-in the *count* variable is increase by one and control is passed back to the simulator.

```
--
--       START OF PYACTION SECTION
--
--       ACTNAME       ACTNSTEP
PYACTION
         'WSHUTIN'     'FIRST_TRUE'                        /
         'pthon/script/WSHUTIN.py'                         /
--
--       END OF PYACTION SECTION
--
```

And then in the Python module file 'pthon/script/WSHUTIN.py' one would have:

```
#
# OPM Flow PYACTION Module Script
#
def run(ecl_state, schedule, report_step, summary_state):
    if summary_state["FWPR"] < 3000:
        return False
    #
    # Define Counter and Check Value
    #
    count = storage.get("COUNT", 0)
    if count == 10:
        return True
    #
    # Get Sorted Well List
    #
    wct_list = sorted( [ (well, summary_state.well_var(well, "WWCT")) for
                         well in summary_state.wells] )
    well, wwct = wct_list[0]
```

```
        #
        # Shut-in Wells
        #
        if wwct > 0:
            schedule.shut_well( well, report_step )
            storage["COUNT"] = count +1
        else:
            return False
```

Note that by using PYACTION it makes sense to combine the UDQ variable into the PYACTION statement, like shown in the example, although this is not necessary, as one could in principle use a normal UDQ statement and then access the variables in the PYACTION script using the summary_state variable.

The final example checks to see if the field's gas rates is below 600 MMscf/d and if the simulation time is greater that January 1, 2030. If it is, then compression is installed by re-setting all the gas producing well's THP and BHP pressures to 450 psia and 300 psia respectively. In addition all gas wells currently shut-in are tested to see if they can be opened up under the new THP and BHP constraints.

```
--
--       START OF PYACTION SECTION
--
--       ACTNAME       ACTNSTEP
PYACTION
         'WSHUTIN'     'FIRST_TRUE'                          /
         'pthon/script/PHASE3.py'                            /
--
--       END OF PYACTION SECTION
--
```

And then in the Python module file 'pthon/script/PHASE3.py' one would have:

```
    #
    # OPM Flow PYACTION Module Script
    #
    # Import Python Modules
    #
    import datetime
    #
    # Start of Routine
    #
    def run(ecl_state, schedule, report_step, summary_state):
        #
        # Check Field Rate
        #
        if summary_state["FGPR"] >= 600000:
            return False
        #
        # Check Date
        #
        sim_time = schedule.start +
                   datetime.timedelta( seconds = summary_state.elapsed() )
        if sim_time > datetime.datetime(2030, 1, 1):
            #
            # Do WELTARG and WTEST action – Currently Not Supported
            #
            ….….….….….….….…….……
            #
            # Return
            #
            return True
```

12.3.171 PYEND – End the Definition of a PYINPUT Section

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords. A PYINPUT Definition Section is terminated by a PYEND keyword on a separate single line.

See *PYEND – End the Definition of a PYINPUT Section* in the GRID section for a full description.

12.3.172 PYINPUT – Define the Start of a PYINPUT Section

The PYINPUT and PYEND keywords are a part of OPM Flow's Python scripting facility that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords used by the simulator. PYINPUT declares the start of a PYINPUT Definition Section on a single separate line, which is then followed by various standard Python commands, with one command per line.

See *PYINPUT – Define the Start of a PYINPUT Section* in the GRID section for a full description.

12.3.173 QDRILL – Define Sequential Drilling Queue Wells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The QDRILL keyword places previously defined wells in the Sequential Drilling Queue. Wells in this type of queue will be automatically drilled and completed in the sequence entered in order to satisfy group targets, as defined by the GCONPROD, GCONINJE and GCONSALE keywords. or a group's production potential as per the GDRILLPOT keyword. All the previously mentioned keywords are in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.174 RAINFALL – Constant Flux Aquifer Rainfall Flux by Month

This keyword, RAINFALL, defines the month by month rainfall flux for constant flux aquifers.

See *RAINFALL – Constant Flux Aquifer Rainfall Flux by Month* in the GRID section for a full description.

12.3.175 RCMASTS – Reservoir Coupling Group Minimum Time Step for Flow Restriction

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RCMASTS is used when reservoir coupling is invoked by the GRUPMAST and SLAVES keywords in the SCHEDULE section. The keyword should be placed within the master file and it sets the minimum time step size for groups for when a group is being restricted by a group's limiting flow rate fractional change (see the GRUPMAST keyword in the SCHEDULE section).

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.176 REACHES – Define River Reaches Structure

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The REACHES keyword defines the reach structure of a previously characterized river system using the RIVERSYS keyword in the SCHEDULE section. The River option must be activated via the RIVRDIMS keyword in the RUNSPEC section in order to use these keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.177 READDATA – READ SCHEDULE DATA BASED ON CURRENT TIME STEP

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The READDATA keyword enables the simulator to read SCHEDULE data files generated by external programs on the fly, that is as the run is progressing. The external program can "hold" the simulation by using a file lock, in order for the external program to evaluate the current simulation results, then write out a SCHEDULE data file for the next time step, and finally releasing the "hold" by deleting the file lock and continuing with newly written SCHEDULE data file. The mechanism can be repeated so that the external program is dictating how the simulation progresses through time,

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.178 REFINE – START THE DEFINITION OF A LOCAL GRID REFINEMENT

The REFINE keyword defines the start of a Cartesian or radial local grid refinement ("LGR") definition that sets the properties of the selected LGR. The keyword is then followed by the property keywords associated with the section where the keyword is being invoked. For example, if the REFINE keyword is used in the GRID section then most of the keywords in that section can be used to set the grid properties for the LGR.

See *REFINE – Start the Definition of a Local Grid Refinement* in the GRID section for a full description.

12.3.179 RIVDEBUG – Define the Debug Data to be Printed to File (Rivers)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the debug data associated with rivers to be written to the debug file (*.DBG), for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.180 RIVERSYS - Define River System (Branch Structure and Boundary Conditions)

RIVERSYS defines a river system by specifying the branch structure of the river together with the branch's associated boundary conditions, for when the River option has been activated via the RIVRDIMS keyword in the RUNSPEC section.

See *RIVERSYS - Define River System (Branch Structure and Boundary Conditions)* in the SOLUTION section for a full description.

12.3.181 RIVRPROP – MODIFY RIVER REACHES PROPERTIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RIVRPROP keyword modifies the individual reaches in a river structure of a previously characterized river system using the RIVERSYS and the REACHES keywords in the SCHEDULE section. The River option must be activated via the RIVRDIMS keyword in the RUNSPEC section in order to use this keyword. RIVRPROP is an alternative and a more concise way to changing the individual reaches in a river structure than the REACHES keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.182 RIVSALT – Define River Upstream Flow Salt Concentrations

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RIVSALT keyword defines the injected salt concentration in individual river branches in a previously characterized river system using the RIVERSYS and the REACHES keywords in the SCHEDULE section. The River option must be activated via the RIVRDIMS keyword in the RUNSPEC section in order to use this keyword. In addition, the Brine option must also be enabled via the BRINE keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.183 RIVTRACE – Define River Upstream Flow Tracer Concentrations

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The RIVTRACE keyword defines the injected tracer concentration in individual river branches in a previously characterized river system using the RIVERSYS and the REACHES keywords in the SCHEDULE section. The River option must be activated via the RIVRDIMS keyword in the RUNSPEC section in order to use this keyword. In addition, the Tracer option must also be enabled by the TRACER keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.184 RPTHMG - Define Well History Match Gradient Reporting (Groups)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, RPTHMG, either enables or disables history match output reporting to the history match file (*.HMD) for the named group, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.185 RPTHMW - Define Well History Match Gradient Reporting (Wells)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, RPTHMG, either enables or disables history match output reporting to the history match file (*.HMD) for the named well, for when the History Match Gradient option has been activated by the HMDIMS keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.186 RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File

This keyword activates the writing out of the SUMMARY file and RSM file data, if the RSM file option has been requested by the RUNSUM keyword in the SUMMARY section, at report time steps only. The default is for all time steps to be written out to the files. This keyword reduces the file size at the expense of lower resolution in the time domain. There is no data required for this keyword.

See *RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File* in the SUMMARY section for a full description.

12.3.187 RPTONLYO - Deactivate the Report Time Steps Only Option for the SUMMARY File

This keyword deactivates the writing out of the SUMMARY file and RSM file data, if the RSM file option has been requested by the RUNSUM keyword in the SUMMARY section, at report time steps only, and switches on writing out all the time steps to the files. This option is the default behavior for when RPTONLY has not been activated. There is no data required for this keyword.

See *RPTONLYO - Deactivate the Report Time Steps Only Option for the SUMMARY File* in the SUMMARY section for a full description.

12.3.188 RPTRST – Define Data to be Written to the RESTART File

This keyword defines the data to be written to the RESTART file at each requested restart point.

See *RPTRST – Define Data to be Written to the RESTART File* in the SOLUTION section for a full description.

12.3.189 RPTSCHED – DEFINE SCHEDULE SECTION REPORTING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data in the SCHEDULE section that is to be printed to the output print file in human readable format. The keyword has two distinct forms, the first of which consists of the keyword followed by a series of integers on the next line indicating the data to be printed (see the first example). This is the original format in the commercial simulator and was subsequently superseded by the second format. The second format consists of the keyword followed by a series of character strings that indicate the data to be printed. In most cases the character string is the keyword used to define the data in the OPM Flow input deck, for example WELSPECS to defined the basic well definitions. OPM Flow only supports the functionality of the second format, the first format although recognized will be completely ignored.

No.	Name	Description	Default
1	FIP	Print the fluid in-place report. The parameter is assigned a value, OPTION, using the form FIP = OPTION, where OPTION is an integer variable set to: 1) OPTION = 1 then the report is for the field only. 2) OPTION = 2 then in addition to the field report, a report is produced for each FIPNUM region, as defined by the FIPNUM keyword in the REGIONS section. Note the commercial simulator also prints the flows to other regions as well as the flows from the wells. This additional reporting option has not been implemented in OPM Flow. 3) OPTION = 3 then in addition to the above, a balance report is also produced for fluid in-place regions defined by the FIP keyword in the REGIONS section.	FIP=2
2	FIPRESV	Print the reservoir volumes in-place report.	N/A
3	NOTHING	Switches off all printed reports in the SCHEDULE section.	N/A
4	SALT	Print grid block salt concentration values. Note this is an OPM Flow sub keyword.	N/A
5	SALTDPST	Print the amount of salt deposited for each grid block. Note this is an OPM Flow sub keyword.	N/A
6	RESTART	RESTART defines the frequency at which the restart data for restarting a run is written to the RESTART file. The parameter is assigned a value, OPTION, using the form RESTART = OPTION, where OPTION is an integer variable set to: 1) OPTION = 1 then the restart files are written at every report time, but only the last one in the run is kept. This minimizes the restart file size but only the final results are stored, limiting the visualization in OPM ResInsight. 2) OPTION = 2 then the phase inter-blocks are written to the restart files, in addition to the standard data. 3) OPTION = 3 then the fluid in-place and phase potentials are also written to the restart file. 4) OPTION = 6 then the restart files are written at every time step. See the RPTRST keyword in the SOLUTION section for a more flexible way to write out restart files.	

No.	Name	Description	Default
7	WELLS	The WELLS option turns on production and injection rate and cumulative volume reporting for produced and injected fluids. The parameter has several levels of reporting details set by the assigned OPTION value, using the form WELLS = OPTION, where OPTION is an integer variable set to: 1) OPTION = 1 report at the volumes at the well level. 2) OPTION = 2 report volumes at the well and the well connection levels. 3) OPTION = 3 report volumes for layer totals. 4) OPTION = 4 report volumes for layer totals and for wells. 5) OPTION = 5 report volumes for layer totals and for wells and well connections. Only OPTION equal to one is supported by OPM Flow.	WELLS=1
8	WELSPECS	WELSPECS switches on reporting of the well connections, wells and groups at each report time step. There are numerous reports associated with this option. Unlike the other reporting parameters that produce a report for each reporting time step, the WELSPECS report option only produces a report if an associated keyword has been activated at the current reporting time step. For example, if the reporting time steps are January, February, and March 2020, and the RPTSCHED WELSPECS option is activated in January, with wells OP01 and OP02 being declared via the WELSPECS and COMPDAT keywords, then a report will be printed for January for these two wells. If there are no further well activations until March, with well OP03 being declared, then there will be no report for February, and only well OP03 will reported at the March reporting time step.	
….		….	

Notes:

1) The keyword is terminated by "/".

Table 12.45: RPTSCHED Keyword Description

Development is current progressing on developing reports in a similar format to the commercial simulator and this section will be updated as additional reports are added to OPM Flow's functionality.

Note

Unlike the other reporting keywords in the RUNSPEC, GRID, EDIT, PROPS and SOLUTION keywords, the requested reports on the this keyword remain in effect until they are switch off by this keyword, that is, the reports are written out every report time step until requested to stop. Use the 'NOTHING' parameter to switch off all reporting.

An example FIP report is shown in Figure 12.4 from the Norne field, note only the field and the first two region reports are shown.

```
                                                  ==================================================
                                                  :                  Field Totals                  :
                                                  :      PAV  =       268.423 BARSA               :
                                                  :      PORV =     673813759   RM3               :
                                                  : Pressure is weighted by hydrocarbon pore volume :
                                                  : Porv volumes are taken at reference conditions  :
                          :--------------- Oil    SM3 ---------------:-- Wat    SM3 --:--------------- Gas    SM3 ---------------:
                          :      Liquid        Vapour        Total   :      Total     :      Free        Dissolved       Total   :
:-------------------------:-----------------------------------------:----------------:-----------------------------------------:
:Currently   in place     :      92852273        506017      93358290:    480610201   :   11202115432    9841722029   21043837461:
:-------------------------:-----------------------------------------:----------------:-----------------------------------------:
:Originally  in place     :     160196505        559893     160756399:    402039147   :    9744843573   17311090896   27055934469:
:=========================:=========================================:================:=========================================:

                                                  ==================================================
                                                  :        FIPNUM report region   1                 :
                                                  :      PAV  =       269.913 BARSA               :
                                                  :      PORV =      44729956   RM3               :
                          :--------------- Oil    SM3 ---------------:-- Wat    SM3 --:--------------- Gas    SM3 ---------------:
                          :      Liquid        Vapour        Total   :      Total     :      Free        Dissolved       Total   :
:-------------------------:-----------------------------------------:----------------:-----------------------------------------:
:Currently   in place     :       5308282        259439       5567722:     12179015   :    5263878362     594212703    5858091065:
:-------------------------:-----------------------------------------:----------------:-----------------------------------------:
:Originally  in place     :       5358346        311293       5669639:     11497281   :    5426018016     591714035    6017732051:
:=========================:=========================================:================:=========================================:

                                                  ==================================================
                                                  :        FIPNUM report region   2                 :
                                                  :      PAV  =       266.851 BARSA               :
                                                  :      PORV =      14745585   RM3               :
                          :--------------- Oil    SM3 ---------------:-- Wat    SM3 --:--------------- Gas    SM3 ---------------:
                          :      Liquid        Vapour        Total   :      Total     :      Free        Dissolved       Total   :
:-------------------------:-----------------------------------------:----------------:-----------------------------------------:
:Currently   in place     :       2744221         88023       2832244:      3078782   :    1655632008     318616757    1974248764:
:-------------------------:-----------------------------------------:----------------:-----------------------------------------:
:Originally  in place     :       3229038         88236       3317274:      3087870   :    1535013525     362544609    1897558134:
:=========================:=========================================:================:=========================================:
```

Figure 12.4: RPTSCHED: FIP (Balance) Report

The WELLS report consists of several sub-reports depending on the selected option for this report type. Figure 12.5 and Figure 12.6 show example Production and Injection sub-reports

```
=================================================== PRODUCTION REPORT ===================================================
:  WELL  :  LOCATION :CTRL:    OIL    :   WATER   :    GAS    :   FLUID   :   WATER   : GAS/OIL  :  WAT/GAS   : BHP OR : THP OR :
:  NAME  :  (I,J,K)  :MODE:    RATE   :   RATE    :    RATE   :  RES.VOL. :    CUT    :  RATIO   :   RATIO    : CON.PR.: BLK.PR.:
:        :           :    :  SCM/DAY  :  SCM/DAY  :  SCM/DAY  :  RCM/DAY  :  SCM/SCM  :  SCM/SCM :  SCM/SCM   :  BARSA :  BARSA :
=========================================================================================================================

:   FIELD:           :    :       0.0:       0.0:       0.0:       0.0:     0.000:     0.00:       -nan:        :        :
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    INJE:           :    :      -0.0:      -0.0:      -0.0:      -0.0:     0.000:     0.00:       -nan:        :        :
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    PROD:           :    :    7271.6:   16679.8:  2297808.0:   33835.4:     0.696:   316.00:      0.0073:        :        :
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    B-2H:   15,   31:RESV:     765.8:    1986.1:   107032.1:    3174.3:     0.722:   139.77:      0.0186:   169.7:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    D-1H:   22,   22:ORAT:      -0.0:      -0.0:      -0.0:      -0.0:     0.000:     0.00:       -nan:     0.0:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    D-2H:   14,   28:RESV:    1020.6:    2130.4:   344837.0:    4633.7:     0.676:   337.87:      0.0062:   165.3:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    B-4H:   10,   32:ORAT:      -0.0:      -0.0:      -0.0:      -0.0:     0.000:     0.00:       -nan:     0.0:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    D-4H:   19,   38:ORAT:      -0.0:      -0.0:      -0.0:      -0.0:     0.000:     0.00:       -nan:     0.0:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    E-3H:   12,   72:ORAT:      -0.0:      -0.0:      -0.0:      -0.0:     0.000:     0.00:       -nan:     0.0:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    B-1H:   14,   34:ORAT:      -0.0:      -0.0:      -0.0:      -0.0:     0.000:     0.00:       -nan:   239.2:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    B-3H:    9,   37:RESV:       8.7:      77.0:      935.2:      91.3:     0.898:   107.22:      0.0823:   243.2:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    E-1H:   18,   68:RESV:     611.5:    6251.1:    66608.1:    7292.1:     0.911:   108.92:      0.0938:   185.4:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:

:    E-2H:   13,   67:ORAT:      -0.0:      -0.0:      -0.0:      -0.0:     0.000:     0.00:       -nan:     0.0:     0.0:
:--------:-----------:----:-----------:-----------:-----------:-----------:-----------:----------:------------:--------:--------:
```

Figure 12.5: RPTSCHED: WELLS - Production Sub-Report

INJECTION REPORT

WELL NAME	LOCATION (I,J,K)	CTRL MODE OIL	CTRL MODE WAT	CTRL MODE GAS	OIL RATE SCM/DAY	WATER RATE SCM/DAY	GAS RATE SCM/DAY	FLUID RES.VOL. RCM/DAY	BHP OR CON.PR. BARSA	THP OR BLK.PR. BARSA
FIELD:					0.0:	0.0:	0.0:	0.0:		
INJE:					0.0:	14237.0:	208381.1:	15761.8:		
PROD:					0.0:	0.0:	0.0:	0.0:		
C-4H:	11, 35:			WRAT:	0.0:	0.0:	0.0:	0.0:	0.0:	0.0:
C-1H:	26, 44:			GRAT:	0.0:	0.0:	56404.2:	265.3:	279.2:	0.0:
C-2H:	23, 15:			WRAT:	0.0:	0.0:	0.0:	0.0:	259.8:	0.0:
C-3H:	9, 13:			GRAT:	0.0:	0.0:	143344.6:	674.3:	266.2:	0.0:
F-1H:	12, 85:			WRAT:	0.0:	9662.4:	0.0:	10031.9:	493.3:	0.0:
F-2H:	18, 83:			WRAT:	0.0:	4574.6:	0.0:	4749.6:	474.3:	0.0:
F-3H:	6, 57:			WRAT:	0.0:	0.0:	0.0:	0.0:	307.7:	0.0:
F-4H:	36, 68:			WRAT:	0.0:	0.0:	0.0:	0.0:	515.1:	0.0:
C-4AH:	29, 51:			GRAT:	0.0:	0.0:	8632.4:	40.6:	283.1:	0.0:

Figure 12.6: RPTSCHED: WELLS - Injection Sub-Report

The third and final report is the Cumulative Production and Injection sub-report, shown in Figure 12.7.

CUMULATIVE PRODUCTION/INJECTION REPORT

WELL NAME	LOCATION (I,J,K)	WELL TYPE	CTRL: MODE:	OIL PROD MSCM	WATER PROD MSCM	GAS PROD MMSCM	Prod RES.VOL. MRCM	OIL INJ MSCM	WATER INJ MSCM	GAS INJ MMSCM	INJ RES.VOL. MRCM
FIELD:				0.0:	0.0:	0.0:	0.0:	0.0:	0.0:	0.0:	0.0:
INJE:				0.0:	0.0:	0.0:	0.0:	0.0:	102009.2:	8684539.9:	149857.6:
PROD:				67225.0:	23347.5:	14642253.8:	148932.4:	0.0:	0.0:	0.0:	0.0:
C-4H:	11, 35:	INJ:	WRAT:	0.0:	0.0:	0.0:	0.0:	0.0:	5468.3:	2927677.5:	20657.3:
B-2H:	15, 31:	PROD:	RESV:	10801.8:	1775.7:	1839025.6:	19365.0:	0.0:	0.0:	0.0:	0.0:
D-1H:	22, 22:	PROD:	ORAT:	5497.3:	509.8:	907510.3:	9404.6:	0.0:	0.0:	0.0:	0.0:
D-2H:	14, 28:	PROD:	RESV:	7539.3:	1242.3:	2698209.2:	20259.7:	0.0:	0.0:	0.0:	0.0:
B-4H:	10, 32:	PROD:	ORAT:	1306.9:	0.6:	269383.9:	2382.8:	0.0:	0.0:	0.0:	0.0:
D-4H:	19, 38:	PROD:	ORAT:	3187.4:	85.6:	678870.9:	6035.6:	0.0:	0.0:	0.0:	0.0:
C-1H:	26, 44:	INJ:	GRAT:	0.0:	0.0:	0.0:	0.0:	0.0:	12768.5:	2186307.8:	24239.9:
E-3H:	12, 72:	PROD:	ORAT:	1686.9:	200.6:	179036.0:	2441.1:	0.0:	0.0:	0.0:	0.0:
C-2H:	23, 15:	INJ:	WRAT:	0.0:	0.0:	0.0:	0.0:	0.0:	21661.2:	0.0:	22503.8:
B-1H:	14, 34:	PROD:	ORAT:	3588.9:	473.2:	1413263.2:	10322.4:	0.0:	0.0:	0.0:	0.0:

Figure 12.7: RPTSCHED: WELLS - Cumulative Production and Injection Sub-Report

Similarly as for the WELLS report, the WELSPECS report consists of several sub-reports, including the Well Production Control report shown in Figure 12.8 for the Volve field.

```
                                 ****************************************************************************
WELSPECS AT        0.00 DAYS *                                                                            * FLOW
REPORT   0      31 DEC 2007  *                                                                            * RUN AT 12:41 ON 12 SEP 2016
                                 ****************************************************************************

                                                WELL SPECIFICATION DATA
                                                -----------------------

-------------------------------------------------------------------------------------------------------------------------------
:   WELL    :   GROUP   : WELLHEAD :  B.H.REF : PREF- : DRAINAGE :  GAS : SHUT-IN : CROSS : PVT : WELL : FIP :     WELL    :
:   NAME    :   NAME    : LOCATION :   DEPTH  : ERRED :  RADIUS  : INFL : INSTRCT :  FLOW : TAB : DENS : REG :  D-FACTOR 1 :
:           :           : ( I, J ) :  METRES  : PHASE :  METRES  : EQUN :         : ABLTY :     : CALC :     :   DAY/SM3   :
-------------------------------------------------------------------------------------------------------------------------------
: I-F-5     : AAR       :  84,  41 :   2997.3 :  WAT  : P.EQUIV.R:  STD :   OPEN  :  YES  :  4  :  SEG :  0  :      0      :
: P-F-14    : AAR       :  65,  48 :   2476.1 :  OIL  : P.EQUIV.R:  STD :   OPEN  :  YES  :  2  :  SEG :  0  :      0      :
: I-F-4     : SRAR      :  73,  28 :   2931.0 :  WAT  : P.EQUIV.R:  STD :   OPEN  :  YES  :  3  :  SEG :  0  :      0      :
: I-F4G     : SRAR      :  73,  28 :   2931.0 :  GAS  : P.EQUIV.R:  STD :   OPEN  :  YES  :  3  :  SEG :  0  :      0      :
: P-F-12    : SRAR      :  58,  37 :   2705.0 :  OIL  : P.EQUIV.R:  STD :   OPEN  :  YES  :  1  :  SEG :  0  :      0      :
: P-F-15C   : SRAR      :  55,  28 :   2551.0 :  OIL  : P.EQUIV.R:  STD :   OPEN  :  YES  :  11 :  SEG :  0  :      0      :
: P-F-11B   : SRAR      :  66,  42 :   2451.0 :  OIL  : P.EQUIV.R:  STD :   SHUT  :  YES  :  2  :  SEG :  0  :      0      :
: I-F-1B    : P_NW      :  66,  58 :   2988.5 :  WAT  : P.EQUIV.R:  STD :   SHUT  :  YES  :  6  :  SEG :  0  :      0      :
: P-F-15D   : AAR       :  63,  47 :   2844.9 :  OIL  : P.EQUIV.R:  STD :   SHUT  :  YES  :  2  :  SEG :  0  :      0      :
: P-F-1C    : P_NW      :  57,  51 :   2889.1 :  OIL  : P.EQUIV.R:  STD :   SHUT  :  YES  :  10 :  SEG :  0  :      0      :
: PIL-N     : P_NORTH   :  80,  54 :   3153.9 :  OIL  : P.EQUIV.R:  STD :   OPEN  :  YES  :  5  :  SEG :  0  :      0      :
: PIL-NW    : P_NW      :  64,  59 :   2959.5 :  OIL  : P.EQUIV.R:  STD :   SHUT  :  YES  :  6  :  SEG :  0  :      0      :
-------------------------------------------------------------------------------------------------------------------------------
1: The WELL D-FACTOR is not implemented - and the report will always show the default value 0.
```

Figure 12.8: RPTSCHED: WELLSPECS - Production Well Control Sub-Report

The COMPDAT keyword data is listed on the Well Connection Data sub-report as depicted in Figure 12.9 for the I-F-5 well. Note that the data is repeated for all connections and for all wells declared at the reporting time step.

```
                                                WELL CONNECTION DATA
                                                --------------------

-------------------------------------------------------------------------------------------------------------------------------
:   WELL    :     GRID     : CMPL:  CENTRE : OPEN: SAT :CONNECTION:   INT   :   K  H  :  SKIN   : CONNECTION : SATURATION SCALING DATA :
:   NAME    :     BLOCK    : NO# :  DEPTH  : SHUT: TAB :  FACTOR* :  DIAM   :  VALUE   : FACTOR : D-FACTOR 1 :SWMIN SWMAX SGMIN SGMAX 2:
:           :              :     :  METRES :      :     : CPM3/D/B : METRES : MD.METRE:        :   DAY/SM3  :                         :
-------------------------------------------------------------------------------------------------------------------------------
: I-F-5     :   84, 41,  1 :   1 :  2997.3 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41,  2 :   2 :  2998.3 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41,  3 :   3 :  2999.4 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41,  4 :   4 :  3000.4 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41,  5 :   5 :  3001.5 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41,  6 :   6 :  3002.5 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41,  7 :   7 :  3003.6 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41,  8 :   8 :  3004.6 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41,  9 :   9 :  3005.6 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41, 10 :  10 :  3006.6 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41, 11 :  11 :  3007.7 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41, 12 :  12 :  3008.8 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41, 13 :  13 :  3009.8 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41, 14 :  14 :  3010.9 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   84, 41, 15 :  15 :  3012.0 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 41, 17 :  18 :  3035.9 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 41, 19 :  19 :  3038.6 : SHUT:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 41, 20 :  20 :  3040.0 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 20 :  21 :  3050.7 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 21 :  22 :  3051.9 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 22 :  23 :  3053.0 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 23 :  24 :  3054.2 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 24 :  25 :  3055.4 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 25 :  26 :  3056.6 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 26 :  27 :  3058.1 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 27 :  28 :  3059.9 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 28 :  29 :  3061.7 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 29 :  30 :  3063.6 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: I-F-5     :   85, 42, 30 :  31 :  3065.4 : OPEN:  1  : 0.000000 :0.216000: 0.000000:0.000000:      0     :                         :
: ..........................................................................................                                         :
-------------------------------------------------------------------------------------------------------------------------------
1: The well connection D-FACTOR is not implemented in opm and the report will always show 0.
2: The saturation scaling data has not been implemented in the report and will show blank
```

Figure 12.9: PTSCHED: WELLSPECS - Well Connection Data Sub-Report

For multi-segment wells both the Production Well Control and Well Connection sub-reports are printed as per Figure 12.8 and Figure 12.9, and in addition the equivalent multi-segment well data is printed as well, as shown in Figure 12.10 and Figure 12.11.

Figure 12.10 shows the Multi-Segment Well Segment Structure sub-report for a single multi-segment well, OP01. See the WELSEGS keyword *Example* in the SCHEDULE section to see how the OP01 well is defined.

MULTI-SEGMENT WELL: SEGMENT STRUCTURE

WELLNAME AND SEG TYPE	SEG NO	BRN NO	MAIN INLET SEGMENT	OUTLET SEGMENT	SEGMENT LENGTH METRES	TOT LENGTH TO END METRES	DEPTH CHANGE METRES	T.V. DEPTH AT END METRES	DIA OR F SCALING METRES	VFP TAB OR ABS ROUGHN METRES	AREA X-SECTN M**2	VOLUME M3	P DROP MULT FACTOR
OP01	1	1	2	0		2512.5		2512.5	0	0	0	0.000	
HFA	2		3	1		2537.5		2534.5	0.3000	0.000100	0.07068	1.767	
	3		4	2		2562.5		2560.5	0.3000	0.000100	0.07068	1.767	
	4		5	3		2587.5		2593.5	0.3000	0.000100	0.07068	1.767	
	5		6	4		2612.5		2614.5	0.3000	0.000100	0.07068	1.767	
	6		22	5		2637.5		2635.5	0.3000	0.000100	0.07068	1.767	
	7	2	8	2		2737.5		2538.5	0.2000	0.000100	0.03141	6.283	
	8		9	7		2937.5		2537.5	0.2000	0.000100	0.03141	6.283	
	9		10	8		3137.5		2539.5	0.2000	0.000100	0.03141	6.283	
	10		11	9		3337.5		2535.5	0.2000	0.000100	0.03141	6.283	
	11		0	10		3537.5		2536.5	0.2000	0.000100	0.03141	6.283	
	12	3	13	3		2762.5		2563.5	0.2000	0.000100	0.03141	6.283	
	13		14	12		2962.5		2562.5	0.1000	0.000100	0.00785	1.570	
	14		15	13		3162.5		2562.5	0.1000	0.000100	0.00785	1.570	
	15		16	14		3362.5		2564.5	0.1000	0.000100	0.00785	1.570	
	16		0	15		3562.5		2562.5	0.1000	0.000100	0.00785	1.570	
	17	4	18	5		2812.5		2613.5	0.2000	0.000100	0.03141	6.283	
	18		19	17		3012.5		2612.5	0.1000	0.000100	0.00785	1.570	
	19		20	18		3212.5		2612.5	0.1000	0.000100	0.00785	1.570	
	20		21	19		3412.5		2612.5	0.1000	0.000100	0.00785	1.570	
	21		0	20		3612.5		2613.5	0.1000	0.000100	0.00785	1.570	
	22	5	23	6		2837.5		2634.5	0.2000	0.000100	0.03141	6.283	
	23		24	22		3037.5		2637.5	0.2000	0.000100	0.03141	6.283	
	24		25	23		3237.5		2638.5	0.2000	0.000100	0.03141	6.283	
	25		26	24		3437.5		2639.5	0.1000	0.000100	0.00785	1.570	
	26		0	25		3637.5		2639.5	0.1000	0.000100	0.00785	1.570	

Figure 12.10: RPTSCHED: WELLSPECS - Multi Segment Well Structure Sub-Report

And Figure 12.11 depicts Multi-Segment Well Connection Data sub-report for the same well.

MULTI-SEGMENT WELL: CONNECTION DATA

WELL NAME	CONNECTION	SEGMENT NUMBER	BRANCH ID	TUB LENGTH START PERFS METRES	TUB LENGTH END PERFS METRES	TUB LENGTH CENTR PERFS METRES	TUB LENGTH END SEGMT METRES	CONNECTION DEPTH METRES	SEGMENT DEPTH METRES	GRID BLOCK DEPTH METRES
OP01	10, 10, 1:	1	1				2512.5	2512.5	2512.5	2512.5
	10, 10, 2:	2	1				2537.5	2534.5	2534.5	2537.5
	10, 10, 3:	3	1				2562.5	2560.5	2560.5	2562.5
	10, 10, 4:	4	1				2587.5	2593.5	2593.5	2587.5
	10, 10, 5:	5	1				2612.5	2614.5	2614.5	2612.5
	10, 10, 6:	6	1				2637.5	2635.5	2635.5	2637.5
	9, 10, 2:	7	2				2737.5	2538.5	2538.5	2537.5
	8, 10, 2:	8	2				2937.5	2537.5	2537.5	2537.5
	7, 10, 2:	9	2				3137.5	2539.5	2539.5	2537.5
	6, 10, 2:	10	2				3337.5	2535.5	2535.5	2537.5
	5, 10, 2:	11	2				3537.5	2536.5	2536.5	2537.5
	10, 9, 3:	12	3				2762.5	2563.5	2563.5	2562.5
	10, 8, 3:	13	3				2962.5	2562.5	2562.5	2562.5
	10, 7, 3:	14	3				3162.5	2562.5	2562.5	2562.5
	10, 6, 3:	15	3				3362.5	2564.5	2564.5	2562.5
	10, 5, 3:	16	3				3562.5	2562.5	2562.5	2562.5
	9, 10, 5:	17	4				2812.5	2613.5	2613.5	2612.5
	8, 10, 5:	18	4				3012.5	2612.5	2612.5	2612.5
	7, 10, 5:	19	4				3212.5	2612.5	2612.5	2612.5
	6, 10, 5:	20	4				3412.5	2612.5	2612.5	2612.5
	5, 10, 5:	21	4				3612.5	2613.5	2613.5	2612.5
	10, 9, 6:	22	5				2837.5	2634.5	2634.5	2637.5
	10, 8, 6:	23	5				3037.5	2637.5	2637.5	2637.5
	10, 7, 6:	24	5				3237.5	2638.5	2638.5	2637.5
	10, 6, 6:	25	5				3437.5	2639.5	2639.5	2637.5
	10, 5, 6:	26	5				3637.5	2639.5	2639.5	2637.5

Figure 12.11: RPTSCHED: WELLSPECS - Multi Segment Well Connection Sub-Report

Example

The first example shows the original format of this keyword; although the keyword and format are recognized by OPM Flow, the format is ignored and is unlikely to be implemented in in the simulator.

```
--
--       DEFINE SCHEDULE SECTION REPORT OPTION (ORIGINAL FORMAT)
--
RPTSCHED
         1        2*0      1        3*1                                        /
```

The next example shows the second format of the keyword which is supported by OPM Flow.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE

-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2000-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
         'WELLS=2'    'WELSPECS'    'CPU=2'     'FIP=2'                         /

DATES
         1  JAN   2000  /
/

RPTSCHED
         'NOTHING'                                                             /

DATES
         1  FEB   2000  /
         1  MAR   2000  /
         1  APR   2000  /
         1  MAY   2000  /
         1  JUN   2000  /
         1  JLY   2000  /
         1  AUG   2000  /
         1  SEP   2000  /
         1  OCT   2000  /
         1  NOV   2000  /
         1  DEC   2000  /
/
```

In the above example monthly reporting time steps have been used with a SCHEDULE section report on the January 1, 2000; after which all reports are switch off for the subsequent reporting time steps.

12.3.190 SAVE – ACTIVATE OUTPUT OF A SAVE FILE FOR FAST RESTARTS

This keyword activates output of a SAVE file for fast restarts. There is no data required for this keyword.

See *SAVE – Activate Output of a SAVE File for Fast Restarts* in the RUNSPEC section for a full description.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.191 SCDATAB – WELL CONNECTION PI MULTIPLIERS VERSUS SCALE DEPOSIT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SCDATAB defines well connection Productivity Index ("PI") reduction multipliers versus scale deposited per unit length of the perforated interval tables, for when the Scale Deposition option has been activated by declaring the dimensions of the scaling deposition tables using the SCDPDIMS keyword in the RUNSPEC section. The SCDATAB tables are allocated to individual wells using the WSCTAB keyword and the rate of scale accumulation around the well connections is given by the SCDPTAB keyword; both keywords are in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.192 SCDETAB – WELL CONNECTION KARST AQUIFER PROPERTIES FOR SCALE DEPOSIT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SCDETAB defines well connection karst[151] aquifer properties for modeling scale deposited by dissolution of calcite from the aquifer water, for when the Scale Deposition option has been activated by declaring the dimensions of the scaling deposition tables using the SCDPDIMS keyword in the RUNSPEC section. The SCDETAB tables are allocated to individual wells using the WSCTAB keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[151] *Karst is a topography formed from the dissolution of soluble rocks such as limestone, dolomite, and gypsum. Karst aquifers are characterized by a network of conduits and caves, with the conduits and caves draining the pore space between the limestone grains (intergranular or primary porosity) and the fractures (secondary porosity) formed by joints, bedding planes, and faults.*

12.3.193 SCDPTAB – WELL CONNECTION SCALE DEPOSITION TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SCDATAB defines the well connection scale deposition rate as a function of sea water flow rate, for when the Scale Deposition option has been activated by declaring the dimensions of the scaling deposition tables using the SCDPDIMS keyword in the RUNSPEC section. The SCDATAB tables are allocated to individual wells using the WSCTAB keyword and the sea water fraction is based on a water tracer entered via the SCDPTRAC keyword; both keywords are in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.194 SCDPTRAC – ALLOCATE SEA WATER TRACER FOR SCALE DEPOSITION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SCDPTRAC keyword is used to allocate an existing passive water tracer defined by the TRACER keyword in the PROPS section, to represent the sea water flowing into a well connection as a fraction of the total water influx. The keyword is used together with the SCDPTAB keyword in the SCHEDULE section to calculated the volume of scale deposited around the well connections.

This keyword is ignored by OPM Flow and has no effect on the simulation, but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	NAME	A three letter character string defining the tracer's name that has previously been defined by the TRACER keyword in the PROPS section			None

Notes:

1) The keyword is terminated by "/".

Table 12.46: SCDPTRAC Keyword Description

Example

In the PROPS section define a tracer in the water phase, for example:

```
--
--        DEFINE TRACER NAMES
--
--        TRACER    TRACER
--        NAME      PHASE
--        ------    ------
TRACER
        'SEA'     'WAT'                                    / SEA WATER TRACER

/
```

Then in the SCHEDULE section allocate the previously defined water tracer as a sea water tracer to be used with the scale deposition facility, that is:

```
--
--        ALLOCATE SEA WATER TRACER FOR SCALE DEPOSITION
--
--        TRACER
--        NAME
--        ------
SCDPTRAC
        'SEA'                                              / SEA WATER TRACER

/
```

12.3.195 SCHEDULE - DEFINE THE START OF THE SCHEDULE SECTION OF KEYWORDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SCHEDULE activation keyword marks the end of the SUMMARY section and the start of the SCHEDULE section that defines the group and well definitions, operating and economic constraints, as well as how OPM Flow should advance through time. Numerical controls are also defined in this section and all parameters can be varied through time.

There is no data required for this keyword.

Example

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE
```

The above example marks the end of the SUMMARY section and the start of the SCHEDULE section in the OPM Flow data input file.

12.3.196 SEPVALS – DEFINE SEPARATOR OIL FORMATION VOLUME FACTOR AND GOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The SEPVALS keyword defines the initial and subsequent separator oil formation volume factor (B_o) and Gas Oil Ratio ("GOR" or R_s). The facility is used in "black-oil" modeling to re-scale the PVT data entered via the PROPS section, based on the saturation point oil formation volume factor (B_{ob}) and the initial saturated gas-oil ratio (R_{si}) entered on the SEVPALS keyword. The first occurrence of this keyword sets the initial conditions and must be followed by the GSEPCOND keyword that assigns previously defined separators to a group.

Note that the keyword can only be used in runs with oil and dissolve gas only, with no vaporized oil (condensate) in the gas phase.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.197 SHRATE - Activate and Define the Polymer Shearing Logarithmic Parameters

This keyword activates the logarithm-based polymer shear thinning/thickening option and defines the shear rate constant. This keyword can only be used in conjunction with the PLYSHLOG in the PROPS section

See *SHRATE - Activate and Define the Polymer Shearing Logarithmic Parameters* in the PROPS section for a full description.

12.3.198 SIMULATE - ACTIVATE THE SIMULATION MODE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

SIMULATE switches the mode of the simulation to run simulation mode from the data input checking mode activated by the NOSIM keyword in the SCHEDULE section. Note that if NOSIM has been used in the RUNSPEC section then SIMULATE will have no effect.

There is no data required for this keyword and there is no terminating "/" for this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

Example

The example below switches OPM Flow to no simulation mode for data checking of the input deck.

```
--
--       ACTIVATE SIMULATION MODE TO RUN THE MODEL
--
SIMULATE
```

12.3.199 SKIPREST – ACTIVATE SKIPPING OF RESTART SCHEDULE DATA

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword turns on skipping of keywords up to the start of the restart point, as defined on the RESTART keyword in the RUNSPEC section. The RESTART keyword defines the parameters to restart the simulation from a previous run that has written a RESTART file out to disk. Activating the SKIPREST keyword causes the simulator to only read in data it requires for restarting the run up to the RESTART point (RSNUM on the RESTART keyword in the SOLUTION section). Note that certain keywords always need to be present in a restart run in the SCHEDULE section as the data is not stored on the RESTART file, for example the VFP tables (VFPPROD and VFPINJ keywords). The SKIPREST keyword automatically processes the input deck and reads the required data.

There is no data required for this keyword.

Example

The example below defines a restart from the previously run NOR-OPM-A01 case at time step number 40.

```
-- ==============================================================================
--
-- SOLUTION SECTION
--
-- ==============================================================================
SOLUTION
--
--       FLEXIBLE RESTART FROM PREVIOUS SIMULATION RUN
--
--       FILE                    RESTART   RESTART   FILE
--       NAME                    NUMBER    TYPE      FORMAT
RESTART
         'NOR-OPM-A01'           40        1*        1*     /
```

Then in the SCHEDULE section the SKIPREST keyword is used to correctly read in the schedule data up to the RESTART point.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE
--
--       ACTIVATE SKIPREST OPTION TO AVOID MODIFYING SCHEDULE SECTION
--
SKIPREST
```

12.3.200 SLAVES – Define Slave Reservoir Simulation Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, SLAVES, defines the name of the slave reservoirs and their associated simulation input files, for when the Reservoir Coupling option has been declared active by the GRUPMAST and SLAVES keywords in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.201 SUMTHIN – DEFINE SUMMARY DATA REPORTING TIME STEPS

This keyword defines a time interval for writing out the SUMMARY data to the SUMMARY file and the RSM file, if the RUNSUM keyword has been has also been activated in the SUMMARY section. Only the data for the first time step in the time interval is written out and the other time steps are skipped until the next time interval. This enable the size of the SUMMARY files to be reduced depending on the size of the time interval. However, the keyword will produce irregular time steps reports of the SUMMARY data.

See *SUMTHIN – Define SUMMARY Data Reporting Time Steps* in the SUMMARY section for a full description.

12.3.202 SURFVISC – SURFACTANT SOLUTION VISCOSITY VERSUS CONCENTRATION

SURFSVISC defines the surfactant viscosity relationship of solution water viscosity with respect to increasing surfactant concentration within a grid block. The surfactant option must be activated by the SURFACT keyword in the RUNSPEC section in order to use this keyword.

See *SURFVISC – Surfactant Solution Viscosity versus Concentration* in the PROPS section for a full description.

12.3.203 SWINGFAC – DEFINE FIELD GAS CONTRACT PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, SWINGFAC, defines the gas contract parameters, swing factor and the monthly seasonal profile factor, for when there is a single gas contract being used in the model. The keyword is used with the Gas Field Operations option which is activated by the GASFIELD keyword in the RUNSPEC section. Gas contracts are commonly based on a Daily Contract Quantity ("DCQ") that determines the gas rate that the field should be produced at, which is normally expressed as a multiple of the DCQ, for example 1.33, and is often referred to as the "swing factor". Some gas contracts also define a maximum DCQ ("Max DCQ") and/ or a minimum take or pay DCQ ("Min DCQ"), as well as seasonal demand characteristics. For example, gas rates may be set higher in the winter months in order to meet heating demand compared with summer months in colder climates, and the opposite in warmer climates where air conditioning demand is high.

Thus, the DCQ must be calculated first over a contract period, where the contract period is commonly contract years, or in some instances contract quarters. This is performed by the simulator using the current DCQ and checking to see if the (DCQ x Swing Factor) can be satisfied throughout the current contract period, if not the DCQ is re-calculated so that the (DCQ x Swing Factor) condition is satisfied. Once this condition is met, the second and final pass uses the calculated DCQ in conjunction with the monthly scaling profile data to set the monthly gas rate for the field:

$$Q_{month} = DCQ \times SWINGFAC_{month} \tag{12.22}$$

Where:

Q_{month} = the monthly gas production target
DCQ = Daily Contract Quantity
$SWINGFAC_{month}$ = monthly rate scaling factor that takes into account seasonal demand, etc.

Here the SWINGFAC keyword sets the gas contract parameters for a single contract at the FIELD group level and is mutually exclusive to GSWINGF keyword in the SCHEDULE section that allows for different gas contract parameters to be assign to different groups.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.204 TIGHTEN – Tighten and Relax Numerical Controls

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TIGHTEN keyword tightens up or slackens the numerical controls for the linear, non-linear and material balance convergence targets and also tightens or relaxes the maximum values for the aforementioned parameters. The keyword should be used with caution as it may result in significantly increasing the run times.

Note that any subsequent use of the TUNING keyword in the SCHEDULE section will result in resetting the numerical controls. See also the TIGHTENP in the SCHEDULE section that allows for greater flexibility in modifying the numerical controls.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.205 TIGHTENP – TIGHTEN AND RELAX NUMERICAL CONTROLS INDIVIDUALLY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The TIGHTENP keyword is similar to the TIGHTEN keyword in the SCHEDULE section, in that it tightens up or slackens the numerical controls for the linear, non-linear and material balance convergence targets and also tightens or relaxes the maximum values for the aforementioned parameters. However, TIGHTENP allows for greater flexibility as there are four parameters on this keyword, as opposed to just one on the TIGHTEN keyword, that can be used to modify the numerical controls. The keyword should be used with caution as it may result in significantly increasing the run times.

Note that any subsequent use of the TUNING keyword in the SCHEDULE section will result in resetting the numerical controls. See also the TIGHTEN keyword in the SCHEDULE section that has more limited flexibility in modifying the numerical controls.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.206 TIME – ADVANCE SIMULATION BY CUMULATIVE REPORTING TIME

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword advances the simulation to a given cumulative report time after which additional keywords may be entered to instruct OPM Flow to perform additional functions via the SCHEDULE section keywords, or further TIME keywords may be entered to advance the simulator to the next report time.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TIME	A vector of real positive numbers that define the cumulative length of the of report times.			
		days	days	hours	None

Notes:

1) The keyword is followed by a vector of numbers separated by a space and the keyword is terminated by a "/".

Table 12.47: TIME Keyword Description

See also the DATES and TSTEP keyword in the SCHEDULE section. Note that since OPM Flow uses the standard Gregorian calendar and therefore leap years are accounted for in the DATES keyword. Thus, it is more accurate to use the DATES keyword to progress the simulator through time if one is matching actual production data.

Whenever possible it is a good idea to always set the start date to be at the beginning of the year, as like most simulators, OPM Flow reports are always stated at the number of days from the start date (and sometimes at a given date). If the start date is at the beginning of the year, then calculating the actual date is relatively straight forward and simple.

Examples

The fist example shows how to advance the simulation three years using the TIME keyword, from the given start date of January 1, 2022 set via the START keyword in the RUNSPEC section.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE

-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2022-01-01
-- ------------------------------------------------------------------------------
--
--       ADVANCE SIMULATION BY REPORTING TIME
--
TIME
         365.25  730.50  1095.75
/
```

The second example shows the same advance but using the TSTEP keyword instead.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE

-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2022-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
          'WELLS=2'    'WELSPECS'    'CPU=2'     FIP=2'                        /
--
--       ADVANCE SIMULATION BY REPORTING TIME
--
TSTEP
         3*365.25
/
```

Again, if the simulated production targets are actual production data or the results are going to be used in economic evaluations then the DATES keyword may be more useful in advancing the simulation via the reporting time steps, as the exact dates will be honored.

12.3.207 TSTEP – ADVANCE SIMULATION BY REPORTING TIME

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword advances the simulation to a given report time after which additional keywords may be entered to instruct OPM Flow to perform additional functions via the SCHEDULE section keywords, or further TSTEP keywords may be entered to advance the simulator to the next report time.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TSTEP	A vector of real positive numbers that define the length of the time intervals to subsequent report steps.			
		days	days	hours	None

Notes:

1) The keyword is followed by a vector of numbers separated by a space and the keyword is terminated by a "/".

Table 12.48:TSTEP Keyword Description

See also the DATES and TIME keywords in the SCHEDULE section. Note that since OPM Flow uses the standard Gregorian calendar and therefore leap years are accounted for in the DATES keyword. Thus, it is more accurate to use the DATES keyword to progress the simulator through time if one is matching actual production data.

Whenever possible it is a good idea to always set the start date to be at the beginning of the year, as like most simulators, OPM Flow reports are always stated at the number of days from the start date (and sometimes at a given date). If the start date is at the beginning of the year, then calculating the actual date is relatively straight forward and simple.

Examples

The fist example shows how to advance the simulation via the reporting time steps from the given start date of January 1, 2022 set via the START keyword in the RUNSPEC section, to the next year, without any actions or reporting taking place.

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE

-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2022-01-01
-- ------------------------------------------------------------------------------
--
--       ADVANCE SIMULATION BY REPORTING TIME
--
--       JAN   FEB   MAR   APR   MAY   JUN   JLY   AUG   SEP   OCT   NOV   DEC
TSTEP
         31    28    31    30    31    30    31    31    30    31    30    31
/
```

The second example is similar to the previous example but with quarterly reporting time steps used instead based on $\frac{365.25}{4}=91.3125$ days per quarter

```
-- ==============================================================================
--
-- SCHEDULE SECTION
--
-- ==============================================================================
SCHEDULE

-- ------------------------------------------------------------------------------
-- SCHEDULE SECTION - 2022-01-01
-- ------------------------------------------------------------------------------
RPTSCHED
          'WELLS=2'    'WELSPECS'    'CPU=2'     FIP=2'                        /

--
--       ADVANCE SIMULATION BY REPORTING TIME
--
--       QUARTERLY
TSTEP
         4*91.3125
/
```

Again, if the simulated production targets are actual production data or the results are going to be used in economic evaluations then the DATES keyword may be more useful in advancing the simulation via the reporting time steps, as the exact dates will be honored.

12.3.208 TUNING - NUMERICAL TUNING CONTROL

Description

TUNING defines the parameters used for controlling the commercial simulator's numerical convergence parameters for the global grid. The keyword is similar to the TUNINGDP keyword in the SCHEDULE section that is optimized for high throughput runs. The keyword is mostly ignored by OPM Flow; however, the simulator can be instructed to read the first record of the TUNING keyword if the appropriate command line parameter has been activated (see section *2.2 Running OPM Flow 2020-04 From The Command Line*).

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	TSINIT	TSINT is a real positive value that defines the maximum length of the next time step. Note that whenever the keyword is used TSINIT is always set back to the default value of one, unless explicitly over written.			
		days	days	hours	1.0
1-2	TSMAXZ	TSMAXZ is a real positive value that defines the maximum length of the next time step following TSINIT.			
		days	days	hours	365.0
1-3	TSMINZ	TSMINZ is a real positive value that defines the minimum length of all time steps.			
		days	days	hours	0.1
1-4	TSMCHP	TSMCHP is a real positive values that sets the minimum length of all chopped time steps.			
		days	days	hours	0.15
1-5	TSFMAX	TSFMAX is a real positive value that specifies the maximum growth rate a time step can be increased by, subject to the maximum allowable time step size set by TSMAXZ. For example, if the current time step has converged at 10 days and TSFMAX is set to the default value, then the next time step will be 3.0 x 10 days, that is 30 days provided it is less than TSMAXZ.			
		dimensionless	dimensionless	dimensionless	3.0
1-6	TSFMIN	TSFMIN is a real positive value that specifies the minimum decay rate a time step can be decreased by, subject to the minimum allowable time step size set by TSMINZ. For example, if the current time step has not converged at 10 days and TSFMAX is set to the default value, then the next time step will be 0.3 x 10 days, that is the maximum of 0.3 days and TSMINZ.			
		dimensionless	dimensionless	dimensionless	0.3
1-7	TSFCNV	TSFCNV real positive value that specifies the decay rate a time step can be decreased by after the number of target iterations has been exceeded.			
		dimensionless	dimensionless	dimensionless	0.1

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-8	TFDIFF	TFDIFFA is a real positive value that sets the time step growth factor of the time step after a convergence failure. For example, if the chopped current convergent time step is 10 days and TFDIFF is set to the default value, then the time step will be increased to 1.25 x 10 days, that is the minimum of 11.25 days and TSMAXZ.			
		dimensionless	dimensionless	dimensionless	1.25
1-9	THRURPT	THRURPT is a real positive value that specifies the maximum throughput ratio over a time step.			
		dimensionless	dimensionless	dimensionless	1.0×10^{20}
1-10	TMAXWC	TMAXWC is a real double precision value that defines maximum allowed time step after a well event; for example, when a well is opened or closed, etc.			
		days	days	hours	None
1-11	/	Record terminated by a "/"			Not Applicable
2-1	TRGTTE	TRGTTE is a real positive value that sets the time truncation error target.			
		dimensionless	dimensionless	dimensionless	0.1
2-2	TRGCNV	TRGCNV a real positive value that defines the non-linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.001
2-3	TRGMBE	TRGMBE is a real positive value that specifies the target material balance error.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-7}
2-4	TRGLCV	TRGLCV is a real positive value that specifies the linear convergence error target.			
		dimensionless	dimensionless	dimensionless	0.00001
2-5	XXXTTE	XXXTTE is a real positive value that sets the maximum time truncation error.			
		dimensionless	dimensionless	dimensionless	10.0
2-6	XXXCNV	XXXCNV is a real positive value that defines the maximum non-linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.01
2-7	XXXMBE	XXXMBE is a real positive value that specifies the maximum mass balance error, that is the tolerated mass balance error relative to total mass present.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-6}
2-8	XXXLCV	XXXLCV is a real positive values that sets the maximum linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.0001

No.	Name	Description			Default
		Field	Metric	Laboratory	
2-9	XXXWFL	XXXWFL is a real positive values that fixes the maximum well flow convergence error.			
		dimensionless	dimensionless	dimensionless	0.001
2-10	TRGFIP	TRGFIP is a real positive value that stipulates the target fluid in-place error in Local Grid Refinements.			
		dimensionless	dimensionless	dimensionless	0.025
2-11	TRGSFT	TRGSFT is a real positive values that defines the target surfactant change when the Surfactant Model is active in the run.			
		dimensionless	dimensionless	dimensionless	None
2-12	THIONX	THIONX is a positive real value used to set the threshold for damping in the ion echange calculation for when the Brine Model is active in the run.			
		dimensionless	dimensionless	dimensionless	0.01
2-13	TRWGHT	TRWGHT is a positive integer that stipulates the implicitness for active tracer updates within the Newtonian iterations, and should be set to: 1) 1: The calculation is explicit, that is fully decoupled. 2) 2: The calculation is implicit, that is fully coupled.			
		dimensionless	dimensionless	dimensionless	1
2-14	/	Record terminated by a "/"			Not Applicable
3-1	NEWTMX	NEWTMX is a positive integer greater or equal to NEWTMN that stipulates the maximum number of Newtonian iterations for a time step.			
		dimensionless	dimensionless	dimensionless	12
3-2	NEWTMN	NEWTMN is a positive integer that is less or equal to NEWTMX that defines the minimum number of Newtonian iterations for a time step.			
		dimensionless	dimensionless	dimensionless	1
3-3	LITMAX	LITMAX is a positive integer greater or equal to LITMIN that sets the maximum number of linear iterations within a Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	25
3-4	LITMIN	LITMIN is a positive integer less or equal to LITMAX that sets the minimum number of linear iterations within a Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	1
3-5	MXWSIT	MXWSIT is a positive integer that defines the maximum number of iterations within a well flow calculation.			
		dimensionless	dimensionless	dimensionless	8
3-6	MXWPIT	MXWPIT is a positive integer that stipulates the maximum number of iterations for solving the bottom-hole pressure for wells under tubing head pressure control within a well flow calculation.			
		dimensionless	dimensionless	dimensionless	8

No.	Name	Description			Default
		Field	Metric	Laboratory	
3-7	DDPLIM	DDPLIM a real positive value that stipulates the maximum pressure change at the last Newtonian iteration.			
		psia	barsa	atma	1.0×10^{-6}
3-8	DDSLIM	DDSLIM a real positive value that sets the maximum saturation change at the last Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-6}
3-9	TRGDPR	TRGDP is a real positive value that defines the target pressure change within a time step.			
		psia	barsa	atma	1.0×10^{-6}
3-10	XXXDPR	XXXDPR is a real positive value that stipulates the maximum tolerable pressure change within a time step.			
		psia	barsa	atma	1.0×10^{-6}
3-11	MNWRFP	MNWRFP is a positive integer greater than one and less than NEWTMX that defines the minimum number of Newtonian iterations before invoking the bisection algorithm for when the polymer phase is active in the model via the POLYMER keyword in the RUNSPEC section.			
		dimensionless	dimensionless	dimensionless	4
3-12	/	Record terminated by a "/"			Not Applicable

Notes:

1) The keyword consists of three records, with items 1-1 to 1-11 representing record one items, 2-1 to 2-14 record two and 3-1 to 3-12 representing record number three. Each of the records are terminated by a "/" and is explicitly shown in the above rows.
2) There is no keyword terminating "/".

Table 12.49: TUNING Keyword Description

Note that for record number two (items 2-1 to 2-13) the maximum values should always be greater than the associated target value; for example, XXXCNV should be greater than TRGCNV. Also note that the TUNING keyword is stored on the restart files (see *RPTRST – Define Data to be Written to the RESTART File*) enabling the parameters to be utilized in a restart run without re-specifying the keyword.

Example

```
--
--       DEFAULT TUNING PARAMETERS
--
TUNING
         1.0    365.0     0.1     0.15     3     0.3     0.1   1.25  1E20  1*   /
                                                                                /

/
```

The above example explicitly sets the default parameters for OPM Flow for when the appropriate command line parameter has been activated (see section *2.2 Running OPM Flow 2020-04 From The Command Line*) to instruct the simulator to read the first record of the TUNING keyword. Alternatively one could just use:

```
TUNING
/
/
/
```

12.3.209 TUNINGDP – NUMERICAL TUNING CONTROL FOR HIGH THROUGHPUT CASES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Defines the parameters used for controlling the commercial simulator's numerical convergence parameters. The keyword is similar to the TUNING keyword in the SCHEDULE section, but the defaults on this keyword are optimized for high throughput runs. See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TRGLCV	TRGLCV is a real positive value that specifies the linear convergence error target. The default value is ten times greater than the default value on the TUNING keyword.			
		dimensionless	dimensionless	dimensionless	0.0001
2	XXXLCV	XXXLCV is a real positive values that sets the maximum linear convergence error. The default value is ten times greater than the default value on the TUNING keyword.			
		dimensionless	dimensionless	dimensionless	0.001
3	TRGDDP	TRGDDP a real positive value that stipulates the maximum pressure change during a Newtonian iteration that enables the solution to be accepted when the residual pressure is still outside its convergence criteria.			
		psia	barsa	atma	1.0
4	TRGDDS	TRGDDS a real positive value that sets the maximum saturation change during a Newtonian iteration that enables the solution to be accepted when the residual saturation is still outside its convergence criteria.			
		dimensionless	dimensionless	dimensionless	0.001

Notes:

1) There is no keyword terminating "/".

Table 12.50: TUNINGDP Keyword Description

Note that the TUNING keyword is stored on the restart files (see *RPTRST – Define Data to be Written to the RESTART File*) enabling the parameters to be utilized in a restart run without re-specifying the keyword.

Example

```
--
--        DEFAULT TUNINGDP PARAMETERS
--
TUNINGDP
/
```

The above example explicitly sets the default parameters.

12.3.210 TUNINGH – NUMERICAL TUNING CONTROL FOR HISTORY MATCH GRADIENT CALCULATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Defines the parameters used for controlling the commercial simulator's numerical convergence parameters. The keyword is similar to the TUNING keyword in the SCHEDULE section, but the defaults on this keyword are optimized for high throughput runs. See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	GRGLCV	GRGLCV is a real positive value that specifies the linear convergence error target.			
		dimensionless	dimensionless	dimensionless	0.0001
2	GXXLCV	GXXLCV is a real positive values that sets the maximum linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.001
3	GMSLCV	GMSLCV is a real positive value that specifies the linear convergence residual reduction.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-20}
4	LGTMIN	LGTMIN is a positive integer less or equal to LGTMAX that sets the minimum number of linear iterations within a Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	1
5	LGTMAX	LGTMAX is a positive integer greater or equal to LGTMIN that sets the maximum number of linear iterations within a Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	25

Notes:

1) There is no keyword terminating "/".

Table 12.51:TUNINGH Keyword Description

Example

```
--
--        DEFAULT TUNINGH PARAMETERS
--
TUNINGH
/
```

The above example explicitly sets the default parameters.

12.3.211 TUNINGL - NUMERICAL TUNING CONTROL FOR ALL LGRS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TUNINGL defines the parameters used for controlling the commercial simulator's numerical convergence parameters for all Local Grid Refinements (LGR"). The keyword is the same as the TUNING keyword in the SCHEDULE section that applies the tuning parameters to the global grid. See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	TSINIT	TSINT is a real positive value that defines the maximum length of the next time step. Note that whenever the keyword is used TSINIT is always set back to the default value of one, unless explicitly over written.			
		days	days	hours	1.0
1-2	TSMAXZ	TSMAXZ is a real positive value that defines the maximum length of the next time step following TSINIT.			
		days	days	hours	365.0
1-3	TSMINZ	TSMINZ is a real positive value that defines the minimum length of all time steps.			
		days	days	hours	0.1
1-4	TSMCHP	TSMCHP is a real positive values that sets the minimum length of all chopped time steps.			
		days	days	hours	0.15
1-5	TSFMAX	TSFMAX is a real positive value that specifies the maximum growth rate a time step can be increased by, subject to the maximum allowable time step size set by TSMAXZ. For example, if the current time step has converged at 10 days and TSFMAX is set to the default value, then the next time step will be 3.0 x 10 days, that is 30 days provided it is less than TSMAXZ.			
		dimensionless	dimensionless	dimensionless	3.0
1-6	TSFMIN	TSFMIN is a real positive value that specifies the minimum decay rate a time step can be decreased by, subject to the minimum allowable time step size set by TSMINZ. For example, if the current time step has not converged at 10 days and TSFMAX is set to the default value, then the next time step will be 0.3 x 10 days, that is the maximum of 0.3 days and TSMINZ.			
		dimensionless	dimensionless	dimensionless	0.3
1-7	TSFCNV	TSFCNV real positive value that specifies the decay rate a time step can be decreased by after the number of target iterations has been exceeded.			
		dimensionless	dimensionless	dimensionless	0.1

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-8	TFDIFF	TFDIFFA is a real positive value that sets the time step growth factor of the time step after a convergence failure. For example, if the chopped current convergent time step is 10 days and TFDIFF is set to the default value, then the time step will be increased to 1.25 x 10 days, that is the minimum of 11.25 days and TSMAXZ.			
		dimensionless	dimensionless	dimensionless	1.25
1-9	THRURPT	THRURPT is a real positive value that specifies the maximum throughput ratio over a time step.			
		dimensionless	dimensionless	dimensionless	1.0×10^{20}
1-10	TMAXWC	TMAXWC is a real double precision value that defines maximum allowed time step after a well event; for example, when a well is opened or closed, etc.			
		days	days	hours	None
1-11	/	Record terminated by a "/"			Not Applicable
2-1	TRGTTE	TRGTTE is a real positive value that sets the time truncation error target.			
		dimensionless	dimensionless	dimensionless	0.1
2-2	TRGCNV	TRGCNV a real positive value that defines the non-linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.001
2-3	TRGMBE	TRGMBE is a real positive value that specifies then target material balance error.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-7}
2-4	TRGLCV	TRGLCV is a real positive value that specifies the linear convergence error target.			
		dimensionless	dimensionless	dimensionless	0.00001
2-5	XXXTTE	XXXTTE is a real positive value that sets the maximum time truncation error.			
		dimensionless	dimensionless	dimensionless	10.0
2-6	XXXCNV	XXXCNV is a real positive value that defines the maximum non-linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.01
2-7	XXXMBE	XXXMBE is a real positive value that specifies the maximum mass balance error, that is the tolerated mass balance error relative to total mass present.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-6}
2-8	XXXLCV	XXXLCV is a real positive values that sets the maximum linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.0001

No.	Name	Description			Default
		Field	Metric	Laboratory	
2-9	XXXWFL	XXXWFL is a real positive values that fixes the maximum well flow convergence error.			
		dimensionless	dimensionless	dimensionless	0.001
2-10	TRGFIP	TRGFIP is a real positive value that stipulates the target fluid in-place error in Local Grid Refinements.			
		dimensionless	dimensionless	dimensionless	0.025
2-11	TRGSFT	TRGSFT is a real positive values that defines the target surfactant change when the Surfactant Model is active in the run.			
		dimensionless	dimensionless	dimensionless	None
2-12	THIONX	THIONX is a positive real value used to set the threshold for damping in the ion echange calculation for when the Brine Model is active in the run.			
		dimensionless	dimensionless	dimensionless	0.01
2-13	TRWGHT	TRWGHT is a positive integer that stipulates the implicitness for active tracer updates within the Newtonian iterations, and should be set to: 1) 1: The calculation is explicit, that is fully decoupled. 2) 2: The calculation is implicit, that is fully coupled.			
		dimensionless	dimensionless	dimensionless	1
2-14	/	Record terminated by a "/"			Not Applicable
3-1	NEWTMX	NEWTMX is a positive integer greater or equal to NEWTMN that stipulates the maximum number of Newtonian iterations for a time step.			
		dimensionless	dimensionless	dimensionless	12
3-2	NEWTMN	NEWTMN is a positive integer that is less or equal to NEWTMX that defines the minimum number of Newtonian iterations for a time step.			
		dimensionless	dimensionless	dimensionless	1
3-3	LITMAX	LITMAX is a positive integer greater or equal to LITMIN that sets the maximum number of linear iterations within a Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	25
3-4	LITMIN	LITMIN is a positive integer less or equal to LITMAX that sets the minimum number of linear iterations within a Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	1
3-5	MXWSIT	MXWSIT is a positive integer that defines the maximum number of iterations within a well flow calculation.			
		dimensionless	dimensionless	dimensionless	8
3-6	MXWPIT	MXWPIT is a positive integer that stipulates the maximum number of iterations for solving the bottom-hole pressure for wells under tubing head pressure control within a well flow calculation.			
		dimensionless	dimensionless	dimensionless	8

No.	Name	Description			Default
		Field	Metric	Laboratory	
3-7	DDPLIM	DDPLIM a real positive value that stipulates the maximum pressure change at the last Newtonian iteration.			
		psia	barsa	atma	1.0×10^{-6}
3-8	DDSLIM	DDSLIM a real positive value that sets the maximum saturation change at the last Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-6}
3-9	TRGDPR	TRGDP is a real positive value that defines the target pressure change within a time step.			
		psia	barsa	atma	1.0×10^{-6}
3-10	XXXDPR	XXXDPR is a real positive value that stipulates the maximum tolerable pressure change within a time step.			
		psia	barsa	atma	1.0×10^{-6}
3-11	MNWRFP	MNWRFP is a positive integer greater than one and less than NEWTMX that defines the minimum number of Newtonian iterations before invoking the bisection algorithm for when the polymer phase is active in the model via the POLYMER keyword in the RUNSPEC section.			
		dimensionless	dimensionless	dimensionless	4
3-12	/	Record terminated by a "/"			Not Applicable

Notes:

1) The keyword consists of three records, with items 1-1 to 1-11 representing record one items, 2-1 to 2-14 record two and 3-1 to 3-12 representing record number three. Each of the records are terminated by a "/" and is explicitly shown in the above rows.
2) There is no keyword terminating "/".

Table 12.52:TUNINGL Keyword Description

Note that for record number two (items 2-1 to 2-13) the maximum values should always be greater than the associated target value; for example, XXXCNV should be greater than TRGCNV. Also note that the TUNINGS keyword is stored on the restart files (see *RPTRST – Define Data to be Written to the RESTART File*) enabling the parameters to be utilized in a restart run without re-specifying the keyword.

See also the TUNINGS keyword in the SCHEDULE section that sets the tuning parameters for individual LGRs.

Example

```
-
--        DEFAULT TUNINGL PARAMETERS
--
TUNINGL
/
/
/
```

The above example explicitly sets the default parameters for all LGRs.

12.3.212 TUNINGS - NUMERICAL TUNING CONTROL FOR INDIVIDUAL LGRS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TUNINGS defines the parameters used for controlling the commercial simulator's numerical convergence parameters for individual Local Grid Refinements (LGR"). The keyword is similar to the TUNINGL keyword in the SCHEDULE section that applies the tuning parameters to the all LGRs, except for an additional first record that includes the LGR name.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to invoke various numerical schemes via the OPM Flow command line interface.

No.	Name	Description			Default
		Field	Metric	Laboratory	
0-1	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which the tuning data is being being defined.			None
0-2	/	Record terminated by a "/"			Not Applicable
1-1	TSINIT	TSINT is a real positive value that defines the maximum length of the next time step. Note that whenever the keyword is used TSINIT is always set back to the default value of one, unless explicitly over written.			
		days	days	hours	1.0
1-2	TSMAXZ	TSMAXZ is a real positive value that defines the maximum length of the next time step following TSINIT.			
		days	days	hours	365.0
1-3	TSMINZ	TSMINZ is a real positive value that defines the minimum length of all time steps.			
		days	days	hours	0.1
1-4	TSMCHP	TSMCHP is a real positive values that sets the minimum length of all chopped time steps.			
		days	days	hours	0.15
1-5	TSFMAX	TSFMAX is a real positive value that specifies the maximum growth rate a time step can be increased by, subject to the maximum allowable time step size set by TSMAXZ. For example, if the current time step has converged at 10 days and TSFMAX is set to the default value, then the next time step will be 3.0 x 10 days, that is 30 days provided it is less than TSMAXZ.			
		dimensionless	dimensionless	dimensionless	3.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-6	TSFMIN	TSFMIN is a real positive value that specifies the minimum decay rate a time step can be decreased by, subject to the minimum allowable time step size set by TSMINZ. For example, if the current time step has not converged at 10 days and TSFMAX is set to the default value, then the next time step will be 0.3 x 10 days, that is the maximum of 0.3 days and TSMINZ.			
		dimensionless	dimensionless	dimensionless	0.3
1-7	TSFCNV	TSFCNV real positive value that specifies the decay rate a time step can be decreased by after the number of target iterations has been exceeded.			
		dimensionless	dimensionless	dimensionless	0.1
1-8	TFDIFF	TFDIFFA is a real positive value that sets the time step growth factor of the time step after a convergence failure. For example, if the chopped current convergent time step is 10 days and TFDIFF is set to the default value, then the time step will be increased to 1.25 x 10 days, that is the minimum of 11.25 days and TSMAXZ.			
		dimensionless	dimensionless	dimensionless	1.25
1-9	THRURPT	THRURPT is a real positive value that specifies the maximum throughput ratio over a time step.			
		dimensionless	dimensionless	dimensionless	1.0×10^{20}
1-10	TMAXWC	TMAXWC is a real double precision value that defines maximum allowed time step after a well event; for example, when a well is opened or closed, etc.			
		days	days	hours	None
1-11	/	Record terminated by a "/"			Not Applicable
2-1	TRGTTE	TRGTTE is a real positive value that sets the time truncation error target.			
		dimensionless	dimensionless	dimensionless	0.1
2-2	TRGCNV	TRGCNV a real positive value that defines the non-linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.001
2-3	TRGMBE	TRGMBE is a real positive value that specifies then target material balance error.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-7}
2-4	TRGLCV	TRGLCV is a real positive value that specifies the linear convergence error target.			
		dimensionless	dimensionless	dimensionless	0.00001
2-5	XXXTTE	XXXTTE is a real positive value that sets the maximum time truncation error.			
		dimensionless	dimensionless	dimensionless	10.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
2-6	XXXCNV	XXXCNV is a real positive value that defines the maximum non-linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.01
2-7	XXXMBE	XXXMBE is a real positive value that specifies the maximum mass balance error, that is the tolerated mass balance error relative to total mass present.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-6}
2-8	XXXLCV	XXXLCV is a real positive values that sets the maximum linear convergence error.			
		dimensionless	dimensionless	dimensionless	0.0001
2-9	XXXWFL	XXXWFL is a real positive values that fixes the maximum well flow convergence error.			
		dimensionless	dimensionless	dimensionless	0.001
2-10	TRGFIP	TRGFIP is a real positive value that stipulates the target fluid in-place error in Local Grid Refinements.			
		dimensionless	dimensionless	dimensionless	0.025
2-11	TRGSFT	TRGSFT is a real positive values that defines the target surfactant change when the Surfactant Model is active in the run.			
		dimensionless	dimensionless	dimensionless	None
2-12	THIONX	THIONX is a positive real value used to set the threshold for damping in the ion echange calculation for when the Brine Model is active in the run.			
		dimensionless	dimensionless	dimensionless	0.01
2-13	TRWGHT	TRWGHT is a positive integer that stipulates the implicitness for active tracer updates within the Newtonian iterations, and should be set to: 1) 1: The calculation is explicit, that is fully decoupled. 2) 2: The calculation is implicit, that is fully coupled.			
		dimensionless	dimensionless	dimensionless	1
2-14	/	Record terminated by a "/"			Not Applicable
3-1	NEWTMX	NEWTMX is a positive integer greater or equal to NEWTMN that stipulates the maximum number of Newtonian iterations for a time step.			
		dimensionless	dimensionless	dimensionless	12
3-2	NEWTMN	NEWTMN is a positive integer that is less or equal to NEWTMX that defines the minimum number of Newtonian iterations for a time step.			
		dimensionless	dimensionless	dimensionless	1
3-3	LITMAX	LITMAX is a positive integer greater or equal to LITMIN that sets the maximum number of linear iterations within a Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	25

No.	Name	Description			Default
		Field	Metric	Laboratory	
3-4	LITMIN	LITMIN is a positive integer less or equal to LITMAX that sets the minimum number of linear iterations within a Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	1
3-5	MXWSIT	MXWSIT is a positive integer that defines the maximum number of iterations within a well flow calculation.			
		dimensionless	dimensionless	dimensionless	8
3-6	MXWPIT	MXWPIT is a positive integer that stipulates the maximum number of iterations for solving the bottom-hole pressure for wells under tubing head pressure control within a well flow calculation.			
		dimensionless	dimensionless	dimensionless	8
3-7	DDPLIM	DDPLIM a real positive value that stipulates the maximum pressure change at the last Newtonian iteration.			
		psia	barsa	atma	1.0×10^{-6}
3-8	DDSLIM	DDSLIM a real positive value that sets the maximum saturation change at the last Newtonian iteration.			
		dimensionless	dimensionless	dimensionless	1.0×10^{-6}
3-9	TRGDPR	TRGDP is a real positive value that defines the target pressure change within a time step.			
		psia	barsa	atma	1.0×10^{-6}
3-10	XXXDPR	XXXDPR is a real positive value that stipulates the maximum tolerable pressure change within a time step.			
		psia	barsa	atma	1.0×10^{-6}
3-11	MNWRFP	MNWRFP is a positive integer greater than one and less than NEWTMX that defines the minimum number of Newtonian iterations before invoking the bisection algorithm for when the polymer phase is active in the model via the POLYMER keyword in the RUNSPEC section.			
		dimensionless	dimensionless	dimensionless	4
3-12	/	Record terminated by a "/"			Not Applicable

Notes:

1) The keyword consists of three records, with items 1-1 to 1-11 representing record one items, 2-1 to 2-14 record two and 3-1 to 3-12 representing record number three. Each of the records are terminated by a "/" and is explicitly shown in the above rows.

2) There is no keyword terminating "/".

Table 12.53:TUNINGS Keyword Description

Note that for record number two (items 2-1 to 2-13) the maximum values should always be greater than the associated target value; for example, XXXCNV should be greater than TRGCNV. Also note that the TUNING keyword is stored on the restart files (see *RPTRST – Define Data to be Written to the RESTART File*) enabling the parameters to be utilized in a restart run without re-specifying the keyword.

See also the TUNINGL keyword in the SCHEDULE section that sets the tuning parameters for all LGRs.

Example

```
--
--       DEFAULT TUNINGS PARAMETERS
--
TUNINGS
OP01-LGR
/
/
/
```

The above example explicitly sets the default parameters for the LGR named OP01-LGR

12.3.213 UDQ - DECLARE USER DEFINE QUANTITIES ("UDQ")

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword starts the definition of a UDQ section that stipulates the variables and operations used to access the User Defined Quantities features in OPM Flow. UDQ variables can be constants, SUMMARY variables, as defined in the SUMMARY section, or a formula using various mathematical functions together with constants and SUMMARY variables. Available operation commands include the ASSIGN, DEFINE UNITS and UPDATE that are sub-keywords to the UDQ section keyword. An UDQ definition section is terminated by a "/" on a single line.

Although this keyword is read by OPM Flow and the ACTION and UDQ computational logic and calculations have been implemented, one should used caution using this facility as it may result in OPM Flow aborting.

No.	Name	Description	Default
UDQ		Define the start of UDQ Definition Section. This is then followed on a new line by any number of UDQ records that define the various operations to be performed using the ASSIGN, DEFINE UNITS and UPDATE sub-keywords for the OPERATOR.	
1	OPERATOR	OPERATOR is a character sting that that defines the type of operations to perform, and should be one of the following: 1) ASSIGN: This option assigns a value to a variable and sets the UPDATE status to OFF. 2) DEFINE: In this case a mathematical formula is defined and assigned to a variable. The variable is initialized with the formula and the UPDATE status is set to ON. 3) UNITS: This option sets the reporting units for a defined variable and has no effect on the calculations. The variable must already have been defined prior to using this option. 4) UPDATE: Stipulates when the defined variable should be re-calculated.	

No.	Name	Description	Default
2	VARIABLE	VARIABLE is a character string of length eight that stipulates the name of the user defined variable that will processed by the OPERATOR command. The first two characters of VARIABLE must be set based on the type of variable being defined, that is: 1) CU: For variables that are associated with connections, for example SUMMARY variable COFR (Connection Oil Flow Rate). 2) FU: For variables that are associated with field data, for example SUMMARY variable FOPR (Field Oil Production Rate). 3) GU: For variables that are associated with groups, for example SUMMARY variable GLPR (Group Liquid Production Rate). 4) RU: For variables that are associated with regions, for example SUMMARY variable RPR (Region Pressure). 5) SU: For variables that are associated with multi-segment wells, for example SUMMARY variable SOFR (Segment Oil Flow Rate). 6) WU: For variables that are associated with wells, for example SUMMARY variable WWCT (Well Water Cut). 7) AU: For variables that are associated with aquifers, for example SUMMARY variable AAQP (Analytical Aquifer Pressure). 8) BU: For variables that are associated with blocks, for example SUMMARY variable BPR (Block oil phase Pressure).	
3	EXPRESSION	The data type for EXPRESSION is based on the OPERATOR option above, namely if OPERATOR is set to: 1) ASSIGN: Then EXPRESSION should be a numerical value. 2) DEFINE: In this case a mathematical formula is defined and assigned to a variable. The variable is initialized with the formula and the UPDATE status is set to ON. 3) UNITS: Then EXPRESSION should be a character string enclosed in quotes it it contains blanks, with a maximum length of eight characters, that declares the units for VARIABLE that will be used for reporting. 4) UPDATE: In this case EXPRESSION can have the value ON to evaluate VARIABLE at all time steps, OFF to not evaluate VARIABLE, or NEXT to evaluate VARIABLE at the next time step.	
	/	Termination of a UDQ record. Note that multiple numbers of records can be entered within a UDQ section with each record terminated by a "/".	
/		Define the end of UDQ Definition Section	

Notes:

1) The keyword is terminated by a "/".

Table 12.54: UDQ Keyword Description

Currently, the simulator only supports well variable names (WU type) variables and simple mathematical formula consisting of opening and closing brackets (( )), and the plus, minus, multiply and divide operators, as illustrated in the examples below.

See also the UDADIMS, UDQDIMS and UDQPARAM keywords in the RUNSPEC section to define the dimensions for the UDQ keyword and associated variables.

Examples

The fist example shows how to define some constant field variables used for calculating facilities corrected condensate and Liquefied Petroleum Gas[152] ("LPG ") yields in a wet gas model:

```
--
-- DEFINE START OF USER DEFINED QUANTITY SECTION
--
UDQ
--
-- OPERATOR VARIABLE  EXPRESSION
--
ASSIGN      FUNGLYLD  1.100000         / Condensate  Yield (stb/Mscf)
ASSIGN      FUNGLSHK  0.000000         / Condensate  Shrinkage Factor set to Zero
ASSIGN      FULPGYLD  0.065775         / LPG Sep Gas Yield (stb/Mscf)
ASSIGN      FULPGSHK  0.080410         / LPG         Shrinkage Factor
ASSIGN      FUFACSHK  0.000935         / Facilities  Shrinkage Factor
ASSIGN      FUFULSHK  0.052924         / Fuel        Utilization
ASSIGN      FUDELTA   1E-10            / Value to avoid diving by zero errors

/  DEFINE END OF USER DEFINED QUANTITY SECTION
```

The next example is a continuation of this example by showing how one can calculate the adjusted field condensate and LPG rates. Note both examples could be merged into a single UDQ definition but have been stated separately for ease of reference.

```
--
-- DEFINE START OF USER DEFINED QUANTITY SECTION
--
UDQ
--
-- OPERATOR VARIABLE  EXPRESSION
--
DEFINE      FU_FNGLR  FGPR *(FOGR * FUNGLYLD)  / Calculate Condensate Rate  Field
UPDATE      FU_FNGLR  ON                       /
UNITS       FU_FNGLR  STBD                     /

DEFINE      FU_FLPGR  FU_FWGPR * FULPGYLD      / Calculate LPG Rate  Field
UPDATE      FU_FLPGR  ON                       /
UNITS       FU_FLPGR  STBD                     /

/  DEFINE END OF USER DEFINED QUANTITY SECTION
```

In the above the DEFINE operator is use to define the equations to calculate the corrected condensate (FU_FNGLR) and LPG rates (FU_FLPGR) with the UPDATE operator set to ON so that the rates are calculate at every time step, and finally, the UNITS operator is used to set the units of the calculated rates.

The final example show the use of the UDADIMS and UDQDIMS keywords in the RUNSPEC section, followed by the keywords in the SCHEDULE section that define a UDQ definition that users the DEFINE operator to calculate adjusted well rates based on an expression. The final set of keywords show how the UDQ defined variables are employed on the WCONPROD keyword to control the production constraints for several wells.

[152] *Liquefied Petroleum Gas or LPG consists mainly of propane, propylene, butane, and butylene in various mixtures. It is produced as a by-product of natural gas processing and petroleum refining. The components of LPG are gases at standard conditions.*

```
                              RUNSPEC SECTION KEYWORDS
                              ------------------------
--
--       USER DEFINED ARGUMENT DIMENSIONS
--       NO.     NOT     TOTAL
--       ARGS    USED    UDQ
UDADIMS
         10       1*     10                                                  /
--
--       USER DEFINED ARGUMENT DIMENSIONS FACILITY
--       MAX     MAX     MAX     MAX     MAX     MAX    MAX    MAX    MAX   MAX    RAND
--       FUNCS   ITEMS   CONNS   FIELD   GROUP   REGS   SEGTM  WELL   AQUF  BLCKS  OPT
UDQDIMS
         50      25      0       50      50      0      0      0      0     0      N  /

                            SCHEDULE SECTION KEYWORDS
                           --------------------------
--
-- DEFINE START OF USER DEFINED QUANTITY SECTION
--
UDQ
--
-- OPERATOR VARIABLE EXPRESSION
--
DEFINE      WUOPRL (WOPR OPL01 - 150) * 0.90 / OIL & LIQ CAPACITIES
DEFINE      WULPRL (WLPR OPL01 - 200) * 0.90 /  at GEFAC = 0.8995
DEFINE      WUOPRU (WOPR OPU01 - 250) * 0.80 /
DEFINE      WULPRU (WLPR OPU01 - 300) * 0.80 /
--
UNITS       WUOPRL SM3/DAY                   / DEFINE REPORTING UNITS
UNITS       WULPRL SM3/DAY                   / FOR UDQ VARIABLES
UNITS       WUOPRU SM3/DAY                   /
UNITS       WULPRU SM3/DAY                   /
/  DEFINE END OF USER DEFINED QUANTITY SECTION
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    LIQ    RES    BHP   THP   VFP    VFP
-- NAME  SHUT   MODE   RATE   RATE   RATE   RATE   RATE   PRES  PRES  TABLE  ALFQ
WCONPROD
OP01     SHUT   GRUP   1*     1*     1*     1*     1*     200.0                /
OP02     SHUT   GRUP   1*     1*     1*     1*     1*     200.0                /
/
DATES
         1  FEB   2020  /
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    LIQ    RES    BHP   THP   VFP    VFP
-- NAME  SHUT   MODE   RATE   RATE   RATE   RATE   RATE   PRES  PRES  TABLE  ALFQ
WCONPROD
OP01     OPEN   GRUP   WUOPRL 1*     1*     WULPRL 1*     60.0                 /
OP02     OPEN   GRUP   WUOPRL 1*     1*     WULPRL 1*     00.0                 /
/
DATES
         1  MAR   2020  /
         1  APR   2020  /
         1  MAY   2020  /
         1  JUN   2020  /
         1  JLY   2020  /
         1  AUG   2020  /
         1  SEP   2020  /
/
```

12.3.214 UDT - DECLARE USER DEFINE TABLES ("UDT")

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword starts the definition of a UDT table that defines a multi-dimensional table that can be used to assign User Defined Quantities ("UDQ") via the UDQ keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.215 USECUPL – Load a Reservoir Coupling File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The USECUPL keyword causes the simulator to read a Reservoir Coupling file that has been previously created in a master run using the DUMPCUPL keyword in the SCHEDULE section, for when reservoir coupling is invoked by the GRUPMAST and SLAVES keywords in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.216 VAPPARS – Oil Vaporization Parameters

VAPPARS defines the rate of oil vaporization in the presence of undersaturated gas and the rate at which the remaining oil gets "heavier" via the reduction in the solution gas-oil ratio ("Rs"). This keyword should only be used if the OIL, GAS, DISGAS and VAPOIL keywords in the RUNSPEC section have been invoked to allow oil, gas, dissolved gas and vaporized oil to be present in the model.

In OPM Flow, VAPPARS can only be set once, and not changed multiple times in the SCHEDULE section.

See *VAPPARS – Oil Vaporization Parameters* in the SOLUTION section for a full description.

12.3.217 VFPCHK – DEFINE PRODUCTION VERTICAL FLOW PERFORMANCE BHP CHECK

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The VFPPROD keyword defines production Vertical Flow Performance ("VFP") tables that are used to determine the outflow or downstream pressure based on the inlet or upstream pressure and the phases flowing through the system. For a well this means the table relates the flowing bottom-hole pressure ("BHP") to the well's tubing head pressure ("THP") based on the oil, gas and water rates (and any artificial lift quantities like gas lift gas), or phases ratios, flowing up the wellbore.

The VFP tables are generated by external programs and may result in some inconsistencies. A common inconsistency is that the curves of BHP versus flow rate at adjacent THP values cross, that is the BHP is increasing with decreasing THP. This will result in numerical convergence problems and should therefore be avoided; which is why the simulator checks for this particular inconsistency. However, there are cases when the external software generating the VFP table outputs "valid" high BHP values, for example, when the flow exceeds the erosion velocity limits, or the flow is supersonic, indicating a no flow condition. The VPFCHK keyword sets the BHP check pressure (VFPCHK) for subsequent VFPPROD tables, so that crossing BHP values above VFPCHK will be ignored.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	VFPCHK	VFPCHK is a real positive value that defines the BHP pressure above which crossing VFP curves will be ignored. Setting VFPCHK to a large number like the default value number will cause all crossing curves to be checked. Also if the keyword is omitted from the input deck then the check is performed using the default value.			1.0^{10}
		psia	barsa	atma	

Notes:

1) The keyword is followed by a vector of numbers separated by a space and the keyword is terminated by a "/".

Table 12.55:VFPCHK Keyword Description

Note

One reason for external programs generating crossing VFP curves is that the curves have been generated with too much resolution. For example, if the GOR entries has been generated with values of 100, 150, 200, 250, 300, 350, 400, 450 and 500, then use a geometric spacing instead to generated the VFP table, that is: 100, 300, 900. This will enable the simulator to interpolate the curves consistently and avoid crossing VFP curves.

Example

Here the example sets the maximum BHP to be 1.0 x10^6 above which crossing VFP curves will be ignored.

```
--
--        DEFINE PRODUCTION VFP CHECK MAX BHP
--
--        MXBHP
VFPCHK
          1.0E6
/
```

12.3.218 VFPINJ – DEFINE INJECTION VERTICAL FLOW PERFORMANCE TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The VFPINJ keyword defines injection Vertical Flow Performance ("VFP") tables that are used to determine the outflow or downstream pressure based on the inlet or upstream pressure and the phases being injected into the system. For a well this means the table relates the flowing bottom-hole pressure ("BHP") to the well's tubing head pressure ("THP") based on the oil, gas or water injection rates. The table is also used to describe the pressure relationship when the network option is being used, although the Network option is not currently implemented in OPM Flow. In this case the table describes the pipeline pressure behavior from the HIGHER group (inlet node) to the LOWER group (outlet node) given the current flowing conditions (the group relationship is defined by the GRUPTREE keyword in SCHEDULE section).

The data for this keyword is generated by an external program and is normally included into the input deck using the INCLUDE keyword as described in section *CHAPTER 4: GLOBAL SECTION KEYWORDS*, as the data can be quite voluminous.

Each VFPINJ table must be entered with a separate VFPINJ keyword that consists of four records, with 1-1, 1-2 representing record one items (1) and (2) and 2-1, 2-2 representing record number two items (1) and (2) and so on in the "No." column in Table 12.56. Each record is terminated by a "/". The fourth record must be repeated to give BHP data as a function of FLO for all THP values.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	VFPTAB	A positive integer greater than zero and less than or equal to the MXVFPTAB variable as defined on the VFPIDIMS keyword in the RUNSPEC section, that defines the vertical flow performance table number.			None
1-2	VFPREF	A real positive value that defines the reference depth used to generate this VFPINJ table data set. OPM Flow automatically corrects any difference between VFPREF and the BHPREF on the WELSPECS and WPAVDEP keywords in the SCHEDULE section, using the current hydrostatic head.			None
1-3	FLO	A defined character string that defines the injection phases, and should be set to one of the following character strings: 1) OIL: for injecting phase being oil. 2) GAS: for injecting phase being gas. 3) WAT: for injecting phase being water.			None
1-4	VFPTYPE	A defined character string that should be defaulted or set equal to THP.			THP
1-5	VFPUNITS	Units used for the BHP-DATA on this keyword. This variable is ignored by OPM Flow and should be defaulted with 1*.			
		FIELD	METRIC	LAB	1*
1-6	VFPVALUE	A defined character string that should be defaulted or set equal to BHP. This variable is ignored by OPM Flow and should be defaulted with 1*.			BHP
1-7	/	Record terminated by a "/"			Not Applicable

No.	Name	Description			Default
		Field	Metric	Laboratory	
2-1	FLO-DATA	A real positive monotonically increasing vector that defines the numerical values of the injection phase declared by the FLO variable. The number of entries must greater than two and less than or equal to MXMFLO as defined on the VFPIDIMS keyword in the RUNSPEC section.			
		Liquid: stb Gas: Mscf	Liquid: sm^3 Gas: sm^3	Liquid: scc Gas: scc	None
2-2	/	Record terminated by a "/"			Not Applicable
3-1	THP-DATA	A real positive monotonically increasing vector that defines the numerical values of the tubing head pressure values. The number of entries must be greater than two and less than or equal to MXMTHP as defined on the VFPIDIMS keyword in the RUNSPEC section.			
		psia	barsa	atma	None
3-2	/	Record terminated by a "/"			Not Applicable
4-1	NTHP	This data record consists of an integer value that defines the index of THP values entered via the THP-DATA records on this keyword. For example, if THP-DATA is equal to 1000, 2000, 3000 and 3500 and NTHP is equal to three then NTHP refers to third entry, that is THP equal to 3000.			
	BHP-DATA	NTHP is then followed by a real vector of BHP values for each FLO injection rate for the corresponding index value (NTHP) and is then terminated with a"/" The (4-1) record, which consists of both NTHP and BHP-DATA data, is then repeated, until all combinations of (NTHP and FLO) and the associate BHP data has been entered.			
		psia	barsa	atma	None
4-2	/	Each Index (NTHP, BHP-DATA) data set is terminated by a "/"			Not Applicable

Notes:

1) Each VFPINJ table must be entered with a separate VFINJ keyword that consists of four records, with items 1-1 to 1-7 representing record one items and 2-1 to 2-2 representing record number two items, etc., in the "No." column in this table.
2) Each of the records are terminated by a "/" and is explicitly shown in the above rows.
3) There is no keyword terminating "/".

Table 12.56: VFPINJ Keyword Description

See also the WELSPECS keyword to define wells and the WCONINJE keyword that is used to allocate the VFPINJ tables to specific wells. Note that one VFPINJ table can be allocated to one or more wells, provided the wells in question have a similar trajectory and similar flow characteristics, for example vertical water injection wells injecting into the same reservoir.

The VFPPROD keyword is used to enter VFP tables for production wells or to describe the pressure relationship when the network option is being used. In this case the table describes the pipeline pressure behavior from the LOWER group (inlet node) to the HIGHER group (outlet node) given the current production conditions.

All the aforementioned keywords are described in the SCHEDULE section.

Examples

The following example shows the VFPINJ table for a water injection well and is taken from the Norne OPM Flow model.

```
VFPINJ

-- Table   Datum Depth   Rate Type
-- -----   -----------   ---------
      12       2718.07       'WAT' /


-- 'WAT' units - SM3/DAY
  500.0  1263.2  2026.3  2789.5  3552.6
 4315.8  5078.9  5842.1  6605.3  7368.4
 8131.6  8894.7  9657.9 10421.1 11184.2
11947.4 12710.5 13473.7 14236.8 15000.0 /

-- 'THP' units - BARSA
  21.01   63.24  105.46  147.68  189.90
 232.12  274.35  316.57  358.79  401.01 /

1  254.51  253.95  252.27  249.83  246.69
   242.88  238.42  233.32  227.59  221.22
   214.23  206.62  198.38  189.53  180.06
   169.97  159.26  147.95  136.00  123.46
/
2  297.02  296.49  294.82  292.39  289.26
   285.47  281.01  275.92  270.20  263.84
   256.87  249.28  241.05  232.22  222.76
   212.70  202.01  190.71  178.79  166.27
/
.......................................... . ............................ . ..............................................................
.......................................... . ............................ . ..............................................................

9  594.67  594.29  592.70  590.34  587.29
   583.57  579.16  574.17  568.55  562.25
   555.40  547.92  539.79  531.09  521.74
   511.82  501.25  490.13  478.34  466.01
/
10 637.19  636.83  635.26  632.91  629.86
   626.16  621.76  616.78  611.17  604.89
   598.05  590.59  582.47  573.79  564.45
   554.56  544.01  532.91  521.14  508.83
/
```

The example shows the first two and the last two records of the fourth kind, as the data is too voluminous to be included.

Note

The VFPTAB variable defines the table number of the VFPINJ data set; if more then one VFPINJ keyword is entered with the same VFPTAB number then the VFPINJ data set will be overwritten by the last VFPINJ keyword with the same VFPTAB number.

The same comment is also applicable to the VFPPROD keyword.

12.3.219 VFPPROD – DEFINE PRODUCTION VERTICAL FLOW PERFORMANCE TABLES

Description

The VFPPROD keyword defines production Vertical Flow Performance ("VFP") tables that are used to determine the outflow or downstream pressure based on the inlet or upstream pressure and the phases flowing through the system. For a well this means the table relates the flowing bottom-hole pressure ("BHP") to the well's tubing head pressure ("THP") based on the oil, gas and water rates (and any artificial lift quantities like gas lift gas), or phases ratios, flowing up the wellbore. The table is also used to describe the pressure relationship when the network option is being used, although the Network option is not currently implemented in OPM Flow. In this case the table describes the pipeline pressure behavior from the LOWER group (inlet node) to the HIGHER group (outlet node) given the current flowing conditions (the group relationship is defined by the GRUPTREE keyword in SCHEDULE section).

Each VFPPROD table must be entered with a separate VFPPROD keyword that consists of seven records, with 1-1, 1-2 representing record one items (1) and (2) and 2-1, 2-2 representing record number two items (1) and (2) in the "No." column in Table 12.57. Each record is terminated by a "/". The seventh record must be repeated to give BHP data as a function of FLO for all THP values.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	VFPTAB	A positive integer greater than zero and less than or equal to the MXVFPTAB variable as defined on the VFPPDIMS keyword in the RUNSPEC section, that defines the vertical lift performance table number.			None
1-2	VFPREF	A real positive value that defines the reference depth used to generate this VFPPROD table data set. OPM Flow automatically corrects any difference between VFPREF and the BHPREF on the WELSPECS and WPAVDEP keywords in the SCHEDULE section, using the current hydrostatic head.			None
1-3	FLO	A defined character string that defines the flowing phases, and should be set to one of the following character strings: 1) GAS: for flowing phase being the gas rate. 2) OIL: for flowing phase being the oil rate. 3) LIQ: for flowing phase being the liquid (oil plus water) rate.			None
1-4	WFR	A defined character string that defines the flowing water fraction and should be set to one of the following character strings: 1) WOR: for the water fraction being the water-oil ratio $\frac{q_w}{q_o}$ and should be used if FLOW is set to OIL or LIQ' 2) WCT: for the water fraction being the water cut $\frac{q_w}{q_o+q_w}$ and should be used if FLOW is set to OIL or LIQ 3) WGR: for the water fraction being the water-gas ratio $\frac{q_w}{q_g}$ and should be used if FLOW is set to GAS.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-5	GFR	A defined character string that defines the flowing gas fraction and should be set to one of the following character strings: 1) GOR: for the gas fraction being the gas-oil ratio $\frac{q_w}{q_o}$ and should be used if FLOW is set to OIL or LIQ' 2) GLR: for the gas fraction being the gas-liquid ratio $\frac{q_g}{q_o+q_w}$ and should be used if FLOW is set to OIL or LIQ 3) OGR: for the gas fraction being the oil-gas ratio $\frac{q_o}{q_g}$ and should be used if FLOW is set to GAS.			None
1-6	VFPTYPE	A defined character string that should be defaulted or set equal to THP.			THP
1-7	ALQ	A defined character string that defines the artificial lift quantity and should be set to one of the following character strings: 1) GRAT: for the artificial lift quantity being the gas lift gas injection rate. 2) IGLR: for the artificial lift quantity being the gas lift gas, injection gas-liquid ratio. 3) TGLR: for the artificial lift quantity being the gas lift gas, injection total gas-liquid ratio. 4) COMP: for the artificial lift quantity being the compressor power, for a compressor. 5) PUMP: for the artificial lift quantity being the pump rating for a pump. 6) DENO: for oil surface density. 7) DENG: for gas surface density. The default value of 1* is " " or undefined that covers the case when the ALQ variable is not entered.			1*
1-8	VFPUNITS	Units used for the BHP-DATA on this keyword. This variable is ignored by OPM Flow and should be defaulted with 1*.			
		FIELD	METRIC	LAB	1*
1-9	VFPVALUE	A defined character string that should be defaulted or set equal to BHP. This variable is ignored by OPM Flow and should be defaulted with 1*.			BHP
1-10	/	Record terminated by a "/"			Not Applicable
2-1	FLO-DATA	A real positive monotonically increasing vector that defines the numerical values of the flowing phase declared by the FLOW variable. The number of entries must greater than two and less than or equal to MXMFLO as defined on the VFPPDIMS keyword in the RUNSPEC section.			
		Liquid: stb Gas: Mscf	Liquid: sm^3 Gas: sm^3	Liquid: scc Gas: scc	None
2-2	/	Record terminated by a "/"			Not Applicable

No.	Name	Description			Default
		Field	Metric	Laboratory	
3-1	THP-DATA	A real positive monotonically increasing vector that defines the numerical values of the tubing head pressure values. The number of entries must greater than two and less than or equal to MXMTHP as defined on the VFPPDIMS keyword in the RUNSPEC section.			
		psia	barsa	atma	None
3-2	/	Record terminated by a "/"			Not Applicable
4-1	WFR-DATA	A real positive monotonically increasing vector that defines the numerical values of the flowing water fraction declared by the WFR variable. The number of entries must greater than two and less than or equal to MXMWFR as defined on the VFPPDIMS keyword in the RUNSPEC section.			
		WOR: dimensionless WCT: dimensionless WGR: stb/Mscf	dimensionless dimensionless dimensionless	dimensionless dimensionless dimensionless	None
4-2	/	Record terminated by a "/"			Not Applicable
5-1	GFR-DATA	A real positive monotonically increasing vector that defines the numerical values of the flowing gas fraction declared by the GFR variable. The number of entries must greater than two and less than or equal to MXMGFR as defined on the VFPPDIMS keyword in the RUNSPEC section.			
		GOR: Mscf/stb GLR: Mscf/stb OGR: stb/Mscf	dimensionless dimensionless dimensionless	dimensionless dimensionless dimensionless	None
5-2	/	Record terminated by a "/"			Not Applicable
6-1	ALQ-DATA	A real positive monotonically increasing vector that defines the numerical values of the artificial lift quantity declared by the ALQ variable. The number of entries must greater than two and less than or equal to MXMALQ as defined on the VFPPDIMS keyword in the RUNSPEC section.			
		GRAT: Mscf/day IGLR: Mscf/stb TGLR: Mscf/day DENO: lb/ft^3 DENG: lb/ft	sm^3/day dimensionless dimensionless kg/m^3 kg/m^3	scc/hour dimensionless dimensionless gm/cc gm/cc	None
6-2	/	Record terminated by a "/"			Not Applicable

No.	Name	Description			Default
		Field	Metric	Laboratory	
7-1	NTHP	This data record consists of a series of integer values that defines the index of THP, WFR, GFR, ALQ entered via the those records on this keyword. The first index, NTHP, is an integer value that defines the index of THP values entered via the THP-DATA records on this keyword. For example, if THP-DATA is equal to 100, 200, 300 and 350 and NTHP is equal to three then NTHP refers to third entry, that is THP equal to 300.			None
	NWFR	The second index, NWFR, is an integer value that defines the index of the water fraction values entered via the WFR-DATA records on this keyword. For example, if WFR-DATA is equal to 0.00, 0.25, 0.50 and 0.75 and NWFR is equal to two then NWFR refers to second entry, that is WFR equal to 0.25.			None
	NGFR	The third index, NGFR, is an integer value that defines the index of the gas fraction values entered via the GFR-DATA records on this keyword. For example, if GFR-DATA is equal to 100.0, 200.0, 500.0 and 750.0 and NGFR is equal to three then NGFR refers to third entry, that is GFR equal to 500.0.			None
	NALQ	The fourth and final index entry, NALQ, is an integer value that defines the index of artificial lift values via the ALQ-DATA records on this keyword. For example, if ALQ-DATA is equal to 50, 100, 200 and 300 and NALQ is equal to one then NALQ refers to first entry, that is ALQ equal to 50. The fourth index is then followed by the BHP values.			None
	BHP-DATA	BHP-DATA is a real vector of BHP values for each FLO production rate for the corresponding index value (NTHP, NWFR, NGFR, NALQ) and is then terminated with a"/" The (7-1) record, which consists of the four indices and BHP data, is then repeated until all combinations of (NTHP, NWFR, NGFR, NALQ) and the associate BHP data has been entered.			
		psia	barsa	atma	None
7-2	/	Each Index (NTHP, NWFR, NGFR, NALQ. BHP-DATA) data set is terminated by a "/"			Not Applicable

Notes:

1) Each VFPPROD table must be entered with a separate VFPPROD keyword that consists of seven records, with entries 1-1 to 1-10 representing record one items and 2-1 to 2-2 representing record number two items, etc., in the "No." column in this table.
2) Each of the records are terminated by a "/" and is explicitly shown in the above rows.
3) There is no keyword terminating "/".

Table 12.57:VFPPROD Keyword Description

The data for this keyword is generated by an external program and is normally included into the input deck using the INCLUDE keyword as described in section *CHAPTER 4: GLOBAL SECTION KEYWORDS*, as the data can be quite voluminous.

See also the WELSPECS keyword to define wells and the WCONPROD keyword that is used to allocate the VFPPROD tables to specific wells. Note that one VFPPROD table can be allocated to one or more wells, provided the wells in question have a similar trajectory and similar flow characteristics, for example vertical oil wells producing from the same reservoir, or different reservoirs with similar PVT properties.

The VFPINJ keyword is used to enter VFP tables for injection wells or to describe the pressure relationship when the network option is being used. In this case the table describes the pipeline pressure behavior from the HIGHER group (inlet node) to the LOWER group (outlet node) given the current injection conditions.

All the aforementioned keywords are described in the SCHEDULE section.

Examples

The following example shows the VFPPROD table for a production gas well and is taken from the Norne OPM Flow model. Here WFR has been set to water-gas ratio and GFR has been set to the oil-gas ratio, and the ALQ value is defaulted.

```
VFPPROD

-- Table   Datum Depth   Rate Type   WFR Type   GFR Type
-- -----   -----------   ---------   --------   --------
       5       2623.39       'GAS'      'WGR'      'OGR' /


-- 'GAS' units - SM3/DAY
  50000.0  100000.0  200000.0  400000.0  800000.0
1200000.0 1600000.0 1999999.9 3000000.0 3999999.8
5000000.5 /

-- 'THP' units - BARSA
  10.00   20.00   40.00   80.00  120.00
 150.00  200.00  250.00 /

-- 'WGR' units - SM3/SM3
      0    1e-9    1e-6    1e-5  0.0001
  0.001    0.01     0.1 /

-- 'OGR' units - SM3/SM3
   1e-7    1e-6    1e-5  0.0001   0.001
   0.01 /

-- 'ALQ' units -
      0 /

 1  1  1  1   11.93   12.22   13.35   17.24   27.93
              39.83   52.06   64.38   95.20  125.89
             156.52
/
 1  1  2  1   11.93   12.22   13.35   17.24   27.94
              39.84   52.07   64.39   95.21  125.91
             156.55
/

.......................................................................
.......................................................................

 8  8  5  1  483.75  511.15  614.09 1044.78 2757.56
            5592.55 9528.36 14567.24 32005.79 56375.24
              87684
/
 8  8  6  1  487.68  516.24  624.74 1075.40 2860.16
            5803.92 9880.58 15093.76 33119.59 58297.57
              90639
/
```

The example shows the first two and the last two records of type seven, as the data is too voluminous to be included.

The next example below shows an example oil producing well VFPPROD, again taken from Norne OPM Flow model. Here WFR has been set to water cut and GFR has been set to the gas-oil ratio, and the ALQ value is defaulted.

```
VFPPROD

-- Table   Datum Depth   Rate Type   WFR Type   GFR Type   TAB Type
-- -----   -----------   ---------   --------   --------   --------
--    37       2641.02       'LIQ'      'WCT'      'GOR'            /

-- Prosper files are corrected from RKB to MSL depth. lmarr

-- Table   Datum Depth   Rate Type   WFR Type   GFR Type   TAB Type
-- -----   -----------   ---------   --------   --------   --------
      37       2617.02       'LIQ'      'WCT'      'GOR'            /

-- 'LIQ' units - SM3/DAY
  200.0   500.0  1000.0  1500.0  2000.0
 2500.0  3000.0  3500.0  4000.0  4500.0
 5000.0  5500.0  6000.0  6500.0  7000.0
 7500.0  8000.0 10000.0 14000.0 /

-- 'THP' units - BARSA
  21.01   51.01   61.01   81.01  101.01
 121.01  141.01  161.01  181.01  201.01 /

-- 'WCT' units - FRACTION
      0     0.1     0.2     0.3     0.4
    0.5     0.6     0.7     0.8       1 /

-- 'GOR' units - SM3/SM3
     90     100     150     200     500
   1000    2000 /

-- 'ALQ' units -
      0 /

 1  1  1  1  160.82  136.70  119.79  115.86  117.38
             121.16  126.08  131.56  137.48  143.74
             150.29  157.07  164.02  171.07  178.13
             185.11  192.09  220.38  280.86
/
 1  1  2  1  155.63  129.40  112.32  108.64  110.44
             114.74  120.15  126.09  132.47  139.05
             146.02  153.41  160.67  167.91  175.13
             182.34  189.55  218.81  281.02
/
.......................................................................
.......................................................................

10 10  6  1  439.30  437.95  437.53  437.79  438.39
             439.26  440.36  441.67  443.19  444.92
             446.85  448.99  451.32  453.85  456.58
             459.51  462.64  477.11  515.47
/
10 10  7  1  439.30  437.95  437.53  437.79  438.39
             439.26  440.36  441.67  443.19  444.92
             446.85  448.99  451.32  453.85  456.58
             459.51  462.64  477.11  515.47
/
```

The example shows the first two and the last two records of type seven, as the data is too voluminous to be included.

12.3.220 VFPTABL – DEFINE PRODUCTION VERTICAL FLOW PERFORMANCE ALQ INTERPOLATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The VFPTABL keyword defines the interpolation method for production Vertical Flow Performance ("VFP") tables for the Artificial Lift Quantity ("ALQ"). Production VFP data is entered via the VFPPROD keyword in the SCHEDULE section. By default the simulator interpolates all the variables in the VFP tables using linear interpolation, including the ALQ quantity. However, if the ALQ values represent gas lift, then linear interpolation may not be insufficient, as the gradient change between the tabulated ALQ values may result in sudden changes. This is particularly important in gas lift optimization studies where the available gas lift gas is being allocated to a group of wells in order to maximize oil production rates. To overcome this issue the VFPTABL keyword allows the ALQ values to be interpolated using cubic spline interpolation, and results in a smother transition between the various ALQ entries.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	VFPTABL	VFPTABL is a defined positive integer that specifies the interpolation method to be used with the ALQ quantity in the VFP production tables, and should be set to one of the following: 1) Apply linear interpolation to all VFPPROD variables. 2) Apply linear interpolation to all VFPPROD variables, except for the ALQ variable, for which cubic spline interpolation should be used. If the keyword is absent from the input deck then linear interpolation will be used for all variables.			
		dimensionless	dimensionless	dimensionless	1

Notes:

1) The keyword is followed by a vector of numbers separated by a space and the keyword is terminated by a "/".

Table 12.58: VFPTABL Keyword Description

Example

The example sets cubic spline interpolation for the ALQ quantity in the VFPPROD tables, with linear interpolation used for all the variables.

```
--
--        ALQ INTERPOLATION OPTION
--
--        OPTION
VFPTABL
          2
/
```

12.3.221 WAITBAL – Wait On Network Balance Before Allowing Further Actions

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword sets the network balance option for all networks when networks are active in the model. Basically, the keyword either activates the PRORDER and GDRILPOT stipulated actions before or after the network has been balanced

The network option is normally used to ensure that the tubing head pressure ("THP") of a group of wells flowing into a common network node is consistent with a group's flow rates, that is each well's THP is flowing at the same THP and at the same time satisfying well and group targets and constraints. This is accomplished by calculating the well THP limits dynamically by balancing the flow rates and pressure losses in the network.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.222 WALKALIN – Define Water Injection Alkaline Concentration

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WAKALIN keyword defines the water injection alkaline concentration for water injection wells for when the surfactant and/or polymer models have been activated by the SURFACT, SURFACTW, or the POLYMER keywords in the RUNSPEC section, combined with the ALKALINE keyword which is also in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.223 WALQCALC – Define Well VFP Surface ALQ Phase Density

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WALQCALC keyword defines the well VFP surface ALQ phase density use in the VFP table lookup and interpolation to be gas surface density, oil surface density, or neither. Note that the user should ensure that generated VFP tables have been generated consistent with the setting on this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.224 WAPI – DEFINE OIL WELL INJECTION API GRAVITY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines an oil injection well's API gravity for when API tracking has been made active via the API keyword in the RUNSPEC section. The American Petroleum Institute (API) classifies oils based on an API gravity (γ_{API}), or degrees API (°API), the relationship between relative density (γ_o) of oil and API gravity (γ_{API}) is given by:

$$\gamma_{API} = \frac{141.5}{\gamma_o} - 131.5 \tag{12.23}$$

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.225 WBHGLR – DEFINE WELL BOTTOM-HOLE GLR CONSTRAINT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WBHGLR, defines a well's bottom-hole Gas Liquid Ratio ("GLR") constraint, where the GLR is the is the ratio of the "free" gas rate and liquid rate at bottom-hole conditions. The reference depth for bottom-hole conditions is given by the BHPREF variable on the WELSPECS keyword in the SCHEDULE section.

Normally this type of well control is applied to pumping wells to avoid the well "pumping off", that is when the liquid column above the pump is low, resulting in an increase in gas intake and an associated loss in pump efficiency.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.226 WBOREVOL – DEFINE EFFECTIVE WELLBORE STORAGE VOLUME

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WBOREVOL defines a well's effective wellbore storage volume. The primary purpose of the keyword is to enable matching of the wellbore storage effects in well tests and the corresponding pressure response observed in the test. Normally, as part of well test interpretation, the pressure, permeability, effective wellbore storage, etc., are derived from the analytical interpretation of the test. This keyword therefore allows the engineer to enter the analytical derived effective wellbore storage.

Wellbore storage, in terms of well testing, is an important variable when the well is shut-in at the surface, as the well continues to flow down-hole until the fluids obtain equilibrium. Most well tests are now conducted using specialized tools that shut-in the well down-hole, thus eliminating, or mostly eliminating, wellbore storage effects.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.227 WCALCVAL – DEFINE GAS WELL CALORIFIC VALUE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines a gas well's calorific value for when the Gas Calorific Value option has been activated by specifying a target calorific value for a group via the GCONCAL keyword in the SCHEDULE section. If this option is invoked then the gas calorific value must be set either by this keyword for a well by well allocation of the calorific value, or by using the Tracer Tracking option (activated by the TRACER keyword in the RUNSPEC section) combined with CALTRAC keyword in the SCHEDULE section that defines the tracer for the calorific value.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.228 WCONHIST – DEFINE WELL HISTORICAL PRODUCTION RATES AND PRESSURES

Description

The WCONHIST keyword defines production rates and pressures for wells that have been declared history matching wells by the use of this keyword. History matching wells are handled differently then ordinary wells that use the WCONPROD keyword for controlling their production targets and constraints. However, the wells still need to be defined like ordinary production wells using the WELSPECS keyword in the SCHEDULE section.

Note that although wells can be allocated to a group when they are specified by the WELSPECS keyword, history matching wells cannot operate under group control. Field and group reporting is still consistent for all wells allocated to a group, but history matching wells cannot be under group control.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the wells observed production rates and pressures are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	STATUS	A defined character string that declares the status of the well. STATUS should be set to one of the following character strings: 1) OPEN: the well is open to flow and will attempt to produce the required production volumes. 2) STOP: the well is "stopped" at the surface and will not produce any fluids to surface; however, if there any open connections then flow may occur within the wellbore and between the open connections depending on a connection's potential with respect to all the other connections. Inter-connection flow (cross flow) can be prevented by setting the XFLOW variable on the WELSPECS keyword to NO. In this case the well's behavior will be similar to the SHUT option described below. 3) SHUT: the well is shut at the surface and downhole, this results in no flow at the surface and no cross flow downhole. Note a well's STATUS should always be set either STOP or SHUT if the well's production is to be set to zero. Just setting a well's production rate to zero means that the well is open to flow with a zero rate.			OPEN

No.	Name	Description			Default
		Field	Metric	Laboratory	
3	TARGET	A defined character string that sets the observed target production phase for the well, all the other phases are calculated unconstrained and used for reporting only. The simulator will attempt to meet the TARGET based on the phase rate stated in items (4) to (6) and (10) on this keyword. TARGET should be set to one of the following character strings: 1) ORAT: the target is set to the surface oil production rate as defined by item (4). 2) WRAT: the target is set to the surface water production rate as defined by item (5). 3) GRAT: the target is set to the surface gas production rate as defined by item (6). 4) LRAT: the target is set to the surface liquid (oil plus water) production rate and is calculated by the simulator using (4) and (5). 5) RESV: the target is set to the in situ reservoir volume rate and is calculated by the simulator using items (4), (5) and (6). 6) BHP: the target rate is set to the bottom-hole pressure as defined by item (10). Note the TARGET control mode may be reset using the WHISTCNTL keyword in the SCHEDULE section, from the time the WHISTCNTL is invoked, thus avoiding changing the control mode on all subsequent WCONHIST keywords.			None
4	ORAT	A real positive value that defines the observed surface oil production rate target or constraint.			
		stb/d 0.0	sm^3/day 0.0	scc/hour 0.0	Defined
5	WRAT	A real positive value that defines the observed surface water production rate target or constraint.			
		stb/d 0.0	sm^3/day 0.0	scc/hour 0.0	Defined
6	GRAT	A real positive value that defines the observed surface gas production rate target or constraint			
		Mscf/d 0.0	sm^3/day 0.0	scc/hour 0.0	Defined
7	VFPTAB	A positive integer greater than or equal to zero that defines the vertical lift performance tables to be used for calculating the tubing head pressure for the well. If a non-zero value is entered then the vertical lift performance tables must be entered via the VFPPROD keyword in the SCHEDULE section and allocated to the well via this item. The default value of zero implies no vertical lift performance table initially. If this value is then reset to be greater than zero then the table will be used to calculate the well's tubing head pressure. Subsequently, the default is to use the previously declared table number.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
8	ALQ-WELL	A real positive value that defines the artificial lift quantity to be used in conjunction with the VFPPROD assigned to the well via VPFTAB variable. VFPTAB vertical lift performance table and the artificial lift quantity ALQ-WELL are used with the well fluid rates to calculate the well's tubing head pressures values from the bottom-hole pressure. Note that the units for ALQ-WELL is dependent on the associated variable on the VFPPROD keyword.			None
9	THP	A real positive value that defines the observed tubing head pressure. This parameter is only used for comparing the actual tubing head pressure given here with those calculated by the simulator, that is history marching wells can only controlled by either the surface injection rate or their bottom-hole pressure.			
		psia 0.0	barsa 0.0	atma 0.0	Defined
10	BHP	A real positive value that defines the observed bottom-hole pressure.			
		psia 0.0	barsa 0.0	atma 0.0	Defined
11		Not Used			
12		Not Used			

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.59: WCONHIST Keyword Description

See also the WHISTCNTL that can be used to reset the TARGET phase, the GCONPROD and GCONINJ keywords to define a group's production and injection targets and constraints, and the WCONPROD keyword to define a production well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Note

One can use TARGET set to RESV in the initial history matching runs to get a "reasonable" pressure match, this ensures that the total reservoir withdrawals are correct, although the individual phase withdrawals will not match. Once a reasonable pressure match is achieved for the reservoir then one can reset TARGET to the sales phase, OIL or GAS, and continue with the matching of all the phases.

In oil reservoirs some engineers prefer to use LIQ rather than OIL as the TARGET phase, although one should consider that as the water phase has no commercial value, the measurement accuracy is significantly less than the oil sales phase.

History matching wells are converted to ordinary wells by restating a well's control mode using either the WCONPROD or WELTARG keywords in the SCHEDULE section.

Examples

The following example below shows the observed gas rates for the OP01 oil producer for the first quarter of 2000.

```
-- ------------------------------------------------------------------------------
-- 01 JAN 2000 START OF SCHEDULE SECTION
-- ------------------------------------------------------------------------------
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.5E3  100.0  1550   10      1*   900.0 1*     /
/
DATES
01 FEB 2000 /
/
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.2E3  150.0  1520   1*      1*   875.0 3250.0 /
/
DATES
01 MAR 2000 /
/
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.0E3  200.0  1500   1*      1*   850.0 1*     /
/
```

From January 1, 2000 well OP01 is open and is on oil rate control, and produces 15,500 stb/d oil, with the observed rates of 100 stb/d of water and 15.5 MMscf/d of gas. The well uses VFPPROD vertical lift table number 10 so that OPM Flow can calculate the tubing head pressures based on the fluids produced and the calculated pressures in the simulator.

The next example illustrates how to convert OP01 from a history match well to a normal production well at the start for the forecast run at August 1, 2017 using the WELTARG keyword.

```
DATES
01 AUG 2017 /
/
--
--       WELL PRODUCTION AND INJECTION TARGETS
--
--  WELL WELL   TARGET
--  NAME TARG   VALUE
WELTARG
OP01     THP    1*                                                  /
/
```

Here by defaulting the bottom-hole pressure via 1* OPM Flow automatically applies the last bottom-hole pressure from the previous time step as the "constraining phase" together with the last historical rates as constraints. This ensures a smooth transition between history and prediction without having to resort to unreasonable changes to the model. <u>This option is currently not implemented in OPM Flow but is expected to be incorporated in a future release.</u>

12.3.229 WCONINJ – WELL INJECTION TARGETS AND CONSTRAINTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WCONINJ is a legacy keyword that is no longer used in the commercial simulator and is not supported by OPM Flow. Instead well injection targets and constraints should be defined using the WCONINJE keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.230 WCONINJE – WELL INJECTION TARGETS AND CONSTRAINTS

Description

The WCONINJE keyword defines injection targets and constraints for wells that have previously been defined by the WELSPECS keyword in the SCHEDULE section. Note that wells can be allocated to a group when they are specified by the WELSPECS keyword. Wells defined to be under group control will have their injection rates controlled by the group to which they belong, in addition to any well constraints defined for the wells using this keyword.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well injection targets and constraints data are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	TYPE	A defined character string that defines the type of injection well. TYPE should be set to one of the following character strings: 1) GAS: for a gas injection well. 2) OIL: for an oil injection well. 3) WAT: for a water injection well.			None
3	STATUS	A defined character string that declares the status of the well. STATUS should be set to one of the following character strings: 1) OPEN: the well is open for injection and will attempt to inject the required injection volumes. 2) STOP: the well is "stopped" at the surface and will not inject any fluids; however, if there any open connections then flow may occur within the wellbore and between the open connections depending on a connection's potential with respect to all the other connections. Inter-connection flow (cross flow) can be prevented by setting the XFLOW variable on the WELSPECS keyword to NO. In this case the well's behavior will be similar to the SHUT option described below. 3) SHUT: the well is shut at the surface and downhole, this results in no injection and no cross flow downhole. 4) AUTO: the well is initially SHUT, but may be opened automatically if an economic limit is violated. This option is currently not supported by OPM Flow. Note a well's STATUS should always be set either STOP or SHUT if the well's production is to be set to zero. Just setting a well's injection rate to zero means that the well is open for injection with a zero rate, this will cause numerical issues especially for wells under THP control.			OPEN

No.	Name	Description			Default
		Field	Metric	Laboratory	
4	TARGET	A defined character string that sets the target injection control mode for the well. TARGET should be set to one of the following character strings: 1) RATE: the injection phase will be control by the surface fluid rate for the given well type as defined by the TYPE variable. For example, if TYPE has been set to WAT then this would mean the surface water injection rate as defined by item (5). 2) RESV: the injection phase will be control by the in situ reservoir volume fluid rate for the given well type as defined by the TYPE variable. For example, if TYPE has been set to GAS then this would mean the gas reservoir volume injection rate as defined by item (6). 3) BHP: the target rate is set to the bottom-hole pressure as defined by item (7). 4) THP: the target rate is set to the tubing head pressure as defined by item (8). If this option is selected then the vertical lift performance tables must be entered via the VFPINJ keyword in the SCHEDULE section and allocated to the well via item (9). 5) GRUP: the well is under group control and injects its share of the group's target as set using the GCONINJ keyword in the SCHEDULE. Section.			None
5	RATE	A real positive value that defines the maximum surface injection rate target or constraint.			
		Liquid stb/d Gas Mscf/d	Liquid sm^3/day Gas sm^3/day	Liquid scc/hour Gas scc/hour	None
6	RESV	A real positive value that defines the maximum reservoir volume injection rate target or constraint.			
		rtb/d	rm^3/day	rcc/hour	None
7	BHP	A real positive value that defines the maximum bottom-hole pressure target or constraint. Note the default value of basically means unlimited injection or no constraint and should therefore be avoided as the BHP will result in unrealistic well potentials as well as optimistic injection forecasts for the well.			
		psia 10,0000	barsa 6,895	atma 6,803	Defined
8	THP	A real positive value that defines the maximum tubing head pressure target or constraint.			None
		psia	barsa	atma	
9	VFPTAB	A positive integer greater than or equal to zero that defines the vertical lift performance tables to be used for calculating the tubing head pressure for the well. If a non-zero value is entered then the vertical lift performance tables must be entered via the VFPINJ keyword in the SCHEDULE section and allocated to the well via this item. The default value of zero implies no vertical lift performance tables and in this case TARGET cannot be set to THP and in addition item (10) should be defaulted or set to zero.			0

No.	Name	Description			Default
		Field	Metric	Laboratory	
10		Not Used			
11		Not Used			
12		Not Used			
13		Not Used			
14		Not Used			
15		Not Used			

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.60:WCONINJE Keyword Description

See also the GCONPROD the GCONINJ keywords to define a group's production and injection targets and constraints, and the WCONPROD keyword to define a production well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the injection targets and constraints for one gas injection well and one water injection well as follows:

```
--
--       WELL INJECTION CONTROLS
--
-- WELL  FLUID  OPEN/  CNTL  SURF   RESV   BHP   THP   VFP
-- NAME  TYPE   SHUT   MODE  RATE   RATE   PRSES PRES  TABLE
WCONINJE
GI01     GAS    OPEN   GRUP  50E3   1*     1*     1*    1*  /
WI01     WAT    OPEN   RATE  25E3   1*     5000.  1*    1*  /
/
```

Well GI01 is a gas injection well directly under group control constrained by a maximum surface gas injection rate of 50 MMscf/d and well WI01 is an open water injection well with a surface water injection rate target of 25,000 stb/d, subject to a maximum bottom-hole pressure constraint 5,000 psia.

12.3.231 WCONINJH – WELL HISTORICAL OBSERVED INJECTION RATES AND PRESSURES

Description

The WCONINJH keyword defines injection rates and pressures for wells that have been declared history matching wells by the use of this keyword. History matching wells are handled differently then ordinary wells that use the WCONINJE keyword for controlling their injection targets and constraints. However, the wells still need to be defined like ordinary injection wells using the WELSPECS keyword in the SCHEDULE section.

Note that although wells can be allocated to a group when they are specified by the WELSPECS keyword, history matching wells cannot operate under group control. Field and group reporting is still consistent for all wells allocated to a group, but history matching wells cannot be under group control.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the wells observed injection rates and pressures are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	TYPE	A defined character string that defines the type of injection well. TYPE should be set to one of the following character strings: 1) GAS: for a gas injection well. 2) OIL: for a water injection well. 3) WAT: for a water injection well.			None
3	STATUS	A defined character string that declares the status of the well. STATUS should be set to one of the following character strings: 1) OPEN: the well is open for injection and will attempt to inject the observed injection volumes. 2) STOP: the well is "stopped" at the surface and will not inject fluids; however, if there any open connections then flow may occur within the wellbore and between the open connections depending on a connection's potential with respect to all the other connections. Inter-connection flow (cross flow) can be prevented by setting the XFLOW variable on the WELSPECS keyword to NO. In this case the well's behavior will be similar to the SHUT option described below. 3) SHUT: the well is shut at the surface and downhole, this results in no injection and no cross flow downhole. Note a well's STATUS should always be set either STOP or SHUT if the well's injection is to be set to zero. Just setting a well's inject rate to zero means that the well is open to flow with a zero injection rate, this may cause numerical issues.			OPEN
4	RATE	A real positive value that defines the observed surface injection rate.			
		Liquid stb/d Gas Mscf/d	Liquid sm^3/day Gas sm^3/day	Liquid scc/hour Gas scc/hour	0.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
5	BHP	A real positive value that defines the observed bottom-hole pressure.			
		psia	barsa	atma	0.0
6	THP	A real positive value that defines the observed tubing head pressure. This parameter is only used for comparing the actual tubing head pressure given here with those calculated by the simulator, that is history marching wells can only controlled by either the surface injection rate or their bottom-hole pressure.			
		psia	barsa	atma	None
7	VFPTAB	A positive integer greater than or equal to zero that defines the vertical lift performance tables to be used for calculating the tubing head pressure for the well. If a non-zero value is entered then the vertical lift performance tables must be entered via the VFPINJ keyword in the SCHEDULE section and allocated to the well via this item. The default value of zero implies no vertical lift performance table initially. If this value is then reset to be greater than zero then the table will be used to calculate the well's tubing head pressure. Subsequently, the default is to use the previously declared table number.			0
8		Not used and should be defaulted with 1*.			
9		Not used and should be defaulted with 1*.			
10		Not used and should be defaulted with 1*.			
11		Not used and should be defaulted with 1*.			
12	TARGET	A defined character string that sets the target injection control mode for the well. TARGET should be set to one of the following character strings: 1) RATE: the injection well will be controlled by the surface injection rate for the given well type as defined by the TYPE variable. For example, if TYPE has been set to WAT then this would mean the surface water injection rate as defined by item (4). 2) BHP: the injection well will be controlled by the bottom-hole pressure as defined by item (5).			RATE

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.61:WCONINJH Keyword Description

This keyword should be repeated at various time steps to fully describe the historical injection performance of the wells. For example, as most production and injection data is reconciled on a monthly basis, then monthly time steps covering the injection history of the wells should be used with WCONINJH keyword entered on a monthly basis.

History matching well are converted to ordinary wells by restating a well's control mode using either the WCONINJE or WELTARG keywords in the SCHEDULE section.

Example

The following example below shows the observed gas rates for the GI01 gas injector for the first quarter of 2000.

```
-- ------------------------------------------------------------------------------
-- 01 JAN 2000 START OF SCHEDULE SECTION
-- ------------------------------------------------------------------------------
--
--       WELL HISTORICAL INJECTION CONTROLS
--
-- WELL  FLUID  OPEN/  SURF   RESV   BHP   THP   VFP    NOT   CNTL
-- NAME  TYPE   SHUT   RATE   RATE   PRSES PRES  TABLE  USED  MODE
WCONINJH
GI01     GAS    OPEN  15.5E3  1*     1*    5462   12    4*    1*  /
/
DATES
01 FEB 2000 /
/
--
--       WELL HISTORICAL INJECTION CONTROLS
--
-- WELL  FLUID  OPEN/  SURF   RESV   BHP   THP   VFP    NOT   CNTL
-- NAME  TYPE   SHUT   RATE   RATE   PRSES PRES  TABLE  USED  MODE
WCONINJH
GI01     GAS    OPEN  15.9E3  1*     1*    5468   1*    4*    1*  /
/
DATES
01 MAR 2000 /
/
--
--
--       WELL HISTORICAL INJECTION CONTROLS
--
-- WELL  FLUID  OPEN/  SURF   RESV   BHP   THP   VFP    NOT   CNTL
-- NAME  TYPE   SHUT   RATE   RATE   PRSES PRES  TABLE  USED  MODE
WCONINJH
GI01     GAS    OPEN  17.2E3  1*     1*    5489   1*    4*    1*  /
/
```

Well GI01is declared as a gas injection well under gas rate control as TARGET variable is defaulted to rate control by using 1* (the last entry on the record). In addition, the well users vertical lift table VFPINJ number 12 (as shown at January 1, 2000) to calculate the tubing head pressures for the well. Note that it is not necessary to declare the VFPINJ table number if it remains the same for subsequent time steps and thus the default 1* is used to indicate the last entry should be used.

12.3.232 WCONINJP – DEFINE WELL INJECTION TARGETS AND CONSTRAINTS FOR PATTERN FLOOD WELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WCONINJP, defines well injection targets and constraints for pattern flood wells. The keyword is similar to the WCONINJE keyword in the SCHEDULE section except that the injection control is applied to a group of wells defined by the first record of this keyword, combined with a second record that defines the wells in the pattern and their contribution to the pattern.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.233 WCONPROD – DEFINE WELL PRODUCTION TARGETS AND CONSTRAINTS

Description

The WCONPROD keyword defines production targets and constraints for wells that have previously been defined by the WELSPECS keyword in the SCHEDULE section. Note that wells can be allocated to a group when they are specified by the WELSPECS keyword. Wells defined to be under group control will have their production rates controlled by the group to which they belong, in addition to any well constraints defined for the wells using this keyword.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well production targets and constraints data are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	STATUS	A defined character string that declares the status of the well. STATUS should be set to one of the following character strings: 1) OPEN: the well is open to flow and will attempt to produce the required production volumes. 2) STOP: the well is "stopped" at the surface and will not produce any fluids to surface; however, if there any open connections then flow may occur within the wellbore and between the open connections depending on a connection's potential with respect to all the other connections. Inter-connection flow (cross flow) can be prevented by setting the XFLOW variable on the WELSPECS keyword to NO. In this case the well's behavior will be similar to the SHUT option described below. 3) SHUT: the well is shut at the surface and downhole, this results in no flow at the surface and no cross flow downhole. 4) AUTO: the well is initially SHUT, but may be opened automatically if an economic limit is violated. This option is currently not supported by OPM Flow. Note a well's STATUS should always be set either STOP or SHUT if the well's production is to be set to zero. Just setting a well's production rate to zero means that the well is open to flow with a zero rate, this will cause numerical issues especially for wells under THP control.			OPEN

No.	Name	Description			Default
		Field	Metric	Laboratory	
3	TARGET	A defined character string that sets the target production phase for the well, all the other phases will therefore act as constraints. The simulator will attempt to meet the TARGET based on the phase rate stated in items (3) to (10) on this keyword. TARGET should be set to one of the following character strings: 1) ORAT: the target is set to the surface oil production rate as defined by item (4). 2) WRAT: the target is set to the surface water production rate as defined by item (5). 3) GRAT: the target is set to the surface gas production rate as defined by item (6). 4) LRAT: the target is set to the surface liquid (oil plus water) production rate as defined by item (7). 5) RESV: the target is set to the in situ reservoir volume rate as defined by item (8). 6) BHP: the target rate is set to the bottom-hole pressure as defined by item (9). 7) THP: the target rate is set to the tubing head pressure as defined by item (10). If this option is selected then the vertical lift performance tables must be entered via the VFPPROD keyword in the SCHEDULE section and allocated to the well via item (11). 8) GRUP: the well is under group control and produces its share of the group's target as set using the GCONPROD keyword in the SCHEDULE section.			None
4	ORAT	A real positive value that defines the maximum surface oil production rate target or constraint.			
		stb/d	sm^3/day	scc/hour	None
5	WRAT	A real positive value that defines the maximum surface water production rate target or constraint.			
		stb/d	sm^3/day	scc/hour	None
6	GRAT	A real positive value that defines the maximum surface gas production rate target or constraint			
		Mscf/d	sm^3/day	scc/hour	None
7	LRAT	A real positive value that defines the maximum surface liquid (oil plus water) production rate target or constraint.			
		stb/d	sm^3/day	scc/hour	None
8	RESV	A real positive value that defines the maximum reservoir volume production rate target or constraint.			
		rtb/d	rm^3/day	rcc/hour	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
9	BHP	A real positive value that defines the minimum bottom-hole pressure target or constraint. Note the default value of one atmosphere should be avoided as the BHP will result in unrealistic well potentials as well as optimistic production forecasts for the well.			
		psia 14.70	barsa 1.01325.	atma 1.0	Defined
10	THP	A real positive value that defines the minimum tubing head pressure target or constraint. Note the default value of zero should be avoided if the well's control TARGET has been set to THP, as this will result in optimistic production forecasts for a well, since a well must flow against a back pressure imposed by the surface facilities.			
		psia 0.0	barsa 0.0	atma 0.0	Defined
11	VFPTAB	A positive integer greater than or equal to zero that defines the vertical lift performance tables to be used for calculating the tubing head pressure for the well. If a non-zero value is entered then the vertical lift performance tables must be entered via the VFPPROD keyword in the SCHEDULE section and allocated to the well via this item. The default value of zero implies no vertical lift performance tables and in this case TARGET cannot be set to THP and in addition item (10) should be defaulted or set to zero.			0
12	ALQ-WELL	A real positive value that defines the artificial lift quantity to be used in conjunction with the VFPPROD assigned to the well via VPFTAB variable. VFPTAB vertical lift performance table and the artificial lift quantity ALQ-WELL are used with the well fluid rates to calculate the well's tubing head pressures values from the bottom-hole pressure. Note that the units for ALQ-WELL is dependent on the associated variable on the VFPPROD keyword.			0.0
13		Not Used			
14		Not Used			
15		Not Used			
16		Not Used			
17		Not Used			
18		Not Used			
19		Not Used			
20		Not Used			

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.62: WCONPROD Keyword Description

See also the GCONPROD and GCONINJ keywords to define a group's production and injection targets and constraints, and the WCONINJE keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the production targets and constraints for five wells as follows:

```
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL  OIL   WAT   GAS   LIQ    RES    BHP    THP   VFP    VFP
-- NAME  SHUT   MODE  RATE  RATE  RATE  RATE   RATE   PRES   PRES  TABLE  ALFQ
WCONPROD
OP01     OPEN   GRUP  5E3   1*     1*    1*    1*     500.0                    /
OP02     OPEN   GRUP 10E3   1*     1*    1*    1*     200.0  500.0  2     0.0  /
OP03     OPEN   GRUP 15E3   1*     1*    1*    1*     200.0  500.0  3    10.0  /
OP04     OPEN   ORAT 20E3   1*     1*    1*    1*     500.0                    /
OP05     SHUT   GRUP 20E3   1*     1*    1*    1*     500.0                    /
/
```

Well OP01 is open and is on group control, subject to a maximum oil rate constraint of 5,000 stb/d and a minimum bottom-hole pressure of 500 psia. OP02 is also open and on group control but it's maximum oil rate constraint has been set 10,000 stb/d, and is subject to a minimum bottom-hole pressure limit of 200 psia and a minimum tubing head pressure limit of 500 psia using VFPPROD vertical lift table number two. Well OP03 is very similar to OP02, but with a 15,000 stb/d maximum oil constraint and using VFPPROD vertical lift table number three with an artificial lift parameter of 10. The next three wells are not on group control, for example, well OP04 is open and has an oil rate target of 20,000 stb/d, subject to a minimum bottom-hole pressure of 500 psia. Finally, well OP05 is shut and will not be brought back on production despite being put under group control, as the well has been declared shut.

12.3.234 WCUTBACK – Define Well Cutback Limits and Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WCUTBACK, defines a well's cutback limits and parameters for both production and injection wells. See also the GCUTBACK keyword in the SCHEDULE section that provides similar functionality for groups.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.235 WCUTBACT – DEFINE WELL TRACER CUTBACK LIMITS AND PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WCUTBACT, defines a production well's cutback limits and parameters based on the named produced tracer from the well. See also the GCUTBACT keyword in the SCHEDULE section that provides similar functionality for groups.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.236 WCYCLE – Define Automatic Well Opening and Closing Cycling Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WCYCLE keyword defines automatic well opening and closing cycling parameters used to model "huff-and puff" cyclic steam injection in heavy oil reservoirs or Water-Alternating-Gas ("WAG") processes in enhanced oil recovery modeling. The keyword defines specific time periods for automatically cycling wells on and off. For example in a WAG scheme the water injection wells would have one set of cycling parameters and the gas injection wells another, such that only one type of well is active at a time.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.237 WDFAC – Define Gas Flow Dependent Skin Factor

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WDFAC keyword defines a gas well's connection D-factor, which is normally derived from well tests or calculated analytically based on the coefficient of inertial resistance, usually known as β, in Forchheimer's flow equation[153, 154 and 155].

See also the WDFACCOR keyword in the SCHEDULE section that users Dake's[156] correlation to calculate the D-factor.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[153] *Geertsma, J., 1974. Estimating the Coefficient of Inertial Resistance in Fluid Flow Through Porous Media. Soc.Pet.Eng.J., October: 445-450.*

[154] *Gewers, C.W.W. and Nichol, L.R., 1969. Gas Turbulence Factor in a Microvugular Carbonate. J.Can.Pet.Tech., April.*

[155] *Wong, S.W., 1970. Effects of Liquid Saturation on Turbulence Factors for Gas Liquid Systems. J.Can.Pet.Tech., October*

[156] *Dake, L.P. Fundamentals of Reservoir Engineering, Amsterdam, The Netherlands, Elsevier Science BV (1978) Chapter 8.6, pages 252-257.*

12.3.238 WDFACCOR – GAS FLOW DEPENDENT SKIN FACTOR (CORRELATION)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WDFACCOR keyword defines the parameters to calculate a gas well's connection D-factor based on a correlation for the coefficient of inertial resistance, usually known as β, in Forchheimer's flow equation [157,158,159] and [160]. This keyword users Dake's correlation to calculate the D-factor.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[157] *Dake, L.P. Fundamentals of Reservoir Engineering, Amsterdam, The Netherlands, Elsevier Science BV (1978) Chapter 8.6, pages 252-257.*

[158] *Geertsma, J., 1974. Estimating the Coefficient of Inertial Resistance in Fluid Flow Through Porous Media. Soc.Pet.Eng.J., October: 445-450.*

[159] *Gewers, C.W.W. and Nichol, L.R., 1969. Gas Turbulence Factor in a Microvugular Carbonate. J.Can.Pet.Tech., April.*

[160] *Wong, S.W., 1970. Effects of Liquid Saturation on Turbulence Factors for Gas Liquid Systems. J.Can.Pet.Tech., October*

12.3.239 WDRILPRI – Add Wells to the Drilling Priority Drilling Queue

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WDRILPRI, adds wells to the Drilling Priority Drilling Queue and defines the well priority and drilling unit number or batch queue sequence for the well. The batch queue sequence number enables all wells with the same sequence number to drilled at the same time.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.240 WDRILRES – Activate Prevention of Multi-Completions in the Same Cell for Queued Wells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WDRILRES keyword activates the prevention of multi-completions being completed in the same cell for wells in a drilling queue. Setting this option stops any well defined as a queued well via the QDRILL and WDRILLPRI keywords in the SCHEDULE section, or any wells set to automatic opening by setting the STATUS variable to AUTO on the WCONPROD keyword in the RUNSPEC section, from opening if there is an already existing active well connection to a cell.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.241 WDRILTIM – DEFINE DRILLING PARAMETERS FOR AUTOMATIC DRILLING OF NEW WELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WDRILTIM defines the automatic drilling parameters used to describe the numbers of days taken to drill a well, the drilling status of the well, and status of other wells when drilling an automatically drilled well.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.242 WECON – WELL ECONOMIC CRITERIA FOR PRODUCTION WELLS

Description

The WECON keyword defines the economic criteria for production wells that have previously been defined by the WELSPECS and WCONPROD keywords in the SCHEDULE section.

Note that wells can be allocated to a group when they are specified by the WELSPECS keyword and groups can also have economic controls. Wells under group control are therefore subject to the economic criteria set via the GCONPROD and GECON keywords in the SCHEDULE section and the controls specified by the WECON keyword. Note that GECON is not supported by OPM Flow in the current release.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well economic criteria data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	ORAT	A real positive value that defines the minimum economic surface oil production rate, below which an economic action will take place, as outlined below: 1) If there are any remaining connections in the well with the STATUS variable set to AUTO on the COMPDAT keyword in the SCHEDULE section, then one of these connections (or completion) will be opened. 2) If there are no remaining connections in the well with the STATUS variable set to AUTO on the COMPDAT keyword, then the well will be shut or stopped as requested by item (9) of the WELSPECS keyword. Only option (2) is supported by OPM Flow as STATUS equals AUTO on the COMPDAT keyword is currently not supported by the simulator. Hence, the well be either shut or stopped. A value less than or equal to zero switches off this criterion.			
		stb/d	sm^3/day	scc/hour	0.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
3	GAS	A real positive value that defines the minimum economic surface gas production rate, below which an economic action will take place, as outlined below: 1) If there are any remaining connections in the well with the STATUS variable set to AUTO on the COMPDAT keyword in the SCHEDULE section, then one of these connections (or completion) will be opened. 2) If there are no remaining connections in the well with the STATUS variable set to AUTO on the COMPDAT keyword, then the well will be shut or stopped as requested by item (9) of the WELSPECS keyword. Only option (2) is supported by OPM Flow as STATUS equals AUTO on the COMPDAT keyword is currently not supported by the simulator. Hence, the well be either shut or stopped. A value less than or equal to zero switches off this criterion.			
		Mscf/d	sm^3/day	scc/hour	0.0
4	WCUT	A real positive value that defines the maximum economic surface water cut, above which an economic action will take place. Water cut is defined as: $f_w = \frac{q_w}{q_w + q_o}$, and the various actions that are available if the water cut limit is exceeded are described in item (7). A value less than or equal to zero switches off this criterion.			
		dimensionless	dimensionless	dimensionless	0.0
5	GOR	A real positive value that defines the maximum economic surface gas-oil ratio, above which an economic action will take place, as defined by item (7). A value less than or equal to zero switches off this criterion.			
		Mscf/stb	sm^3/sm^3	scc/scc	0.0
6	WGR	A real positive value that defines the maximum economic surface water-gas ratio, above which an economic action will take place, as defined by item (7). A value less than or equal to zero switches off this criterion. Note that this feature is currently not supported in OPM Flow.			
		stb/Mscf	sm^3/sm^3	scc/scc	0.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
7	ACTION	A defined character string that defines the action to be taken if the economic WCUT, GOR, or WGR limits are violated. ACTION should be set to one of the following character strings: 1) NONE: no action is taken. 2) CON: close the worst offending connection. If connections have been grouped as completions then the worst offending completion will be closed. 3) +CON: close the worst offending connection and all below it. If connections have been grouped as completions then the worst offending completion and all below it will be closed. 4) WELL: shut or stop the well as per the AUTO variable on the WELSPECS keyword. The corrective action takes places at the end of the time step in which the constraint is violated. Only ACTION equal to CON is currently supported by OPM Flow.			None
8	END	A defined character string that defines if the simulation should terminate if the well is shut or stopped. END should be set to one of the following character strings: 1) NO: no action is taken and the run continues. 2) YES: terminate the run at the next report time step. Only the default value of NO is supported in OPM Flow.			NO
9		Not used			
10		Not used			
11		Not used			
12		Not used			
13		Not used			
14		Not used			
15		Not used			
16		Not used			

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.63: WECON Keyword Description

See also the WELSPECS keyword to define a wells shut-in or stop options, GCONPROD for group controls, and GECON for setting a group's economic criteria. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines one oil well and one gas well using the WELSPECS keyword, together with their economic criteria.

```
--
-- WELL SPECIFICATION DATA
--
-- WELL     GROUP      LOCATION  BHP    PHASE  DRAIN  INFLOW  SHUT  CROSS  PRESS
-- NAME     NAME        I    J   DEPTH  FLUID  AREA   EQUA.   IN    FLOW   TABLE
WELSPECS
GP01      PLATFORM     14   13   1*      GAS   1*     GPP     SHUT   NO    1*  /
OP01      PLATFORM     28   96   1*      OIL   1*     STD     SHUT   NO    1*  /
/
--
--       WELL ECONOMIC CRITERIA FOR PRODUCTION WELLS
-- WELL  MIN    MIN    MAX    MAX    MAX    CNTL    END
-- NAME  ORAT   GRAT   WCUT   GOR    WGR    MODE    RUN
WECON
GP01     1*     5.0E3  1*     1*     1*    'WELL'  'NO'                      /
OP01     500    1*     0.95   15E3   1*    'WELL'  'YES'                     /
/
```

Well GP01 has a minimum economic gas rate of 5 MMscf/d and will shut-in if the gas rate falls below this rate, but the simulation will continue even if this occurs. Well OP02 as a minimum economic oil rate of 500 stb/d, a maximum water cut limit of 95%, and a maximum GOR of 15 MMscf/d, if any any of these limits are violated the well will be shut-in and the run terminated at the next reporting time step.

12.3.243 WECONINJ – WELL ECONOMIC CRITERIA FOR INJECTION WELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WECONINJ keyword defines economic criteria for injection wells that have previously been defined by the WELSPECS and WCONINJE keywords in the SCHEDULE section.

Note that wells can be allocated to a group when they are specified by the WELSPECS keyword and groups can also have economic controls. Wells under group control are therefore subject to the economic criteria set via the GCONINJ keyword in the SCHEDULE section and the controls specified by this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well economic injection criteria data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	MINVALUE	A real positive value that defines the minimum economic injection value, below which an economic action will take place, as defined by the AUTO parameter on the WELSPECS keyword (SHUT or STOP). Note that TYPE determines if the minimum value is applied to the well's actual injection rate or the well's potential. A value less than or equal to zero switches off this criterion.			
		Liquid stb/d Gas Mscf/d	Liquid sm^3/day Gas sm^3/day	Liquid scc/hour Gas scc/hour	0.0
3	TYPE	A defined character string that determines if MINVALUE is applied to a well's actual rate or potential, and should be set to one of the following: 1) RATE: In this case the MINVALUE is applied to a well's actual rate. 2) POTN: Here, MINVALUE is applied to the well's potential with only the BHP and THP constraints applied. The default value is RATE.			RATE

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.64: WECONINJ Keyword Description

See also the WELSPECS keyword to define a wells shut-in or stop options and GCONINJ for group controls in the SCHEDULE section.

Example

The following example defines the economic injection parameters for all gas and water injection wells.

```
--
--       WELL ECONOMIC LIMIT DATA FOR INJECTION WELLS
--
-- WELL  MIN    RATE
-- NAME  VALUE  POTN
WECONINJ
GI*      2.0E3  RATE                                                    /
WI*      5.0E3  POTN                                                    /
/
```

Here all the gas injection wells have a minimum economic gas injection rate of 2 MMscf/d and the water injection wells have a minimum water potential rate of 5,000 stb/day. The AUTO parameter on the WELSPECS keyword will determine if the wells will be shut-in or stopped.

12.3.244 WECONT – WELL ECONOMIC TRACER CRITERIA FOR PRODUCTION WELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WECONT keyword defines the tracer economic criteria for production wells that have previously been defined by the WELSPECS and WCONPROD keywords in the SCHEDULE section, for tracers define by the TRACER keyword in the PROPS section.

Note that wells can be allocated to a group when they are specified by the WELSPECS keyword and groups can also have economic controls. Wells under group control are therefore subject to the economic criteria set via the GECONT keyword in the SCHEDULE section and the controls specified by this keyword. Note that GECONT is not supported by OPM Flow in the current release

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well target and constraints are being defined.			None
1-2	ACTION	A defined character string that defines the action to be taken if the economic WCUT, GOR, or WGR limits are violated. ACTION should be set to one of the following character strings: 1) NONE: no action is taken. 2) CON: close the worst offending connection in the worst offending. If connections have been welled as completions then the worst offending completion will be closed. 3) +CON: close the worst offending connection and all below it in the worst offending well. If connections have been welled as completions then the worst offending completion and all below it in the worst offending well will be closed. 4) WELL: shut or stop the well as per the AUTO variable on the WELSPECS keyword. 5) PLUG: plug back the worst offending well based on the plug back length and options defined on the WPLUG keyword in the SCHEDULE. The corrective action takes places at the end of the time step in which the constraint is violated.			None
1-3	END	A defined character string that defines if the simulation should terminate if the well is shut or stopped. END should be set to one of the following character strings: 1) NO: no action is taken and the run continues. 2) YES: terminate the run at the next report time step.			NO
1-4	WELL	A character string of up to eight characters in length that defines the well name of a fully defined well that will be "opened" when the well WELNAME is shut-in or stopped.			None
1-5	/	Record one terminated by a "/"			Not Applicable

No.	Name	Description			Default
		Field	Metric	Laboratory	
2-1	Name	A three letter character string defining the tracer's name. Note it is best to void names beginning with the letters F, S, and T as these names may create naming issues in post-processing software.			None
2-2		A real positive value that defines the maximum total (free plus solution) tracer rate. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-3		A real positive value that defines the maximum total (free plus solution) tracer concentration. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-4		A real positive value that defines the maximum free tracer rate. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-5		A real positive value that defines the maximum free tracer concentration. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-6		A real positive value that defines the maximum solution rate. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			None
2-7		A real positive value that defines the maximum solution concentration. Tracer units are per those defined by the carrying fluid, oil, gas, water, etc.			
2-8	/	Record two terminated by a "/"			Not Applicable
3-1	/	well terminated by a "/"			Not Applicable

Notes:

1) WECONT keyword consists of two records, with entries 1-1 to 1-5 representing record one items and 2-1 to 2-8 representing record number two items, in the "No." column in this table. A maximum of three type two records can be entered following a type one record.
2) Each type one and type two records are terminate by a "/" as indicated in the table, and a well data set is terminated by a further "/", after which additional well data sets can be entered stating with a record of type one followed by type two.
3) The keyword the keyword should be terminated by an additional "/" after the well data set termination "/" character.

Table 12.65: WECONT Keyword Description

See also the WELSPECS keyword to define a wells shut-in or stop options, and WECON for setting a well's economic criteria. Both the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the tracer economic criteria for the field and two wells, OP01 and OP02.

```
--
--       WELL TRACER ECONOMIC CRITERIA FOR PRODUCTION WELLS
--
-- WELL  WORK    END    MAX
-- NAME  OVER    RUN    WELLS
WECONT
OP01     +CON   'YES'   1*                                    / START OF WELL
--
--       TRACER  TRACER  TRACER  TRACER  TRACER  TRACER  TRACER
--       NAME    TOTAL   TOTAL   FREE    FREE    SOLN    SOLN
--               RATE    CONCEN  RATE    CONCEN  RATE    CONCEN
         PLY     800.0                                         /
         BRI     800.0                                         /
                                                               /
OP02     +CON   'YES'   1*                                    / START OF WELL
--
--       TRACER  TRACER  TRACER  TRACER  TRACER  TRACER  TRACER
--       NAME    TOTAL   TOTAL   FREE    FREE    SOLN    SOLN
--               RATE    CONCEN  RATE    CONCEN  RATE    CONCEN
         PLY     800.0                                         /
         BRI     800.0                                         / END OF WELL
                                                               / END OF KEYWORD
```

If the economic limits are violated then the worst offending connection and all below it in the worst offending well will be closed, If connections have been grouped as completions then the worst offending completion and all below it in the worst offending well will be closed

12.3.245 WEFAC – DEFINE WELL EFFICIENCY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Defines a well's efficiency or up-time as opposed to setting the efficiency at the group level. Note that wells are allocated to a group when they are specified by the WELSPECS keyword and groups can also have efficient factors.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well efficient factor is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	FACTOR	A real positive value that is less than or equal to one that defines the efficiency factor for the well. If a well's down time is 5% then FACTOR should be set to 0.95 (1.0 – 0.05).			
		dimensionless	dimensionless	dimensionless	1.0
3	NETOPTN	Not used			1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.66:WEFAC Keyword Description

See also the GEFAC keyword in the SCHEDULE section to set the efficiency at the group level, as oppose to applying the efficiency to individual wells..

Example

```
--
--       WELL EFFICIENCY FACTORS
--
-- WELL  EFF    NETWK
-- NAME  FACT   OPTN
WEFAC
'GP*  '  0.950                                                    /
'OP*  '  0.862                                                    /
/
```

In the above example the all the gas wells are are defined as having a well efficiency factor (up time) of 0.950 and all the oil wells have a lower efficiency factor of 0.862.

12.3.246 WELCNTL – MODIFY WELL CONTROL AND TARGETS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WELCNTL keyword modifies a well's target control and value, both rates and pressures, for previously defined wells without having to define all the variables on the well control keywords: WCONPROD, WCONHIST, WCONDINJE, or WCONDINJH keywords. Variables not changed by the WELCNTL keyword remain the same as those previously entered via the well control keywords or previously entered WELCNTL keywords. Note that the well must still be initially be fully defined using the WCONPROD or WCONINJE keywords. All the aforementioned keywords are described in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well production rates and pressures data are being redefined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS and WCONPROD (or WELCONINJE) keywords in the SCHEDULE section, otherwise an error may occur.			None
2	TARGET	A defined character string that sets the item to be changed for the well the value of the item is set by item (3). 1) ORAT: reset the surface oil production rate value as defined by item (3). 2) WRAT: reset the surface water production rate value as defined by item (3). 3) GRAT: reset the surface gas production rate value as defined by item (3). 4) LRAT: reset the surface liquid (oil plus water) production rate value as defined by (3). 5) RESV: reset he in situ reservoir volume rate value as defined by (3). 6) BHP: reset the bottom-hole pressure value as defined by item (3). 7) THP: reset the tubing head pressure value for the well as defined by item (3). 8) VFP: reset the vertical lift performance table number as defined by (3). 9) LIFT: reset the artificial lift quantity for use with vertical lift performance tables. 10) GUID: reset the guide rate value for wells operating under group control. Note TARGET redefines the target controlled for a well and the control value on item (4). For example, if a well is operating on ORAT control, as defined by the previously entered WCONPROD keyword, entering TARGET equal to LRAT with a value, sets the TARGET to liquid rate with the given value. That is the well will be targeting a liquid rate not the previously requested oil ratel. Use the WELTARG keyword in the SCHEDULE section to change the target and constraint values for a well.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
3	VALUE	A real positive value that defines the value of the variable declared by TARGET			
	Liquid	stb/d	sm^3/day	scc/hour	
	Gas	Mscf/d	sm^3/day	scc/hour	
	Res Vol	rb/d	rm^3/day	rcc/hour	
	Pressure	psia	barsa	atma	
	VFP	dimensionless	dimensionless	dimensionless	
	LIFT	same as VFPPROD or VFPINJ	same as VFPPROD or VFPINJ	same as VFPPROD or VFPINJ	None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.67: WELCNTL Keyword Description

If a well is currently a history matching well, then WELCNTL can be used to change the well to a standard well.

See also the WELTARG keyword, in the SCHEDULE section that can be used to reset a well's target and constraints of both rates and pressures.

Example

The following example below shows the oil rates for the OP01 oil producer at the start of the schedule section (January 1, 2000).

```
-- ------------------------------------------------------------------------------
-- 01 JAN 2000 START OF SCHEDULE SECTION
-- ------------------------------------------------------------------------------
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    LIQ    RES    BHP    THP   VFP    VFP
-- NAME  SHUT   MODE   RATE   RATE   RATE   RATE   RATE   PRES   PRES  TABLE  ALFQ
WCONPROD
OP01     OPEN   ORAT   3000   1*     1*     1*     1*     750.0  500.  9      1* /
/
DATES
01 FEB 2000 /
/
--
--       WELL CONTROL MODE AND OPERATING TARGET
--
--  WELL WELL   TARGET
--  NAME CNTL   VALUE
WELCNTL
OP01     LRAT   5000                                          /
/
```

From January 1, 2000 to February 1, 2000 well OP01 is open and is on oil rate control and has a target oil rate of 3,000 stb/d and uses VFPPROD vertical lift table number 9 with a minimum tubing head pressure constraint of 500 psia. After February 1, 2000 the well is changed to liquid control with a target rate of 5,000 stb/d of liquid and all the other parameters remain unchanged.

12.3.247 WELDEBUG – Define the Well Debug Data to be Printed to File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the well debug data to be written to the debug file (*.DBG), it is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.248 WELDRAW – Define Maximum Draw Down for Production Wells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WELDRAW, defines the maximum draw down for production wells The keyword may be useful in wells that are subject to fines or sand production to limit the draw down between the sand face and the well in order to limit or avoid sand production.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.249 WELEVNT – Define Well WPWEM Summary Mnemonic Output Value

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WELEVNT, defines an integer value to be assigned to an individual well's WPWEM summary variable that is written to the SUMMARY file. The value is set to zero after the current time step.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.250 WELMOVEL – Move Global Well Into an LGR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WELMOVEL, moves a previously defined gloabal well into a previously declared Local Grid Refinement ("LGR"), in a RESTART run. The keyword should only be used in RESTART runs.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.251 WELOPEN – DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WELOPEN keyword defines the status of wells and well connections, and is used to open and shut previously defined well and well connections without having to re-specify all the data on the well control keywords: WCONPROD, WCONHIST, WCONINJE, or WCONINJH keywords. Note that the well must still be initially be fully defined using the WCONPROD or WCONINJE keywords. All the aforementioned keywords are described in the SCHEDULE section

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well and well connection status data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	STATUS	A character string of length four that defines the well and a well's connections' operational status, STATUS should be set to one of the following character strings: 1) OPEN: the connections are open to flow. 2) SHUT: the connections are closed to flow (shut-in). 3) AUTO: the connection are initially closed, but may be opened automatically if an economic limit is violated.			OPEN
3	I	An integer less than or equal to NX that defines the connection location in the I-direction.			1*
4	J	An integer less than or equal to NY that defines the connection location in the J-direction.			1*
5	K	An integer less than or equal to NZ that defines the connection location in the K-direction.			1*
6	K1	An integer less than or equal to NZ that defines the UPPER connection location in the K-direction. If connections have been lumped into completions via the COMPLUMP keyword, then K1 refers to the completion number instead of the connection (layer) value.			1*
7	K2	An integer less than or equal to NZ that defines the LOWER connection location in the K-direction. If connections have been lumped into completions via the COMPLUMP keyword, then K2 refers to the completion number instead of the connection (layer) value.			1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.68: WELOPEN Keyword Description

If variables I, J K, K1 and K2 are all set to a negative number or defaulted with 1* then STATUS is applied to the well and the well connection remain unchanged.

If variables I, J K, K1 and K2 are all set to zero or a positive value then STATUS is applied to the defined connections and the well status remains unchanged. The defined connections are those with the I, J, K variables the specified location and a completion number in the range specified by K1 and K2.

See also the COMPDAT keyword to define a well's connections, the COMPLUMP keyword to group well connections into well completions, the WCONPROD and WCONDINJE keywords to define a well's production and injections targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Examples

The following example defines three vertical oil wells using the WELSPECS keyword and their associated connection data.

```
-- WELL SPECIFICATION DATA
--
-- WELL     GROUP      LOCATION  BHP    PHASE  DRAIN  INFLOW  SHUT  CROSS  PRESS
-- NAME     NAME        I    J   DEPTH  FLUID  AREA   EQUA.   IN    FLOW   TABLE
WELSPECS
OP01      PLATFORM     14   13   1*      OIL   1*     STD     OPEN   NO    1*  /
OP02      PLATFORM     28   96   1*      OIL   1*     STD     OPEN   NO    1*  /
OP03      PLATFORM    128   56   1*      OIL   1*     STD     OPEN   NO    1*  /
/
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    LIQ    RES    BHP    THP   VFP    VFP
-- NAME  SHUT   MODE   RATE   RATE   RATE   RATE   RATE   PRES   PRES  TABLE  ALFQ
WCONPROD
'*'      SHUT   GRUP   1*     1*     1*     1*     1*     200.0                  /
/
--       WELL CONNECTION DATA
--
-- WELL  --- LOCATION ---  OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME   II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
OP01      1*  1*   1  10   SHUT   1*    1*    0.708  1*    0.0    1*    'Z' /
OP01      1*  1*  15  30   SHUT   1*    1*    0.708  1*    0.0    1*    'Z' /
OP01      1*  1*  35  90   SHUT   1*    1*    0.708  1*    0.0    1*    'Z' /
OP02      1*  1*   1  10   SHUT   1*    1*    0.708  1*    0.0    1*    'Z' /
OP03      1*  1*  35  90   SHUT   1*    1*    0.708  1*    0.0    1*    'Z' /
/
--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
OP01     OPEN                                          /
OP01     OPEN     0   0    0    35    90               /
OP02     OPEN                                          /
OP02     OPEN     0   0    0     2     5               /
OP03     OPEN                                          /
OP03     OPEN     0   0    0     0     0               /
/
```

In this example the first record of each well WELOPEN keyword changes the well status from shut (as per the WCONPROD keyword) to open. Then for well OP01 well connections 35 to 90 are opened for flow, connections two to five for well OP02 and all the connections for well OP03.

The next example shows the use of the COMPLUMP keyword to group the well connections into well completions for wells OP01 and OP03, and then use the WELOPEN keyword to open the well and the well connections.

```
--
--       ASSIGN WELL CONNECTIONS TO COMPLETIONS
--
-- WELL  --- LOCATION ---  COMPL
-- NAME   II  JJ  K1  K2   NO.
COMPLUMP
OP01       0   0   1  10    1                              / COMPLETION NO. 01
OP01       0   0  15  30    2                              / COMPLETION NO. 02
OP01       0   0  35  90    3                              / COMPLETION NO. 03
OP03       0   0  35  90    3                              / COMPLETION NO. 03
/
--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
OP01     OPEN                                             /
OP01     OPEN     0   0    0     3     3                  /
OP02     OPEN                                             /
OP02     OPEN     0   0    0     2     5                  /
OP03     OPEN                                             /
OP03     OPEN     0   0    0     3     3                  /
/
```

Again, the first record of each well WELOPEN keyword changes the well status from shut (as per the WCONPROD keyword) to open. Then for well OP01 well completion number three is opened (connections 35 to 90), connections two to five for well OP02 and completion number three (all the connections) for well OP03.

Note the completion number for well OP03 was named completion number three, but it could have been named number one as well. The reason why it was named number three instead of one was because it was assumed (for the example) that layers 35 to 90 represent a particular reservoir, and therefore allowing for the tracking of completions for individual reservoirs., as shown in the example.

This example shows how one can open all the wells and well completions for a given reservoir.

```
--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
'*'      OPEN                                             /
'*'      OPEN     0   0    0     3     3                  /
OP02     SHUT     0   0    0     0     0                  /
OP02     OPEN     0   0    0     2     5                  /
/
```

In this case well OP01 and OP03 are opened via completion number three, and well OP02 is opened on well connection (or layer) number three – which we do not want. Hence, all the connection for OP02 are shut, and then connections two to five are opened instead for well OP02.

12.3.252 WELOPENL – DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS (LGR)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WELOPENL keyword defines the status of wells and well connection in Local Grid Refinement Grids ("LGR") and is used to open and shut previously defined well and well connections without having to re-specify all the data on the well control keywords: WCONPROD, WCONHIST, WCONINJE, or WCONINJH keywords. Note that the well must still be initially be fully defined using the WCONPROD or WCONINJE keywords. All the aforementioned keywords are described in the SCHEDULE section

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well and well connection status data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which the well LGR connection data are being defined. Note that the well name (LGRNAME) must have been declared previously using the WELSPECL keyword in the SCHEDULE section, otherwise an error may occur. If defaulted with 1* the LGR on the WELSPECL keyword will be utilized.			Defined
3	STATUS	A character string of length four that defines the well and a well's connections' operational status, STATUS should be set to one of the following character strings: 4) OPEN: the connections are open to flow. 5) SHUT: the connections are closed to flow (shut-in). 6) AUTO: the connection are initially closed, but may be opened automatically if an economic limit is violated.			OPEN
4	I	An integer less than or equal to NX that defines the connection location in the I-direction.			1*
5	J	An integer less than or equal to NY that defines the connection location in the J-direction.			1*
6	K	An integer less than or equal to NZ that defines the connection location in the K-direction.			1*
7	K1	An integer less than or equal to NZ that defines the UPPER connection location in the K-direction. If connections have been lumped into completions via the COMPLUMP keyword, then K1 refers to the completion number instead of the connection (layer) value.			1*

No.	Name	Description			Default
		Field	Metric	Laboratory	
8	K2	An integer less than or equal to NZ that defines the LOWER connection location in the K-direction. If connections have been lumped into completions via the COMPLUMP keyword, then K2 refers to the completion number instead of the connection (layer) value.			1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.69: WELOPENL Keyword Description

If variables I, J K, K1 and K2 are all set to a negative number or defaulted with 1* then STATUS is applied to the well and the well connection remain unchanged.

If variables I, J K, K1 and K2 are all set to zero or a positive value then STATUS is applied to the defined connections and the well status remains unchanged. The defined connections are those with the I, J, K variables the specified location and a completion number in the range specified by K1 and K2.

See also the COMPDATL keyword to define a well's connections, the COMPLMPL keyword to group LGR well connections into well completions, the WCONPROD and WCONDINJE keywords to define a well's production and injections targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example shows the use of the COMPLMPL keyword to group the well connections into well completions for well OP01 and then use the WELOPEN keyword to open the well and the well connections.

```
--
--       ASSIGN WELL LGR CONNECTIONS TO COMPLETIONS
--
--       WELL   LGR       ---LOCATION---   COMPL
--       NAME   NAME      II  JJ  K1  K2   NO.
COMPLMPL
         OP01   LGR1      26  58   1   3    1              /
         OP01   LGR1      26  58   4  10    2              /
         OP01   LGR1      26  58  11  12    3              /
/
--
--
--       WELL PRODUCTION STATUS FOR LGR WELLS
--
--  WELL   LGR      WELL   --LOCATION--  COMPLETION
--  NAME   NAME     STAT     I   J    K  FIRST LAST
WELOPENL
OP01       LGR1     OPEN                                          /
OP01       LGR1     OPEN     0   0    0     1     2               /
OP01       LGR2     SHUT     0   0    0     3     3               /
/
```

The first record of the WELOPENL keyword changes the well status from shut (as per the WCONPROD keyword) to open, in case it has been shut-in. Then well completion number one and two are opened (connections 1 to 10), and completion number three shut-in (connections 11 to 12).

12.3.253 WELPI – Define Well Productivity and Injectivity Indices

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WELPI keyword is used to define a well's productivity or injectivity index and the values enter on this keyword for a given well will override any previously calculated values or values previously entered using this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.254 WELPRI – ASSIGN WELL PRIORITY

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WELPRI keyword is used to re-assign a priority number to a well for when the PRIORITY keyword has been used in the SCHEDULE section. The PRIORITY keyword activates the Well Priority option and defines the coefficients in the well priority equation; WELPRI keyword can be used to over write these calculated priority numbers

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.255 WELSEGS – DEFINE MULTI-SEGMENT WELLS AND THEIR SEGMENT STRUCTURE

Description

The WELSEGS keyword defines a well to be a multi-segment well and defines the well's segment structure. Note that the well must have been previously define by the WELSPECS keyword in the SCHEDULE section and that the WELSEGS keyword should be repeated for each multi-segment well in the model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-1	WELNAME	A character string of up to eight characters in length that defines the well name for which a multi-segment well is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
1-2	BHPREF	A real value that must be entered that defines the reference depth for reporting the bottom-hole pressure for the multi-segment well. Ideally this value should be set to the nodal point of the top segment. If the keyword is entered multiple times for the same well, due to for example the well configuration changing through time, then it is only necessary to enter this data the first time the keyword is used for a well.			
		feet	m	cm	None
1-3	TUBDZ	TUBDZ is a real positive value that defines the length of the tubing from the tubing head or wellhead at the surface to the nodal point of the top segment (BHPREF). Tubing pressures from BHREF up to the tubing length of TUBDZ to the surface are not calculated by the multi-segment well option as these are taken into account by the VFP tables allocated to well and entered via the VFPROD and VPINJ keywords in the SCHEDULE section. If TUBDZ is set to zero or defaulted then the tubing length is measured from the nodal point of the top segment, that is BHPREF.			
		feet	m	cm	0
1-4	WBORVOL	WBORVOL is a real positive value that defines the effective wellbore volume for the top segment, that is from the tubing head or wellhead at the surface to the nodal point of the top segment (BHPREF). The default value of 1.0×10^{-5} results in minimal wellbore storage.			
		ft^3	m^3	cm^3	1.0E-5
1-5	TUBOPT	TUBOPT is a character string that defines the type of length and depth data entered for DEPTH1 and DEPTH2 on the second record and should be set to one of the following: 1) INC: Incremental values, that is the length of each segment. 2) ABS: Absolute values, that si the depth of each segment. There is no default value for TUBOPT one of the above options must be explicitly defined.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-6	PRESOPT	PRESOPT is a character string that defines the pressure drop calculation used for each well segment and should be set to one of the following: 1) HFA: Sets the pressure calculation to include the hydrostatic, friction and acceleration terms. 2) HF-: Sets the pressure calculation to include the hydrostatic and friction terms only. 3) H--: Sets the pressure calculation to include the hydrostatic pressure drop term only. The default value for PRESOPT of HFA sets the pressure calculation to include the hydrostatic, friction and acceleration terms.			HFA
1-7	FLOWOPT	FLOWOPT is a character string that defines the type of multi-phase calculation used for each well segment and should be set to one of the following: 1) HO: Sets the multi-phase calculation to the homogeneous model, that is all phases flow at the same velocity. 2) DF-: Sets the multi-phase calculation to the *Drift Flux Slip* model. OPM Flow only supports the default value of HO.			HO
1-8	XCORD	A real positive values equal to or greater than zero that defines the coordinate in the x-direction of the nodal point of the top segment that is used for display purposes only. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
1-9	YCORD	A real positive value equal to or greater than zero that defines the coordinate in the y-direction of the nodal point of the top segment that is used for display purposes only. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
1-10	XAREATH	XAREATH is real positive value equal to or greater than zero that defines the cross sectional area of the pipe wall used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			
		ft^2	m^2	cm^2	None
1-11	VHEATCAP	VHEATCAP is real positive value equal to or greater than zero that defines the volumetric heat capacity of the pipe wall used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
1-12	THCON	THCON is real positive value equal to or greater than zero that defines the thermal conductivity of the pipe wall used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None
1-13	/	Record terminated by a "/"			Not Applicable
2-1	ISEG1	A positive integer greater than or equal to two and less than or equal to MXSEGS on WSEGDIMS keyword in the RUNSPEC section that defines the start of a segment			None
2-2	ISEG2	A positive integer greater than or equal to two and less than or equal to ISEG1 on this record and MXSEGS on the WSEGDIMS keyword in the RUNSPEC section that defines the end of a segment.			None
2-3	IBRANCH	A positive integer greater than or equal to one and less than or equal to MXBRAN on WSEGDIMS keyword in the RUNSPEC section that defines the branch number of a segment. All segments on the main stem must have IBRANCH set to one and lateral branches should have values between two and MXSEGS on the WSEGDIMS keyword in the RUNSPEC section.			None
2-4	ISEG3	A positive integer greater than or equal to two and less than or equal to MXSEGS on the WSEGDIMS keyword in the RUNSPEC section that defines the outlet segment.			None
2-5	DEPTH1	DEPTH1 is a real positive value that: 1) If TUBOPT is set to INC then DEPTH1 is the total length of the tubing for this segment. 2) If TUBOPT is set to ABS then DEPTH is the length of the tubing from the tubing head or wellhead at the surface to the last segment in the range.			
		feet	m	cm	None
2-6	DEPTH2	DEPTH2 is a real positive value that: 1) If TUBOPT is set to INC then DEPTH2 is the total incremental depth change of the tubing for this segment. 2) If TUBOPT is set to ABS then DEPTH defines the depth of the tubing at the last nodal point of this segment. in this range.			
		feet	m	cm	None
2-7	ID	A real positive value that defines the tubing internal diameter of the segment for the well.			
		feet	m	cm	None
2-8	EPSILON	A real positive value that defines the tubing absolute roughness of the segment for the well.			
		feet	m	cm	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
2-9	XAREA	XAREA is real positive value equal to or greater than zero that defines the cross sectional area for fluid flow. Currently this option is not supported by OPM Flow.			
		ft^2	m^2	cm^2	None
2-10	VOLSEG	VOLSEG is a real positive value that defines the effective segment volume for the this segment. Currently this option is not supported by OPM Flow.			
		ft^3	m^3	cm^3	None
2-11	XCORDS	A real positive values equal to or greater than zero that defines the coordinate in the x-direction of the nodal point of this segment that is used for display purposes only. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
12-2	YCORDS	A real positive value equal to or greater than zero that defines the coordinate in the y-direction of the nodal point of this top segment that is used for display purposes only. Currently this option is not supported by OPM Flow.			
		feet	m	cm	None
2-13	XAREAS	XAREAS is real positive value equal to or greater than zero that defines the cross sectional area of the pipe wall for this segment, that is used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			
		ft^2	m^2	cm^2	None
2-14	VHEATSEG	VHEATCAP is real positive value equal to or greater than zero that defines the volumetric heat capacity of the pipe wall for this segment, that is used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None
2.15	THCSEG	THCON is real positive value equal to or greater than zero that defines the thermal conductivity of the pipe wall for this segment, that is used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	None
2-16	/	Record terminated by a "/"			Not Applicable

No.	Name	Description			Default
		Field	Metric	Laboratory	

Notes:

1) Each multi-segment wells must be defined by a separate WELSEGS keyword that consists of two records, with entries 1-1 to 1-12 representing record one items and 2-1 to 2-15 representing record number two items in the "No." column in this table.

2) Record number two of the keyword, items 2-1 to 2-15, is followed by up to MXCONS records as declared on the WSEGDIMS keyword in the RUNSPEC section.

3) Each of the records are terminated by a "/" and is explicitly shown in the above rows and the keyword should be terminated by a "/".

Table 12.70: WELSEGS Keyword Description

The total number of wells should be defined via the WELLSDIMS keyword and the number of multi-segment wells should be declared on the WSEGDIMS keyword, both keywords are in the RUNSPEC section.

See also the WELSPECS keyword to define wells, the COMPDAT keyword to define the well completions for both ordinary wells and multi-segment wells, and the COMPSEGS keyword to define a multi-segment well segment completions. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines one producing well segment oil well (OP01) using the WELSPECS, WELSEGS COMPDAT and COMPSEGS keywords, and one water injection well (WI01) using the WELSPECS and COMPDAT keywords.

```
--
--       WELL SPECIFICATION DATA
--
-- WELL  GROUP     LOCATION  BHP    PHASE  DRAIN  INFLOW  OPEN  CROSS  PVT
-- NAME  NAME        I    J  DEPTH  FLUID  AREA   EQUANS  SHUT  FLOW   TABLE
WELSPECS
OP01     PLATFORM   10   10   1*     OIL                                    /
WI01     PLATFORM    1    1   1*     WATER                                  /
/
--
--       WELL CONNECTION DATA
--
-- WELL  --- LOCATION ---  OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME   II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
OP01      10  10   1   1   OPEN   1*    200.   0.5                          /
OP01      10  10   2   2   OPEN   1*    200.   0.5                          /
OP01      10  10   3   3   OPEN   1*    200.   0.4                          /
OP01      10  10   4   4   OPEN   1*    200.   0.4                          /
OP01      10  10   5   5   OPEN   1*    200.   0.4                          /
OP01      10  10   6   6   OPEN   1*    200.   0.4                          /

OP01       9  10   2   2   OPEN   1*    200.   0.4                          /
OP01       8  10   2   2   OPEN   1*    200.   0.4                          /
OP01       7  10   2   2   OPEN   1*    200.   0.4                          /
OP01       6  10   2   2   OPEN   1*    200.   0.4                          /
OP01       5  10   2   2   OPEN   1*    200.   0.4                          /

OP01      10   9   3   3   OPEN   1*    200.   0.4                          /
OP01      10   8   3   3   OPEN   1*    200.   0.4                          /
OP01      10   7   3   3   OPEN   1*    200.   0.4                          /
OP01      10   6   3   3   OPEN   1*    200.   0.4                          /
```

```
OP01      10   5   3   3   OPEN   1*    200.   0.4                          /

OP01       9  10   5   5   OPEN   1*    200.   0.4                          /
OP01       8  10   5   5   OPEN   1*    200.   0.4                          /
OP01       7  10   5   5   OPEN   1*    200.   0.4                          /
OP01       6  10   5   5   OPEN   1*    200.   0.4                          /
OP01       5  10   5   5   OPEN   1*    200.   0.4                          /

OP01      10   9   6   6   OPEN   1*    200.   0.4                          /
OP01      10   8   6   6   OPEN   1*    200.   0.4                          /
OP01      10   7   6   6   OPEN   1*    200.   0.4                          /
OP01      10   6   6   6   OPEN   1*    200.   0.4                          /
OP01      10   5   6   6   OPEN   1*    200.   0.4                          /

WI01       1   1   7   9   OPEN   1*    200.   0.5                          /
/
--
--       WELL SEGMENT SPECIFICATION DATA
--
-- WELL  NODAL       LEN     WELL    DEPH    PRESS   FLOW
-- NAME  DEPTH       TUBING  VOLM    OPTN    CALC    MODEL
WELSEGS
OP01     2512.5      2512.5  1.0E-5  ABS     HFA     HO                       /
--
--       SEG   SEG   BRAN    SEG     TUBING  NODAL   TUBE    TUBE     XSEC  VOL
--       ISTR  IEND  NO      NO      LENGTH  DEPTH   ID      ROUGH    AREA  SEG
           2     2    1       1      2537.5  2534.5  0.3     0.00010            /
           3     3    1       2      2562.5  2560.5  0.3     0.00010            /
           4     4    1       3      2587.5  2593.5  0.3     0.00010            /
           5     5    1       4      2612.5  2614.5  0.3     0.00010            /
           6     6    1       5      2637.5  2635.5  0.3     0.00010            /

           7     7    2       2      2737.5  2538.5  0.2     0.00010            /
           8     8    2       7      2937.5  2537.5  0.2     0.00010            /
           9     9    2       8      3137.5  2539.5  0.2     0.00010            /
          10    10    2       9      3337.5  2535.5  0.2     0.00010            /
          11    11    2      10      3537.5  2536.5  0.2     0.00010            /

          12    12    3       3      2762.5  2563.5  0.2     0.00010            /
          13    13    3      12      2962.5  2562.5  0.1     0.00010            /
          14    14    3      13      3162.5  2562.5  0.1     0.00010            /
          15    15    3      14      3362.5  2564.5  0.1     0.00010            /
          16    16    3      15      3562.5  2562.5  0.1     0.00010            /

          17    17    4       5      2812.5  2613.5  0.2     0.00010            /
          18    18    4      17      3012.5  2612.5  0.1     0.00010            /
          19    19    4      18      3212.5  2612.5  0.1     0.00010            /
          20    20    4      19      3412.5  2612.5  0.1     0.00010            /
          21    21    4      20      3612.5  2613.5  0.1     0.00010            /

          22    22    5       6      2837.5  2634.5  0.2     0.00010            /
          23    23    5      22      3037.5  2637.5  0.2     0.00010            /
          24    24    5      23      3237.5  2638.5  0.2     0.00010            /
          25    25    5      24      3437.5  2639.5  0.1     0.00010            /
          26    26    5      25      3637.5  2639.5  0.1     0.00010            /
/
```

```
--
--       COMPLETION SEGMENT SPECIFICATION DATA
--
-- WELL
-- NAME
COMPSEGS
OP01                                                                    /
--
--      --LOCATION--  BRAN  TUBING  NODAL   DIR  LOC    MID    COMP    ISEG
--       II  JJ  K1   NO    LENGTH  DEPTH   PEN  I,J,K  PERFS  LENGTH  NO.
         10  10   1    1    2512.5  2525.0                                /
         10  10   2    1    2525.0  2550.0                                /
         10  10   3    1    2550.0  2575.0                                /
         10  10   4    1    2575.0  2600.0                                /
         10  10   5    1    2600.0  2625.0                                /
         10  10   6    1    2625.0  2650.0                                /

          9  10   2    2    2637.5  2837.5                                /
          8  10   2    2    2837.5  3037.5                                /
          7  10   2    2    3037.5  3237.5                                /
          6  10   2    2    3237.5  3437.5                                /
          5  10   2    2    3437.5  3637.5                                /

         10   9   3    3    2662.5  2862.5                                /
         10   8   3    3    2862.5  3062.5                                /
         10   7   3    3    3062.5  3262.5                                /
         10   6   3    3    3262.5  3462.5                                /
         10   5   3    3    3462.5  3662.5                                /

          9  10   5    4    2712.5  2912.5                                /
          8  10   5    4    2912.5  3112.5                                /
          7  10   5    4    3112.5  3312.5                                /
          6  10   5    4    3312.5  3512.5                                /
          5  10   5    4    3512.5  3712.5                                /

         10   9   6    5    2737.5  2937.5                                /
         10   8   6    5    2937.5  3137.5                                /
         10   7   6    5    3137.5  3337.5                                /
         10   6   6    5    3337.5  3537.5                                /
         10   5   6    5    3537.5  3737.5                                /
/
```

Note the use of both the COMPDAT and COMPSEGS keywords to fully define a multi-segment well's completion.

Finally, Figure 12.12 depicts the resulting well configuration for both wells, with the conventional water injection well shown in blue and the multi-segment oil producer shown in green.

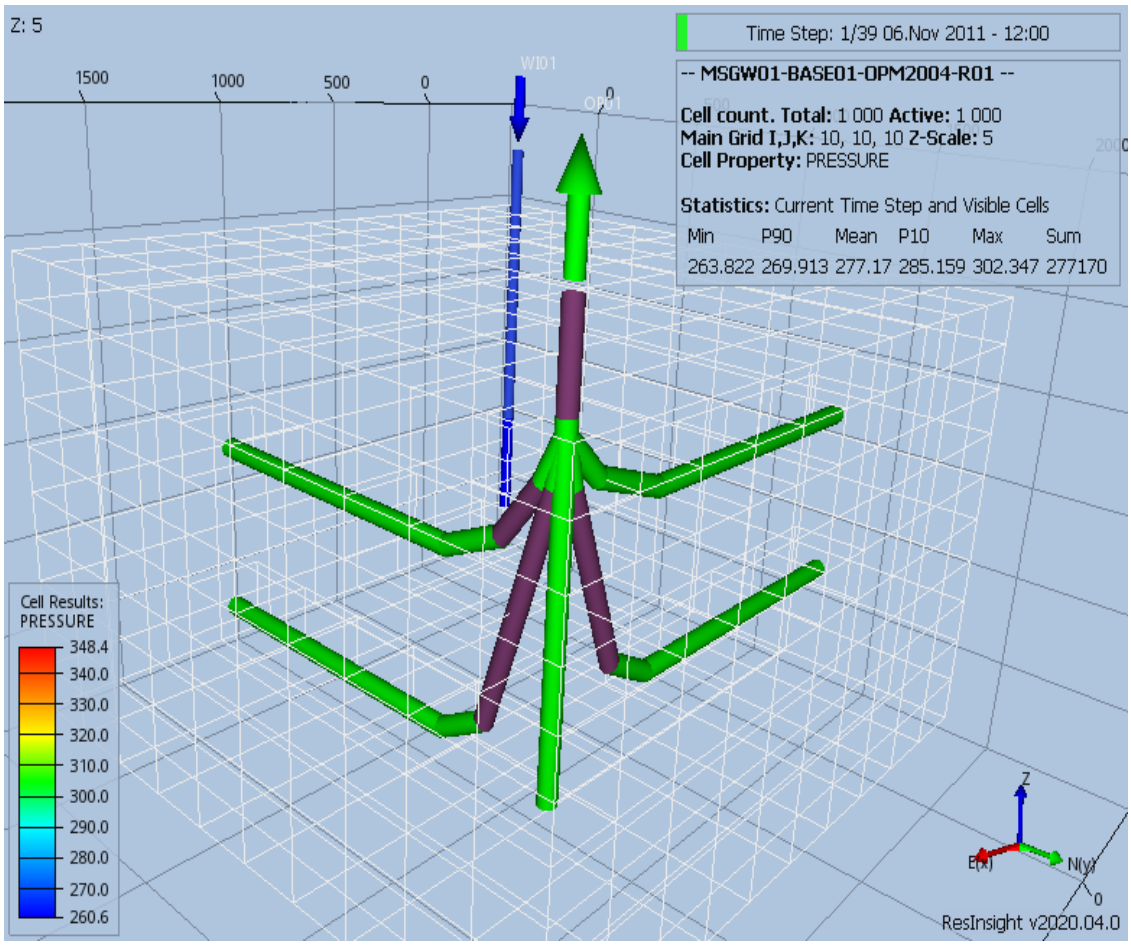


Figure 12.12: Multi-Segment Well OP01 Completion 3D View

12.3.256 WELSOMIN – DEFINE WELL CONNECTION MINIMUM OIL SATURATION FOR OPENING

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WELSOMIN defines a minimum oil saturation for a well connection above which the connection will be opened automatically. If the grid block connection is below WELSOMIN then connection will not be automatically opened. Automatic opening of connection is controlled by the STATUS parameter on the COMPDAT keyword in the SCHEDULE section. Note that if the COMPLUMP keyword in the SCHEDULE section has been used to lump connections into completions then WELSOMIN is compared to the average oil saturation of the completion.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.257 WELSPECL – DEFINE WELL SPECIFICATIONS FOR LOCAL GRID REFINEMENTS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WELSPECL keyword defines the general well specification data for all well types and must be used for all wells contained within a Local Grid Refinement ("LGR") instead of the WELSPECS keyword. WELSPECL must declare wells first before any other LGR well specification keywords are used in the input file. The keyword declares the name of well, the group the well belongs to, the LGR the well is incorporated into, the wellhead location and other key parameters.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data is being defined.			None
2	GRPNAME	A character string of up to eight characters in length that defines the group name for which the well is assigned to. The group named FIELD is the top most group. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
3	LGRNAME	A character string of up to eight characters in length that defines the name of the local grid refinement for which the well is assigned to.			None
4	I	A positive integer greater than or equal to zero and less than or equal to NX on the CARFIN keyword for Cartesian grids, that defines the wellhead location for a vertical or deviated well, or the heel for a horizontal well in the I-direction within the LGR. For radial LGRs this parameter should be set to one.			None
5	J	A positive integer greater than or equal to zero and less than or equal to NY on the CARFIN keyword for Cartesian grids, that defines the wellhead location for a vertical or deviated well, or the heel for a horizontal well in the J-direction within the LGR. For radial LGRs this parameter should be set to one.			None
6	BHPREF	A real value that defines the reference depth for reporting the bottom-hole pressure for the well. Ideally this value should be set to the midpoint of the perforations as defined by the COMPDATL keyword in the SCHEDULE section. If defaulted by 1* or set to a value less than or equal to zero, then the mid-point of shallowest connection defined by the COMPDATL keyword will be used.			Mid-point of shallowest connection defined by the COMPDAT keyword
		feet	m	cm	

No.	Name	Description			Default
		Field	Metric	Laboratory	
7	TYPE	A defined character that defines the "main" phase for the well, and should be set to one of the following character strings: 1) GAS: for a gas well. 2) OIL: for an oil well. 3) WAT: for a water injection well. 4) LIQ: for an oil well when the liquid productivity index is required for the well. This parameter defines the phase used to calculate a well's productivity or injectivity index and the type of well, or a well's connection, to close when a group's production constraints, as defined on the GCONPROD keyword in the SCHEDULE section, have been violated. For example, if the well is declared as an oil well, then excessive gas and water connections will be subject to closure.			None
8	DRADIUS	A real value that defines the well drainage radius for the well used to calculate a well's productivity or injectivity index. A default of zero results in the pressure equivalent radius of the grid blocks containing the well connections are used.			
		feet	m	cm	0.0
9	INFLOW	A defined character string that defines the inflow equation to be used for the well in calculating the well's flow rates. INFLOW should be set to one of the following character strings: 1) STD: the standard inflow equation will be used. This is normally used for wells that are primary oil or water wells. 2) NO: an alias for STD. 3) R-G: the Russell Goodrich[161] pressure square inflow equation will used. This option can be used for dry gas wells. 4) YES: an alias for R-G. 5) P-P: the general dry gas pseudo pressure inflow equation will be used. Normally used for dry gas wells. 6) GPP: the generalized gas pseudo pressure inflow equation used with wet gas wells, that is condensate gas wells. This inflow equation is based on the formulation of Whitson et. al.[162] For oil and water wells the INFLOW should be set to STD, why for dry gas wells INFLOW can be set to either R-G or P-P; however, the P-P option is preferred for dry gas wells due to the more rigorous treatment of gas flow. For wet gas wells, that is gas condensate wells, INFLOW should be set to GPP. Only INFLOW equal to STD and NO are currently implemented in OPM Flow.			STD

[161] *Russell, D.G., Goodrich, J.H., Perry, G.E and Bruskotter, J.F "Methods of Predicting Gas Well Performance", Transactions of the ASME, Journal of Petroleum Technology (1966) 99-108.*

[162] *Whitson, C. H. and Fevang, Ø. "Generalised Pseudopressure Well Treatment in Reservoir Simulation," Presented at the IBC Technical Services Conference on Optimisation of Gas Condensate Fields, Aberdeen, UK (June 26-27, 1997).*

No.	Name	Description			Default
		Field	Metric	Laboratory	
10	AUTO	A defined character string that defines the automatic action to be taken if the economic WCUT, GOR, or WGR limits are violated and the well is to cease production. AUTO should be set to one of the following character strings: 1) STOP: the well is "stopped" at the surface and will not produce any fluids to surface; however, if there any open connections then flow may occur within the wellbore and between the open connections depending on a connection's potential with respect to all the other connections. Inter-connection flow (cross flow) can be prevented by setting the XFLOW variable to NO. In this case the well's behavior will be similar to the SHUT option described below. 2) SHUT: the well is shut at the surface and downhole, this results in no flow at the surface and no cross flow downhole. The corrective action takes places at the end of the time step in which the constraint is violated.			SHUT
11	XFLOW	A defined character string that defines the if cross flow should occur within the wellbore, and should be set to either: 1) YES: to allow cross flow in the wellbore through well connections. 2) NO: to disallow cross flow within the wellbore, even if the flow potentials in the well connections would allow such flow to occur. In some cases numerical issues can occur if this variable is set to YES, and resetting it to NO may resolve the issue; however the results may not represent the physical process in this case.			YES
12	PVTNUM	A positive integer greater than or equal to zero that defines the PVT table used to calculate the wellbore fluid properties that define the relationship between reservoir and surface volume rates. The default value of zero sets PVTNUM to be the PVT table of the deepest connection in the well.			0
13	DENOPT	A defined character string that sets the type of density calculation used in calculating the wellbore hydrostatic head, and should be set to one of the following character strings: 1) SEG: sets the hydrostatic head density calculation to segmented. In this cases the density is calculated between neighboring well connections and the volumes flowing from the connections. This is the more accurate calculation if the fluid properties flowing from the well connections are variable. The density calculation itself is explicit, i.e. uses the flowing volumes of the last time step. 2) AVG: sets the hydrostatic head density calculation to the average density calculation. Here the density is considered uniform across a given reservoir and is dependent on total inflow rates of each phase and the well's bottom-hole pressure The default option of 1* invokes the SEG option and is the only option implemented in OPM Flow.			SEG

No.	Name	Description			Default
		Field	Metric	Laboratory	
14	FIPNUM	An integer value defines the FIPNUM region used to determine the reservoir conditions in calculating the well's reservoir volumes. If set to a negative integer value then the FIPNUM region of the deepest connection in the well will be used. If set to zero, the default value, then the average properties for the field will be used. If set to an integer value greater than zero, then the FIPNUM indicated by this value will be used.			0
15		Not used.			
16		Not used.			
17		Not used.			
18		Not used.			

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".
2) Note that the total number of individual wells declared by the WELSPECS cannot exceed the valued entered via the MXWELS variable on the WELLDIMS keyword in the RUNSPEC section.

Table 12.71: WELSPECL Keyword Description

See also the COMPDATL keyword to define a well's connections in a LGR, the WCONPROD and WCONDINJE keywords to define a well's production and injections targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines three wells using the WELSPECL keyword

```
--
-- WELL SPECIFICATION DATA FOR LGR WELLS
--
-- WELL   GROUP    LGR    LOCATION  BHP    PHASE  DRAIN  INFLOW  SHUT  CROSS  PVT
-- NAME   NAME     NAME    I    J   DEPTH  FLUID  AREA   EQUA.   IN    FLOW  TABLE
WELSPECL
GI01      PLATFORM LGR01  14   13   1*     GAS    1*     P-P     SHUT  NO     1* /
GP01      PLATFORM LGR01  64   80   1*     GAS    1*     GPP     SHUT  NO     1* /
OP01      PLATFORM LGR02  24   10   1*     OIL    1*     STD     SHUT  NO     1* /
/
```

Here, well GI01 and GP01 are in the same LGR named LGR01 and OP01 is in a separate LGR named LGR02. GI01 is a dry gas injection well that users the dry gas pseudo inflow equation, GP01 is a gas condensate well that users the generalized gas pseudo pressure inflow equation, and finally, OP01 is an oil well that users the standard inflow equation. All wells: will be shut if they are required to cease production, all wells disallow cross flow, and the hydrostatic head calculation is defaulted to the segment option for all wells.

12.3.258 WELSPECS – DEFINE WELL SPECIFICATIONS

Description

The WELSPECS keyword defines the general well specification data for all well types, and must be used for all wells before any other well specification keywords are used in the input file. The keyword declares the name of well, the group the well initial belongs to, the wellhead location and other key parameters.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data is being defined.			None
2	GRPNAME	A character string of up to eight characters in length that defines the group name for which the well is assigned to. The group named FIELD is the top most group. Note that the group hierarchy should be defined by the GRUPTREE keyword when there is more than one level of groups, otherwise all the groups will sit directly under the FIELD group in the group tree hierarchy.			None
3	I	A positive integer greater than or equal to zero and less than or equal to NX that defines the wellhead location for a vertical or deviated well, or the heel for a horizontal well in the I-direction.			None
4	J	A positive integer greater than or equal to zero and less than or equal to NY that defines the wellhead location for a vertical or deviated well, or the heel for a horizontal well in the J-direction..			None
5	BHPREF	A real value that defines the reference depth for reporting the bottom-hole pressure for the well. Ideally this value should be set to the midpoint of the perforations as defined by the COMPDAT keyword in the SCHEDULE section. If defaulted by 1* or set to a value less than or equal to zero, then the mid-point of shallowest connection defined by the COMPDAT keyword will be used.			Mid-point of shallowest connection defined by the COMPDAT keyword
		feet	m	cm	
6	TYPE	A defined character that defines the "main" phase for the well, and should be set to one of the following character strings: 1) GAS: for a gas well. 2) OIL: for an oil well. 3) WAT: for a water injection well. 4) LIQ: for an oil well when the liquid productivity index is required for the well. This parameter defines the phase used to calculate a well's productivity or injectivity index and the type of well, or a well's connection, to close when a group's production constraints, as defined on the GCONPROD keyword in the SCHEDULE section, have been violated. For example, if the well is declared as an oil well, then excessive gas and water connections will be subject to closure.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
7	DRADIUS	A real value that defines the well drainage radius for the well used to calculate a well's productivity or injectivity index. A default of zero results in the pressure equivalent radius of the grid blocks containing the well connections are used.			0.0
		feet	m	cm	
8	INFLOW	A defined character string that defines the inflow equation to be used for the well in calculating the well's flow rates. INFLOW should be set to one of the following character strings: 1) STD: the standard inflow equation will be used. This is normally used for wells that are primary oil or water wells. 2) NO: an alias for STD. 3) R-G: the Russell Goodrich[163] pressure square inflow equation will used. This option can be used for dry gas wells. 4) YES: an alias for R-G. 5) P-P: the general dry gas pseudo pressure inflow equation will be used. Normally used for dry gas wells. 6) GPP: the generalized gas pseudo pressure inflow equation used with wet gas wells, that is condensate gas wells. This inflow equation is based on the formulation of Whitson et. al.[164] For oil and water wells the INFLOW should be set to STD, why for dry gas wells INFLOW can be set to either R-G or P-P; however, the P-P option is preferred for dry gas wells due to the more rigorous treatment of gas flow. For wet gas wells, that is gas condensate wells, INFLOW should be set to GPP. Only INFLOW equal to STD and NO are currently implemented in OPM Flow.			STD
9	AUTO	A defined character string that defines the automatic action to be taken if the economic WCUT, GOR, or WGR limits are violated and the well is to cease production. AUTO should be set to one of the following character strings: 1) STOP: the well is "stopped" at the surface and will not produce any fluids to surface; however, if there any open connections then flow may occur within the wellbore and between the open connections depending on a connection's potential with respect to all the other connections. Inter-connection flow (cross flow) can be prevented by setting the XFLOW variable to NO. In this case the well's behavior will be similar to the SHUT option described below. 2) SHUT: the well is shut at the surface and downhole, this results in no flow at the surface and no cross flow downhole. The corrective action takes places at the end of the time step in which the constraint is violated.			SHUT

[163] *Russell, D.G., Goodrich, J.H., Perry, G.E and Bruskotter, J.F "Methods of Predicting Gas Well Performance", Transactions of the ASME, Journal of Petroleum Technology (1966) 99-108.*

[164] *Whitson, C. H. and Fevang, Ø. "Generalised Pseudopressure Well Treatment in Reservoir Simulation," Presented at the IBC Technical Services Conference on Optimisation of Gas Condensate Fields, Aberdeen, UK (June 26-27, 1997).*

No.	Name	Description			Default
		Field	Metric	Laboratory	
10	XFLOW	A defined character string that defines the if cross flow should occur within the wellbore, and should be set to either: 1) YES: to allow cross flow in the wellbore through well connections. 2) NO: to disallow cross flow within the wellbore, even if the flow potentials in the well connections would allow such flow to occur. In some cases numerical issues can occur if this variable is set to YES, and resetting it to NO may resolve the issue; however the results may not represent the physical process in this case.			YES
11	PVTNUM	A positive integer greater than or equal to zero that defines the PVT table used to calculate the wellbore fluid properties that define the relationship between reservoir and surface volume rates. The default value of zero sets PVTNUM to be the PVT table of the deepest connection in the well.			0
12	DENOPT	A defined character string that sets the type of density calculation used in calculating the wellbore hydrostatic head, and should be set to one of the following character strings: 1) SEG: sets the hydrostatic head density calculation to segmented. In this cases the density is calculated between neighboring well connections and the volumes flowing from the connections. This is the more accurate calculation if the fluid properties flowing from the well connections are variable. The density calculation itself is explicit, i.e. uses the flowing volumes of the last time step. 2) AVG: sets the hydrostatic head density calculation to the average density calculation. Here the density is considered uniform across a given reservoir and is dependent on total inflow rates of each phase and the well's bottom-hole pressure The default option of 1* invokes the SEG option and is the only option implemented in OPM Flow.			SEG
13	FIPNUM	An integer value defines the FIPNUM region used to determine the reservoir conditions in calculating the well's reservoir volumes. If set to a negative integer value then the FIPNUM region of the deepest connection in the well will be used. If set to zero, the default value, then the average properties for the field will be used. If set to an integer value greater than zero, then the FIPNUM indicated by this value will be used.			0
14		Not used.			
15		Not used.			
16		Not used.			
17		Not used.			

Notes:

1) The keyword is followed by any number records with each record terminated by a "/" and the keyword should be terminated by a "/".
2) Note that the total number of individual wells declared by the WELSPECS cannot exceed the valued entered via the MXWELS variable on the WELLDIMS keyword in the RUNSPEC section.

Table 12.72: WELSPECS Keyword Description

See also the COMPDAT keyword to define a well's connections, the WCONPROD and WCONDINJE keywords to define a well's production and injections targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines three wells using the WELSPECS keyword

```
--
--       WELL SPECIFICATION DATA
--
-- WELL  GROUP     LOCATION  BHP    PHASE  DRAIN  INFLOW  OPEN  CROSS  PVT
-- NAME  NAME        I    J  DEPTH  FLUID  AREA   EQUANS  SHUT  FLOW   TABLE
WELSPECS
GI01     PLATFORM   14   13   1*     GAS    1*     P-P    SHUT   NO     1*     /
GP01     PLATFORM   64   80   1*     GAS    1*     GPP    SHUT   NO     1*     /
OP01     PLATFORM   24  110   1*     OIL    1*     STD    SHUT   NO     1*     /
/
```

Here, well GI01 is a dry gas injection well that users the dry gas pseudo inflow equation, GP01 is a gas condensate well that users the generalized gas pseudo pressure inflow equation, and finally, OP01 is an oil well that users the standard inflow equation. All wells: will be shut if they are required to cease production, all wells disallow cross flow, and the hydrostatic head calculation is defaulted to the segment option for all wells.

12.3.259 WELTARG – MODIFY WELL TARGET AND CONSTRAINT VALUES

Description

The WELTARG keyword modifies the target and constraints values of both rates and pressures for previously defined wells without having to define all the variables on the well control keywords: WCONPROD, WCONHIST, WCONINJE, or WCONINJH keywords. Variables not changed by the WELTARG keyword remain the same as those previously entered via the well control keywords or previously entered WELTARG keywords. Note that the well must still be initially be fully defined using the WCONPROD or WCONINJE keywords.

All the aforementioned keywords are described in the SCHEDULE section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well production rates and pressures data are being redefined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS and WCONPROD (or WCONINJE) keywords in the SCHEDULE section, otherwise an error may occur.			None
2	TARGET	A defined character string that sets the item to be changed for the well the value of the item is set by item (3). 1) ORAT: reset the surface oil production rate value as defined by item (3). 2) WRAT: reset the surface water production rate value as defined by item (3). 3) GRAT: reset the surface gas production rate value as defined by item (3). 4) LRAT: reset the surface liquid (oil plus water) production rate value as defined by (3). 5) RESV: reset the in situ reservoir volume rate value as defined by (3). 6) BHP: reset the bottom-hole pressure value as defined by item (3). 7) THP: reset the tubing head pressure value for the well as defined by item (3). 8) VFP: reset the vertical lift performance table number as defined by (3). 9) LIFT: reset the artificial lift quantity for use with vertical lift performance tables. 10) GUID: reset the guide rate value for wells operating under group control. Note TARGET only defines the variable to be changed, it does not change how a well is controlled. For example, if a well is operating on ORAT control, as defined by the previously entered WCONPROD keyword, entering TARGET equal to LRAT with a value, changes the liquid constraint but the well still remains on ORAT control. Use the WELCNTL keyword in the SCHEDULE section to change the control mode of a well.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
3	VALUE	A real positive value that defines the value of the variable declared by TARGET			
	Liquid	stb/d	sm^3/day	scc/hour	
	Gas	Mscf/d	sm^3/day	scc/hour	
	Res Vol	rb/d	rm^3/day	rcc/hour	
	Pressure	psia	barsa	atma	
	VFP	dimensionless	dimensionless	dimensionless	
	LIFT	same as VFPPROD or VFPINJ	same as VFPPROD or VFPINJ	same as VFPPROD or VFPINJ	None

Notes:

1) The keyword is followed by any number records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.73: WELTARG Keyword Description

If a well is currently a history matching well, then WELTARG should only be used to change a wells bottom-hole pressure limit, vertical flow performance table number or the artificial lift quantity.

See also the WELCNTL keyword, in the SCHEDULE section that can be used to reset the control mode, as well as a well's target and constraints of both rates and pressures.

Example

The following example below shows the oil rates for the OP01 oil producer at the start of the schedule section (January 1, 2000).

```
-- ------------------------------------------------------------------------------
-- 01 JAN 2000 START OF SCHEDULE SECTION
-- ------------------------------------------------------------------------------
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    LIQ    RES    BHP    THP   VFP    VFP
-- NAME  SHUT   MODE   RATE   RATE   RATE   RATE   RATE   PRES   PRES  TABLE  ALFQ
WCONPROD
OP01     OPEN   ORAT   3000   1*     1*     1*     1*     750.0  500.  9      1* /
/
DATES
01 FEB 2000 /
/
--
--       WELL PRODUCTION AND INJECTION TARGETS
--
--  WELL WELL   TARGET
--  NAME TARG   VALUE
WELTARG
OP01     ORAT   2000                                          /
/
```

From January 1, 2000 to February 1, 2000 well OP01 is open and is on oil rate control and has a target oil rate of 3,000 stb/d, and uses VFPPROD vertical lift table number 9 with a minimum tubing head pressure constraint of 500 psia. After February 1, 2000 the well's oil rate is reduced to 2,000 stb/d and all the other parameters remain unchanged.

12.3.260 WFOAM - DEFINE WELL FOAM INJECTION CONCENTRATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WFOAM keyword defines an injection wells foam concentration. The foam option must be activated by the FOAM keyword in the RUNSPEC section in order to use this keyword. Note if a well's foam concentration is not set with this keyword then default value of zero is assigned to a well.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well injection foam concentration is being defined.			None
2	FOAMCON	A real positive value that defines the well's injection foam concentration. Units are dependent on the transport phase specified via the FOAMOPT1 variable on the FOAMOPTS keyword in the PROPS section. FOAMOPT1 should be set to either GAS or WATER. Currently OPM Flow only supports injecting foam via the GAS phase.			
		Gas: lb/Mscf Water: lb/stb	Gas: kg/sm^3 Water: kg/sm^3	Gas: gm/scc Water: gm/scc	None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

2) Note that the total number of individual wells declared by the WELSPECS cannot exceed the valued entered via the MXWELS variable on the WELLDIMS keyword in the RUNSPEC section.

Table 12.74: WFOAM Keyword Description

See also the FOAM keyword in the RUNSPEC section, the FOAMADS, FOAMOPTS and FOAMROCK keywords in the PROPS section.

Example

```
--
--       WELL INJECTION FOAM CONCENTRATION
--
-- WELL  FOAM
-- NAME  FOAMCON
WFOAM
GI01     0.020                                                    /
GI02     0.020                                                    /
GI03     0.020                                                    /
/
```

Here three gas wells are given an injection foam concentration of 0.020 lb/Mscf, assuming field units.

12.3.261 WFRICSEG – CONVERT FRICTION WELL TO MULTI-SEGMENT WELL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WFRICSEG converts a previously defined friction well, as per the WFRICTN keyword in the SCHEDULE section, to a multi-segment well. The keyword thus acts as a replacement for the WELSEGS and COMPSEGS keywords for multi-segment wells. See also the WFRICSGL keyword in the SCHEDULE section that performs similar functionality for wells in Local Grid Refinements.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.262 WFRICSGL – CONVERT FRICTION WELL TO MULTI-SEGMENT WELL (LGR)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WFRICSGL converts a previously defined Local Grid Refinement ("LGR") friction well, as per the WFRICTNL keyword in the SCHEDULE section, to a multi-segment LGR well. The keyword thus acts as a replacement for the WELSEGS and COMPSEGL keywords for LGR multi-segment wells. See also the WFRICSEG keyword in the SCHEDULE section that performs similar functionality for wells in the global grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.263 WFRICTN – Define Well as a Friction Well

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WFRICTN keyword is used to declare a previously defined well as a friction well and to set the characteristics for this type of well including: tubing size, pipe roughness, and the connections to the grid. Wellbore friction is important in horizontal and multi-lateral wells where the pressure loss along the pipe can effect a well's performance. Note that unlike other SCHEDULE section well keywords, multiple wells cannot be entered with one WFRICTN keyword, that is, the keyword must be repeated for each well.

See also the WFRICTNL keyword in the SCHEDULE section that performs similar functionality for wells in Local Grid Refinements.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.264 WFRICTNL – DEFINE WELL AS A FRICTION WELL (LGR)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WFRICTNL keyword is used to declare a previously defined Local Grid Refinement ("LGR") well as a LGR friction well and to set the characteristics for this type of well including: tubing size, pipe roughness, and the connections to the grid. Wellbore friction is important in horizontal and multi-lateral wells where the pressure loss along the pipe can effect a well's performance. Note that unlike other SCHEDULE section well keywords, multiple wells cannot be entered with one WFRICTNL keyword, that is, the keyword must be repeated for each well.

See also the WFRICTN keyword in the SCHEDULE section that performs similar functionality for wells in the global grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.265 WGASPROD – DEFINE SALE GAS WELL PRODUCTION TARGETS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WGASPROD keyword declares wells to be Sales Gas producers and sets the incremental gas rate for a well and the maximum number of increments that this rate can be increased. Wells must have been previously been defined via the WELSPECS and WCONPROD keywords in the SCHEDULE section and are subject to any targets or constraints on WCONPROD keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.266 WGORPEN – DEFINE WELL GOR PENALTY PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WGORPEN keyword defines a well's Gas-Oil Ratio ("GOR") penalty parameters used to calculate a well's oil production target for the current month, as a function of the well's previous month's average GOR. The WGORPEN calculated oil rate overwrites any oil targets set by the WCONPROD and WELTARG keywords in the SCHEDULE section. In North American, it is common practice for the regulator to enforce GOR penalties, in order to control gas production in depletion drive oil reservoirs, with the stated intention to maximize oil recovery by limiting the energy loss from the reservoir by excessive gas production.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.267 WGRUPCON – DEFINE WELL GUIDE RATES FOR GROUP CONTROL

Description

The WGRUPCON keyword defines a well's production or injection guide rate for when a well is under group control. The guide rate is used to determine a well's production target under group control in order to satisfy a group's targets and constraints, including any higher level related groups as well as the FIELD group.

Wells must have been previously defined and allocated to a group by the WELSPECS keyword in the SCHEDULE section. Wells defined to be under group control will have their production rates controlled by the group to which they belong, in addition to any well constraints defined for the wells via the WCONPROD and WCONINJE keywords in the SCHEDULE section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well production targets and constraints data are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	STATUS	A defined character string that declares the status of the well to be under group control or not under group control. STATUS should be set to one of the following character strings: 1) YES: the well is under group control and its production behavior will be influenced by its assigned group, including connecting higher level groups as well as the FIELD group. 2) NO: the well is NOT under group control and its production behavior will only be influenced by its own targets and constraints. Note the default value of YES puts all wells under group control unless specified otherwise by the STATUS variable, or the TARGET variable on the WCONPROD and WCONINJE keywords in the SCHEDULE section.			YES
3	GUIDERAT	A dimensionless real number that determines the well's share of it's group production (or injection) target rate. If GUIDERAT is a positive number then the guide rate for the well is fixed until modified by this keyword at a subsequent time. If TARGET variable on this keyword is not equal to the group's controlling phase, then the GUIDERAT is converted into the groups' controlling phase and is updated every time step. If GUIDERAT is less than or equal to zero then the well's guide rate is based on the well's potential (unrestricted flow) and the potential is calculated every time step.			
		dimensionless	dimensionless	dimensionless	-1.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
4	TARGET	A defined character string that sets the well's guide rate phase that the GUIDERAT value should be applied to. TARGET should be set to one of the following character strings: 1) OIL: the well's guide rate applies to the surface oil production rate. 2) WAT: the well's guide rate applies to the surface water production rate. 3) GAS: the well's guide rate applies to the surface gas production rate. 4) LRAT: the well's guide rate applies to the surface liquid (oil plus water) production rate. 5) RES: the well's guide rate applies to the in situ reservoir volume rate. 6) RAT: the well's guide rate applies to the injection phase. This should only be used if the well has been declared an injection via the WCONINJE keyword in the SCHEDULE section.			None
5	SCALE	A real value that is used to multiple the GUIDERAT or the calculated well potentials to determine the final GUIDERAT for the well.			
		dimensionless	dimensionless	dimensionless	1.0

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.75: WGRUPCON Keyword Description

See also the GCONPROD the GCONINJ keywords to define a group's production and injection targets and constraints, and the WCONPROD and WCONINJE keyword to define a well's production and injection characteristics. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the guides rates all oil and gas producers and the gas injectors as follows:

```
--
--        DEFINE WELL GUIDES FOR GROUP CONTROL
--
-- WELL   GRUP   GUIDE   GUIDE   SCALE
-- NAME   CNTL   RATE    PHASE   FACT
WGRUPCON
'GI*'     YES    0       RAT     1.0                          /
'GP*'     YES    0       GAS     1.0                          /
'OP*'     NO     2       OIL     1.0                          /
/
```

Both the gas producers ('GP*') and injectors ('GI'*) are under group control with their guide rates based on their potentials. The gas injector wells are controlled based on their reservoir potential volumes and the producers on their potential gas rates. In comparison, all the oil wells controlled by their oil rates.

12.3.268 WHEDREFD – DEFINE WELL HYDRAULIC HEAD REFERENCE DEPTH

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WHEDREFD keyword sets the hydraulic head reference depth for reporting the hydraulic head pressure for the well, for wells that have previously been defined by the WELSPECS keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well hydraulic head reference depth data is being defined.			None
2	HYDREF	A real value that defines the hydraulic head reference depth for reporting the hydraulic head pressure for the well. HYDREF cannot be defaulted on the keyword; however if a well has not been set by this keyword HYDREF is set equal to the value on the HYDRAHEAD keyword.			
		feet	m	cm	None

Notes:

1) The keyword is followed by any number records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.76:WHEDREFD Keyword Description

See also the HYDRAHEAD in the PROPS section.

Example

The following example defines three wells hydraulic head reference depths for reporting, using the WHEDREFD keyword

```
--
--        WELL HYDRAULIC HEAD REFERENCE DEPTH
--
-- WELL   HYDREF
-- NAME   DEPTH
WHEDREFD
OP01      150.0                                                    /
OP02      175.0                                                    /
OP03      150.0                                                    /
/
```

Here, well OP01 and OP03 have their hydraulic head reference depths set to 150.0 ft and well OP02's hydraulic head reference depth is set to 175.0 ft.

12.3.269 WHISTCTL - DEFINE WELL HISTORICAL TARGET PHASE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WHISCTL keyword changes the target control for wells declared as history match wells via the WCONHIST keyword in the SCHEDULE section. The target phase is set on the WCONHIST keyword and WHISCTL overrides this value for all subsequent entries on the WCONHIST keyword.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	TARGET	A defined character string that sets the observed target production phase for the well, all the other phases are calculated unconstrained and used for reporting only. The simulator will attempt to meet the TARGET based on the phase rate stated in items (4) to (6) and (10) on the WCONHIST keyword. TARGET should be set to one of the following character strings: 1) ORAT: the target is set to the surface oil production rate as defined by item (4) on the WCONHIST keyword. 2) WRAT: the target is set to the surface water production rate as defined by item (5) on the WCONHIST keyword. 3) GRAT: the target is set to the surface gas production rate as defined by item (6) on the WCONHIST keyword. 4) LRAT: the target is set to the surface liquid (oil plus water) production rate and is calculated by the simulator using (4) and (5) on the WCONHIST keyword. 5) RESV: the target is set to the in situ reservoir volume rate and is calculated by the simulator using items (4), (5) and (6) on the WCONHIST keyword. 6) BHP: the target rate is set to the bottom-hole pressure as defined by item (10) on the WCONHIST keyword. 7) NONE: revert back to the TARGET control mode on the WCONHIST keyword. The TARGET control mode defined on this keyword resets the TARGET control mode on the WCONHIST keyword in the SCHEDULE section, from the time the WHISTCNTL is invoked, thus avoiding changing the control model on all subsequent WCONHIST keywords.			None
2	END	A defined character string that defines if the simulation should terminate if the well has switch to BHP control by the simulator, and should be set to one of the following character strings: 1) NO: no action is taken and the run continues. 2) YES: terminate the run at the next report time step. Wells set to BHP control via the WCONHIST or WHISCTL keywords are ignored. Only END equal to NO is currently supported in OPM Flow.			NO

Notes:

1) The keyword is terminated by a "/".

Table 12.77: WHISTCTL Keyword Description

History matching wells are handled differently then ordinary wells that use the WCONPROD keyword for controlling their production targets and constraints. However, the wells still need to be defined like ordinary

production wells using the WELSPECS keyword in the SCHEDULE section. History matching well are converted to ordinary wells by restating a well's control mode using either the WCONPROD or WELTARG keywords in the SCHEDULE section.

See also the WCONHIST and WCONINJH keywords that are used to define the historical production and injection data, All the aforementioned keywords are described in the SCHEDULE section.

Example

The example below shows the observed gas rates for the OP01 oil producer for the first quarter of 2000.

```
-- ------------------------------------------------------------------------------
-- 01 JAN 2000 START OF SCHEDULE SECTION
-- ------------------------------------------------------------------------------
--
--       DEFINE WELL HISTORICAL TARGET PHASE
--
--       CNTL    BHP
--       MODE    STOP
WHISTCTL
         RESV    NO                                                    /
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.5E3  100.0  1550   10      1*   900.0 1*     /
/
DATES
01 FEB 2000 /
/
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.2E3  150.0  1520   1*      1*   875.0 3250.0 /
/
DATES
01 MAR 2000 /
/
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.0E3  200.0  1500   1*      1*   850.0 1*     /
/
```

From January 1, 2000 the WCONHIST keyword defines well OP01, which is open and is on oil rate control, to produce 15,500 stb/d oil, with the observed rates of 100 stb/d of water and 15.5 MMscf/d of gas. However the WHISCTL keyword resets the target control to reservoir voidage from January 1, 2000 and onward. This is useful in initial history matching runs to get a "reasonable" pressure match, by ensuring that the total reservoir withdrawals are correct, although the individual phase withdrawals will not match. Once a reasonable pressure match is achieved for the reservoir then one can reset TARGET to the sales phase, OIL or GAS, and continue with the matching of all the phases.

12.3.270 WHTEMP – DEFINE WELL TUBING HEAD TEMPERATURE PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WHTEMP, sets the parameters for the Tubing Head Temperature calculation, which can either be a constant value, or from a table lookup using a VFPPROD table, via the VFPPROD keyword in the SCHEDULE section, containing tubing head temperature data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the data is being defined.			None
2	VFPTAB	A positive integer greater than or equal to zero that references the production vertical lift performance table (VFPPROD) containing the tubing head temperature data for the well. Note a well must have both a VFPPROD pressure and VFPPROD temperature table.			None
		dimensionless	dimensionless	dimensionless	
3	TEMP	A real positive value greater than zero that defines a constant tubing head temperature for a production well.			
		°F	°C	°C	None

Notes:

1) Note either VFPTAB or TEMP must be supplies, that is one can specify both.

2) The keyword is followed by any number records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.78: WHTEMP Keyword Description

See also the VFPPROD keyword in the SCHEDULE section.

Example

The following example defines three wells tubing head temperature parameters using the WHTEMP keyword

```
--
--       DEFINE WELL TUBING HEAD TEMPERATURE PARAMETERS
--
-- WELL  VFP    TUB
-- NAME  TABLE  TEMP
WHTEMP
OP01     5                                                    /
OP02     1*     150                                           /
OP03     5                                                    /
/
```

Here, well OP01 and OP03 used VFPPROD table number five to calculate the tubing head temperature, and well OP02's users a constant 150° tubing head temperature.

12.3.271 WINJMULT – DEFINE WELL PRESSURE DEPENDENT INJECTIVITY MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WINJMULT keyword defines pressure dependent injectivity multipliers for injection wells and can be used to approximate the increase or decrease in a well's injectivity due to hydraulic fracturing in water injection wells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.272 WINJTEMP – DEFINE INJECTION FLUID THERMAL PROPERTIES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WINJTEMP defines the injection fluid thermal properties for when the thermal option has been activated by the THERMAL keywords in the RUNSPEC. Only water and gas injection is supported.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well injection fluid thermal properties are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	STEAMQAL	STEAMQAL is a real positive value greater than or equal to zero and less than or equal to one that defines the steam quality of the injected fluid for the defined well. This parameter should be defaulted using 1* as STEAMQUAL is not used by OPM FLOW, as only water and gas injection is supported. This data is used by the commercial simulator's THERMAL option and is not supported by OPM Flow's THERMAL option.			
		dimensionless	dimensionless	dimensionless	1*
3	TEMP	TEMP is a real positive value that defines the temperature of the injected fluid for the defined well.			
		°F	°C	°C	None
4	PRES	PRES is a real positive value that defines the pressure of the injected fluid for the defined well.			
		psia	barsa	atma	None
5	ENTHALPY	ENTHALPY is a real positive value that defines the specific enthalpy of the injected fluid for the defined well. This is data is used by the commercial simulator's THERMAL option and is not supported by OPM Flow's THERMAL option.			
		Btu/lbs-M	kJ/kg-M	J/gm-M	None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.79: WINJTEMP Keyword Description

Example

The following example shows the WINJTEMP keyword for when OPM Flow's temperature option has been activated by the THERMAL keyword in the RUNSPEC section.

```
--
--        INJECTION FLUID THERMAL PROPERTIES
--
-- WELL   STEAM   INJ     INJ     SPEC
-- NAME   QUAL    TEMP    PRES    ENTH
WINJTEMP
WI01      1*      68.0    220.0    1*                        /
WI02      1*      70.0    230.0    1*                        /
/
```

Here the water injection fluid's temperature and pressure, in field units, for two water injections well are defined. Notice that both the steam quality and the specific enthalpy of the injected fluid for the defined wells are defaulted (or skipped), as OPM Flow's THERMAL option does not support this data.

12.3.273 WLIFT – Define Well Re-Tubing, THP and Lift Switching Workover Operations

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WLIFT defines the automatic workovers parameters for changing out wellbore tubing, changing the THP limit (for example switching from the high stage pressure separator to the low stage pressure separator), or changing the artificial lift parameters, for wells.

OPM Flow does not have this feature and hence this keyword is ignored by OPM Flow and the WLIFT keyword has no effect on the simulation.

12.3.274 WLIFTOPT – DEFINE WELL GAS LIFT OPTIMIZATION PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WLIFTOPT defines which wells should use the gas lift optimization facility in order to maximize oil production, as well as defining the associated gas lift optimization parameters for a given well. The keyword can also be used to switch off gas lift optimization for a well.

OPM Flow does not have this feature and hence this keyword is ignored by OPM Flow and the WLIFTOPT keyword has no effect on the simulation.

12.3.275 WLIMTOL – DEFINE WELL CONSTRAINT TOLERANCE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WLIMTOL keyword defines the tolerance to be used for various constraints applied to connections, completions (if connections have been lumped via the COMPLUMP keyword in the SCHEDULE section), wells, and groups, including the field group. See also the GCONTOL keyword in the SCHEDULE section that sets the tolerance parameters for groups.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.276 WLIST – DEFINE WELL LISTS (STATIC)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WLIST declares a group of wells to belong to a named static well list. Wells in a named well list are treated as a group of wells for which the standard well keywords can be applied. For example, instead of repeating a well keyword for each well, the keyword only needs to have the named well list instead, for the action to be applied to all wells in the named well list. In general any well keyword that allows well name roots as a well name, for example, PROD*, can use a named well list.

No.	Name	Description	Default
1	WLIST	A character string of up to eight characters in length, enclosed in quotes, that defines the well list name for the WELLNAMES declared by this record. Note the first character must be asterisk ("*") and the second character must be a letter, for example, *PROD.	None
2	ACTION	A defined character string that determines how the WELLNAMES should be handled with respect to the named well list (WLIST). ACTION should be set to one of the following:: 1) ADD: Add the WELLNAMES to an existing WLIST. 2) DEL; Delete WELLNAMES from an existing WLIST. 3) MOV: WELLNAMES from another existing named well list and ADD them to WLIST. 4) NEW: Define a new named well list and add the WELLNAMES to WLIST.	
3-52	WELNAMES	A character string of up to eight characters in length that defines the well name that belongs to the named well list (WLIST). A total of 50 well names can be added to WLIST at a time. If additional wells are needed to added then use the ADD option of ACTION to add additional wells. Well names roots may all be used in WELLNAMES as long as they are enclosed in quotes and end with an asterisk ("*"). In this case all wells that match the specification will be added to the list. For example, wells named OP01, OP02 and OP03, can be added as group by using "OP*" as the well name. Note that the well names must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur	

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.80: WLIST Keyword Description

Note that named well list production data in the SUMMARY file is well dependent, that is, if the wells belonging to a named well list is changed through time, the SUMMARY data will be based on the wells in the named well list group at the end of the run. Thus, if there are three wells in a named well list called *PROD1 at the beginning of a run; OP01, OP02 and OP03, and during the run OP03 is moved to a well named list called *PROD2, then the SUMMARY data for *PROD1 will only contain the production data for wells OP01 and OP02 and *PROD2 will only contain the SUMMARY data for OP03 from the start to the end of the run.

Example

The following example defines two named well lists using the WLIST keyword.

```
--
--          WELL LIST SPECIFICATION
--
-- LIST     OPER     WELL NAME LIST
-- NAME
WLIST
'*BLK-1'    NEW      WEL-01M WEL-02M WEL-03M WEL-04M WEL-05M WEL-06M WEL-07M   /
'*BLK-1'    ADD      WEL-08M WEL-09M WEL-10M WEL-11M WEL-12M WEL-13M WEL-14M   /
'*BLK-1'    ADD      WEL-15M WEL-16M WEL-17M WEL-18M WEL-19M WEL-20M WEL-23M   /
'*BLK-1'    ADD      WEL-24M WEL-25M WEL-26M WEL-28M                           /

'*BLK-2'    NEW      WEL-03U WEL-05U WEL-06U WEL-10U WEL-11U WEL-13U WEL-14U   /
'*BLK-2'    ADD      WEL-15U WEL-16U WEL-17U WEL-18U WEL-19U WEL-25U WEL-27U   /
/
DATES
          1  JAN   2020  /
/
--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
'*BLK-1' OPEN                                          /
'*BLK-1' OPEN     0   0    0     0     0               /
/
DATES
          1  JAN   2021  /
          1  JLY   2021  /
          1  OCT   2021  /
/
--
--       DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS
--
--  WELL WELL   --LOCATION--  COMPLETION
--  NAME STAT     I   J    K  FIRST LAST
WELOPEN
'*BLK-2' OPEN                                          /
'*BLK-2' OPEN     0   0    0     0     0               /
/
```

In this example the wells in named well list "*BLK-1" are opened on January 1, 2020 and wells in named well list '*BLK-2" are opened October 1, 2021.

12.3.277 WLISTARG – MODIFY WELL LIST TARGET AND CONSTRAINT VALUES (STATIC)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WLISTARG keyword modifies the target and constraint values of both rates and pressures for wells previously defined in a well list by the WLIST or WLISTNAM keywords. WLISTARG is similar to the WELTARG keyword in it that allows for modifying targets and constraints without having to define all the variables on the well control keywords: WCONPROD, WCONHIST, WCONINJE, or WCONINJH keywords. Variables not changed by the WLISTARG keyword remain the same as those previously entered via the well control keywords or previously entered WLISTARG keywords. Note that the well must still be initially be fully defined using the WCONPROD or WCONINJE keywords. All the aforementioned keywords are described in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WLIST	A character string of up to eight characters in length, enclosed in quotes, that defines the well list name declared by the WLIST keyword. Note the first character must be asterisk ("*") and the second character must be a letter, for example, *PROD.			None
2	TARGET	A defined character string that sets the item to be changed for the well the value of the item is set by item (3). 1) ORAT: reset the surface oil production rate value as defined by item (3). 2) WRAT: reset the surface water production rate value as defined by item (3). 3) GRAT: reset the surface gas production rate value as defined by item (3). 4) LRAT: reset the surface liquid (oil plus water) production rate value as defined by (3). 5) RESV: reset the in situ reservoir volume rate value as defined by (3). 6) BHP: reset the bottom-hole pressure value as defined by item (3). 7) THP: reset the tubing head pressure value for the well as defined by item (3). 8) VFP: reset the vertical lift performance table number as defined by (3). 9) LIFT: reset the artificial lift quantity for use with vertical lift performance tables. 10) GUID: reset the guide rate value for wells operating under group control. Note TARGET only defines the variable to be changed, it does not change how a well is controlled. For example, if a well is operating on ORAT control, as defined by the previously entered WCONPROD keyword, entering TARGET equal to LRAT with a value, changes the liquid constraint but the well still remains on ORAT control. Use the WELCNTL keyword in the SCHEDULE section to change the control mode of a well.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
3	VALUE	A real positive vector of values that defines the value of the variable declared by TARGET for all the wells contained in WLIST. For example if there are four wells in WLIST then there must four real numbers for VALUE. The vector should be terminated by a "/" as indicated in the notes below.			
	Liquid	stb/d	sm^3/day	scc/hour	
	Gas	Mscf/d	sm^3/day	scc/hour	
	Res Vol	rb/d	rm^3/day	rcc/hour	
	Pressure	psia	barsa	atma	
	VFP	dimensionless	dimensionless	dimensionless	
	LIFT	same as VFPPROD or VFPINJ	same as VFPPROD or VFPINJ	same as VFPPROD or VFPINJ	None

Notes:

1) The keyword is followed by any number records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.81: WLISTARG Keyword Description

If a well is currently a history matching well, then WLISELTARG should only be used to change a wells bottom-hole pressure limit, vertical flow performance table number or the artificial lift quantity.

See also the WELCNTL keyword, in the SCHEDULE section that can be used to reset the control mode, as well as a well's target and constraints of both rates and pressures.

Example

The following example defines two named well lists using the WLIST keyword.

```
--
--       WELL LIST SPECIFICATION
--
-- LIST  OPER     WELL NAME LIST
-- NAME
WLIST
'*BLK-1' NEW      WEL-01M WEL-02M WEL-03M                                /
'*BLK-2' NEW      WEL-03U WEL-05U WEL-06U WEL-10U                        /
/
--
--       WELL PRODUCTION AND INJECTION TARGETS
--
--  WELL WELL   TARGET
--  NAME TARG   VALUE
WLISTARG
'*BLK-1' ORAT   2000.0  2000.00  2000.0                    /
'*BLK-2' ORAT   3000.0  3500.00  4000.0  2000.0            /
/
```

The wells in the '*BLK-1' well list are all given an oil rate of 2,000 stb/d and wells in the '*BLK-2' well list are given rates of 3,000, 3,500, 4,000 and 2,000 stb/d.

12.3.278 WLISTNAM – DEFINE WELL LISTS (WLISTARG)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WLISTNAM declares a group of wells to belong to a named WLISTARG well list for use with the WLISTARG keyword. Only the WLISTARG keyword can be used with this type of well list, and therefore it is better to use the WLIST keyword instead, that defines a static well list but offers more flexibility than a WLISTNAM well list.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description	Default
1	WLIST	A character string of up to eight characters in length, enclosed in quotes, that defines the well list name for the WELLNAMES declared by this record. Note the first character must be asterisk ("*") and the second character must be a letter, for example, *PROD.	None
2-51	WELNAMES	A character string of up to eight characters in length that defines the well name that belongs to the named well list (WLIST). A total of 50 well names can be added to WLISTNAM at a time. If the first well name in the list is the default value ("*1"), then the list is first cleared of all wells, before adding the subsequent wells in WELLNAMES. Well names roots may all be used in WELLNAMES as long as they are enclosed in quotes and end with an asterisk ("*"). In this case all wells that match the specification will be added to the list. For example, wells named OP01, OP02 and OP03, can be added as group by using "OP*" as the well name. Note that the well names must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.	1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.82:WLISTNAM Keyword Description

Note that named well list production data in the SUMMARY file is well dependent, that is, if the wells belonging to a named well list is changed through time, the SUMMARY data will be based on the wells in the named well list group at the end of the run. Thus, if there are three wells in a named well list called *PROD1 at the beginning of a run; OP01, OP02 and OP03, and during the run OP03 is moved to a well named list called *PROD2, then the SUMMARY data for *PROD1 will only contain the production data for wells OP01 and OP02 and *PROD2 will only contain the SUMMARY data for OP03 from the start to the end of the run.

Example

The following example defines two named well lists using the WLISTNAM keyword.

```
--
--          WELL LIST SPECIFICATION
--
-- LIST     WELL NAME LIST
-- NAME
WLISTNAM
'*BLK-1'    WEL-01M WEL-02M WEL-03M WEL-04M WEL-05M WEL-06M WEL-07M           /
'*BLK-1'    WEL-08M WEL-09M WEL-10M WEL-11M WEL-12M WEL-13M WEL-14M           /
'*BLK-1'    WEL-15M WEL-16M WEL-17M WEL-18M WEL-19M WEL-20M WEL-23M           /
'*BLK-1'    WEL-24M WEL-25M WEL-26M WEL-28M                                   /

'*BLK-2'    1*      WEL-03U WEL-05U WEL-06U WEL-10U WEL-11U WEL-13U WEL-14U   /
'*BLK-2'            WEL-15U WEL-16U WEL-17U WEL-18U WEL-19U WEL-25U WEL-27U   /
/
```

Here well list "*BLK-1' contains 28 wells, that is wells WEL-01M to WEL-28M. For the '*BLK-2' well list all wells are first deleted due to the "1*" default value and then wells WEL-03U to WEL-27U are added to the list.

12.3.279 WNETCTRL – DEFINE WELL CONTROL FOR NETWORK CONTROL OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WNETCNTL keyword sets a well's control mode that should remain fixed after each network balancing calculation, for when the either the Standard Network or the Extended Network options have been activated, and the well is part of a network. The keyword allows for a well's Tubing Head Pressure ("THP"), oil, gas, liquid, or water rate to be selected as fixed after each network balance calculation. Normally this should be the THP, and if the keyword is absent from the input deck then THP will be used as the default value. The Standard Network option is invoked if the GRUPTREE, GRUPNET, GNETINJE, GNETPUMP, etc. series of keywords have been used in the SCHEDULE section. Whereas, the Extended Network option is activated by the NETWORK keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.280 WNETDP – Define Well THP to Network Pressure Drop

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WNETDP keyword allows for a constant pressure drop between a well's Tubing Head Pressure ("THP") and the well's connecting network node, for when the either the Standard Network or the Extended Network options have been activated, and the well is part of a network. For production wells in a production network, WNETDP is added to the well's connecting network node pressure to arrive at the well's THP value. Whereas for injection wells in an injection network, WNETDP is subtracted from the well's connecting network node pressure to arrive at the well's THP value. The Standard Network option is invoked if the GRUPTREE, GRUPNET, GNETINJE, GNETPUMP, etc. series of keywords have been used in the SCHEDULE section. The Extended Network option is activated by the NETWORK keyword in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.281 WORKLIM – Define Well Workover Time

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WORKLIM sets the numbers of days taken to complete a workover.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.282 WORKTHP – DEFINE WELL WORKOVER OPTIONS FOR THP KILLED WELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WORKTHP keyword defines workover options for when a well dies, that is unable to produce at the current operating conditions, when under Tubing Head Pressure ("THP") control. For example, if a well is producing to the high pressure separator and therefore has a high THP constraint, then the WORKTHP keyword can be used to switch the well to the lower pressure separator via re-setting the THP constraint.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.283 WPAVE – WELL BLOCK AVERAGE PRESSURE CALCULATION PARAMETERS FOR ALL WELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WPAVE keyword defines the method and parameters for calculating a well's block average pressures for all wells in the model. The resulting average pressure can be written out to the summary file in order to compared with field observed data.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WPAVE1	A real dimensionless value that defines the weighting factor between the inner block and the surrounding blocks used to calculated the connection factor weighted average pressures. If WPAVE1 is greater than or equal to zero and less than or equal to one, then the average pressures are calculate based on the connection factors. A value of zero indicates only the surrounding blocks should be used in the calculation and a value of one indicates only the inner blocks. If WPAVE1 is equal to zero, then average pressure is calculate based on the pore volumes of the blocks.			0.5
2	WPAVE2	A real dimensionless value greater than or equal to zero and less than or equal to one, that defines the weighting factor between the connection weighted average pressures and the pore volume weighted average pressures. If WPAVE2 is equal to one, then the average pressures are calculate based only using the connection factor calculated pressures. If WPAVE2 is equal to zero, then average pressures are calculate based on only using the pore volumes calculated pressures.			1.0
3	WPAVE3	A defined character string that determines how the hydrostatic head calculation is performed in correcting the pressures to the BHP reference depth on the WELSPECS or WPAVEDEP keywords in the RUNSPEC section. WPAVE3 should be set to one of the following character strings: 1) WELL: the hydrostatic head is calculated using the density of the fluid in the wellbore at the well connections. 2) RES: he hydrostatic head is calculated using the density of the fluid in the reservoir with well connections and averaged over the connections. 3) NONE: no hydrostatic correction is applied to the pressures.			WELL

No.	Name	Description			Default
		Field	Metric	Laboratory	
4	WPAVE4	A defined character string that determines which connections should be used in the calculations, WPAVE4 should be set to one of the following character strings: 1) OPEN: only open connections and associated grid blocks should be used in the calculations. This option may result in pressure discontinuities if connections are opened and closed during the run. 2) ALL: all currently defined open and closed connections and associated grid blocks are used in the calculations. The pressure discontinuities issue mentioned above can be avoided with this option and defining all the well connections for a well at the beginning of the run.			OPEN
Notes: 1) The keyword should be terminated by a "/".					

Table 12.83: WPAVE Keyword Description

See also the WELSPECS keyword that defines a well and a well's bottom-hole pressure reference depth, the WPAVEDEP keyword that also defines a well's bottom-hole pressure reference depth, and the COMPDAT keyword to define a well's connections. All the aforementioned keywords are described in the SCHEDULE section.

Examples

The following example defines the default well block average pressure calculation parameters

```
--
--        DEFINE WELL BLOCK AVERAGE PRESSURE CALCULATION PARAMETERS
--
--        INNER   PORV   WELL  OPEN
--        OUTER   CONN   RES   ALL
--        -----   ----   ----  ----
WPAVE
          0.5     1.0    WELL  ALL                                    /
```

And the next example shows the parameters used in the Norne model.

```
--
--        DEFINE WELL BLOCK AVERAGE PRESSURE CALCULATION PARAMETERS
--
--        INNER   PORV   WELL  OPEN
--        OUTER   CONN   RES   ALL
--        -----   ----   ----  ----
WPAVE
          1*      0.0    WELL  ALL                                    /
```

Here only pore volume weighting is used instead of connection weighting.

12.3.284 WPAVEDEP – DEFINE WELL REFERENCE DEPTH FOR PRESSURE CALCULATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WPAVEDEP keyword defines the reference depth to be used to calculate and report grid block average bottom-hole pressures for a well. This keyword can be used to override the values entered or defaulted on the WELPSPECS keyword in the SCHEDULE section. The simulator corrects the grid block calculated pressures to a well's reference depth using the hydrostatic well of the producing fluids.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well and well connection status data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	BHPREF	A real value that defines the reference depth for reporting the bottom-hole pressure for the well. Ideally this value should be set to the midpoint of the perforations as defined by the COMPDAT keyword in the SCHEDULE section. If defaulted by 1* or set to a value less than or equal to zero, then the mid-point of shallowest connection defined by the COMPDAT keyword will be used.			Mid-point of shallowest connection defined by the COMPDAT keyword
		feet	m	cm	

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.84: WPAVDEP Keyword Description

See also the WELSPECS keyword that defines a well, the COMPDAT keyword to define a well's connections, and the WPAVE for defining how the average bottom-hole pressure should be calculated. All the aforementioned keywords are described in the SCHEDULE section.

Note

The keyword is normally used to reset a well's bottom-hole pressure depth to match the pressure gauge depth for when observed pressure is available, for example when conducting a history match for a well test, or when attempting to match static bottom-hole surveys conducted on a well.

Example

The following example illustrates how to set the bottom-hole reference depth for wells completed in different reservoirs that have different datum depths. Here it is assumed that all wells in a reservoir A have RES-A as part of their well name, and similarly for reservoirs B and C.

```
--
-- WELL SPECIFICATION DATA
--
-- WELL      GROUP       LOCATION   BHP     PHASE   DRAIN   INFLOW   SHUT   CROSS   PRESS
-- NAME      NAME         I    J    DEPTH   FLUID   AREA    EQUA.    IN     FLOW    TABLE
WELSPECS
RES-AOP1  PLATFORM      14   13   1*       OIL   1*      STD      OPEN    NO     1*   /
RES-AOP2  PLATFORM      17   16   1*       OIL   1*      STD      OPEN    NO     1*   /
RES-AOP3  PLATFORM      21   19   1*       OIL   1*      STD      OPEN    NO     1*   /
RES-BOP4  PLATFORM      28   96   1*       OIL   1*      STD      OPEN    NO     1*   /
RES-BOP5  PLATFORM      34   89   1*       OIL   1*      STD      OPEN    NO     1*   /
RES-COP6  PLATFORM     128   52   1*       OIL   1*      STD      OPEN    NO     1*   /
RES-COP7  PLATFORM     134   56   1*       OIL   1*      STD      OPEN    NO     1*   /
RES-COP8  PLATFORM     138   50   1*       OIL   1*      STD      OPEN    NO     1*   /
RES-COP9  PLATFORM     120   52   1*       OIL   1*      STD      OPEN    NO     1*   /
/
--
--       DEFINE WELL REFERENCE DEPTH FOR PRESSURE CALCULATIONS
--
-- WELL  REF
-- NAME  DEPTH
-- ----  ------
WPAVEDEP
'RES-A*' 3100.0                                                                    /
'RES-B*' 3300.0                                                                    /
'RES-C*' 5909.0                                                                    /
/
```

In the example the all wells dedicated to RES-A will have their bottom-hole reference depth set to 3,000 ft. TVDSS, RES-B wells to 3,300 ft. TVDSS and well RES-C wells to 5909 ft. TVDSS.

12.3.285 WPIMULT – DEFINE WELL CONNECTION MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WPIMULT keyword defines a well connection multiplier factor that scales the existing well connection values. The resulting effect is to scale the well's productivity at the reporting time step the keyword is entered.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well and well connection status data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	PIMULT	A real positive value that will be used to scale the well connection factors defined by I, J, K, K1 and K2 below.			1.0
3	I	An integer less than or equal to NX that defines the connection location in the I-direction.			1*
4	J	An integer less than or equal to NY that defines the connection location in the J-direction.			1*
5	K	An integer less than or equal to NZ that defines the connection location in the K-direction.			1*
6	K1	An integer less than or equal to NZ that defines the UPPER connection location in the K-direction. If connections have been lumped into completions via the COMPLUMP keyword, then K1 refers to the completion number instead of the connection (layer) value.			1*
7	K2	An integer less than or equal to NZ that defines the LOWER connection location in the K-direction. If connections have been lumped into completions via the COMPLUMP keyword, then K2 refers to the completion number instead of the connection (layer) value.			1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.85: WPIMULT Keyword Description

If variables I, J K, K1 and K2 are all defaulted with zero or 1* then PIMULT is applied to all the well connections in the well. If variables I, J K, K1 and K2 are set to zero (meaning any or all values), or a positive value then PIMULT is applied to the defined connections. The defined connections are those with the I, J, K variables in the specified location and a completion number in the range specified by K1 and K2.

Note that PIMULT variable is applied at the time the WPIMULT keyword is entered and is cumulative if there are intervening time steps between consecutive WPIMULT keywords.

See also the PIMULTAB keyword that defines productivity index multiplier versus water cut tables that are used to scaled a well's connection factors based on a wells connection current producing water cut. The keyword is documented in the SCHEDULE section.

Example

The following example defines three vertical oil wells using the WELSPECS keyword and their associated connection data.

```
--
-- WELL SPECIFICATION DATA
--
-- WELL     GROUP      LOCATION  BHP    PHASE  DRAIN  INFLOW  SHUT  CROSS  PRESS
-- NAME     NAME        I    J   DEPTH  FLUID  AREA   EQUA.   IN    FLOW   TABLE
WELSPECS
OP01      PLATFORM     14   13   1*      OIL   1*     STD     OPEN   NO    1*  /
OP02      PLATFORM     28   96   1*      OIL   1*     STD     OPEN   NO    1*  /
OP03      PLATFORM    128   56   1*      OIL   1*     STD     OPEN   NO    1*  /
/
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS   LIQ    RES    BHP    THP   VFP    VFP
-- NAME  SHUT   MODE   RATE   RATE   RATE  RATE   RATE   PRES   PRES  TABLE  ALFQ
WCONPROD
'*'      SHUT   GRUP   1*     1*     1*    1*     1*     200.0                  /
/
--
--       WELL CONNECTION DATA
--
-- WELL  --- LOCATION ---  OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME   II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
OP01      1*  1*   1  10   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
OP01      1*  1*  15  30   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
OP01      1*  1*  35  90   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
OP02      1*  1*   1  10   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
OP03      1*  1*  35  90   OPEN   1*    1*    0.708  1*    0.0    1*    'Z' /
/
--       ASSIGN WELL CONNECTIONS TO COMPLETIONS
--
-- WELL  --- LOCATION ---  COMPL
-- NAME   II  JJ  K1  K2   NO.
COMPLUMP
OP03      1*  1*  35  45    1                              / COMPLETION NO. 01
OP03      1*  1*  50  90    2                              / COMPLETION NO. 02
/--
--       DEFINE WELL CONNECTION MULTIPLIERS
--
-- WELL  PI     --LOCATION--  COMPLETION
-- NAME  MULT     I   J    K  FIRST LAST
WPIMULT
OP01     1.250    1*  1*   1*   1*    1*                  /
OP02     0.750    1*  1*   10   1*    1*                  /
OP03     1.100    1*  1*   1*   1     2                  /
/
```

In this example the WPIMULT scales the well productivity of well OP01 by 1.25, scales all the well connection factors in layer 10 only by 0.75 for well OP02, and for OP03, scales all the connections in completions one and two by 1.100.

12.3.286 WPIMULTL – DEFINE WELL CONNECTION MULTIPLIERS (LGR)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WPIMULTL keyword defines a well connection multiplier factor that scales the existing well connection values, for a well in a Local Grid Refinement ("LGR"). The resulting effect is scale the well's productivity at the reporting time step the keyword is entered.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well and well connection status data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	PIMULT	A real positive value that will be used to scale the well connection factors defined by I, J, K, K1 and K2 below.			1.0
3	LGRNAME	A character string of up to eight characters in length that defines the LGR name for which the well LGR connection multiplier factor (PIMULT) is being defined. Note that the well name (LGRNAME) must have been declared previously using the WELSPECL keyword in the SCHEDULE section, otherwise an error may occur. If defaulted with 1* the LGR on the WELSPECL keyword will be utilized.			Defined
3	I	An integer less than or equal to NX that defines the connection location in the I-direction.			1*
4	J	An integer less than or equal to NY that defines the connection location in the J-direction.			1*
5	K	An integer less than or equal to NZ that defines the connection location in the K-direction.			1*
6	K1	An integer less than or equal to NZ that defines the UPPER connection location in the K-direction. If connections have been lumped into completions via the COMPLUMP keyword, then K1 refers to the completion number instead of the connection (layer) value.			1*
7	K2	An integer less than or equal to NZ that defines the LOWER connection location in the K-direction. If connections have been lumped into completions via the COMPLUMP keyword, then K2 refers to the completion number instead of the connection (layer) value.			1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.86: WPIMULT Keyword Description

If variables I, J K, K1 and K2 are all defaulted with zero or 1* then PIMULT is applied to all the well connections in the well. If variables I, J K, K1 and K2 are set to zero (meaning any or all values), or a positive value then PIMULT is applied to the defined connections. The defined connections are those with the I, J, K variables in the specified location and a completion number in the range specified by K1 and K2.

Note that PIMULT variable is applied at the time the WPIMULTL keyword is entered and is cumulative if there are intervening time steps between consecutive WPIMULTL keywords.

See also the PIMULTAB keyword that defines productivity index multiplier versus water cut tables that are used to scaled a well's connection factors based on a wells connection current producing water cut. The keyword is documented in the SCHEDULE section.

Example

The following example defines two vertical oil wells using the WELSPECS keyword and their associated connection data.

```
--
--       WELL LGR SPECIFICATION DATA
--
--       WELL GROUP  LGR    -LOCATION- BHP    PHASE DRAIN INFLOW SHUT CROSS PVT
--       NAME NAME   NAME     I    J   DEPTH  FLUID AREA  EQUA.  IN   FLOW  TABLE
WELSPECL
         OP01  PLAT OP01LGR  14   13   1*     OIL   1*    STD    SHUT  NO   1*  /
         OP02  PLAT OP02LGR  28   96   1*     OIL   1*    STD    SHUT  NO   1*  /
/
--
--       WELL LGR CONNECTION DATA
--
--       WELL  LGR   ---LOCATION---   OPEN   SAT CONN  WELL KH   SKIN  D    DIR
--       NAME  NAME   II  JJ  K1  K2  SHUT   TAB FACT  DIA  FACT FACT  FACT PEN
COMPDATL
         OP01 OP01LGR 1*  1*  20  56  OPEN   1*  1*  0.708   1*   1*   1*   Z /
         OP01 OP01LGR 1*  1*  75 100  SHUT   1*  1*  0.708   1*   1*   1*   Z /
         OP02 OP02LGR 1*  1*  75 100  OPEN   1*  1*  0.708   1*   1*   1*   Z /
         OP03 OP02LGR 1*  1*  75 100  OPEN   1*  1*  0.708   1*   1*   1*   Z /
/
--
--       ASSIGN WELL CONNECTIONS TO COMPLETIONS
--
--       WELL    LGR      --- LOCATION ---  COMPL
--       NAME    NAME      II  JJ  K1  K2   NO.
COMPLMPL
         OP03    OP02LGR   1*  1*  75  85   1          / COMPLETION NO. 01
         OP03    OP21LGR   1*  1*  86 100   2          / COMPLETION NO. 02
/--
--       DEFINE WELL CONNECTION MULTIPLIERS
--
-- WELL  PI     LGR     --LOCATION--  COMPLETION
-- NAME  MULT   NAME      I   J    K  FIRST LAST
WPIMULTL
OP01     1.250  OP01LGR  1*  1*   1*   1*    1*          /
OP02     0.750  OP01LGR  1*  1*   10   1*    1*          /
OP03     1.100  OP02LGR  1*  1*   1*   1     2           /
/
```

In this example the WPIMULT scales the well productivity of well OP01 by 1.25, scales all the well connection factors in layer 10 only by 0.75 for well OP02, and for OP03, scales all the connections in completions one and two by 1.100.

12.3.287 WPITAB - ASSIGN WELL PRODUCTIVITY INDEX VERSUS WATER CUT TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WPITAB keyword assigns the well productivity index multiplier versus water cut tables, that are used to scaled a well's connection factors based on the connection's current producing water cut, to a well. The tables are defined via the PIMULTAB keyword in the SCHEDULE section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well economic criteria data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	NTABLE	An integer positive value that defines the corresponding PIMULTAB table to be allocated to the well. A value less than or equal to zero means that no PIMULTAB table is allocated to the well			0

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.87:WPITAB Keyword Description

See also the PIMULTAB keyword that defines productivity index multiplier versus water cut tables and also the WPIMULT keyword that scales a well's productivity index by a constant value, both of which are in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

Example

Given NTPIMT equals two on the PIMTDIMS keyword in the RUNSPEC section, then:

```
--
--       ASSIGN WELL PRODUCTIVITY INDEX VS WATER CUT TABLE
--
-- WELL  PI
-- NAME  TABLE
WPITAB
OP01     1                                                    /
OP02     1                                                    /
OP03     2                                                    /
/
```

Assigns PIMULTAB table one to wells OP01 and OP02 and table two to OP03.

12.3.288 WPLUG – DEFINE WELL PLUG BACK LENGTH

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Various keywords in the SCHEDULE section (WECON, GECON etc.) allow for a well to be automatically plugged back if the well violates a constraint, that is to close existing perforations (well connections). For example if the water cut exceeds 90%, then plug back the well. The WPLUG keyword defines for automatic plug backs the length of the perforations (length of connections) to be closed each time an automatic plug back is performed, together with various options on how the workover should be performed, top down, bottom up, etc.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.289 WPOLYMER - DEFINE WATER INJECTION WELL POLYMER AND SALT CONCENTRATIONS

Description

The WPOLYMER keyword defines a water injection well's polymer and salt injection stream concentrations that are to be used for when the polymer and salt options have been activated by the POLYMER and BRINE keywords in the RUNSPEC section.

Note that if the Brine option has not be activated by the BRINE keyword in the RUNSPEC section, then the salt concentrations in the third column are ignored. Secondly, if the brine phase is declared but the polymer phase has not been made active, then the WSALT keyword in the SCHEDULE section can be used to set the salt concentration.

Currently the Brine option is not implemented in OPM Flow and therefore both the SALTCON and GRPSALT variables on this keyword are ignored.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	POLCON	A real positive value that defines the polymer concentration of the well's injection stream.			
		lb/stb	kg/sm^3	gm/scc	None
3	SALTCON	A real positive value that defines the salt concentration of the well's injection stream. This variable is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.			
		lb/stb	kg/sm^3	gm/scc	None
4	GRPPOL	A character string of up to eight characters in length that defines the group name for which the group's produced polymer concentration should be used instead of the well's POLCON value stated on this keyword.			None
5	GRPSALT	A character string of up to eight characters in length that defines the group name for which the group's produced salt concentration should be used instead of the well's SALTCON value stated on this keyword. This variable is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.			None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.88: WPOLYMER Keyword Description

Water injection wells that are not declared via this keyword have their concentrations defaulted to zero.

See also the GCONPROD and GCONINJE keywords to define a group's production and injection targets and constraints, and the WCONINJE keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the polymer and salt injection stream concentrations for three water injection wells for when the polymer option has been activated by the POLYMER keyword in the RUNSPEC section.

```
--
--       DEFINE WATER INJECTION WELL POLYMER AND SALT CONCENTRATIONS
--
-- WELL  POLYMER    SALT       POLYMER    SALT
-- NAME  POLCON     SALTCON    GROUP      GROUP
--       -------    --------   --------   --------
WPOLYMER
WI01     0.2500                                      /
WI02     1*         1*         GRPINJ1                /
WI03     0.2500     1*         GRPINJ1                /
/
```

The polymer concentration for well WI01 is set to 0.25 and the stated polymer concentration for well WI02 will be ignored, as both WI02 and WI03 will re-inject the produced polymer from the GRPINJ1 group.

12.3.290 WPOLYRED – Define Well Polymer-Water Viscosity Reduction Factor

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WPOLYRED keyword defines the polymer-water reduction factor for injection wells, for when the polymer phase has been activated by the POLYMER keyword in the RUNSPEC section. WPOLYRED should be set to a value greater than or equal to zero and less than or equal to one that determines the injection mixture's viscosity. A value of zero indicates for pure water injection and a value of one will use the simulator's valuated mixture viscosity. A value between zero and one will use an interpolated mixture viscosity.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.291 WREGROUP – AUTOMATIC RE-ASSIGNMENT OF WELLS TO GROUPS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WREGROUP defines the criteria to automatically re-assign wells to various other groups. This can be used, for example, to move wells on THP control flowing through a high pressure separator group to a low pressure separator group in order for the wells to be under different group controls for low pressure wells.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

12.3.292 WRFT – ACTIVATE WELL RFT REPORTING TO THE RFT FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword activates reporting of a well's depth pressure profile to the RFT file for the requested wells at the time the keyword is activated. Data written out by OPM Flow is used to match the field measured data collected from a Repeat Formation Tester ("RFT") tool.

The RFT tool is an open hole device which is an updated version of the Formation Interval Tester ("FIT"), both of which are run on wire line. Both tools take multiple pressure readings (at various depths) thus enabling a pressure depth profile to be obtained from the formation, and, in addition, they can also take fluid samples from the formation. The latest tool available from Schlumberger is the Modular Formation Dynamics Tester ("MDT"), which, as its name suggests, is a modular tool that can be assembled in different configurations depending on what are the objectives for running the tool. Note other vendors have similar wire line logging tools with alternative names for the tools. Throughout this section the term RFT applies to all tools that measure a pressure profile versus depth (RFT/FIT/MDT etc.).

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A columnar vector of character strings of up to eight characters in length for each item, that defines the well name for which the RFT data should be written to the RFT file. Note that the WELNAME must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur. If the WELNAME is left blank then the data is written out for all wells at the time they are first opened to flow. If the WELNAME is given, then the RFT data for the well at the time step the keyword is invoked is written out.			None

Notes:

1) The keyword is followed by any number of records.
2) Each record is terminated by a "/" and the keyword should be terminated by a "/".

Table 12.89: WRFT Keyword Description

See also the WRFTPLT keyword in the SCHEDULE section that has more flexible reporting options.

Examples

The first example activates RFT reporting for all wells at the time a well is first opened to flow:

```
--
--        ACTIVATE WELL RFT REPORTING TO THE RFT FILE
--
-- WELL
-- NAME
WRFT
/
```

Ideally, this version of the keyword should be place at the beginning of the SCHEDULE section to obtain the data for the wells in the run before they are opened up through time.

The next example shows how to use the keyword to request the output for several wells at different reporting time steps.

```
-- ------------------------------------------------------------------------------
-- 01 JAN 2000 START OF SCHEDULE SECTION
-- ------------------------------------------------------------------------------
DATES
15 JAN 2000 /
/
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.5E3  0.0    1550   10      1*   900.0 1*     /
OP02     SHUT                                                        /
/
--
--       ACTIVATE WELL RFT REPORTING TO THE RFT FILE
--
-- WELL
-- NAME
WRFT
OP01                                                                 /
OP02                                                                 /
/
DATES
01 FEB 2000 /
/
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.5E3  0.0    1550   10      1*   900.0 1*     /
OP02     SHUT                                                        /
/
--
--       ACTIVATE WELL RFT REPORTING TO THE RFT FILE
--
-- WELL
-- NAME
WRFT
OP01                                                                 /
OP02                                                                 /
/
DATES
01 MAR 2000 /
/
--
--       WELL HISTORICAL PRODUCTION CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS    VFP    VFP   THP   BHP
-- NAME  SHUT   MODE   RATE   RATE   RATE   TABLE  ALFQ  PRES  PRES
WCONHIST
OP01     OPEN   ORAT  15.5E3  0.0    1550   10      1*   900.0 1*     /
OP02     OPEN   ORAT  10.5E3  0.0    1000   10      1*   900.0 1*     /
/
```

In this example, both well's have their RFT written out on February 1 and March 1 2000.

12.3.293 WRFTPLT – ACTIVATE WELL RFT AND PLT REPORTING TO THE RFT FILE

Description

This keyword activates reporting of a well's depth pressure and fluid rates profile to the RFT file for the requested wells at the time the keyword is activated. Data written out by the simulator is used to match the field measured data collected from both the Repeat Formation Tester ("RFT") tool and various Production Logging Tools ("PLT").

See the WRFT keyword in the SCHEDULE section for a brief description of the RFT data set. This keyword also actives the writing out of each well connection's fluid rates, connection factors and KH data, etc., as the PLT data. The PLT data is used to compare with measured data from wire line production logging tools.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A columnar vector of character strings of up to eight characters in length for each item, that defines the well name for which the RFT data should be written to the RFT file. Note that the WELNAME must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur. If the WELNAME is left blank then the data is written out for all wells at the time they are first opened to flow. If the WELNAME is given, then the RFT data for the well at the time step the keyword is invoked is written out.			None
2	RFT	A defined character string that sets the RFT data set output options and should be set to one of the following character strings. 1) NO: do not write RFT data for the well. 2) YES: write out the RFT data at the current reporting time step. 3) REPT: write out the RFT data at the current reporting time step and all subsequent reporting time steps. 4) TIMESTEP: write out the RFT data at the current reporting time step and all subsequent time steps. 5) FOPN: write out the RFT data at the current reporting time step for the well if it is opened, otherwise write the RFT data out the first time the named well is opened.			NO
3	PLT	A defined character string that sets the PLT data set output options and should be set to one of the following character strings. 1) NO: do not write PLT data for the well. 2) YES: write out the PLT data at the current reporting time step. 3) REPT: write out the PLT data at the current reporting time step and all subsequent reporting time steps. 4) TIMESTEP: write out the PLT data at the current reporting time step and all subsequent time steps.			NO
4		Not Used.			

Notes:

1) The keyword is followed by any number of records terminated by a "/" and the keyword should be terminated by a "/".

Table 12.90: WRFTPLT Keyword Description

See also the WRFT keyword in the SCHEDULE section that has less flexible reporting options.

Examples

The first example activates RFT output at the current reporting time step for all the wells that are opened to flow, otherwise the RFT data is written out the first time a well is opened.

```
--
--       WELL RFT, PLT AND SEGMENT DATA
--
-- WELL  RFT   PLT   SEGMENT
-- NAME  DATA  DATA  DATA
WRFTPLT
'*'      FOPN                                                          /
/
```

The next example writes out the RFT and PLT data for two wells at the current reporting time step.

```
--
--       WELL RFT, PLT AND SEGMENT DATA
--
-- WELL  RFT   PLT   SEGMENT
-- NAME  DATA  DATA  DATA
WRFTPLT
OP01     YES   YES                                                     /
OP02     YES   YES                                                     /
/
```

The final example is shown below:

```
--
--       WELL RFT, PLT AND SEGMENT DATA
--
-- WELL  RFT   PLT   SEGMENT
-- NAME  DATA  DATA  DATA
WRFTPLT
OP01     REPT  NO                                                      /
OP02     NO    YES                                                     /
/
```

In this case the RFT data for well OP01 is written out at the current reporting time step and all subsequent reporting time steps. For well OP02, no RFT is written out but the PLT data is written out for the current report time step only.

12.3.294 WSALT - DEFINE WATER INJECTION WELL SALT CONCENTRATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSALT keyword defines a water injection well's salt injection stream concentration that is to be used for when the salt option has been activated by the BRINE keywords in the RUNSPEC section. Note that if the Polymer option has also been activated by the POLYMER keyword in the RUNSPEC section, then the WPOLYMER keyword in the SCHEDULE section should be used to enter both the polymer and salt concentrations.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the injection salt concentrations are being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	SALTCON	A real positive vector of values that defines the salt concentration of the well's injection stream and consists of: 1) If the Standard Brine model has been invoked by the BRINE keyword, then SALTCON consist of one value representing the injection salt concentration; 2) If OPM Flow's Water Vaporization and Salt Precipitation models have been activated by the VAPWAT and PRECSALT keywords in the RUNSPEC section, then SALTCON consist of one value representing the injection salt concentration; or, 3) If the Multi-Component Brine option has been activated by the BRINE and ECLMC keywords in the RUNSPEC section, then SALTCON consists of a vector of values representing the salt concentration of each brine within the injected brine mixture. Only options (1) and (2) are currently supported. Note if SALTCON is defaulted (1*) then the well's salt concentration will be use the well's group salt concentration.			
		lb/stb	kg/sm^3	gm/scc	1*

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.91: WSALT Keyword Description

Water injection wells that are not declared via this keyword have their concentrations defaulted to zero.

See also the GCONPROD and GCONINJE keywords to define a group's production and injection targets and constraints, and the WCONINJE keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Examples

The following example defines the salt injection stream concentration for three water injection wells for when the brine phase has been activated by the BRINE keyword in the RUNSPEC section.

```
--
--       DEFINE WATER INJECTION WELL SALT CONCENTRATIONS (STANDARD)
--
-- WELL  SALT-1     SALT-2     SALT-3     SALT-4
-- NAME  SALTCON    SALTCON    SALTCON    SALTCON
--       -------    -------    -------    -------
WSALT
WI01     0.2500                                          /
WI02     1*                                              /
WI03     0.2500                                          /
/
```

The salt concentration for both well WI01 and WI03 is set to 0.25, and for well WI02 the salt concentration will be taken from the well's group salt concentration.

The next example is based on using the Multi-Component Brine option, that is the BRINE and ECLMC keywords have been used in the RUNSPEC section, and assuming three salts.

```
--
--       DEFINE WATER INJECTION WELL SALT CONCENTRATIONS (MULTIPLE)
--
-- WELL  SALT-1     SALT-2     SALT-3     SALT-4
-- NAME  SALTCON    SALTCON    SALTCON    SALTCON
--       -------    -------    -------    -------
WSALT
WI01     0.1500     0.0500     0.0500                      /
WI02     0.1500     0.0500     0.0500                      /
WI03     0.2000     0.0500     0.0600                      /
/
```

Here the salt concentrations for both well WI01 and WI02 are set to 0.1500, 0.0500, 0.0500 for the three salts and for well WI03 the salt concentrations are 0.2000, 0.0500 and 0.0600.

Note that OPM Flow does not currently support the Multi-Component brine model.

12.3.295 WSCCLEAN – WELL DEPOSITED SCALE ADJUSTMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSCCLEAN keyword adjusts the amount of scale currently accumulated around a well's well connections for wells located in the global grid. For example, if a workover has been performed on a well to remove (or reduce) the deposited scale over the perforations, then this keyword can be used to implement the effects of the workover. Scale deposits reduce the productivity of well and this relationship is defined in the SCDPTAB and SCDATAB keywords in SCHEDULE section. The tables are allocated to a well via the WSCTAB keyword, which is also in the SCHEDULE section. Note that the Scale Deposition option must have been activated by declaring the dimensions of the scaling deposition tables using the SCDPDIMS keyword in the RUNSPEC section.

See also the WSSCLENL keyword in the SCHEDULE section that performs similar functionality for wells located in a Local Grid Refinement.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.296 WSCCLENL – Well Deposited Scale Adjustment (LGR)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSCCLENL keyword adjusts the amount of scale currently accumulated around a well's well connections for wells located in a Local Grid Refinement (LGR). For example, if a workover has been performed on a well to remove (or reduce) the deposited scale over the perforations, then this keyword can be used to implement the effects of the workover. Scale deposits reduce the productivity of well and this relationship is defined in the SCDPTAB and SCDATAB keywords in SCHEDULE section. The tables are allocated to a well via the WSCTAB keyword, which is also in the SCHEDULE section. Note that the Scale Deposition option must have been activated by declaring the dimensions of the scaling deposition tables using the SCDPDIMS keyword in the RUNSPEC section.

See also the WSSCLEAN keyword in the SCHEDULE section that performs similar functionality for wells located in the global grid.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.297 WSCTAB – ASSIGN WELL SCALE DEPOSITION AND SCALE DAMAGE TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WSCTAB assigns scale deposition and scale damage tables to a well, for when the Scale Deposition option has been activated by declaring the dimensions of the scaling deposition tables using the SCDPDIMS keyword in the RUNSPEC section. Scale deposits reduce the productivity of well and this relationship is defined in the SCDPTAB and SCDATAB keywords in the SCHEDULE section, and are allocated to a well by the WSCTAB keyword.

See also the WPIMULT keyword in the SCHEDULE section that adjusts a well's productivity index by a constant value.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.298 WSEGAICD – DEFINE MULTI-SEGMENT WELL AUTONOMOUS ICD CONNECTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGAICD keyword defines a multi-segment well segment to be an autonomous Inflow Control Device. ("ICD") as part of a completion for a multi-segment well. Note that the well must have been previously define by the WELSPECS and WELSEGS keywords in the SCHEDULE section and that the data for the keyword should be repeated for each multi-segment completion that contains an autonomous ICD.

An ICD is a well completion component usually installed along the producing section of a well to minimize the unwanted water and gas breakthrough in an oil well, or early water production in a gas well, due to an uneven flow profile over the completed interval. Permeability variations over the producing interval cause the high permeability zones to produce higher quantities of fluids than the lower permeability zones and this uneven producing fluid profile may result in bypassed hydrocarbons. Secondly, for horizontal wells, the pressure loss from the "toe" to the "heel" of the well again results in an uneven fluid profile over the producing interval. In order to rectify this ICDs can be installed so that the well fluids have to flow through an ICD before entering the tubing; thus, creating an additional "designed" pressure loss.

An autonomous ICD inhibits the production of high-mobility fluids such as water and gas since the pressure drop in each unit is dependent on fluid properties and mobility, the device automatically increases the pressure differential across zones with high water or gas saturations, thus choking back production from these zones. Although this type of ICD is not implemented in OPM Flow, it works in a similar fashion to how a spiral ICD works. Spiral ICDs are implemented in OPM Flow and the data is entered via the WSEGSICD keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.299 WSEGDFIN – DEFINE MULTI-SEGMENT WELL DRIFT FLUX SLIP MODEL INPUT DATA

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGDFIN keyword defines a multi-segment well's drift flux slip model parameters. A slip model[165] and [166] enables the different phases in the wellbore to flow at different velocities, for example gas will flow up the tubing at a higher velocity than oil and water. The option is activated by the FLOWOPT parameter on the WELSEGS keyword in the SCHEDULE section; however, the slip model flow calculation is not available in OPM Flow.

See also the WSEGFMD keyword in the SCHEDULE section that sets which type of slip model should be used.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[165] *Shi, H., Holmes, J.A., Durlofsky, L. J., Aziz, K., Diaz, L. R., Alkaya, B., and Oddie, G. "Drift-Flux Modeling of Two-Phase Flow in Wellbores," paper SPE 84228, Society of Petroleum Engineers Journal (2005) 10, No. 1, 24-33; also presented as "Drift-Flux Modeling of Multiphase Flow in Wellbores," at the SPE Annual Technical Conference and Exhibition, Denver, Colorado, USA(October 5-8, 2003).*

[166] *Shi, H., Holmes, J.A., Diaz, L. R., Durlofsky, L. J., and Aziz, K. "Drift-Flux Parameters for Three-Phase Steady-State Flow in Wellbores," paper SPE 89836, Society of Petroleum Engineers Journal(2005) 10, No. 2, 130-137; also presented at the SPE Annual Technical Conference and Exhibition, Houston, Texas, USA (September 26-29, 2004).*

12.3.300 WSEGDFMD – DEFINE MULTI-SEGMENT WELL DRIFT FLUX SLIP MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGDFMD keyword defines a multi-segment well's drift flux slip model definition that sets the type of slip model to be used. A slip model[167] and [168] enables the different phases in the wellbore to flow at different velocities, for example gas will flow up the tubing at a higher velocity than oil and water. The option is activated by the FLOWOPT parameter on the WELSEGS keyword in the SCHEDULE section; however, the slip model flow calculation is not available in OPM Flow.

See also the WSEGDFIN keyword that sets the slip model's input parameters and the WSEGDFPA keyword that allows the model default values employed by WSEGDFMD to be modified..

This keyword is ignored by OPM Flow and has no effect on the simulation.

[167] *Shi, H., Holmes, J.A., Durlofsky, L. J., Aziz, K., Diaz, L. R., Alkaya, B., and Oddie, G. "Drift-Flux Modeling of Two-Phase Flow in Wellbores," paper SPE 84228, Society of Petroleum Engineers Journal (2005) 10, No. 1, 24-33; also presented as "Drift-Flux Modeling of Multiphase Flow in Wellbores," at the SPE Annual Technical Conference and Exhibition, Denver, Colorado, USA(October 5-8, 2003).*

[168] *Shi, H., Holmes, J.A., Diaz, L. R., Durlofsky, L. J., and Aziz, K. "Drift-Flux Parameters for Three-Phase Steady-State Flow in Wellbores," paper SPE 89836, Society of Petroleum Engineers Journal(2005) 10, No. 2, 130-137; also presented at the SPE Annual Technical Conference and Exhibition, Houston, Texas, USA (September 26-29, 2004).*

12.3.301 WSEGDFPA – DEFINE MULTI-SEGMENT WELL DRIFT FLUX SLIP MODEL PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WSEGDFPA, enables modification of a multi-segment well's drift flux slip model default parameters used by the WSEGDFMA keyword in the SCHEDULE section to define the model. A slip model[169] and [170] enables the different phases in the wellbore to flow at different velocities, for example gas will flow up the tubing at a higher velocity than oil and water. The option is activated by the FLOWOPT parameter on the WELSEGS keyword in the SCHEDULE section; however, the slip model flow calculation is not available in OPM Flow.

See also the WSEGDFIN keyword that sets the slip model's input parameters and the WSEGDFMD keyword that sets which drift flux slip model should be used. Note if the WSEGDFPA keyword is used than it must be placed after the WSEGDFMD keyword, but before the WELSEGS keyword that defines a multi-segment well. All the aforementioned keywords are in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

[169] *Shi, H., Holmes, J.A., Durlofsky, L. J., Aziz, K., Diaz, L. R., Alkaya, B., and Oddie, G. "Drift-Flux Modeling of Two-Phase Flow in Wellbores," paper SPE 84228, Society of Petroleum Engineers Journal (2005) 10, No. 1, 24-33; also presented as "Drift-Flux Modeling of Multiphase Flow in Wellbores," at the SPE Annual Technical Conference and Exhibition, Denver, Colorado, USA(October 5-8, 2003).*

[170] *Shi, H., Holmes, J.A., Diaz, L. R., Durlofsky, L. J., and Aziz, K. "Drift-Flux Parameters for Three-Phase Steady-State Flow in Wellbores," paper SPE 89836, Society of Petroleum Engineers Journal(2005) 10, No. 2, 130-137; also presented at the SPE Annual Technical Conference and Exhibition, Houston, Texas, USA (September 26-29, 2004).*

12.3.302 WSEGEXSS – Define Multi-Segment Well Import-Export Segment Volumes

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WSEGEXSS, enables the import or export of fluids from a segment in a multi-segment well. This can be used to, for example, model gas lift injection for oil wells under artificial lift, or to approximate the behavior of a down-hole separator. The import-export fluid volumes can either be expressed as rates or defined as a function of a segment's pressure value.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.303 WSEGFLIM - DEFINE MULTI-SEGMENT WELL ARTIFICIAL CHOKE CONNECTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WSEGFLIMS enables an artificial choke that chokes a given phase flow rate for a segment in a multi-segment well. This can be used, for example, to constraint unwanted production phase through a section of tubing, or to model a down-hole choke. The keyword provides coefficients that are applied to the frictional pressure drop across a multi-segment well's segment in order to inhibit production from that particular zone or segment. As such, the keyword does not actually model a down-hole choke; hence, the term artificial.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.304 WSEGFMOD – DEFINE MULTI-SEGMENT WELL MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGFMOD declares the multi-phase flow model to be used to calculate the pressure drop within an individual segment for multi-segment wells. The FLOWOPT parameter on the WELSEGS keyword in the SCHEDULE section sets the default multi-segment well model. FLOWOPT is a character string that can be set to HO that activates the homogeneous model, that is all phases flow at the same velocity, or DF that invokes the Drift Flux Slip model (note OPM Flow only supports the default value of HO for the homogeneous model). Here WSEGFMOD can be used to set the flow model for a segment to either the homogeneous model or the Drift Flux Slip model, and addition a: VLP table allocated via the WSEGTABL keyword, or a specific model as defined by the WSEGVALV, WSEGFLIM and WSEGLABY keywords. All the aforementioned keywords are in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.305 WSEGINIT - DEFINE MULTI-SEGMENT WELL INITIAL CONDITIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Normally the simulator calculates the initial conditions for multi-segment wells, that is the pressure and fluid distributions in each segment. However, there are occasions when manually setting the pressures and phase distributions for each segment to investigate certain flow conditions may be useful. In this case the WSEGINIT keyword may be used to specify the initial conditions manually. Note that segments not initialized by this keyword will be automatically initialized by the simulator

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.306 WSEGITER – DEFINE MULTI-SEGMENT WELLS ITERATION PARAMETERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGSITER keyword defines the multi-segment well solution iteration sequence and solution controls.

OPM Flow users a different numerical scheme which makes this keyword redundant; hence, OPM Flow ignores this keyword. It is documented here for completeness. See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to set the numerical control parameters for OPM Flow.

12.3.307 WSEGLABY - DEFINE MULTI-SEGMENT WELL LABYRINTH ICD CONNECTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGSICD keyword defines a multi-segment well segment to be a labyrinth Inflow Control Device. ("ICD") as part of a completion for a multi-segment well. Note that the well must have been previously define by the WELSPECS and WELSEGS keywords in the SCHEDULE section and that the data for the keyword should be repeated for each multi-segment completion that contains a labyrinth ICD.

An ICD is a well completion component usually installed along the producing section of a well to minimize the unwanted water and gas breakthrough in an oil well, or early water production in a gas well, due to an uneven flow profile over the completed interval. Permeability variations over the producing interval cause the high permeability zones to produce higher quantities of fluids than the lower permeability zones and this uneven producing fluid profile may result in bypassed hydrocarbons. Secondly, for horizontal wells, the pressure loss from the "toe" to the "heel" of the well again results in an uneven fluid profile over the producing interval. In order to rectify this ICDs can be installed so that the well fluids have to flow through an ICD before entering the tubing; thus, creating an additional "designed" pressure loss.

A labyrinth ICD is a type of frictional ICD that adds an additional pressure loss by directing the fluid along a series of channels before entering the tubing. The channel flow path is designed in such a manner as to create the desired pressure loss for a given ICD. By placing various ICD's over the production interval one can design a completion that results in a more uniform producing fluid profile throughout the length of the producing interval. Although this type of ICD is not implemented in OPM Flow, it works in a similar fashion to how a spiral ICD works. Spiral ICDs are implemented in OPM Flow and the data is entered via the WSEGSICD keyword in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.308 WSEGLINK - Define Multi-Segment Well Looped Flow Paths

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WSEGLINK, specifies multi-segment well looped flow paths as part of a completion for a multi-segment well. A looped segment results in the nodes of the two individual segments that are looped (or connected) having the same solution pressures and oil, water and gas flowing rates.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.309 WSEGMULT – DEFINE MULTI-SEGMENT WELL FRICTIONAL PRESSURE LOSS MULTIPLIERS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WEGMULT supplies a set of constants used to modify (or scale) a multi-segment well's segment frictional pressure drop between connecting segments The constants enable either a constant pressure to be applied, or for the pressure drop to vary as a function of the Gas-Oil Ratio ("GOR") or the Water-Oil Ratio ("WOR"). The simulator calculated pressure drop is multiplied by the following resulting value:

$$Frictional\ Loss\ Multipler\ =\ min\left(x_1 + x_2(WOR)^{x_3} + x_4\left(\frac{GOR}{GOR_{min}}\right)^{x^5},\ 1.0\right) \tag{12.24}$$

Where the constants x_1 to x_5 are defined by the values on this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.310 WSEGPROP – MODIFY MULTI-SEGMENT WELLS AND THEIR SEGMENT STRUCTURE

Description

The WSEGPROP keyword allows for the editing of exiting multi-segment wells created by WELSEGS keyword in the SCHEDULE section without having to re-define all the information that is on the WELSEGS keyword. Note that the well must have been previously define by both the WELSPECS and WELSEGS keywords in the SCHEDULE section to use the WSEGPROP keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which a multi-segment well is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	ISEG1	A positive integer greater than or equal to two and less than or equal to MXSEGS on WSEGDIMS keyword in the RUNSPEC section that defines the start of a segment			None
3	ISEG2	A positive integer greater than or equal to two and less than or equal to ISEG1 on this record and MXSEGS on the WSEGDIMS keyword in the RUNSPEC section that defines the end of a segment.			None
4	ID	A real positive value that defines the tubing internal diameter of the segment for the well.			Previous Entered Value
		feet	m	cm	
5	EPSILON	A real positive value that defines the tubing absolute roughness of the segment for the well.			Previous Entered Value
		feet	m	cm	
6	XAREA	XAREA is real positive value equal to or greater than zero that defines the cross sectional area for fluid flow. Currently this option is not supported by OPM Flow.			Previous Entered Value
		ft^2	m^2	cm^2	
7	VOLSEG	VOLSEG is a real positive value that defines the effective segment volume for the this segment. Currently this option is not supported by OPM Flow.			Previous Entered Value
		ft^3	m^3	cm^3	
8	XAREAS	XAREAS is real positive value equal to or greater than zero that defines the cross sectional area of the pipe wall for this segment, that is used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			Previous Entered Value
		ft^2	m^2	cm^2	

No.	Name	Description			Default
		Field	Metric	Laboratory	
9	VHEATCAP	VHEATCAP is real positive value equal to or greater than zero that defines the volumetric heat capacity of the pipe wall used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			Previous Entered Value
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	
10	THCON	THCON is real positive value equal to or greater than zero that defines the thermal conductivity of the pipe wall used in thermal conductivity calculations for when the temperature calculation is activated by the TEMP keyword in the RUNSPEC section. Currently this option is not supported by OPM Flow.			Previous Entered Value
		Btu/ft/day/°R	kJ/m/day/K	J/cm/hr/K	

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.92: WSEGPROP Keyword Description

The total number of wells should be defined via the WELLSDIMS keyword and the number of multi-segment wells should be declared on the WSEGDIMS keyword, both keywords are in the RUNSPEC section.

See also the WELSPECS keyword to define wells, the COMPDAT keyword to define the well completions for both ordinary wells and multi-segment wells, and the COMPSEGS keyword to define a multi-segment well segment completions. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example modifies two segments in well OP01 and one segment in well OP02.

```
--
--        WELL SEGMENT SPECIFICATION DATA
--
-- WELL   SEG    SEG    TUBE    TUBE      XSEC   VOL
-- NAME   ISTR   IEND   ID      ROUGH     AREA   SEG
WSEGPROP
OP01       12     14    0.3     0.00010                                    /
OP01       13     15    0.275   0.00010                                    /
OP02       14     14    0.275   0.00010                                    /
/
```

Note that the two multi-segment wells and their respective segments must have been previously defined by the WELSEGS keyword.

12.3.311 WSEGPULL – Define a Multi-Segment Well Down-Hole Separator Pump

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WSEGPULL, specifies a multi-segment well segment to be a pull-through pump for a down-hole water separator, defined by the WSEGSEP keyword in the SCHEDULE section, and defines the various parameters for this type of pump. Down-hole separators are used to separate water or free gas from the in situ fluid entering the wellbore in order to increase hydrocarbon recovery.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.312 WSEGSEP – Define a Multi-Segment Well Down-Hole Separator

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WSEGSEP specifies a multi-segment well segment to be a down-hole separator, that enables the separation of fluids down-hole. Down-hole separators are used to separate water or free gas from the in situ fluid entering the wellbore in order to increase hydrocarbon recovery. See also the WSEGPULL keyword in the SCHEDULE section that specifies a pull-through pump for a down-hole water separator.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.313 WSEGSICD – DEFINE MULTI-SEGMENT WELL SPIRAL ICD CONNECTIONS

Description

The WSEGSICD keyword defines a multi-segment well segment to be a spiral Inflow Control Device. ("ICD") as part of a completion for a multi-segment well. Note that the well must have been previously define by the WELSPECS and WELSEGS keywords in the SCHEDULE section and that the data for the keyword should be repeated for each multi-segment completion that contains a spiral ICD.

An ICD is a well completion component usually installed along the producing section of a well to minimize the unwanted water and gas breakthrough in an oil well, or early water production in a gas well, due to an uneven flow profile over the completed interval. Permeability variations over the producing interval cause the high permeability zones to produce higher quantities of fluids than the lower permeability zones and this uneven producing fluid profile may result in bypassed hydrocarbons. Secondly, for horizontal wells, the pressure loss from the "toe" to the "heel" of the well again results in an uneven fluid profile over the producing interval. In order to rectify this ICDs can be installed so that the well fluids have to flow through an ICD before entering the tubing; thus, creating an additional "designed" pressure loss.

A spiral ICD is a type of frictional ICD that adds an additional pressure loss by directing the fluid along a "channel" (spiral/helix) before entering the tubing. The channel flow path is designed in such a manner as to create the desired pressure loss for a given ICD. By placing various ICD's over the production interval one can design a completion that results in a more uniform producing fluid profile throughout the length of the producing interval.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which a multi-segment well is being defined. Note that the well name (WELNAME) must have been declared previously using both the WELSPECS and WELSEGS keywords in the SCHEDULE section, otherwise an error may occur.			None
2	ISEG1	A positive integer greater than or equal to two and less than or equal to MXSEGS on the WSEGDIMS keyword in the RUNSPEC section that defines the start of a segment			None
3	ISEG2	A positive integer greater than or equal to two and less than or equal to ISEG1 on this record and MXSEGS on the WSEGDIMS keyword in the RUNSPEC section that defines the end of a segment.			None
4	ICDSTREN	A real positive value greater than zero that defines an empirical constant for the strength of the given ICD as determined from measurements using the calibrated fluid.			
		psia(rft^3/day)^2	barsa/(rm^3/day)^2	atma/(rcc/day)^2	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
5	ICDLEN	A real value defines the length of the ICD used in conjunction with NSCAFAC to calculate a scaling factor to be applied to the reservoir flow to adjust the flow through each ICD, that is: 1) If NSCAFAC equals zero: then the scale factor is equal to the length of the ICD (ICDLEN) divided by the length of the tubing section, that is the parent of the ICDs, then this allows for the case when the ICD segment may represent a number of ICDs in parallel. 2) If NSCAFAC equals one: then the scale factor is equal to the absolute value of ICDLEN. 3) If NSCAFAC equals two: then the scale factor is equal to the length to ICDLEN, divided by the total length of the completions which supply the ICD. NSCALFAC explicitly sets which of the above three options is used. If NSCALFAC is defaulted, then option 1) is used whenever ICDLEN is positive and option 2) when ICDLEN is negative.			
		feet 39.37	m 12.00	cm 1,2000	Defined
6	CALDEN	CALDEN is a real positive value greater than zero that defines the density of the calibrating fluid at surface conditions.			
		lb/ft^3 62.416	kg/m^3 1000.25	gm/cc 1.00025	Defined
7	CALVISC	CALVISC is a real positive value greater than zero that defines the viscosity of the calibrating fluid at surface conditions.			
		cP	cP	cP	0.45
8	EMLCRT	EMLCRT is a real positive value greater than zero that defines the "local water" in liquid fraction used to determine whether the "water-in-oil" or "oil-in-water" viscosity emulation equation should be applied.			
		dimensionless	dimensionless	dimensionless	0.5
9	EMLTRANS	EMLTRANS is a real positive value greater than zero that defines the width of the transition zone around EMLCRT and is used to ensure that the calculated viscosity forms a continuous function of water in liquid fraction. Within this region, the emulsion viscosity is a linear interpolation between the "water-in-oil" and "oil-in-water" viscosity values either side of the region.			
		dimensionless	dimensionless	dimensionless	0.05
10	EMLMAX	EMLMAX is a real positive value greater than zero that defines the maximum emulsion viscosity to continuous phase viscosity (oil or water) ratio.			
		dimensionless	dimensionless	dimensionless	5.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
11	NSCAFAC	NSCALFAC is a positive integer value that is greater than or equal to zero, that sets the method to be used when applying the scaling factor and should be set to one of the following: 1) If NSCAFAC equals zero: then the scale factor is equal to the length of the ICD (ICDLEN) divided by the length of the tubing section, that is the parent of the ICDs, then this allows for the case when the ICD segment may represent a number of ICDs in parallel. 2) If NSCAFAC equals one: then the scale factor is equal to the absolute value of ICDLEN. 3) If NSCAFAC equals two: then the scale factor is equal to the length to ICDLEN, divided by the total length of the completions which supply the ICD. NSCALFAC explicitly sets which of the above three options is used. If NSCALFAC is defaulted, then option 1) is used whenever ICDLEN is positive and option 2) when ICDLEN is negative.			
		dimensionless	dimensionless	dimensionless	None
12	CALRATE	A real positive value that defines the maximum surface flow rate for which the ICD was calibrated.			
		scf/d	sm^3/day	scc/hour	None
13	STATUS	A character string of length four that defines the ICD's operational status, STATUS should be set to one of the following character strings: 1) OPEN: the ICD connection is are open to flow. 2) SHUT: the ICD connections is closed to flow (shut-in).			OPEN

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.93:WSEGSICD Keyword Description

The total number of wells should be defined via the WELLSDIMS keyword and the number of multi-segment wells should be declared on the WSEGDIMS keyword, both keywords are in the RUNSPEC section. In addition, the WELSPECS keyword should be used to define wells, the COMPDAT keyword to define the well completions for both ordinary wells and multi-segment wells, and the COMPSEGS keyword to define a multi-segment segment completions. Finally, the WSEGSICD keyword can then be use to define ICD connections for the well. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines one producing well segment oil well (OP01) using the WELSPECS, WELSEGS COMPDAT and COMPSEGS keywords, followed by the WSEGSICD keyword to define the spiral inflow control devices for the well.

```
--
--       WELL SPECIFICATION DATA
--
-- WELL  GROUP     LOCATION  BHP    PHASE  DRAIN  INFLOW  OPEN  CROSS  PVT
-- NAME  NAME        I    J  DEPTH  FLUID  AREA   EQUANS  SHUT  FLOW   TABLE
WELSPECS
OP01     PLATFORM   10   10   1*     OIL                                    /
/
--
--       WELL CONNECTION DATA
--
-- WELL  --- LOCATION ---  OPEN   SAT   CONN   WELL   KH    SKIN   D     DIR
-- NAME   II  JJ  K1  K2   SHUT   TAB   FACT   DIA    FACT  FACT   FACT  PEN
COMPDAT
OP01      10  10   1   1   OPEN   1*    200.   0.5                          /
OP01      10  10   2   2   OPEN   1*    200.   0.5                          /
OP01      10  10   3   6   OPEN   1*    200.   0.4                          /
OP01      10  10   4   4   OPEN   1*    200.   0.4                          /
OP01      10  10   5   5   OPEN   1*    200.   0.4                          /
OP01      10  10   6   6   OPEN   1*    200.   0.4                          /

OP01       9  10   2   2   OPEN   1*    200.   0.4                          /
OP01       8  10   2   2   OPEN   1*    200.   0.4                          /
OP01       7  10   2   2   OPEN   1*    200.   0.4                          /
OP01       6  10   2   2   OPEN   1*    200.   0.4                          /
OP01       5  10   2   2   OPEN   1*    200.   0.4                          /

OP01      10   9   3   3   OPEN   1*    200.   0.4                          /
OP01      10   8   3   3   OPEN   1*    200.   0.4                          /
OP01      10   7   3   3   OPEN   1*    200.   0.4                          /
OP01      10   6   3   3   OPEN   1*    200.   0.4                          /
OP01      10   5   3   3   OPEN   1*    200.   0.4                          /

OP01       9  10   5   5   OPEN   1*    200.   0.4                          /
OP01       8  10   5   5   OPEN   1*    200.   0.4                          /
OP01       7  10   5   5   OPEN   1*    200.   0.4                          /
OP01       6  10   5   5   OPEN   1*    200.   0.4                          /
OP01       5  10   5   5   OPEN   1*    200.   0.4                          /

OP01      10   9   6   6   OPEN   1*    200.   0.4                          /
OP01      10   8   6   6   OPEN   1*    200.   0.4                          /
OP01      10   7   6   6   OPEN   1*    200.   0.4                          /
OP01      10   6   6   6   OPEN   1*    200.   0.4                          /
OP01      10   5   6   6   OPEN   1*    200.   0.4                          /
/
--
--       WELL SEGMENT SPECIFICATION DATA
--
-- WELL  NODAL       LEN     WELL    DEPH    PRESS   FLOW
-- NAME  DEPTH       TUBING  VOLM    OPTN    CALC    MODEL
WELSEGS
OP01     2512.5      2512.5  1.0E-5  ABS     HFA     HO                     /
--
--       SEG   SEG   BRAN    SEG     TUBING  NODAL   TUBE   TUBE     XSEC  VOL
--       ISTR  IEND  NO      NO      LENGTH  DEPTH   ID     ROUGH    AREA  SEG
           2     2    1       1      2537.5  2534.5  0.3    0.00010         /
           3     3    1       2      2562.5  2560.5  0.3    0.00010         /
```

```
            4     4    1       3      2587.5  2593.5  0.3    0.00010            /
            5     5    1       4      2612.5  2614.5  0.3    0.00010            /
            6     6    1       5      2637.5  2635.5  0.3    0.00010            /

            7     7    2       2      2737.5  2538.5  0.2    0.00010            /
            8     8    2       7      2937.5  2537.5  0.2    0.00010            /
            9     9    2       8      3137.5  2539.5  0.2    0.00010            /
           10    10    2       9      3337.5  2535.5  0.2    0.00010            /
           11    11    2      10      3537.5  2536.5  0.2    0.00010            /

           12    12    3       3      2762.5  2563.5  0.2    0.00010            /
           13    13    3      12      2962.5  2562.5  0.1    0.00010            /
           14    14    3      13      3162.5  2562.5  0.1    0.00010            /
           15    15    3      14      3362.5  2564.5  0.1    0.00010            /
           16    16    3      15      3562.5  2562.5  0.1    0.00010            /

           17    17    4       5      2812.5  2613.5  0.2    0.00010            /
           18    18    4      17      3012.5  2612.5  0.1    0.00010            /
           19    19    4      18      3212.5  2612.5  0.1    0.00010            /
           20    20    4      19      3412.5  2612.5  0.1    0.00010            /
           21    21    4      20      3612.5  2613.5  0.1    0.00010            /

           22    22    5       6      2837.5  2634.5  0.2    0.00010            /
           23    23    5      22      3037.5  2637.5  0.2    0.00010            /
           24    24    5      23      3237.5  2638.5  0.2    0.00010            /
           25    25    5      24      3437.5  2639.5  0.1    0.00010            /
           26    26    5      25      3637.5  2639.5  0.1    0.00010            /
/
--
--       COMPLETION SEGMENT SPECIFICATION DATA
--
-- WELL
-- NAME
COMPSEGS
OP01                                                                            /
--
--      --LOCATION--  BRAN  TUBING  NODAL   DIR  LOC    MID    COMP    ISEG
--       II  JJ  K1   NO    LENGTH  DEPTH   PEN  I,J,K  PERFS  LENGTH  NO.
         10  10   1    1    2512.5  2525.0                                      /
         10  10   2    1    2525.0  2550.0                                      /
         10  10   3    1    2550.0  2575.0                                      /
         10  10   4    1    2575.0  2600.0                                      /
         10  10   5    1    2600.0  2625.0                                      /
         10  10   6    1    2625.0  2650.0                                      /

          9  10   2    2    2637.5  2837.5                                      /
          8  10   2    2    2837.5  3037.5                                      /
          7  10   2    2    3037.5  3237.5                                      /
          6  10   2    2    3237.5  3437.5                                      /
          5  10   2    2    3437.5  3637.5                                      /

         10   9   3    3    2662.5  2862.5                                      /
         10   8   3    3    2862.5  3062.5                                      /
         10   7   3    3    3062.5  3262.5                                      /
         10   6   3    3    3262.5  3462.5                                      /
         10   5   3    3    3462.5  3662.5                                      /

          9  10   5    4    2712.5  2912.5                                      /
          8  10   5    4    2912.5  3112.5                                      /
          7  10   5    4    3112.5  3312.5                                      /
          6  10   5    4    3312.5  3512.5                                      /
          5  10   5    4    3512.5  3712.5                                      /
```

```
          10   9   6    5    2737.5  2937.5                                  /
          10   8   6    5    2937.5  3137.5                                  /
          10   7   6    5    3137.5  3337.5                                  /
          10   6   6    5    3337.5  3537.5                                  /
          10   5   6    5    3537.5  3737.5                                  /
--
--        MULTI-SEGMENT WELL ICD SEGMENT SPECIFICATION DATA
--
-- WELL  SEG   SEG   ICD     ICD  CAL  CAL   EML   EML    EML  SCAL  CAL   OPEN
-- NAME  ISTR  IEND  STRNEN  LEN  DEN  VISC  CRIT  TRANS  MAX  FAC   RATE  CLOSE
WSEGSICD
OP01       7    10  0.00025   1*  1.0  0.45  0.50  0.05   5.0   2    1*    OPEN /

OP01      12    15  0.00025   1*  1.0  0.45  0.50  0.05   5.0   2    1*    OPEN /

OP01      17    20  0.00025   1*  1.0  0.45  0.50  0.05   5.0   2    1*    OPEN /

OP01      22    22  0.00025   1*  1.0  0.45  0.50  0.05   5.0   2    1*    OPEN /
OP01      23    23  0.00025   1*  1.0  0.45  0.50  0.05   5.0   2    1*    OPEN /
OP01      24    24  0.00025   1*  1.0  0.45  0.50  0.05   5.0   2    1*    OPEN /
OP01      25    25  0.00050 10.0  1.0  0.45  0.50  0.05   5.0   2    1*    OPEN /
/
```

Branch number two users one ICD for segments seven to ten, branch number three again users only one ICD for segments 12 to 15 and similarly branch number three users one ICD. The fifth and final branch has a total of four ICDs with the last interval having a 10 foot length. Since NSCAFAC equals two for the ICDs, then the scale factor is equal to the length to ICDLEN, divided by the total length of the completions which supply the ICD. Where ICDLEN is defaulted, the default value of 39.37 ft will be used for field units and 12 m for SI units.

12.3.314 WSEGSOLV Define Multi-Segment Well Iterative Linear Solver Parameters

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGSOLV keyword defines the numerical control parameters for the iterative linear solver for multi-segment well looped flow paths, as defined by the WSEGLINK keyword in the SCHEDULE section. A looped segment results in the nodes of the two individual segments that are looped (or connected) having the same solution pressures and oil, water and gas flowing rates.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.315 WSEGTABL – Assign Multi-Segment Well VLP Tables to Segments

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WSEGTABL assigns previously defined Vertical Lift Performance ("VLP") tables as specified by the VFPROD keyword in the SCHEDULE section, to multi-segment well segments, as well as stipulating how the tables are to be applied.

The FLOWOPT parameter on the WELSEGS keyword in the SCHEDULE section sets the default multi-segment well model. FLOWOPT either activates the homogeneous model, that is all phases flow at the same velocity, or the Drift Flux Slip model. However, the WSEGFMOD keyword in the SCHEDULE section, can be used to set the flow model for a segment to either the homogeneous model or the Drift Flux Slip model, and addition a: VLP table allocated via the WSEGTABL keyword, or a specific model as defined by the WSEGVALV, WSEGFLIM and WSEGLABY keywords.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.316 WSEGVALV – DEFINE MULTI-SEGMENT WELL SUB-CRITICAL VALVE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WSEGVALV keyword defines a multi-segment well segment to be a sub-critical valve Inflow Control Device. ("ICD") as part of a completion for a multi-segment well. Note that the well must have been previously define by the WELSPECS and WELSEGS keywords in the SCHEDULE section and that the data for the keyword should be repeated for each multi-segment completion that contains a sub-critical valve ICD.

An ICD is a well completion component usually installed along the producing section of a well to minimize the unwanted water and gas breakthrough in an oil well, or early water production in a gas well, due to an uneven flow profile over the completed interval. Permeability variations over the producing interval cause the high permeability zones to produce higher quantities of fluids than the lower permeability zones and this uneven producing fluid profile may result in bypassed hydrocarbons. Secondly, for horizontal wells, the pressure loss from the "toe" to the "heel" of the well again results in an uneven fluid profile over the producing interval. In order to rectify this ICDs can be installed so that the well fluids have to flow through an ICD before entering the tubing; thus, creating an additional "designed" pressure loss.

A sub-critical valve ICD is a type of frictional ICD that adds an additional pressure loss by directing the fluid through a constriction before entering the tubing. The pressure drop is a function of the fluid density, the volumetric flow rate, and the diameter of the constriction. By placing various ICD's over the production interval one can design a completion that results in a more uniform producing fluid profile throughout the length of the producing interval.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which a multi-segment well is being defined. Note that the well name (WELNAME) must have been declared previously using both the WELSPECS and WELSEGS keywords in the SCHEDULE section, otherwise an error may occur.			None
2	ISEG1	A positive integer greater than or equal to two and less than or equal to MXSEGS on the WSEGDIMS keyword in the RUNSPEC section that defines the segment containing the sub-critical valve.			None
3	ICDCV	A real positive value greater than zero that defines the dimensionless flow coefficient for the valve (C_v). This a vendor specific value for a given vendor's ICD.			
		dimensionless	dimensionless	dimensionless	None
4	AREAREST	A real positive value that defines the cross-sectional area of flow in the restricted section of the valve (A_r) and should have a minimum value of 1.0×10^{-10}. AREAREST is used to convert the segment volumetric flow rate into the flow velocity at the constriction (υ_r).			
		ft^2	m^2	cm^2	None

No.	Name	Description			Default
		Field	Metric	Laboratory	
5	SEGLEN	A real positive value greater than or equal to zero that defines the additional pipe length for the frictional pressure drop (L). If set to zero then there is no additional pressure loss due to friction, whereas, if set to the default (1*), then the segment pipe length is calculated from the corresponding WELSEGS keyword.			
		ft	m	cm	Defined
6	ID	A real positive value that defines the pipe internal diameter of the segment used to calculate the pressure drop due to friction (D). The value is used to replace the segment pipe internal diameter defined on the WELSEGS keyword in record 2-7, also named ID. If ID is defaulted on this keyword then the equivalent value on the WELSEGS keyword will be used instead. Note for non-circular pipe segments use the equivalent diameter instead, that is: $Equivalent\ ID = \frac{4.0 \times (Cross-Sectional\ Area)}{Perimeter}$			
		feet	m	cm	Defined
7	EPSILON	A real positive value that defines the pipe absolute roughness for this segment. The value is used to replace the segment pipe absolute roughness defined on the WELSEGS keyword in record 2-8, also named EPSILON. If EPSILON is defaulted on this keyword then the equivalent value on the WELSEGS keyword will be used instead.			
		feet	m	cm	Defined
8	AREAPIPE	A real positive value that defines the cross-sectional area of flow in the pipe (A_p), as opposed to the restricted section of the valve (A_r). AREAPIPE is used to convert the segment volumetric flow rate into the flow velocity through the pipe (υ_p). The value is used to replace the segment pipe cross-sectional area of flow defined on the WELSEGS keyword in record 2-9, named XAREA. If AREAPIPE is defaulted on this keyword then the equivalent value on the WELSEGS keyword will be used instead.			
		ft^2	m^2	cm^2	Defined
9	STATUS	A character string of length four that defines the ICD's operational status, STATUS should be set to one of the following character strings: 1) OPEN: the ICD connection is are open to flow. 2) SHUT: the ICD connections is closed to flow (shut-in).			OPEN
10	AREAMAX	A real positive value that defines the maximum cross-sectional area of flow in the restricted section of the valve (A_{max}). AREAMAX is used to convert the segment volumetric flow rate into the maximum flow velocity at the constriction (υ_r). If defaulted then AREAPIPE will be used if defined, otherwise XAREA (item 2-9) on the WELSEGS keyword will be used.			
		ft^2	m^2	cm^2	Defined

No.	Name	Description			Default
		Field	Metric	Laboratory	
Notes: 1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.94:WSEGVALV Keyword Description

The total number of wells should be defined via the WELLSDIMS keyword and the number of multi-segment wells should be declared on the WSEGDIMS keyword, both keywords are in the RUNSPEC section. In addition, the WELSPECS keyword should be used to define wells, the COMPDAT keyword to define the well completions for both ordinary wells and multi-segment wells, and the COMPSEGS keyword to define a multi-segment segment completions. Finally, the WSEGVALV keyword can then be use to define ICD connections for the well. All the aforementioned keywords are described in the SCHEDULE section.

OPM flow calculates the pressure drop across the ICD using a homogeneous sub-critical flow through a constriction model. The model consists of two variables, the pressure drop due to the constriction, $\delta P_{restriction}$, and the pressure drop due to friction, $\delta P_{friction}$, as shown in equation (12.25).

$$\delta P = \delta P_{restriction} + \delta P_{friction}$$

$$where$$

$$\delta P_{restriction} = C_1 \frac{\rho \upsilon_r^2}{2 C_v^2} \qquad (12.25)$$

$$\delta P_{friction} = 2 C_2 f \frac{L}{D} \upsilon_p^2$$

Where:

C_1 and C_2	=	Unit conversion constants as listed in Table 12.95.
C_v	=	Vendor supplied dimensionless flow coefficient for the valve.
D	=	Diameter of the pipe.
f	=	Fanning friction factor.
L	=	Segment pipe length.
ρ	=	Fluid mixture density.
υ_r	=	The flow velocity of the mixture through the constriction.
υ_p	=	The flow velocity of the mixture through the segment pipe.

Conversion Factor Constants and Variable Units					
No.	**Name**	**Field**	**Metric**	**Laboratory**	**Property**
1	C_1	2.159×10^{-4}	1.0×10^{-5}	9.869×10^{-7}	Constant
2	C_2	2.892×10^{-14}	1.340×10^{-15}	7.615×10^{-14}	
3	Density	lb/ft^3	kg/m^3	gm/cc	Units
4	Pressure	psia	bars	atm	
5	Velocity	ft/s	m/s	cm/s	
6	Volumetric Flow	ft^3/day	m^3/day	cc/hour	

Table 12.95:WELVALV Conversion Factor Constants and Units

In addition as both υ_r and υ_p are dependent on their respective cross-section areas then the volumetric flow (q) through the device requires that:

$$q = \upsilon_r A_r = \upsilon_p A_p \tag{12.26}$$

Substituting equation (12.26) for $\delta P_{restriction}$ in equation (12.25) one obtains:

$$\delta P_{restriction} = C_2 \frac{\rho q^2}{2 C_v^2 A_r^2} \tag{12.27}$$

Where:

A_r	=	Cross-sectional area of the constriction.
C_2	=	Unit conversion constants as listed in Table 12.95.
C_v	=	Vendor supplied dimensionless flow coefficient for the valve.
ρ	=	Fluid mixture density.
q	=	Volumetric flow rate.

The base strength of the device, K is defined using equation (12.27) as follows:

$$K = \frac{C_2}{2 C_v^2 A_r^2} \tag{12.28}$$

Note if K is greater than 0.1 then the device will be shut.

The setting of the device, that is how open the device is; is related to the restricted area and the maximum restricted area of the device, that is:

$$Seting\ of\ Device = \frac{A_r}{A_{max}} \tag{12.29}$$

Where:

A_r	=	Cross-sectional area of the constriction.
A_{max}	=	Maximum cross-sectional area of the constriction.

Example

The following example is based on one producing well segment oil well (OP01) using the WELSPECS, WELSEGS COMPDAT and COMPSEGS keywords, as per the WSEGSICD keyword example (*Example*), and is therefore not repeated here.

```
--
--        MULTI-SEGMENT WELL ICD SEGMENT SPECIFICATION DATA
--
-- WELL   SEG   DEVICE   AREA    PIPE    PIPE   PIPE   PIPE   OPEN   MAX
-- NAME   NO    CV       REST    LENG    ID     EPSI   AREA   SHUT   AREA
WSEGVALV
OP01        7   0.960    0.012   1*      1*     1*     1*     OPEN   1*   / DEFAULT VALUES
OP01       12   0.960    0.012   1*      1*     1*     1*     OPEN   1*   / TAKEN FROM
OP01       17   0.960    0.012   1*      1*     1*     1*     OPEN   1*   / WELSEGS KEYWORD

OP01       22   0.850    0.100   1*      1*     1*     1*     OPEN   1*   /
OP01       23   0.850    0.100   1*      1*     1*     1*     OPEN   1*   /
OP01       24   0.850    0.100   1*      1*     1*     1*     OPEN   1*   /
OP01       25   0.850    0.100   1*      1*     1*     1*     OPEN   1*   /
/
```

Here segments 7, 12 and 17 have the same type of sub-critical valves with their pipe properties taken from the WELSEGS keyword used to define well OP01 as a multi-segment well. Similarly, segments 22 to 25 have the same ICD properties, and again the pipe properties are taken from the WELSEGS keyword.

12.3.317 WSOLVENT - DEFINE GAS INJECTION WELL SOLVENT FRACTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WSOLVENT defines a gas injection well's solvent faction in the injection stream that is to be used when the Solvent option has been activated by the SOLVENT keyword in the RUNSPEC section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name of a gas injection well for which the solvent fraction data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
4	SOLFRA	A real positive value greater than or equal to zero and less than or equal to one that defines the fraction of solvent in the gas well's injection stream.			
		fraction	fraction	fraction	None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.96: WSOLVENT Keyword Description

Gas injection wells that are not declared via this keyword have their solvent fractions set to zero.

See also the GCONINJE keyword to define a group's injection targets and constraints, and the WCONINJE keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the solvent fractions for three gas injection wells for when the solvent option has been activated by the SOLVENT keyword in the RUNSPEC section.

```
--
--       DEFINE GAS INJECTION WELL SOLVENT FRACTION
--
-- WELL  SOLVENT
-- NAME  FRACTION
--       --------
WSOLVENT
GI01     0.0000                                          /
GI02     0.5000                                          /
GI03     0.5000                                          /
/
```

The solvent fraction for the GI01 gas injector is set to zero and both GI02 and GI03 gas injectors have solvent fraction values of 0.5 for their injection streams.

12.3.318 WSURFACT - DEFINE WATER INJECTION WELL SURFACTANT CONCENTRATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WSURFACT defines a water injection well's surfactant concentration in the injection stream that is to be used when the Surfactant phase has been activated by either the SURFACT or SURFACTW keywords in the RUNSPEC section.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name of a gas injection well for which the solvent fraction data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	SURCON	A real positive value that defines the surfactant concentration of the well's injection stream.			None
		lb/stb	kg/sm^3	gm/scc	

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.97: WSURFACT Keyword Description

Water injection wells that are not declared via this keyword have their surfactant concentrations set to zero.

See also the GCONINJE keyword to define a group's injection targets and constraints, and the WCONINJE keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the surfactant concentrations for three water injection wells for when the surfactant phase option has been activated by either the SURFACT or SURFACTW keywords in the RUNSPEC section.

```
--
--        DEFINE WATER INJECTION WELL SURFACTANT CONCENTRATION
--
-- WELL   SURFACT
-- NAME   SURCON
--        --------
WSURFACT
WI01      0.2000                                          /
WI02      0.2000                                          /
WI03      0.2000                                          /
/
```

Here the surfactant concentration has been set to 0.200 for all three wells.

12.3.319 WTADD – ADD A CONSTANT TO A WELL TARGET OR CONSTRAINT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WTADD, adds a constant to a previously define well's target or constraint, as stated on the WCONPROD, WCONINJE, or WELTARG keywords, but not for the history matching wells using the WCONHIST or WCONINJH keywords. All the aforementioned keywords are in the SCHEDULE section. The constant can be positive or negative.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.320 WTEMP – DEFINE AN INJECTION WELL'S FLUID TEMPERATURE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WTEMP keyword defines the temperature of the injection fluid being injected by an injection well.

This keyword can only be used if OPM Flow's thermal option has been activated by the THERMAL keyword in the RUNSPEC section. Note this is different to the commercial simulator that users the TEMP keyword in the RUNSPEC section to activate the "black-oil" thermal model.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for an injection well for which the injection well fluid's temperature data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	TEMP	A real positive value greater than zero that defines the temperature of the injected fluid.			None
		°F	°C	°C	

Notes:

1) Injection wells that are not declared via this keyword have their injection fluid temperatures set to zero degrees in the run's units.

2) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.98: WTEMP Keyword Description

See also the GCONINJE keyword to define a group's injection targets and constraints, and the WCONINJE keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the injected fluid temperatures for three water injection wells for when the thermal option has been activated by the THERMAL keyword in the RUNSPEC section.

```
--
--       DEFINE INJECTION WELL FLUID TEMPERATURE
--
-- WELL  FLUID
-- NAME  TEMP.
--       --------
WTEMP
WI01     39.00                                          /
WI02     37.00                                          /
WI03     39.00                                          /
/
```

Here wells WI01 and WI03 inject water with a water temperature of 39 °F and well WI02's injection water temperature is 37 °F.

12.3.321 WTEMPQ – Output Well Names and Well Lists to the Print File

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WTEMPQ prints out a user defined selected list of currently defined wells and well lists to the print file (*.PRT). The keyword allows for sub-setting the well names etc., using the normal well and well list naming conventions. For example to list all wells beginning with the characters "OP" then one would use "OP*" as the well name on this keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.322 WTEST – WELL TESTING CRITERIA FOR RE-OPENING CLOSED WELLS

Description

The WTEST keyword outlined the testing procedures to be applied to wells that are closed for various reason to see if the wells are capable flowing under the current operating conditions. The keyword can be applied to single wells or groups of wells.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which the well connection data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	TIME	A real value greater than to zero that defines the period before another test is performed, for example if TIME is set equal to 365.25 (days), the test is performed every year.			
		days	days	hours	None
3	TEST	A character string of up to five characters that defines the reason the well was closed. If a well was closed for one of the criteria then the well is tested to see if it can be put back on production. The characters that can be used to define TEST are as follows: 1) P: meaning the well was closed due to a bottom-hole or tubing head pressure limit, or other physical limit then the well is tested to see if it can flow, if it can then it is put back on production, otherwise it remains closed. 2) E: meaning the well was closed due to a well or a well connection economic constraint then the well is tested to see if it can flow, if it can then it is put back on production, otherwise it remains closed. 3) G: meaning the well was closed due to a group economic constraint then the well is tested to see if it can flow, if it can then it is put back on production, otherwise it remains closed. 4) D: not used by OPM Flow. 5) C: not used by OPM Flow. The default value is an empty string " " that switches of testing. ***Note that only the E option is currently supported in OPM Flow.***			" "
4	NTIME	A positive integer greater than or equal to zero that define the number of times a well can be tested. The default value of zero means an infinite number of times.			0
5	START	A real positive value that defines the start up time used to prorate the rate at which the well is put back on production. If START is large compared to the tiime step size, then the well is brought on gradually, if it is less then the well is opened faster. The default value of 0.0 means the well is opened immediately.			
		days	days	hours	0.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
Notes: 1) The keyword is followed by any number of records and each record is terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.99: WTEST Keyword Description

See also the WELSPECS keyword to define a wells shut-in or stop options, WECON for setting a well's economic criteria, GCONPROD and GCONINJE for group controls, and GECON for setting a group's economic criteria. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines test criteria for all gas wells ("GP*") and three oil wells (OP01, OP02, and OP03).

```
--
--
--       WELL TESTING CRITERIA FOR RE-OPENING CLOSED WELLS
--
-- WELL  TST    TST    NO.    STRT
-- NAME  INTV   TYPE   TSTS   TIME
-- ----  ----   ----   ----   ----
WTEST
'GP*'    365.25 P      5      0.0
OP01     30.0   PEG    0      0.0                                                    /
OP02     30.0   PEG    0      0.0                                                    /
OP03     30.0   PEG    0      0.0                                                    /
/
```

All the gas wells are test annually if they have been shut-in due to a bottom-hole or tubing head pressure limit, are tested five times after they have been closed, and are opened up immediately. The oil wells are tested every 30 days if they have been closes due bottom-hole or tubing head pressure limit, a well economic limit or a group economic limit. All the oil wells are tested an infinite amount of times and are opened up immediately. ***Note that only the E option is currently supported in OPM Flow.***

12.3.323 WTHPMAX – Define a Well's Maximum Flowing THP for Shut-In

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

WTHPMAX stipulates a well's maximum flowing Tubing Head Pressure ("THP"), above which the well will be shut-in. The facility is useful if the THP exceeds the wellhead maximum design pressure, which can occur if excessive gas invades the wellbore. In addition to setting the maximum THP, the keyword defines the criteria for re-testing the well to see if the THP has fallen below the maximum value.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.324 WTMULT – MULTIPLE A WELL TARGET OR CONSTRAINT BY A CONSTANT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WTMULT multiplies a define well's target or constraint by a constant, for the target and constraints previously stipulated on the WCONPROD, WCONINJE, or WELTARG keywords, but not for the history matching wells using the WCONHIST or WCONINJH keywords. All the aforementioned keywords are in the SCHEDULE section. The constant should be positive value.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.325 WTRACER – DEFINE AN INJECTION WELL'S TRACER CONCENTRATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WTRACER keyword defines the tracer concentration of the injection fluid being injected by an injection well. This keyword should only be used if the Tracer option has been invoked by the TRACERS keyword in the RUNSPEC section and the tracers have be declared via the TRACER keyword in the PROPS section.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name of an injection well for which the tracer fraction data is being defined. Note that the well name (WELNAME) must have been declared previously using the WELSPECS keyword in the SCHEDULE section, otherwise an error may occur.			None
2	NAME	A three letter character string defining the tracer's name which has previously been defined via the TRACER keyword in the PROPS section. Note it is best to void names beginning with the letters F, S, and T as these names may create naming issues in post-processing software.			None
3	TRCON	A real positive value that defines the tracer concentration of the well's injection stream.			Same as the phases in the model
		Liquid: 1/stb Gas: 1/Mscf	Liquid: 1/sm^3 Gas: 1/sm^3	Liquid: 1/scc Gas: 1/scc	
4	TRCUM	A real positive value that defines the cumulative tracer concentration factor of the well's injection stream. This feature is currently not supported by OPM Flow.			Same as the phases in the model
		Liquid: 1/stb Gas: 1/Mscf	Liquid: 1/sm^3 Gas: 1/sm^3	Liquid: 1/scc Gas: 1/scc	
5	GRPNAME	A character string of up to eight characters in length that defines the group from which the produced tracer concentration should be used for the well's injection stream. GRPNAME must have been previously defined via the GCONPROD keyword in the SCHEDULE section, unless the FIELD group has been specified here. Note if GRPNAME is not defined then TRCON will be used for the tracer concentration of the well's injection stream. This feature is currently not supported by OPM Flow.			None

Notes:

1) The keyword is followed by any number of records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.100: WTRACER Keyword Description

Injection wells that are not declared via this keyword have their tracer concentrations set to zero.

See also the GCONINJE keyword to define a group's injection targets and constraints, and the WCONINJE

keyword to define an injection well's targets and constraints. All the aforementioned keywords are described in the SCHEDULE section.

Example

The following example defines the tracer concentrations for two gas injectors and three water injection wells, with water injection well WI02 having no 'WAT' tracer injected in the water phase.

```
--
--       DEFINE CONCENTRATION OF TRACERS IN THE INJECTION STREAMS,
--       INJECTION TRACER CONCENTRATIONS NOT DEFINED USING THE WTRACER
--       KEYWORD ARE ASSUMED TO BE ZERO.
--
-- WELL  NAME    TRACER  TRACER  TRACER
-- NAME  TRACER  CONC    CUM     GROUP
WTRACER
GI01     'GAS'   1.0                                    /
GI02     'GAS'   1.0                                    /

WI01     'WAT'   1.0                                    /
WI02     'WAT'   0.0                                    /
WI03     'WAT'   1.0                                    /
/
```

Note the terminating "/" for the keyword.

12.3.326 WVFPDP – MODIFY WELL BHP OBTAINED FROM VFP TABLES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WVFPDP keyword modifies a well's Bottom-Hole Pressure ("BHP") estimated by the simulator by interpolation of the Vertical Flow Performance ("VFP") tables. The production VFP tables are entered via the VFPPROD keyword and the injection tables by the VFPINJ keyword; both keywords are in the SCHEDULE section.

Note that simulator automatically adjusts the interpolated BHP to account for hydrostatic head using the density of the wellbore fluid and the difference between a well's BHP reference depth, as per the BHPREF parameter on the WELSPECS or WELSPECL keywords in the SCHEDULE section, and the VFPREF parameter reference depth on the VFPPROD and VFPINJ keywords. Thus, WVFPDP applies an additional adjustment in order to match a well's flow rate to a given tubing head pressure, by adjusting the BHP.

This keyword is ignored by OPM Flow and has no effect on the simulation but is documented here for completeness.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	WELNAME	A character string of up to eight characters in length that defines the well name for which VFP interpolated BHP adjustment is to be applied. Note that the well name (WELNAME) must have been declared previously using the WELSPECS and WCONPROD (or WCONINJE) keywords in the SCHEDULE section, otherwise an error may occur.			None
2	DELTAP	A real positive or negative value that is added to the VFP interpolated BHP value (BHP_{VFP}). A positive value of DELTAP increases the BHP and therefore makes a production well less productive; whereas, a negative value is subtracted from the BHP and therefore increases the productivity of a production well. Consequently, the opposite effect occurs for injection wells, that is, a positive value of BHP_{VFP} increases the BHP and therefore increases an injection well's injectivity; whereas, a negative value is subtracted from the BHP and therefore decreases the injectivity of an injection well.			
		psia	barsa	atma	0.0
3	MULTP	MULTP is a real positive or negative value that scales the tubing pressure loss by the following equation; $BHP_{Adjusted} = THP + MULTP\left(BHP_{VFP} - THP\right)$ Thus, a MULTP value greater then 1.0 increases the BHP and therefore makes a production well less productive; whereas, a value less than 1.0 increases the productivity of a production well. Consequently, the opposite effect occurs for injection wells			
		dimensionless	dimensionless	dimensionless	1.0

Notes:

1) The keyword is followed by any number records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.101: WVFPDP Keyword Description

Example

The following example below shows three oils operating under THP control.

```
-- ------------------------------------------------------------------------------
-- 01 JAN 2000 START OF SCHEDULE SECTION
-- ------------------------------------------------------------------------------
--
--       WELL PRODUCTION WELL CONTROLS
--
-- WELL  OPEN/  CNTL   OIL    WAT    GAS   LIQ    RES    BHP    THP   VFP    VFP
-- NAME  SHUT   MODE   RATE   RATE   RATE  RATE   RATE   PRES   PRES  TABLE  ALFQ
WCONPROD
OP01     OPEN   THP    1*     1*     1*    5000   1*     750.0  500.  9      1* /
OP02     OPEN   THP    1*     1*     1*    5000   1*     750.0  500.  9      1* /
OP03     OPEN   THP    1*     1*     1*    5000   1*     750.0  500.  9      1* /
/
--
--       WELL VFP BHP-THP CORRECTION DATA
--
--  WELL BHP     BHP
--  NAME DELTAP  MULTP
WVFPDP
OP01     20.0    1*                                          /
OP01     -5.0    1*                                          /
OP01      0.0    1.10                                        /
/
```

Well OP01 has a delta pressure correction of 20 psia applied to it's BHP resulting in a reduction in the well's productivity for the given 500.0 psia THP operating target. For well OP02, the well's productivity is increased by subtracting 5.0 psia from the BHP. And finally for well OP03, the MULTP value of 1.10 decreases the well's productivity by increasing the pressure loss between the THP and BHP by 10%.

12.3.327 WVFPEXP – DEFINE WELL VFP INTERPOLATION OPTIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword, WVFPEXP, defines how Vertical Flow Performance ("VFP") tables are interpolated and can be used to resolve certain issues with wells operating under tubing head pressure control. For example, setting the VFP table to interpolate explicitly, that is using the previous time step results of the gas and water ratios for an oil well, may improve convergence. The default is to use implicit interpolation that uses the current time step values and may result in solution convergence oscillations in solving the linear equations.

The WCONPROD keyword is used to allocate the VFPPROD tables to specific production wells and the WCONINJE keyword for assigning the VFPINJ tables for injection wells. Note that one VFP table can be allocated to one or more wells; however, WVFPEXP is applied to a well's allocated VFP table, not to all wells that use the same table, unless specially requestd. All the aforementioned keywords are in the SCHEDULE section.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.328 WWPAVE – Well Block Average Pressure Calculation Parameters for Individual Wells

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The WWPAVE keyword defines the method and parameters for calculating a well's block average pressures for individual wells. The resulting average pressure can be written out to the summary file in order to compared with field observed data. The keyword is similar to the WPAVE keyword in the SCHEDULE section that has similar functionality, but is applied to all wells in the model.

Note that WWPAVE will overwrite any parameters on the WPAVE keyword for a given well, and that WWPAVE can also be overwritten by any subsequent WPAVE keyword.

This keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.329 ZIPP2OFF – DEACTIVATE AUTOMATIC TIME STEP CONTROL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ZIPP2OFF keyword deactivates the commercial simulator's alternative automatic time step selection algorithm that assumes no prior knowledge of the problem, as opposed to the standard time step algorithm that is controlled via the TUNNING keyword in the SCHEDULE section, combined with posterior knowledge gained from previous time steps.

This keyword is ignored by OPM Flow and has no effect on the simulation.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to control time stepping for OPM Flow.

12.3.330 ZIPPY2 – ACTIVATE AUTOMATIC TIME STEP CONTROL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ZIPPY2 keyword activates the commercial simulator's alternative automatic time step selection algorithm that assumes no prior knowledge of the problem, as opposed to the standard time step algorithm that is controlled via the TUNNING keyword in the SCHEDULE section, combined with posterior knowledge gained from previous time steps.

This keyword is ignored by OPM Flow and has no effect on the simulation.

See section *2.2 Running OPM Flow 2020-04 From The Command Line* on how to control time stepping for OPM Flow.

APPENDIX A: KEYWORD INDEX - ALPHABETIC LISTING

A

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter A	Status
ACTDIMS – ACTION Keyword Dimensions	
ACTION – Define Action Conditions and Command Processing (Field)	
ACTIONG – Define Action Conditions and Command Processing (Groups)	
ACTIONR – Define Action Conditions and Command Processing (Regions)	
ACTIONS – Define Action Conditions and Command Processing (Well Segments)	
ACTIONW – Define Action Conditions and Command Processing (Wells)	
ACTIONX – Define Action Conditions and Command Processing	
ACTNUM – Set the Status of a Grid Block To Active or Inactive	
ACTPARAM – Define Action Facility Target and Tolerance Parameters	
ADD – Add a Constant to a Specified Array	
ADDREG – Add a Constant to an Array based on a Region Number	
ADDZCORN – Add a Constant to the ZCORN Depth Array	
ADSALNOD – Salt Concentration Based on SATNUM Array	
ADSORP – Define Generalized Langmuir Adsorption Function	
AITS – Activate Intelligent Time Stepping	
AITSOFF – Deactivate Intelligent Time Stepping	
ALKADS – Define Alkaline Adsorption Functions	
ALKALINE – Activate the Alkaline Phase and Model	
ALKROCK – Define Rock Alkaline Properties	
ALL – Export Standard Summary Variable Vectors to File	
ALPOLADS – Polymer Adsorption versus Alkaline Concentration Multipliers	
ALSURFAD – Surfactant Adsorption versus Alkaline Concentration Multipliers	
ALSURFST – Water-Oil Surface Tension versus Alkaline Concentration Multipliers	
AMALGAM – Define LGR Amalgamations	
API – Activate API Tracking	
APIGROUP – Define API Tracking Number of Grouped Oil PVT Tables	
APILIM – Define API Tracking Grid Block Limits	
APIVD - Equilibration Oil API Gravity versus Depth Tables	
AQANCONL – Define Analytical Connections to a LGR Grid	
AQANNC – Define Analytic Aquifer Non-Neighbor Connections	
AQANTRC - Define Analytic Aquifer Initial Tracer Concentrations	

A

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter A	Status
AQUALIST – Define An Analytic Aquifer Name to Aquifer Numbers	
AQUANCON – Define Analytical Connections to the Grid	
AQUCHGAS – Define Constant Pressure Gas Analytical Aquifer Properties	
AQUCHWAT – Define Constant Pressure Water Analytical Aquifer Properties	
AQUCON – Define Numerical Aquifer Connections to the Grid	
AQUCT – Define Carter-Tracy Analytical Aquifers	
AQUCWFAC – Modify Constant Pressure Water Analytical Aquifer Properties	
AQUDIMS – Define Aquifer Dimensions	
AQUFET – Define Fetkovich Analytical Aquifer and Connections	
AQUFETP – Define Fetkovich Analytical Aquifers	
AQUFLUX - Define Constant Flux Analytical Aquifer	
AQUNNC – Define Numerical Aquifer Non-Neighbor Connections	
AQUNUM – Define Numerical Aquifer Properties	
AQUTAB – Define Carter-Tracy Aquifer Influence Functions	
AUTOCOAR - Define Auto Refinement Grid Coarsen Area	
AUTOREF - Define Auto Refinement Options	

B

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter B	Status
BDENSITY – Define the Surface Brine Density for the Fluid	
BGGI - Define Gi Gas Formation Volume Factor Pressure Tables	
BIGMODEL – Activate Big Model Option (Retired)	
BLACKOIL – Activate Black Oil Phases	
BOGI - Define Gi Oil Formation Volume Factor Pressure Tables	
BOUNDARY – Define a Boundary Box for Printing	
BOX - Define a Range of Grid Blocks to Enter Property Data	
BPARA – Activate Block Parallel License	
BPIDIMS – Define the Dimensions of the Interpolated Block Quantities	
BRANPROP – Define Network Branch Properties for Extended Network Option	
BRINE – Activate Brine Tracking Option	
BTOBALFA – Dual Porosity Matrix to Fracture Multiplier (All Cells)	
BTOBALFV – Dual Porosity Matrix to Fracture Multiplier (Individual Cells)	

C

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter C	Status
CALTRAC – Define a Gas Calorfic Value Tracer	
CARFIN – Define a Cartesian Local Grid Refinement	
CART – Activate Cartesian Geometry	
CBMOPTS – Define Coal Bed Methane Options	
CECON – Define Well Connections Economic Limit Criteria	
CECONT – Define Well Connections Tracer Economic Limit Criteria	
COAL – Activate the Coal Phase (CBM Model)	
COALADS – Define Gas and Solvent Relative Adsorption Tables	
COALNUM – Define the Coal Region Numbers	
COALPP – Define Gas and Solvent Partial Pressure Adsorption Tables	
COARSEN – Define Grid Coarsening Cells	
COLLAPSE – Define Compressed Vertical Equilibrium Cells	
COLUMNS – Define Input File Column Margins	
COMPDAT – Define Well Connections to the Grid	
COMPDATL – Define Well Connections to a LGR Grid	
COMPDATM – Define Well Connections to an Amalgamated LGR Grid	
COMPIMB – Assign Imbibition Saturation Tables to Well Connections	
COMPINJK – Assign Injection well Relative Permeability Values	
COMPLMPL – Assign Well LGR Connections to Completions	
COMPLUMP – Assign Well Connections to Completions	
COMPOFF – Deactivate Network Automatic Compressors	
COMPORD - Define Well Connection Ordering	
COMPRIV – Define Grid Cell Connections to a River	
COMPRP – Re-Scale Fluid Saturations of Well Connections	
COMPRPL – Re-Scale Fluid Saturations of Well LGR Connections	
COMPSEGL – Define Well Connections for Multi-Segment Wells in a LGR	
COMPSEGS – Define Well Connections for Multi-Segment Wells	
COMPVE – Re-Define Well Connection Depths	
COMPVEL – Re-Define Well LGR Connection Depths	
COORD – Define a Set of Coordinates Lines for a Reservoir Grid	

C

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter C	Status
COORDSYS – Define Coordinate Grid Options	
COPY – Copy Array Data to Another Array	
COPYBOX – Copy Array Data Defined by a Box	
COPYREG – Copy an Array to Another Array based on a Region Number	
CPIFACT – Define Well Connection Transmissibility Multipliers	
CPIFACTL – Define Well Connection Transmissibility Multipliers in a LGR	
CPR – Activate Constrained Pressure Residual ("CPR") Linear Solver	
CRITPERM – Define Minimum Permeability for Vertical Equilibrium Grid Cell Compression	
CSKIN – Re-Define Well Connection Skin Factors	

D

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter D	Status
DATE - Activate the DATE Option for the SUMMARY File	
DATES – Advance Simulation by Reporting Date	
DATUM – Define the Datum Depth for the Model	
DATUMR – Define Datum Depths for the FIPNUM Regions	
DATUMRX – Define Datum Depths for the FIP Allocated Regions	
DCQDEFN – Define Gas DCQ Units as Rate or Energy	
DEBUG – Define the Debug Data to be Printed to File	
DELAYACT - Define Delayed Action Keywords	
DENSITY – Define the Surface Oil, Water Gas Densities for the Fluids	
DEPTH - Edits the Depth at the Center of Each Cell	
DEPTHTAB – River Time and Depth Tables	
DIAGDISP – Activate Alternate Form of Tracer Dispersion	
DIFFC – Define PVT Region Molecular Diffusion Tables	
DIFFCOAL – Define Coal Bed Methane Gas Diffusion Data	
DIFFDP – Activate Dual Porosity Molecular Diffusion for Matrix-Fracture Flow Only	
DIFFMMF – Define Diffusivity Multipliers for Matrix-Fractures	
DIFFMR – Define Grid Block Radial Direction Diffusivity Multipliers	
DIFFMR- – Define Grid Block Negative Radial Direction Diffusivity Multipliers	
DIFFMTHT – Define Grid Block Theta Direction Diffusivity Multipliers	
DIFFMTH- – Define Grid Block Negative Theta Direction Diffusivity Multipliers	
DIFFMX – Define Grid Block X-Direction Diffusivity Multipliers	
DIFFMX- – Define Grid Block Negative X-Direction Diffusivity Multipliers	
DIFFMY – Define Grid Block Y-Direction Diffusivity Multipliers	
DIFFMY- – Define Grid Block Negative Y-Direction Diffusivity Multipliers	
DIFFMZ – Define Grid Block Z-Direction Diffusivity Multipliers	
DIFFMZ- – Define Grid Block Negative Z-Direction Diffusivity Multipliers	
DIFFR – Define Grid Block Radial Direction Diffusivity Values	
DIFFTHT – Define Grid Block Theta Direction Diffusivity Values	
DIFFUSE – Activate Molecular Diffusion Option	
DIFFX – Define Grid Block X-Direction Diffusivity Values	

D

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

DIFFY – Define Grid Block Y-Direction Diffusivity Values	
DIFFZ – Define Grid Block Z-Direction Diffusivity Values	
DIMENS – Define the Dimension of the Model	
DIMPES – Define IMPES Dynamic Solution Parameters	
DIMPLICT – Activate Fully Implicit Dynamic Solution Formulation	
DISGAS – Activate the Dissolved Gas Phase in the Model	
DISPDIMS – Define the Maximum Number of Dispersion Tables	
DISPERSE– Define Dispersion Tables	
DOMAINS – Define the Parallel Domain Properties	
DPGRID – Activate The Matrix Cell to Fracture Cell Option	
DPKRMOD – Modify Matrix Oil Relative Permeability Data	
DPNUM – Define Dual and Single Porosity Grid Block Array	
DR - Define the Size of Grid Blocks in the R Direction for All Cells	
DRILPRI – Define Prioritized Drilling Queue Priority Parameters	
DRSDT – Solution Gas (Rs) Maximum Rate of Increase Parameters	
DRSDTR – Solution Gas (Rs) Maximum Rate of Increase Parameters by Region	
DRV - Define the Size of Grid Blocks in the R Direction via a Vector	
DRVDT – Solution Oil (Rv) Maximum Rate of Increase Parameters	
DRVDTR – Solution Oil (Rv) Maximum Rate of Increase Parameters by Region	
DSPDEINT – Activate Brine Tracer Dispersion Interpolation by Water Density	
DTHETA - Define the Size of Grid Blocks in the THETA Direction for All Cells	
DTHETAV - Sets the Size of Grid Blocks in THETA Direction via a Vector	
DUALPERM – Activate Dual Permeability Model	
DUALPORO – Activate Dual Porosity Model	
DUMPCUPL – Activate Output to the Reservoir Coupling File	
DUMPFLUX – Activate Writing Out of a Flux File	
DX - Define the Size of Grid Blocks in the X Direction for All Cells	
DXV - Define the Size of Grid Blocks in the X Direction via a Vector	
DY - Define the Size of Grid Blocks in the Y Direction for All Cells	
DYNAMICR – Start of Dynamic Region Parameter Definition	
DYNRDIMS – Define Dynamic Region Dimensions	

D

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

DYV - Define the Size of Grid Blocks in the Y Direction via a Vector	
DZ - Define the Size of Grid Blocks in the Z Direction for All Cells	
DZMATRIX - Matrix Block Height for Gravity Drainage Model For All Cells	
DZMTRX - Matrix Block Height for Gravity Drainage Model for the Grid	
DZMTRXV - Matrix Block Height for Gravity Drainage Model For All Cells	
DZNET – Define Grid Block Net Thickness for All Cells	
DZV - Define the Size of Grid Blocks in the Z Direction via a Vector	

E

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter E	Status
ECHO – Activate Echoing of User Input Files to the Print File	
ECLMC – Activate Multi-Component Brine Model	
EDIT - Define the Start of the EDIT Section of Keywords	
EDITNNC – Scale Non-Neighbor Connections Between Cells Manually	
EDITNNCR – Reset Non-Neighbor Connections Between Cells Manually	
EHYSTR – Define Hysteresis Model and Parameters	
EHYSTRR – Define Hysteresis Model and Parameters via SATNUM	
END – Define the End of the Input File	
ENDACTIO – End the Definition of ACTION Commands	
ENDBOX – Define the End of the BOX Defined Grid	
ENDDYN– End of Dynamic Region Parameter Definition	
ENDFIN – End the Definition of a Local Grid Refinement	
ENDINC – Define the End of an Include File	
ENDNUM – Define the End-Point Scaling Depth Region Numbers	
ENDSCALE – Activate Relative Permeability End-Point Scaling Option	
ENDSKIP – DeActivate Skipping of Keywords and Input Data	
ENKRVD – Define Relative Permeability End-Points versus Depth Functions	
ENKRVDX	
ENKRVDX-	
ENKRVDY	
ENKRVDY-	
ENKRVDZ	
ENKRVDZ-	
ENPCVD – Define Maximum Capillary Pressure versus Depth Functions	
ENPTVD – Define Relative Permeability Saturation End-Points versus Depth	
ENPTVDX	
ENPTVDX-	
ENPTVDY	
ENPTVDY-	
ENPTVDZ	

E

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter E	Status
ENPTVDZ-	
ENSPCVD – Define Capillary Pressure End-Points versus Depth	
EPSDBGS - Write End-Point Debug Data to the DEBUG File (Multiple)	
EPSDEBUG - Write End-Point Debug Data to the DEBUG File (Individual)	
EQLDIMS – Define the Equilibration Data Dimensions	
EQLNUM – Define the Equilibration Region Numbers	
EQLOPTS – Activate the Equilibration Options	
EQLZCORN - Modify the Depth of the Corner-Point Depth Array	
EQUALREG – Sets an Array to a Constant by Region Number	
EQUALS – Sets a Specified Array to a Constant	
EQUIL – Define the Equilibration Initialization Data	
ESSNODE – Define Salt Concentration Data for Water-Oil Surface Tension	
EXCAVATE - Set the Status of a Grid Block To Active or Excavate	
EXCEL - Activate the EXCEL Option for the SUMMARY File	
EXIT – Exit Simulation from within an Action Section	OPM Flow
EXTFIN - Define an External Unstructured Local Grid Refinement	
EXTHOST - Define Host Cells for External LGRs	
EXTRAPMS – Activate Extrapolation Warning Messages	
EXTREPGL - Define Host Cells for External Unstructured LGRs	

F

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter F	Status
FAULTDIM – Define the Number of Fault Segments	
FAULTS – Define Faults in the Grid Geometry	
FBHPDEF – Define Well Default BHP Target and Constraints	
FHERCHBL – Define Herschel-Bulkley Data versus Polymer Concentration	
FIELD – Activate the Oil Field System of Units for the Model	
FILEUNIT – Activate Unit Consistency Checking	
FILLEPS – Activate Saturation End-Point Export to the INIT File	
FIP – Define the Fluid In-Place Names and Region and Numbers	
FIPNUM – Define the Fluid In-Place Region Numbers	
FIPOWG – Activate Oil, Gas, and Water FIP Zone Reporting	
FLUXNUM – Define the Flux Regions	
FLUXREG – Define Active Flux Regions	
FLUXTYPE – Defines the Flux Boundary Type	
FMTHMD – Activate The Format History Match Gradient File Option	
FMTIN – Activate The Format Input File Option	
FMTOUT – Activate The Format Output File Option	
FMWSET - Export Well Status Vectors for the Field to File	
FOAM – Activate the Foam Phase and Model	
FOAMADS - Define Foam Rock Adsorption Tables	
FOAMDCYO – Define Foam Decay versus Oil Saturation Tables	
FOAMDCYW – Define Foam Decay versus Water Saturation Tables	
FOAMFCN – Define Foam Gas Mobility Reduction versus Capillary Number	
FOAMFRM – Define Foam Gas Mobility Reduction versus Reference Mobility	
FOAMFSC – Define Foam Gas Mobility versus Surfactant Concentration Functions	
FOAMFSO – Define Foam Gas Mobility Reduction versus Oil Saturation	
FOAMFST – Define Foam Gas-Water Surface Tension versus Surfactant Concentration	
FOAMFSW – Define Foam Gas Mobility Reduction versus Water Saturation	
FOAMMOB - Define Foam Gas Mobility versus Foam Concentration Tables	
FOAMMOBP – Define Foam Mobility Reduction versus Oil Pressure	
FOAMMOBS – Define Foam Mobility Reduction versus Shear	

F

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter F	Status
FOAMOPTS - Define Foam Model Options	
FOAMROCK - Define Foam Rock Properties	
FORMFEED – Defined the Print File Form-Feed Character	
FMWSET - Export Well Status Vectors for the Field to File	
FRICTION – Activate Wellbore Friction Option	
FULLIMP – Activate Fully Implicit Solution Option	

G

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter G	Status
GAS – Activate the Gas Phase in the Model	
GASBEGIN – Define Start of Annual Scheduling Section	
GASCONC – Define the Initial Equilibration Coal Gas Concentration for All Grid Blocks	
GASDENT – Define Gas Density Temperature Coefficients	OMP Flow
GASEND – Define End of Annual Scheduling Section	
GASFCOMP – Define Automatic Gas Compressors	
GASFDECR – Define Field Gas Sales Contract Monthly Reduction	
GASFDELC – Define Gas Deliverability Calculation	
GASFIELD – Define Gas Field Operations Options	
GASFTARG – Define Field Gas Sales Contract Monthly Target	
GASMONTH – Define Start of Annual Scheduling Event	
GASPERIO – Advance Simulation by Gas Contract Period	
GASSATC – Define the Initial Equilibration Saturated Coal Gas Concentration for All Grid Blocks	
GASVISCT – Define Gas Viscosity versus Temperature Functions	
GASYEAR – Advance Simulation by Gas Contract Year	
GCALECON – Group Economic Criteria for Production Calorific Groups	
GCONCAL – Group Production Calorific Targets	
GCONENG – Group Production Energy Targets	
GCONINJE – Group Injection Targets and Constraints	
GCONPRI – Group Production Priority Targets and Constraints	
GCONPROD – Group Production Targets and Constraints	
GCONSALE – Define Group Sales Gas Production Targets and Constraints	
GCONSUMP – Define Group Gas Consumption and Gas Import Targets	
GCONTOL – Define Group Constraint Tolerance	
GCUTBACK – Define Group Cutback Limits and Parameters	
GCUTBACT – Define Group Tracer Cutback Limits and Parameters	
GCVD – Define Equilibration Coal Gas Concentration versus Depth Tables	
GDCQ – Define Group Multiple Daily Contract Quantities	
GDCQECON – Group Economic Criteria for DCQ Production Groups	
GDFILE – Load a Grid File	

G

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter G	Status
GDIMS – Activate Instantaneous Gradient Option and Define Dimensions	
GDORIENT - Define Grid Orientation Parameters	
GDRILPOT – Define Group Potential Rates for Automatic Drilling	
GECON – Group Economic Criteria for Production Groups	
GECONT – Group Tracer Economic Criteria for Production Groups	
GEFAC – Define Group Efficiency	
GETDATA – Load and Assign Data Array from INIT or RESTART Files	
GETGLOB – Activate Loading of Global Grid Restart Data Option	
GI - Define the Initial Equilibration Gi Values for All Grid Blocks	
GIALL – Define Gi Values and PVT Properties versus Pressure	
GIMODEL – Activate Gi Pseudo Compositional Option	
GINODE – Define Gi Node Values	
GLIFTLIM – Group Artificial Lift Constraints	
GLIFTOPT – Define Group Gas Optimization Limits	
GMWSET - Export Well Status Vectors by Group to File	
GNETDP – Group Network Pressure and Rate Controls	
GNETINJE – Define Group Injection Network Configuration	
GNETPUMP – Standard Network Automatic Compressor and Pumps	
GPMAINT – Define Group Pressure Maintenance Targets and Controls	
GRADGRUP – Define Group History Match Gradient File Output	
GRADRESV – Define Solution Derivative History Match Gradient Output	
GRADRFT – Define RFT Derivative History Match Gradient Output	
GRADWELL – Define Well History Match Gradient File Output	
GRAVCONS – Re-Define Gravity Constant	
GRAVDR – Activate Gravity Drainage and Imbibition for Dual Porosity Model	
GRAVDRB - Activate Vertical Discretized Gravity Drainage and Imbibition for Dual Porosity Model	
GRAVDRM - Activate Alternative Gravity Drainage and Imbibition for Dual Porosity Model	
GRAVITY– Define the Surface Oil, Water Gas Gravities for the Fluids	
GRDREACH – Define River and Grid Block Connections	
GRID - Define the Start of the GRID Section of Keywords	

G

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter G	Status
GRIDFILE – Set the Grid File Output Options	
GRIDOPTS - Grid Processing Options	
GRIDUNIT – Define the Grid Units	
GRUPMAST – Define Master and Slave Groups	
GRUPNET – Define Group Standard Network Parameters	
GRUPRIG – Group Drilling and Workover Rig Specifications	
GRUPSLAV – Define Slave Groups in Slave Reservoirs	
GRUPTARG – Modify Group Targets and Constraints Values	
GRUPTREE – Define Group Tree Hierarchy	
GSATINJE – Define Group Satellite Injection Rates	
GSATPROD – Define Group Satellite Production Rates	
GSEPCOND – Assign Group Separators	
GSSCPTST – Perform Sustainable Capacity Test	
GSWINGF – Define Group Multiple Gas Contract Parameters	
GTADD – Add a Constant to a Group Target or Constraint	
GTMULT – Multiply Group Target or Constraint by a Constant	
GUIDECAL – Scale Guide Rates Based on Gas Calorific Value	
GUIDERAT – Define Group Guide Rate Formula	
GUPFREQ – Instantaneous Gradient Option Update Frequency	
GWRTWCV – Instantaneous Gradient Option Well Variables	

H

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter H	Status
HALFTRAN – Activate Half Block Transmissibility Calculations	
HA – History Match End-Point Gradient Additive Modifier	
HAKRG	
HAKRGR	
HAKRO	
HAKRORG	
HAKRORW	
HAKRW	
HAKRWR	
HAPCG	
HAPCG	
HASGLPC	
HASOGCR	
HASOWCR	
HASWL	
HASWLPC	
HBNUM – Define Herschel-Bulkley Region Numbers	
HDISP – Define Tracer Mechanical Dispersivity Parameters	
HEATCR – Define Reservoir Rock Heat Capacity for All Cells	
HEATCRT – Define Reservoir Rock Heat Capacity Temperature Dependence for All Cells	
HM – History Match End-Point Gradient Multiplicative Modifier	
HMKRG	
HMKRGR	
HMKRO	
HMKRORG	
HMKRORW	
HMKRW	
HMKRWR	
HMPCG	
HMPCG	
HMSGLPC	

H

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter H	Status
HMSOGCR	
HMSOWCR	
HMSWL	
HMSWLPC	
HM – History Match Region Gradient Parameters	
HMKRG	
HMKRGR	
HMKRO	
HMKRORG	
HMKRORW	
HMKRW	
HMKRWR	
HMPERMX	
HMPERMY	
HMPERMZ	
HMPORVM	
HMPRMXY	
HMSGCR	
HMSGL	
HMSGLPC	
HMSIGMA	
HMSOGCR	
HMSOWCR	
HMSWCR	
HMSWL	
HMSWLPC	
HMTRANX	
HMTRANY	
HMTRANZ	
HMTRNXY	
HMAQUCT – History Match Carter-Tracy Aquifer Gradient Parameters	

H

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter H	Status
HMAQUFET – History Match Fetkovich Aquifer Gradient Parameters	
HMAQUNUM - History Match Numerical Aquifer Gradient Parameters	
HMDIMS – Define History Match Gradient Parameter Dimensions	
HMFAULTS – History Match Fault Gradient Parameters	
HMMLAQUN – History Match Numerical Aquifer Gradient Multipliers	
HMMLCTAQ – History Match Carter-Tracy Aquifer Gradient Multipliers	
HMMLFTAQ – History Match Fetkovich Aquifer Gradient Multipliers	
HMMLT – History Match Grid Permeability Gradient Cumulative Multipliers	
HMMLTPR	
HMMLTPTH	
HMMLTPX	
HMMLTPXY	
HMMLTPY	
HMMLTPZ	
HMMLTWCN – History Match Well Connection and Skin Multipliers	
HMMMREGT - History Match Region Transmissibility Gradient Cumulative Multipliers	
HMMROCK – History Match Rock Compressibility Gradient Cumulative Multipliers	
HMMROCKT – History Match Rock Compaction Gradient Cumulative Multipliers	
HMMULRGT – History Match Region Transmissibility Parameters	
HMMULT – History Match Grid Transmissibility & Pore Volume Gradient Cumulative Multipliers	
HMULTPV	
HMMULTR	
HMMULTTH	
HMMULTX	
HMMULTXY	
HMMULTY	
HMMULTZ	
HMMULTFT – History Match Fault Transmissibility Gradient Cumulative Multipliers	
HMMULTSG – History Match Dual porosity Sigma Gradient Cumulative Multipliers	
HMPROPS – History Match End-Point Section Start	
HMROCK – History Match Rock Compressibility Gradient Parameters	

H

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter H	Status
HMROCKT – History Match Rock Compaction Gradient Parameters	
HMRREF – History Match Rock Table Reference Pressure Values	
HMWELCON – History Match Well Connection and Skin Parameters	
HMWPIMLT – History Match Well Productivity Index Parameters	
HRFIN - Define the Ratio of LGR Grid Blocks in the R-Direction	
HWKRO – End-Point Scaling of Grid Cell Kro(Swl) (High Salinity and Water Wet)	
HWKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (High Salinity and Water Wet)	
HWKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (High Salinity and Water Wet)	
HWKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (High Salinity and Water Wet)	
HWKRWR – End-Point Scaling of Grid Cell KRWR(Sw=1.0) (High Salinity and Water Wet)	
HWPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (High Salinity and Water Wet)	
HWSNUM – Define the Saturation Table Region Numbers (High Salinity and Water Wet)	
HWSOGCR – End-Point Scaling Grid Cell SOGCR (High Salinity and Water Wet)	
HWSOWCR – End-Point Scaling Grid Cell SOWCR (High Salinity and Water Wet)	
HWSWCR – End-Point Scaling Grid Cell SWCR (High Salinity and Water Wet)	
HWSWL – End-Point Scaling Grid Cell SWL (High Salinity and Water Wet)	
HWSWLPC – End-Point Scaling Grid Cell SWLPC (High Salinity and Water Wet)	
HWSWU – End-Point Scaling Grid Cell SWU (High Salinity and Water Wet)	
HXFIN - Define the Ratio of LGR Grid Blocks in the X-Direction	
HYDRHEAD – Define Hydraulic Head Output Reference Data	
HYFIN - Define the Ratio of LGR Grid Blocks in the Y-Direction	
HYMOBGDR – Activate Carlson and Killough Alternative Drainage Hysteresis Option	
HYST – Activate the Hysteresis Option (Retired)	
HYSTCHCK - Activate Hysteresis Inhibition and Drainage End-Point Validation	
HZFIN - Define the Ratio of LGR Grid Blocks in the Z-Direction	

I

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter I	Status
IHOST – Assign LGRs to Parallel Process Number	
IKRG – End-Point Scaling of Grid Cell Krg(Sgu) (Imbibition)	
IKRGX	
IKRGX-	
IKRGY	
IKRGY-	
IKRGZ	
IKRGZ-	
IKRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Imbibition)	
IKRGRX	
IKRGRX-	
IKRGRY	
IKRGRY-	
IKRGRZ	
IKRGRZ-	
IKRO – End-Point Scaling of Grid Cell Kro(Swl) (Imbibition)	
IKROX	
IKROX-	
IKROY	
IKROY-	
IKROZ	
KROZ-	
IKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Imbibition)	
IKRORGX	
IKRORGX-	
IKRORGY	
IKRORGY-	
IKRORGZ	
IKRORGZ-	
IKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Imbibition)	
IKRORWX	

I

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter I	Status
IKRORWX-	
IKRORWY	
IKRORWY-	
IKRORWZ	
IKRORWZ-	
IKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Imbibition)	
IKRWX	
IKRWX-	
IKRWY	
IKRWY-	
IKRWZ	
IKRWZ-	
IKRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Imbibition)	
IKRWRX	
IKRWRX-	
IKRWRY	
IKRWRY-	
IKRWRZ	
IKRWRZ-	
IMBNUM – Define the Imbibition Saturation Table Region Numbers	
IMBNUMX	
IMBNUMY	
IMBNUMZ	
IMBNUMX-	
IMBNUMY-	
IMBNUMZ-	
IMBNUMMF – Define the Imbibition Saturation Table Region Numbers (Matrix-Fracture)	
IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions	
IMKRVDX	
IMKRVDX-	
IMKRVDY	

I

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter I	Status
IMKRVDY-	
IMKRVDX	
IMKRVDZ-	
IMPCVD – Imbibition Maximum Capillary Pressure versus Depth Functions	
IMPES – Activate Implicit Pressure Explicit Saturation Solution Option	
IMPLICIT – Activate Fully Implicit Solution Option	
IMPORT – Import Grid File Data at the Current Position	
IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth	
IMPTVDX	
IMPTVDX-	
IMPTVDY	
IMPTVDY-	
IMPTVDZ	
IMPTVDZ-	
IMSPCVD – Imbibition Capillary Pressure Connate Saturations versus Depth	
INCLUDE – Load Another Data File at the Current Position	
INIT – Activate the INIT File Option	
INRAD – Define the Inner Radius of a Radial Grid	
INSPEC – Activate the INSPEC File Option	
INTPC – Activate Dual Porosity Integrated Capillary Pressure Option	
IONROCK – Define the Ion Exchange Capacity for All the Cells	
IONXROCK - Define Ion Exchange Constant by Saturation Table Regions	
IONXSURF - Define Surfactant Ion Exchange Constant by Saturation Table Regions	
IPCG – End-Point Scaling of Grid Cell Gas Capillary Pressure (Imbibition)	
IPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Imbibition)	
ISGCR – End-Point Scaling of Grid Cell Critical Gas Saturation (Imbibition)	
ISGCRX	
ISGCRX-	
ISGCRY	
ISGCRY-	
ISGCRZ	

I

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter I	Status
ISGCRZ-	
ISGL – End-Point Scaling of Grid Cell Connate Gas Saturation (Imbibition)	
ISGLX	
ISGLX-	
ISGLY	
ISGLY-	
ISGLZ	
ISGLZ-	
ISGLPC – End-Point Scaling of Grid Cell Capillary Pressure Connate Gas Saturation (Imbibition)	
ISGU – End-Point Scaling of Grid Cell Maximum Gas Saturation (Imbibition)	
ISGUX	
ISGUX-	
ISGUY	
ISGUY-	
ISGUZ	
ISGUZ-	
ISOGCR – End-Point Scaling of Grid Cell Critical Oil Saturation to Gas (Imbibition)	
ISOGCRX	
ISOGCRX-	
ISOGCRY	
ISOGCRY-	
ISOGCRZ	
ISOGCRZ-	
ISOLNUM – Define the Independent Reservoir Regions	
ISOWCR – End-Point Scaling of Grid Cell Critical Oil Saturation to Water (Imbib.)	
ISOWCRX	
ISOWCRX-	
ISOWCRY	
ISOWCRY-	
ISOWCRZ	

I

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter I	Status
ISOWCRZ-	
ISWCR – End-Point Scaling of Grid Cell Critical Water Saturation (Imbibition)	
ISWCRX	
ISWCRX-	
ISWCRY	
ISWCRY-	
ISWCRZ	
ISWCRZ-	
ISWL – End-Point Scaling of Grid Cell Connate Water Saturation (Imbibition)	
ISWLX	
ISWLX-	
ISWLY	
ISWLY-	
ISWLZ	
ISWLZ-	
ISWLPC – End-Point Scaling Grid Cell Capillary Pressure Connate Water Saturations (Imbibition)	
ISWU – End-Point Scaling of Grid Cell Maximum Water Saturation (Imbibition)	
ISWUX	
ISWUX-	
ISWUY	
ISWUY-	
ISWUZ	
ISWUZ-	

J

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter J	Status
JFUNC - Activate the Leverett J-function Option	
JFUNCR - Activate the Leverett J-function Saturation Table Option	

K

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter K	Status
KRG – End-Point Scaling of Grid Cell Krg(Sgu) (Drainage)	
KRGX	
KRGX-	
KRGY	
KRGY-	
KRGZ	
KRGZ-	
KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)	
KRGRX	
KRGRX-	
KRGRY	
KRGRY-	
KRGRZ	
KRGRZ-	
KRNUM – Define the Directional Saturation Table Region Numbers	
KRNUMMF – Define the Saturation Table Region Numbers (Matrix-Fracture)	
KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)	
KROX	
KROX-	
KROY	
KROY-	
KROZ	
KROZ-	
KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)	
KRORGX	
KRORGX-	
KRORGY	
KRORGY-	
KRORGZ	
KRORGZ-	
KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)	

K

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter K	Status
KRORWX	
KRORWX-	
KRORWY	
KRORWY-	
KRORWZ	
KRORWZ-	
KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)	
KRWX	
KRWX-	
KRWY	
KRWY-	
KRWZ	
KRWZ-	
KRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Drainage)	
KRWRX	
KRWRX-	
KRWRY	
KRWRY-	
KRWRZ	
KRWRZ-	

L

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter L	Status
LAB - Activate the Laboratory System of Units for the Model	
LANGMPL – Define Langmuir Pressure Grid Cell Multiplier	
LANGMUIR – Langmuir Adsorption Isotherm Tables	
LANGSOLV – Langmuir Adsorption Isotherm Solvent Tables	
LCUNIT – Define Linear Combination Rate and Volume Units	
LGR – Define Local Grid Refinement Dimensions and Parameters	
LGRCOPY – Activate Local Grid Refinement Inheritance	
LGRFREE – Activate Local Grid Refinement Independent Time Steps	
LGRLOCK – Deactivate Local Grid Refinement Independent Time Steps	
LGROFF – Deactivate a Local Grid Refinement	
LGRON – Activate a Local Grid Refinement	
LICENSES – Define Required Licenses for Run	
LIFTOPT – Activate Gas Lift Optimization	
LINCOM – Define Linear Combination Coefficients	
LINKPERM - Assign Cell Permeabilities to Cell Faces	
LIVEOIL – Activate the Live Oil Phase (Oil with Free and Dissolved Gas)	
LKRO – End-Point Scaling of Grid Cell Kro(Swl) (Low Salinity and Oil Wet)	
LKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Low Salinity and Oil Wet)	
LKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Low Salinity and Oil Wet)	
LKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Low Salinity and Oil Wet)	
LKRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Low Salinity and Oil Wet)	
LOAD – Load a SAVE File for a Fast Restart	
LOWSALT – Activate the Low Salt Brine Phase in the Brine Model	
LPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Low Salinity and Oil Wet)	
LSALTFNC - Define Low Salt Weighting Factors versus Salt Concentration Functions	
LSLTWNUM – Define the Low Salt Water Wet Saturation Table Region Numbers	
LSNUM – Define the Low Salt Oil Wet Saturation Table Region Numbers	
LSOGCR – End-Point Scaling Grid Cell SOGCR (Low Salinity and Oil Wet)	
LSOWCR – End-Point Scaling Grid Cell SOWCR (Low Salinity and Oil Wet)	
LSWCR – End-Point Scaling Grid Cell SWCR (Low Salinity and Oil Wet)	

L

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter L	Status
LSWL – End-Point Scaling Grid Cell SWL (Low Salinity and Oil Wet)	
LSWLPC – End-Point Scaling Grid Cell SWLPC (Low Salinity and Oil Wet)	
LSWU – End-Point Scaling Grid Cell SWU (Low Salinity and Oil Wet)	
LTOSIGMA - Dual Porosity Viscous Displacement Sigma Parameters	
LWKRO – End-Point Scaling of Grid Cell Kro(Swl) (Low Salinity and Water Wet)	
LWKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Low Salinity and Water Wet)	
LWKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Low Salinity and Water Wet)	
LWKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Low Salinity and Water Wet)	
LWKRWR – End-Point Scaling of Grid Cell KRWR(Sw=1.0) (Low Salinity and Water Wet)	
LWPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Low Salinity and Water Wet)	
LWSLTNUM – Define the Low Salt Oil Wet Saturation Table Region Numbers	
LWSNUM – Define the Low Salt Water Wet Saturation Table Region Numbers	
LWSOGCR – End-Point Scaling Grid Cell SOGCR (Low Salinity and Water Wet)	
LWSOWCR – End-Point Scaling Grid Cell SOWCR (Low Salinity and Water Wet)	
LWSWCR – End-Point Scaling Grid Cell SWCR (Low Salinity and Water Wet)	
LWSWL – End-Point Scaling Grid Cell SWL (Low Salinity and Water Wet)	
LWSWLPC – End-Point Scaling Grid Cell SWLPC (Low Salinity and Water Wet)	
LWSWU – End-Point Scaling Grid Cell SWU (Low Salinity and Water Wet)	
LX - Dual Porosity Viscous Displacement X Direction Matrix Size for All Cells	
LXFIN – Define Logarithmic LGR Grid Block Spacing in the X-Direction	
LY - Dual Porosity Viscous Displacement Y Direction Matrix Size for All Cells	
LYFIN – Define Logarithmic LGR Grid Block Spacing in the Y-Direction	
LZ - Dual Porosity Viscous Displacement Z Direction Matrix Size for All Cells	
LZFIN – Define Logarithmic LGR Grid Block Spacing in the Z-Direction	

M

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter M	Status
MAPAXES- Define the Map Origin Input Data	
MAPUNITS – Define the Map Axes Units	
MASSFLOW – Define River Mass Flow versus Time Tables	
MATCORR – Activate the Material Balance Correction Option	
MAXVALUE – Sets a Maximum Value for an Array Element	
MEMORY – Define Allocated Memory (Retired)	
MESSAGE – Output User Message	
MESSAGES – Define Message Print Limits and Stop Limits	
MESSOPTS – Reset Severity Level for Forced Time Steps	
MESSSRVC - Activate or Deactivate Database Message File Output	
METRIC – Activate the Metric System of Units for the Model	
MINNNCT – Set a Minimum Non-Neighbor Connection Transmissibility	
MINPORV – Set a Minimum Grid Block Pore Volume Threshold for All Cells	
MINPV – Set a Minimum Grid Block Pore Volume Threshold for All Cells	
MINPVV – Set a Minimum Grid Block Pore Volume Threshold for Individual Cells	
MINVALUE – Set a Minimum Value for an Array Element	
MISC – Define Solvent Miscibility-Immiscibility Transform Functions	
MISCIBLE – Define Miscibility Todd-Longstaff Parameters	
MISNUM – Define the Miscibility Region Numbers	
MLANG – Define Langmuir Maximum Gas Concentration for All Grid Cells	
MLANGSLV – Define Langmuir Maximum Solvent Concentration for All Grid Cells	
MONITOR – Activate Output of the Monitoring Data and File	
MPFANUM – Define Multi-Point Flux Discretization Regions	
MPFNNC – Define Multi-Point Flux Non-Neighbor Connections	
MSFN – Miscible Normalized Relative Permeability Tables	
MSGFILE – Active or Deactivate Message File Output	
MULSGGD – Multiply Matrix-Fracture Coupling for Oil-Gas Gravity Drainage for All Cells	
MULSGGDV – Multiply Matrix-Fracture Coupling for Oil-Gas Gravity Drainage for Individual Cells	
MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant	
MULTIN – Activate the Non-Unified Multiple Input File Option	

M

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter M	Status
MULTIPLY – Multiply a Specified Array by a Constant	
MULTIREG – Multiply an Array by a Constant based on a Region Number	
MULTNUM – Define the Multiple Transmissibility Regions	
MULTOUT – Activate the Non-Unified Multiple Output File Option	
MULTOUTS – Activate Non-Unified Multiple Summary Output File Option	
MULTPV – Multiply Cell Pore Volumes by a Constant	
MULTR - Multiply Cell Transmissibility in the +R Direction	
MULTR- - Multiply Cell Transmissibility in the -R Direction	
MULTREAL – Activate Commercial Simulator's Multi-Realization License	
MULTREGD – Multiply Diffusivities Between Regions	
MULTREGH – Multiply Thermal Conductivities Between Regions	
MULTREGP – Multiply Pore Volumes Based On Region Number	
MULTREGT – Multiply Transmissibilities Between Regions	
MULTSIG – Multiply Matrix-Fracture Coupling for All Cells	
MULTSIGV – Multiply Matrix-Fracture Coupling for Individual Cells	
MULTTHT - Multiply Cell Transmissibility in the +Theta Direction	
MULTTHT- - Multiply Cell Transmissibility in the -Theta Direction	
MULTX - Multiply Cell Transmissibility in the +X Direction	
MULTX- - Multiply Cell Transmissibility in the -X Direction	
MULTY - Multiply Cell Transmissibility in the +Y Direction	
MULTY- - Multiply Cell Transmissibility in the -Y Direction	
MULTZ - Multiply Cell Transmissibility in the +Z Direction	
MULTZ- - Multiply Cell Transmissibility in the -Z Direction	

N

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter N	Status
NARROW – Activate Run Summary Narrow Column Output Option	
NCONSUMP - Node Gas Consumption (Extended Network)	
NEFAC - Node Efficiency Factors (Extended Network)	
NETBALAN – Network Balancing Parameters	
NETCOMPA – Define Automatic Compressors (Extended Network)	
NETWORK – Activate the Extended Network Option and Define Parameters	
NEWTON – Activate Newton Iteration SUMMARY Output	
NEWTRAN – Activate Irregular Corner-Point Grid Transmissibilities	
NEXT – Maximum Next Time Step Size (Alias for NEXTSTEP)	
NEXTSTEP – Maximum Next Time Step Size	
NEXTSTPL – Maximum Next Time Step Size (LGR)	
NINENUM – Define the Nine-Point Discretization Region	
NINEPOIN – Activate the Nine-Point Discretization Option	
NMATOPTS – Define the Discretized Matrix Dual Porosity Parameters	
NMESSAGE – Export Cumulative Message Summary Variables to File	
NMATRIX – Activate the Discretized Matrix Dual Porosity Option	
NNC – Define Non-Neighbor Connections Between Cells Manually	
NNEWTF – Activate the Non-Newtonian Fluid Model	
NOCASC – Activate Linear Solver Tracer Algorithm	
NODEPROP – Define Network Node Properties for Extended Network	
NODPPM – Deactivate Fracture Porosity-Permeability Calculation	
NOECHO – Deactivate Echoing of User Input Files to the Print File	
NOGGF – Deactivate Output of Grid Geometry File	
NOHMD – Deactivate History Match Gradient Derivative Calculations	
NOHMO – Deactivate History Match Gradient Derivative Calculations (Alias)	
NOHYST - Deactivate the Hysteresis Option	
NOINSPEC – Deactivate Output of the INIT Index File	
NOMONITO – Deactivate Output of the Monitoring Data and File	
NONNC – Deactivate Non-Neighbor Connections	
NORSSPEC – Deactivate Output of the RESTART Index File	

N

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter N	Status
NOSIM – Activate the No Simulation Mode for Data File Checking	
NOWARN – Deactivate Warning Messages	
NOWARNEP – Deactivate End-Point Scaling Warning Messages	
NRSOUT – Defined Maximum Number of RESTART Elements	
NSTACK – Define the Stack Length for the Iterative Linear Solver	
NTG – Define the Net-to-Gross Ratio for All the Cells	
NUMRES – Define the Number of Reservoir Grids	
NUPCOL – Define the Number of Newtonian Iterations Used to Update Well Targets	
NWATREM – Node Water Removal (Extended Network)	
NXFIN – Define the Number of LGR Grid Blocks in the X-Direction	
NYFIN – Define the Number of LGR Grid Blocks in the Y-Direction	
NZFIN – Define the Number of LGR Grid Blocks in the Z-Direction	

O

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter O	Status
OFM – Activate OFM File Output of the SUMMARY Data	
OIL – Activate the Oil Phase in the Model	
OILAPI – Define the Initial Equilibration Oil API for All Grid Blocks	
OILDENT – Define Oil Density Temperature Coefficients	OPM Flow
OILVISCT – Define Oil Viscosity versus Temperature Functions	
OLDTRAN – Activate Cartesian Regular Grid Transmissibilities	
OLDTRANR – Activate Radial Regular Grid Transmissibilities	
OPERATE – Define Mathematical Operations on Arrays	
OPERATER – Define Mathematical Operations on Arrays by Region	
OPERNUM – Define Regions for Mathematical Operations on Arrays	
OPTIONS – Activate Various Program Options	
OUTRAD - Define the Outer Radius of a Radial Grid	
OUTSOL – Define Data to be Written to the RESTART File (Retired)	
OVERBURD – Define Rock Overburden Pressure versus Depth Tables	

P

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter P	Status
PARALLEL – Define Parallel Run Configuration	
PARAOPTS – Define Parallel Run Options	
PARTTRAC – Activate and Define Partitioned Tracer Option	
PATHS – Define Filename Directory Path Aliases	
PBUB – Define the Initial Equilibration Bubble-Point Pressure for All Grid Blocks	
PBVD – Equilibration Bubble-Point versus Depth Tables	
PCG – End-Point Scaling of Grid Cell Maximum Gas Capillary Pressure (Drainage)	
PCG32D – Gas-Oil Capillary Pressure versus Oil and Water Saturation Tables	
PCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Drainage)	
PCW32D – Water-Oil Capillary Pressure versus Oil and Gas Saturation Tables	
PDEW – Define the Initial Equilibration Dew-Point Pressure for All Grid Blocks	
PDVD – Define Equilibration Dew-Point versus Depth Tables	
PEBI – Activate and Defined PEBI Grid Options	
PECOEFS – Define Petro-Elastic Model Coefficients	
PEDIMS – Define Petro-Elastic Model Regions and Table Dimensions	
PEGTAB – Petro-Elastic Pressure Shear Modulus Table	
PEGTAB0	
PEGTAB1	
PEGTAB2	
PEGTAB3	
PEGTAB4	
PEGTAB5	
PEGTAB6	
PEGTAB7	
PEKTAB – Petro-Elastic Pressure Bulk Modulus Table	
PEKTAB0	
PEKTAB1	
PEKTAB2	
PEKTAB3	
PEKTAB4	
PEKTAB5	

P

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter P	Status
PEKTAB6	
PEKTAB7	
PENUM – Define the Petro-Elastic Region Numbers	
PERFORMA – Export Standard Simulator Performance Summary Variables to File	
PERMAVE – Define Average Transmissibility Coefficients	
PERMFACT– Permeability Multiplication Factor as a Function of Porosity Change	OPM Flow
PERMJFUN – Define Leverett J-Function Permeability for All Cells	
PERMR – Define the Permeability for Each Cell in the R Direction	
PERMTHT – Define the Permeability for Each Cell in the THETA Direction	
PERMX - Define the Permeability in the X Direction for All the Cells	
PERMY - Define the Permeability in the Y Direction for All the Cells	
PERMZ - Define the Permeability in the Z Direction for All the Cells	
PETGRID – Load a Generic Simulation Grid File	
PETOPTS – Define Petrel and Generic Simulation File Options	
PICOND – Define the Generalized Pseudo Pressure Parameters	
PIMTDIMS – Define Well Productivity Scaling Table Dimensions	
PIMULTAB – Define Well Productivity Index versus Water Cut Tables	
PINCH – Define Pinch-Out Layer Options	
PINCHNUM – Define Pinch-Out Regions for the PINCHREG Keyword	
PINCHOUT - Define Pinch-Out Layers Option (Fixed)	
PINCHREG - Define Pinch-Out Region Options	
PINCHXY – Define Pinch-Out Areal Options	
PLMIXNUM – Define the Polymer Region Numbers	
PLMIXPAR – Define the Polymer Todd-Longstaff Mixing Parameters	
PLYADS - Define Polymer Rock Adsorption Tables	
PLYADSS - Define Polymer Rock Adsorption with Salt Dependence Tables	
PLYATEMP – Define Polymer Adsorption Table Temperature	
PLYCAMAX - Define Polymer-Rock Maximum Adsorption by Cell	
PLYDHFLF - Define Polymer Thermal Degradation Half-Life Tables	
PLYESAL – Define Polymer Effective Salinity Coefficient	

P

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter P	Status
PLYKRRF – Define Polymer Rock Permeability Reduction by Cell	
PLYMAX - Define Polymer-Salt Viscosity Mixing Concentrations	
PLYRMDEN - Define Polymer Model In Situ Rock Density	
PLYROCK - Define Polymer-Rock Properties	
PLYROCKM - Modify Polymer-Rock Properties	
PLYSHEAR – Activate and Define Polymer Shearing Parameters	
PLYSHLOG - Activate and Define the Polymer Shearing Logarithmic Parameters	
PLYTRRF – Define Polymer Rock Permeability Reduction versus Temperature	
PLYTRRFA – Define Polymer Rock Permeability Reduction versus Temperature Option	
PLYVISC – Define Polymer Viscosity Scaling Factors	
PLYVISCS – Define Polymer-Salt Viscosity Scaling Factors	
PLYVISCT – Define Polymer-Temperature Viscosity Scaling Factors	
PLYVSCST – Define Polymer-Salt-Temperature Viscosity Scaling Factors	
PMAX – Maximum and Minimum Pressure for Total Compressibility Check	
PMISC – Define Miscibility versus Pressure Tables	
POLYMER – Activate the Polymer Phase in the Model	
PORO - Define the Porosity Values for All the Cells	
PORV - Define the Pore Volumes for All the Cells	
PPCWMAX – Define SWATINIT Calculated Capillary Pressure Constraints	
PRECSALT – Activate the OPM Flow Salt Precipitation Model	OPM Flow
PRESSURE – Define the Initial Equilibration Pressures for All Grid Blocks	
PRIORITY – Activate and Define Well Prioritization Coefficients	
PROPS - Define the Start of the PROPS Section of Keywords	
PRORDER – Define a Group Production Rules Sequence	
PRVD – Define the Initial Equilibration Pressures versus Depth	
PSTEADY – Activate Pseudo Steady State Flow Calculation Option	
PVCDO - Oil PVT Properties for Dead Oil (Constant Compressibility)	
PVCO - Oil PVT Properties for Live Oil	
PVDG - Gas PVT Properties for Dry Gas	
PVDO – Oil PVT Properties for Dead Oil	

P

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter P	Status
PVDS - Solvent PVT Properties for the Solvent Model	
PVTG - Gas PVT Properties for Wet Gas with Vaporized Oil	
PVTGW - Gas PVT Properties for Dry Gas with Vaporized Water	OPM Flow
PVTGWO - Gas PVT Properties for Wet Gas with Vaporized Water and Oil	OPM Flow
PVTNUM – Define the PVT Regions	
PVTO - Oil PVT Properties for Live Oil	
PVTW - Define Water Fluid Properties for Various Regions	
PVTWSALT - Define Brine Water Fluid Properties for Various Regions	
PVZG - Gas PVT Properties for Dry Gas (Z-Factor)	
PYACTION – Define Python Based Action Conditions and Command Processing	OPM Flow
PYEND – End the Definition of a PYINPUT Section	OPM Flow
PYINPUT – Define the Start of a PYINPUT Section	OPM Flow

Q

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter Q	Status
QDRILL – Define Sequential Drilling Queue Wells	
QHRATING – Define River Mass Flow versus Depth Tables	
QMOBIL Activate or Deactivate LGR End-Point Mobility Correction	

R

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter R	Status
RADFIN – Define a Radial Local Grid Refinement with One Column	
RADFIN4 – Define a Radial Local Grid Refinement with Four Columns	
RADIAL – Radial Grid Activation Option	
RAINFALL – Constant Flux Aquifer Rainfall Flux by Month	
RBEDCONT – Define River Grid Block Contact Area versus Depth	
RCMASTS – Reservoir Coupling Group Minimum Time Step for Flow Restriction	
REACHES – Define River Reaches Structure	
READDATA – Read Schedule Data Based on Current Time Step	
REFINE – Start the Definition of a Local Grid Refinement	
REGDIMS – Define the Maximum Number of Regions for a Region Array	
REGIONS - Define the Start of the REGIONS Section of Keywords	
RESIDNUM – Define Vertical Equilibrium Residual Flow Region Numbers	
RESTART – Restart Run From an Existing Restart File	
RESVNUM – Define Reservoir Coordinate Data Set	
RIVDEBUG – Define the Debug Data to be Printed to File (Rivers)	
RIVERSYS - Define River System (Branch Structure and Boundary Conditions)	
RIVRDIMS – Define the River Dimensions and Associated Data	
RIVRPROP – Modify River Reaches Properties	
RIVRXSEC – Define River Cross-Section versus Depth Parameters	
RIVSALT – Define River Upstream Flow Salt Concentrations	
RIVTRACE – Define River Upstream Flow Tracer Concentrations	
RKTRMDIR - Activate ROCKTAB Keyword Directional Transmissibility Multipliers	
ROCK - Define the Rock Compressibility for Various Regions	
ROCK2D – Pore Volume Compaction versus Pressure and Sw Tables	
ROCK2DTR – Transmissibility Compaction versus Pressure and Sw Tables	
ROCKCOMP – Activate Rock Compaction	
ROCKFRAC - Define the Rock Volume to Bulk Volume Fraction for All the Cells	
ROCKNUM – Define Rock Compaction Table Region Numbers	
ROCKOPTS – Define Rock Compaction and Compressibility Options	
ROCKPAMA – Define Coal Palmer-Mansorri Rock Model Parameters	

R

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter R	Status
ROCKTAB – Rock Compaction Tables	
ROCKTABH – Rock Compaction Hysteresis Tables	
ROCKTABW – Rock Compaction Tables (Water Induced)	
ROCKTHSG – Rock Compaction Hysteresis Tables (Dual Porosity)	
ROCKTSIG – Rock Compaction Tables (Dual Porosity)	
ROCKWNODE – Water Saturation Values for Compaction Pressure-Sw Tables	
RPTCPL – Activate Couple Simulation Reporting	
RPTGRID – Define GRID Section Reporting	
RPTGRIDL – Define GRID Section Reporting for LGRs	
RPTHMD - Define Well History Match Gradient Reporting Options	
RPTHMG - Define Well History Match Gradient Reporting (Groups)	
RPTHMW - Define Well History Match Gradient Reporting (Wells)	
RPTINIT – Define Output to the INIT File	
RPTISOL – Activate Isolated Reservoir Number Reporting	
RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File	
RPTONLYO - Deactivate the Report Time Steps Only Option for the SUMMARY File	
RPTPROPS – Define PROPS Section Reporting	
RPTREGS – Define REGIONS Section Reporting	
RPTRST – Define Data to be Written to the RESTART File	
RPTRUNSP – Activate RUNSPEC Reporting	
RPTSCHED – Define SCHEDULE Section Reporting	
RPTSMRY - Activate or Deactivate Summary List Report	
RPTSOL – Define SOLUTION Section Reporting	
RS – Define the Initial Equilibration GOR (Rs) for All Grid Blocks	
RSCONST – Define Constant GOR (Rs) for All Dead Oil PVT Fluids	
RSCONSTT – Define Constant GOR (Rs) for Each Dead Oil PVT Fluid	
RSGI – Define Gas-Oil Ratio versus Pressure and Gi Tables	
RSSPEC – Activate Output of the RESTART Index File	
RSVD – Equilibration Dissolved Gas-Oil Ratio (Rs) versus Depth Tables	
RTEMP - Define the Initial Reservoir Temperature for the Model	

R

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter R	Status
RTEMPA - Define the Initial Reservoir Temperature for the Model	
RTEMPVD - Define the Initial Reservoir Temperature versus Depth Tables	
RUNSPEC - Define the Start of the RUNSPEC Section of Keywords	
RUNSUM – Activate RSM File Output of the SUMMARY Data	
RV – Define the Initial Equilibration CGR (Rv) for All Grid Blocks	
RVCONST – Define Constant CGR (Rv) for All Dry Gas PVT Fluids	
RVCONSTT – Define Constant CGR (Rv) for Each Dry Gas PVT Fluid	
RVGI – Define Condensate-Gas Ratio versus Pressure and Gi Tables	
RVVD – Equilibration Vaporized Oil-Gas Ratio (Rv) versus Depth Tables	
RWGSALT – Water Vaporization versus Pressure and Salt Concentration	OPM Flow

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SALT – Define the Initial Equilibration Salt Concentration for All Grid Blocks	
SALTNODE – Salt Concentration Based PVTNUM Array	
SALTPVD – Equilibration Salt Precipitated Concentration versus Depth Tables	OPM Flow
SALTREST – Define the Restart Salt Concentration for All Grid Blocks	
SALTSOL – Define the Salt Solubility Limit for All Cells	OPM Flow
SALTVD – Equilibration Salt Concentration versus Depth Tables	
SAMG – Activate Algebraic Multi-Grid Linear Solver	
SATNUM – Define the Saturation Table Region Numbers	
SATOPTS – Activate Relative Permeability Assignment Options	
SAVE – Activate Output of a SAVE File for Fast Restarts	
SCALECRS – Define End-Point Scaling Option	
SCALELIM – End-Point Scaling versus Depth Maximum Water Saturation	
SCDATAB – Well Connection PI Multipliers versus Scale Deposit	
SCDETAB – Well Connection Karst Aquifer Properties for Scale Deposit	
SCDPDIMS – Define Scale Deposition and Damage Table Dimensions	
SCDPTAB – Well Connection Scale Deposition Tables	
SCDPTRAC – Allocate Sea Water Tracer for Scale Deposition	
SCHEDULE - Define the Start of the SCHEDULE Section of Keywords	
SCVD – Define Equilibration Coal Solvent Concentration versus Depth Tables	
SDENSITY – Define the Miscible or Solvent Surface Gas Density	
SEPARATE – Activate the Separate RSM File Output Option	
SEPVALS – Define Separator Oil Formation Volume Factor and GOR	
SFOAM – Define the Initial Equilibration Foam Concentration for All Grid Blocks	
SGAS – Define the Initial Equilibration Gas Saturation for All Grid Blocks	
SGCR – End-Point Scaling Grid Cell Critical Gas Saturations	
SGCRX	
SGCRX-	
SGCRY	
SGCRY-	
SGCRZ	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SGCRZ-	
SGCWMIS – Miscible Critical Gas versus Water Saturation Functions	
SGF32D – Gas Saturation Tables versus Oil and Water Saturations	
SGFN – Gas Saturation Tables (Format Type 2)	
SGL – End-Point Scaling Grid Cell Connate Gas Saturations	
SGLX	
SGLX-	
SGLY	
SGLY-	
SGLZ	
SGLZ-	
SGLPC – End-Point Scaling Grid Cell Capillary Pressure Connate Gas Saturations	
SGOF – Gas-Oil Saturation Tables versus Gas (Format Type 1)	
SGU – End-Point Scaling Grid Cell Gas Saturation	
SGUX	
SGUX-	
SGUY	
SGUY-	
SGUZ	
SGUZ-	
SGWFN – Gas-Water Saturation Tables (Format Type 2)	
SHRATE - Activate and Define the Polymer Shearing Logarithmic Parameters	
SIGMA – Dual Porosity Matrix to Fracture Sigma (All Cells)	
SIGMAGD – Dual Porosity Matrix to Fracture Sigma for Gravity Drainage (All Cells)	
SIGMAGDV – Dual Porosity Matrix to Fracture Sigma Gravity Drainage (Individual Cells)	
SIGMAV – Dual Porosity Matrix to Fracture Sigma (Individual Cells)	
SIMULATE - Activate the Simulation Mode	
SKIP – Activate Skipping of All Keywords and Input Date	
SKIP100 – Activate Skipping of "Black-Oil" Keywords and Input Date	
SKIP300 – Activate Skipping of "Compositional" Keywords and Input Date	
SKIPREST – Activate Skipping of Restart Schedule Data	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SKRO – End-Point Scaling of Grid Cell Kro(Swl) (Surfactant)	
SKRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Surfactant)	
SKRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Surfactant)	
SKRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Surfactant)	
SKRWR – End-Point Scaling of Grid Cell KRWR(Sowcr) (Surfactant)	
SLAVES – Define Slave Reservoir Simulation Parameters	
SLGOF – Gas-Oil Saturation Tables versus Gas (Format Type 1)	
SMRYDIMS – Define Maximum Number of Summary Vectors to be Written	
SMULTX - Multiply Cell Transmissibility in the +X Direction (Auto-Refinement)	
SMULTY - Multiply Cell Transmissibility in the +Y Direction (Auto-Refinement)	
SMULTZ - Multiply Cell Transmissibility in the +Z Direction (Auto-Refinement)	
SOCRS – End-Point Scaling Grid Cell Miscible Critical Oil Saturation with Respect to Water	
SOF2 – Oil Saturation Tables with Respect to Gas or Water (Format Type 2)	
SOF3 – Oil Saturation Tables with Respect to Gas and Water (Format Type 2)	
SOF32D – Oil Saturation Tables with Respect to Water and Gas (Three Phase)	
SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas	
SOGCRX	
SOGCRX-	
SOGCRY	
SOGCRY-	
SOGCRZ	
SOGCRZ-	
SOIL – Define the Initial Equilibration Oil Saturation for All Grid Blocks	
SOLUTION - Define the Start of the SOLUTION Section of Keywords	
SOLVCONC – Define the Initial Coal Solvent Concentration for All Grid Blocks	
SOLVDIMS – Define PEBI Grid Nested Factorization Solver Dimensions	
SOLVDIRS – Define Linear Solver Principal Directions	
SOLVENT – Activate the SOLVENT Phase in the Model	
SOLVFRAC – Define the Initial Gas Solvent Fraction for All Grid Blocks	
SOLVNUM – Define PEBI Grid Correspondence to Solver Order	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SOMGAS – STONE1 Model Minimum Oil Saturation versus Gas Saturation	
SOMWAT – STONE1 Model Minimum Oil Saturation versus Water Saturation	
SORWMIS – Miscible Residual Oil versus Water Saturation Functions	
SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water	
SOWCRX	
SOWCRX-	
SOWCRY	
SOWCRY-	
SOWCRZ	
SOWCRZ-	
SPECGRID- Define the Dimensions of a Corner-Point Grid	
SPECHEAT – Define the Specific Heat of Oil, Water and Gas	
SPECROCK – Define the Specific Heat of the Reservoir Rock	
SPOLY – Define the Initial Equilibration Polymer Concentration for All Grid Blocks	
SSFN – Solvent and Gas Relative Permeability Tables	
SSGCR – End-Point Scaling Grid Cell Surfactant Critical Gas Saturations	
SSGL – End-Point Scaling Grid Cell Surfactant Connate Gas Saturations	
SSOGCR – End-Point Scaling Grid Cell Surfactant Critical Oil Saturation with Respect to Gas	
SSOL – Define the Initial Equilibration Solvent Saturation for All Grid Blocks	
SSOWCR – End-Point Scaling Grid Cell Surfactant Critical Oil Saturation with Respect to Water	
SSWCR – End-Point Scaling Grid Cell Critical Water Saturation	
SSWL – End-Point Scaling Grid Cell Surfactant Connate Water Saturation	
SSWU – End-Point Scaling Grid Cell Surfactant Maximum Water Saturation	
START – Simulation Start Date	
STOG Define Capillary Pressure Oil-Gas Surface Tension versus Pressure	
STONE – Activate Stone's Second Three Phase Oil Relative Permeability Model (Alias for STONE2)	
STONE1 – Activate Stone's First Three Phase Oil Relative Permeability Model	
STONE1EX – Define Stone's First Three Phase Oil Relative Permeability Parameter	
STONE2 – Activate Stone's Second Three Phase Oil Relative Permeability Model	
STOW Define Capillary Pressure Oil-Water Surface Tension versus Pressure	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
STWG Define Capillary Pressure Water-Gas Surface Tension versus Pressure	
SUMMARY - Define the Start of the SUMMARY Section of Keywords	
SUMTHIN – Define SUMMARY Data Reporting Time Steps	
SURF – Define the Initial Equilibration Polymer Concentration for All Grid Blocks	
SURFACT – Activate the Surfactant Phase in the Model	
SURFACTW – Activate the Surfactant Phase with Wettability Changes in the Model	
SURFADDW – Defined Surfactant Adsorbed Concentration versus Wettability Fraction	
SURFADS - Define Surfactant Rock Adsorption Tables	
SURFCAPD – Capillary Number versus Miscibility Tables	
SURFESAL – Define Surfactant Effective Salinity Coefficient	
SURFNUM – Define the Surfactant Miscible Saturation Table Region Numbers	
SURFROCK - Define Surfactant-Rock Properties	
SURFST - Surfactant Water-Oil Surface Tension versus Surfactant Concentration	
SURFSTES - Surfactant Water-Oil Surface Tension versus Surfactant and Salt Concentrations	
SURFVISC – Surfactant Solution Viscosity versus Concentration	
SURFWNUM – Define the Saturation Table Region Numbers (High Salinity and Water Wet)	
SWAT – Define the Initial Equilibration Water Saturation for All Grid Blocks	
SWATINIT – Define the Initial Water Saturation Array for Capillary Pressure Scaling	
SWCR – End-Point Scaling Grid Cell Critical Water Saturation	
SWCRX	
SWCRX-	
SWCRY	
SWCRY-	
SWCRZ	
SWCRZ-	
SWF32D – Water Saturation Tables with Respect to Oil and Gas (Three Phase)	
SWFN – Water Saturation Tables (Format Type 2)	
SWINGFAC – Define Field Gas Contract Parameters	
SWL – End-Point Scaling Grid Cell Connate Water Saturation	
SWLX	
SWLX-	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SWLY	
SWLY-	
SWLZ	
SWLZ-	
SWLPC – End-Point Scaling Grid Cell Capillary Pressure Connate Water Saturations	
SWOF – Water-Oil Saturation Tables (Format Type 1)	
SWU – End-Point Scaling Grid Cell Maximum Water Saturation	
SWUX	
SWUX-	
SWUY	
SWUY-	
SWUZ	
SWUZ-	

T

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter T	Status
TABDIMS – Define the Number of Tables and the Table Dimensions	
TBLK – Define Tracer Initial Grid Block Concentrations	
TEMP – Activate the Temperature Modeling Option	
TEMPI – Define the Initial Temperature Values for All Cells	
TEMPNODE - Temperature Table for Polymer Solution Viscosity	
TEMPTVD – Activate Temperature Flux Limited Transport Option	
TEMPVD - Define the Initial Reservoir Temperature versus Depth Tables	
THCGAS – Define Gas Phase Thermal Conductivity for All Cells	
THCOIL – Define Oil Phase Thermal Conductivity for All Cells	
THCONR – Define Rock and Fluid Thermal Conductivity for All Cells	
THCONSF – Define Gas Saturation Dependent Thermal Conductivity Scaling Factor for All Cells	
THCROCK – Define Reservoir Rock Thermal Conductivity for All Cells	
THCWATER – Define Water Phase Thermal Conductivity for All Cells	
THERMAL– Activate the Thermal Modeling Option	
THPRES - Define Equilibration Region Threshold Pressures	
THPRESFT - Define Fault Threshold Pressures	
TIGHTEN – Tighten and Relax Numerical Controls	
TIGHTENP – Tighten and Relax Numerical Controls Individually	
TIME – Advance Simulation by Cumulative Reporting Time	
TITLE – Define the Title for the Input Deck	
TLMIXPAR – Define the Miscible Todd-Longstaff Mixing Parameters	
TNUM – Define Passive Tracer Concentration Regions	
TOLCRIT – Define The Critical Saturation Tolerance	
TOPS - Define the Depth at the Center of the Top Face for Each Cell	
TPAMEPS – Volumetric Strain versus Coal Gas Concentration Tables	
TPAMEPSS - Volumetric Strain versus Coal Solvent Concentration Tables	
TRACER – Define Passive Tracer Variables	
TRACERKM – Multi-Partitioned Tracer Option K(P) Tables	
TRACERKP – Standard Partitioned Tracer Option K(P) Tables	
TRACERS – Activate Tracer Options and Set Tracer Array Dimensions	

T

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter T	Status
TRACITVD – Activate and Define Tracer Implicit Flux Limited Transport Option	
TRACTVD – Activate Tracer Explicit Flux Limited Transport Option	
TRADS – Environmental Tracer Adsorption Tables	
TRANGL – Define Non-Neighbor Connections Between Global and LGR Cells Manually	
TRANR - Define the Transmissibility in the +R Direction for All the Cells	
TRANTHT - Define the Transmissibility in the +Theta Direction for All the Cells	
TRANX - Define the Transmissibility in the X Direction for All the Cells	
TRANY - Define the Transmissibility in the Y Direction for All the Cells	
TRANZ - Define the Transmissibility in the Z Direction for All the Cells	
TRDCY – Environmental Tracer Decay Tables	
TRDIF – Tracer Diffusion Tables	
TRDIS – Tracer Dispersion Table Number Allocation	
TRKPF – Define Partitioned Tracer Regions	
TRNHD – Activate Dispersion Non-Homogeneous Diffusion Option	
TRPLPORO – Activate the Triple Porosity Model Option	
TRROCK – Environmental Tracer-Rock Property Data	
TSTEP – Advance Simulation by Reporting Time	
TUNING - Numerical Tuning Control	
TUNINGDP – Numerical Tuning Control for High Throughput Cases	
TUNINGH – Numerical Tuning Control for History Match Gradient Calculations	
TUNINGL - Numerical Tuning Control for All LGRs	
TUNINGS - Numerical Tuning Control for Individual LGRs	
TVDP – Define the Initial Equilibration Tracer Saturation versus Depth Functions	
TZONE – End-Point Scaling Transition Zone Options	

U

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter U	Status
UDADIMS – Define the Dimensions of the User Defined Arguments	
UDQ - Declare User Define Quantities ("UDQ")	
UDQDIMS – Define the Dimensions of the User Defined UDQ Feature	
UDQPARAM – Define Parameters for the User Defined Quantity Feature	
UDT - Declare User Define Tables ("UDT")	
UDTDIMS – Define the Dimensions of the User Defined Tables	
UNCODHMD – Activate History Match Gradient Unencoded Output	
UNIFIN – Activate The Unified Input File Option	
UNIFOUT – Activate The Unified Output File Option	
UNIFOUTS – Activate The Unified Output Summary File Option	
UNIFSAVE – Activate The Unified Output Save File Option	
USECUPL – Load a Reservoir Coupling File	
USEFLUX – Activate Flux Boundary Model and Define Flux File	
USENOFLO – Activate Flux Boundary Model Without a Flux File	

V

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter V	Status
VAPOIL – Activate the Vaporize Oil in Wet Gas Phase in the Model	
VAPPARS – Oil Vaporization Parameters	
VAPWAT – Activate Vaporize Water in the Dry and Wet Gas Phases	OPM Flow
VDFLOW – Velocity Dependent Flow Coefficient for Grid Block Flow (Grid)	
VDFLOWR – Velocity Dependent Flow Coefficient for Grid Block Flow (Region)	
VE – Activate Vertical Equilibrium Model (Global)	
VEDEBUG – Vertical Equilibrium Debug Data Output	
VEFIN – Activate Vertical Equilibrium Model (LGR)	
VEFRAC – Vertical Equilibrium Relative Permeability Fraction (Grid)	
VEFRACP – Vertical Equilibrium Capillary Pressure Fraction (Grid)	
VEFRACPV – Vertical Equilibrium Capillary Pressure Fraction (Cell)	
VEFRACV – Vertical Equilibrium Relative Permeability Fraction (Cell)	
VFPCHK – Define Production Vertical Flow Performance BHP Check	
VFPIDIMS – Injection Vertical Flow Performance Table Dimensions	
VFPINJ – Define Injection Vertical Flow Performance Tables	
VFPPDIMS – Production Vertical Flow Performance Table Dimensions	
VFPPROD – Define Production Vertical Flow Performance Tables	
VFPTABL – Define Production Vertical Flow Performance ALQ Interpolation	
VISAGE - Activate External Reservoir Geo-Mechanics VISAGE Option	
VISCD – Activate Dual Porosity Viscous Displacement Option	
VISCREF - Define Viscosity-Temperature Reference Conditions	
VISDATES – Define External Reservoir Geo-Mechanics VISAGE Stress Dates	
VISOPTS – Define External Reservoir Geo-Mechanics VISAGE Options	

W

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter W	Status
WAGHYSTR – Define Water-Alternating-Gas Hysteresis Parameters	
WAITBAL – Wait On Network Balance Before Allowing Further Actions	
WALKALIN – Define Water Injection Alkaline Concentration	
WALQCALC – Define Well VFP Surface ALQ Phase Density	
WAPI – Define Oil Well Injection API Gravity	
WARN – Activate Warning Messages	
WATDENT – Define Water Density Temperature Coefficients	
WATER – Activate the Water Phase in the Model	
WATVISCT – Define Water Viscosity versus Temperature Functions	
WBHGLR – Define Well Bottom-Hole GLR Constraint	
WBOREVOL – Define Effective Wellbore Storage Volume	
WCALCVAL – Define Gas Well Calorific Value	
WCONHIST – Define Well Historical Production Rates and Pressures	
WCONINJ – Well Injection Targets and Constraints	
WCONINJE – Well Injection Targets and Constraints	
WCONINJH – Well Historical Observed Injection Rates and Pressures	
WCONINJP – Define Well Injection Targets and Constraints for Pattern Flood Wells	
WCONPROD – Define Well Production Targets and Constraints	
WCUTBACK – Define Well Cutback Limits and Parameters	
WCUTBACT – Define Well Tracer Cutback Limits and Parameters	
WCYCLE – Define Automatic Well Opening and Closing Cycling Parameters	
WDFAC – Define Gas Flow Dependent Skin Factor	
WDFACCOR – Gas Flow Dependent Skin Factor (Correlation)	
WDRILPRI – Add Wells to the Drilling Priority Drilling Queue	
WDRILRES – Activate Prevention of Multi-Completions in the Same Cell for Queued Wells	
WDRILTIM – Define Drilling Parameters for Automatic Drilling of New Wells	
WECON – Well Economic Criteria for Production Wells	
WECONINJ – Well Economic Criteria for Injection Wells	
WECONT – Well Economic Tracer Criteria for Production Wells	
WEFAC – Define Well Efficiency	
WELCNTL – Modify Well Control and Targets	

W

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter W	Status
WELDEBUG – Define the Well Debug Data to be Printed to File	
WELDRAW – Define Maximum Draw Down for Production Wells	
WELEVNT – Define Well WPWEM Summary Mnemonic Output Value	
WELLDIMS – Define the Wells and Group Dimensions	
WELMOVEL – Move Global Well Into an LGR	
WELOPEN – Define Well and Well Connections Flowing Status	
WELOPENL – Define Well and Well Connections Flowing Status (LGR)	
WELPI – Define Well Productivity and Injectivity Indices	
WELPRI – Assign Well Priority	
WELSEGS – Define Multi-Segment Wells and Their Segment Structure	
WELSOMIN – Define Well Connection Minimum Oil Saturation for Opening	
WELSPECL – Define Well Specifications for Local Grid Refinements	
WELSPECS – Define Well Specifications	
WELTARG – Modify Well Target and Constraint Values	
WFOAM - Define Well Foam Injection Concentrations	
WFRICSEG – Convert Friction Well to Multi-Segment Well	
WFRICSGL – Convert Friction Well to Multi-Segment Well (LGR)	
WFRICTN – Define Well as a Friction Well	
WFRICTNL – Define Well as a Friction Well (LGR)	
WGASPROD – Define Sale Gas Well Production Targets	
WGORPEN – Define Well GOR Penalty Parameters	
WGRUPCON – Define Well Guide Rates for Group Control	
WH2NUM – Define WAG Hysteresis Saturation Table Region Numbers (Two Phase)	
WH3NUM – Define WAG Hysteresis Saturation Table Region Numbers (Three Phase)	
WHEDREFD – Define Well Hydraulic Head Reference Depth	
WHISTCTL - Define Well Historical Target Phase	
WHTEMP – Define Well Tubing Head Temperature Parameters	
WINJMULT – Define Well Pressure Dependent Injectivity Multipliers	
WINJTEMP – Define Injection Fluid Thermal Properties	
WLIFT – Define Well Re-Tubing, THP and Lift Switching Workover Operations	
WLIFTOPT – Define Well Gas Lift Optimization Parameters	

W

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter W	Status
WLIMTOL – Define Well Constraint Tolerance	
WLIST – Define Well Lists (Static)	
WLISTARG – Modify Well List Target and Constraint Values (Static)	
WLISTNAM – Define Well Lists (WLISTARG)	
WNETCTRL – Define Well Control for Network Control Option	
WNETDP – Define Well THP to Network Pressure Drop	
WORKLIM – Define Well Workover Time	
WORKTHP – Define Well Workover Options for THP Killed Wells	
WPAVE – Well Block Average Pressure Calculation Parameters for All Wells	
WPAVEDEP – Define Well Reference Depth for Pressure Calculations	
WPIMULT – Define Well Connection Multipliers	
WPIMULTL – Define Well Connection Multipliers (LGR)	
WPITAB - Assign Well Productivity Index versus Water Cut Tables	
WPLUG – Define Well Plug Back Length	
WPOLYMER - Define Water Injection Well Polymer and Salt Concentrations	
WPOLYRED – Define Well Polymer-Water Viscosity Reduction Factor	
WPOTCALC – Well Potential Calculation Options	
WREGROUP – Automatic Re-Assignment of Wells to Groups	
WRFT – Activate Well RFT Reporting to the RFT File	
WRFTPLT – Activate Well RFT and PLT Reporting to the RFT File	
WSALT - Define Water Injection Well Salt Concentrations	
WSCCLEAN – Well Deposited Scale Adjustment	
WSCCLENL – Well Deposited Scale Adjustment (LGR)	
WSCTAB – Assign Well Scale Deposition and Scale Damage Tables	
WSEGAICD – Define Multi-Segment Well Autonomous ICD Connections	
WSEGDFIN – Define Multi-Segment Well Drift Flux Slip Model Input Data	
WSEGDFMD – Define Multi-Segment Well Drift Flux Slip Model	
WSEGDFPA – Define Multi-Segment Well Drift Flux Slip Model Parameters	
WSEGDIMS – Define Multi-Segment Well Dimensions	
WSEGEXSS – Define Multi-Segment Well Import-Export Segment Volumes	
WSEGFLIM - Define Multi-Segment Well Artificial Choke Connections	

W

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter W	Status
WSEGFMOD – Define Multi-Segment Well Model	
WSEGINIT - Define Multi-Segment Well Initial Conditions	
WSEGITER – Define Multi-Segment Wells Iteration Parameters	
WSEGLABY - Define Multi-Segment Well Labyrinth ICD Connections	
WSEGLINK - Define Multi-Segment Well Looped Flow Paths	
WSEGMULT – Define Multi-Segment Well Frictional Pressure Loss Multipliers	
WSEGPROP – Modify Multi-Segment Wells and Their Segment Structure	
WSEGPULL – Define a Multi-Segment Well Down-Hole Separator Pump	
WSEGSEP – Define a Multi-Segment Well Down-Hole Separator	
WSEGSICD – Define Multi-Segment Well Spiral ICD Connections	
WSEGSOLV Define Multi-Segment Well Iterative Linear Solver Parameters	
WSEGTABL – Assign Multi-Segment Well VLP Tables to Segments	
WSEGVALV – Define Multi-Segment Well Sub-Critical Valve	
WSOLVENT - Define Gas Injection Well Solvent Fraction	
WSURFACT - Define Water Injection Well Surfactant Concentration	
WTADD – Add a Constant to a Well Target or Constraint	
WTEMP – Define An Injection Well's Fluid Temperature	
WTEMPQ – Output Well Names and Well Lists to the Print File	
WTEST – Well Testing Criteria for Re-Opening Closed Wells	
WTHPMAX – Define a Well's Maximum Flowing THP for Shut-In	
WTMULT – Multiple a Well Target or Constraint by a Constant	
WTRACER – Define An Injection Well's Tracer Concentration	
WVFPDP – Modify Well BHP Obtained from VFP Tables	
WVFPEXP – Define Well VFP Interpolation Options	
WWPAVE – Well Block Average Pressure Calculation Parameters for Individual Wells	

X

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter X	Status
There Are Keywords Beginning with the Letter X	

Y

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter Y	Status
There Are Keywords Beginning with the Letter Y	

Z

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter Z	Status
ZCORN – Define the Depth of Each Corner-Point of a Grid Block	
ZIPP2OFF – Deactivate Automatic Time Step Control	
ZIPPY2 – Activate Automatic Time Step Control	

APPENDIX B: OPM FLOW RELEASE HISTORY

B.1 RELEASE 2020-04

New Features

Writing out of the SUMMARY file data in a columnar format to the RSM file has been implemented. Normally the SEPARATE keyword in the SUMMARY section is invoked to direct the data stream to a separate RSM file for easy loading into other programs, for example, Microsoft's EXCEL or LibreOffice's CALC spreadsheet program. However, this is the default behavior for OPM Flow.

Additional SCHEDULE section reports has been added to this release including the WELLS and WELSPECS options on the RPTSCHED keyword. The reports are similar to those from the commercial simulator.

The Brine Tracking option has now been activated in this release and should be considered experimental and used with caution. The keywords associated with this feature are BRINE, BDENSITY, PVTWALT and WSALT.

A Python scripting facility has been implemented in OPM Flow via the:

1) PYINPUT/PYEND keywords that processes standard Python commands that can be used to manipulate and define the simulators input parameters during processing of the input deck. The main purpose of the facility is to script the construction of the various keywords.
2) PYACTION keyword that provides similar functionality as the ACTIONX scripting facility, but instead users the standard Python interpreter. PYACTION provides an interface between the simulator and Python via a Python function that enables obtaining various run times parameters from the simulator.

Experimental support for using the Graphics Processing Unit ("GPU") *–cusparseSolver* as the linear solver has been implemented, see the command line parameter *–use-gpu* in section *2.2 Running OPM Flow 2020-04 From The Command Line*.

A command line parameter *–sched-restart* has been added to allow a restart run to initialize wells and groups from the historical SCHEDULE section (current and past default behavior), or from the well and group data on the RESTART file. Note that the commercial simulator always uses data from the restart file. The intention is to duplicate the behavior of the commercial simulator after suitable testing.

The initialization of parallel cases has been completely reworked, the simulator now uses considerably less memory when initializing a parallel run.

Group control of wells in prediction mode has been made more consistent and improved in several ways, this may impact the results compared to previous versions of the simulator.

All "black-oil" keywords are now documented to varying level of detail depending on the functionality implemented in OPM Flow, and all are now recognized by the OPM Flow input deck parser.

In addition the following new keywords are now recognized with varying functionality as described by the comments in Table B.1.

No.	Keyword	Comment
1	BDENSITY	Define the Surface Brine Density for the Fluid.
2	BRINE	Activate Brine Tracking Option.
3	DATE	Activate the DATE Option for the SUMMARY File.
4	EXIT	Exit Simulation from within an Action Section, this is an OPM Flow specific keyword.
5	PERMFAC	Permeability Factor Reduction Due to Salt Precipitation for OPM Flow's Salt Precipitation model.
6	PVTGW	Gas PVT Properties for Dry Gas with Vaporized Water for OPM Flow's Salt Precipitation model.

No.	Keyword	Comment
7	PVTGWO	Gas PVT Properties for Wet Gas with Vaporized Water and Oil for OPM Flow's Salt Precipitation model.
8	PVTWSALT	Define Brine Water Fluid Properties for Various Regions for the Brine Tracking and Salt Precipitation models.
9	PYACTION	Define Python Based Action Conditions and Command Processing
10	PYEND	End the Definition of a PYINPUT Section
11	PYINPUT	Define the Start of a PYINPUT Section
12	RUNSUM	Activate RSM File Output of the SUMMARY Data.
13	RWGSALT	Water Vaporization versus Pressure and Salt Concentration or OPM Flow's Salt Precipitation model.
14	SALTSOL	Define the Salt Solubility Limit for All Cells for OPM Flow's Salt Precipitation model.
15	SALTVD	Define the Equilibration Salt Concentration versus Depth Tables for the Brine model. Note: Although the data is read by the simulator it is currently ignored.
16	SEPARATE	Activate the Separate RSM File Output Option.
17	SKIPREST	Activate Skipping of Restart Schedule Data (this keyword is now functional, previously it was only recognized by the input deck).
18	WSALT	Define Water Injection Well Salt Concentrations.
19	WSEGVALV	Define Multi-Segment Well Sub-Critical Valve for Inflow Control Device

Notes:

1) Cells colored in green in the "No." column indicate that the keyword is recognized by the input deck parser and fully or partially supported by OPM Flow.
2) Cells colored in orange in the "No." column indicate that the keyword is recognized by the input deck parser but not supported by OPM Flow.
3) Cells colored in red in the "No." column indicate that the keyword is not recognized by the input deck parser and OPM Flow.

Table B.1: New Keywords for the 2020-04 Release

Bug Fixes

The following bug fixes and improvements have been incorporated into this release.

1) Fixed a bug with the PVTSALT keyword that caused the keyword to be set to unrecognized.

Known Issues

1) Two phase gas-water models (GAS and WATER only keywords in the RUNSPEC section) will not initialize in OPM Flow, this has been the status for past versions of the simulator as well. The work around is to convert the model to a three phase model (OIL, GAS and WATER keywords in the RUNSPEC section) and modify the PROPS section keywords data accordingly.

2) OPM Flow incorrectly reports that the MAXVALUE keyword is not supported. The warning message is incorrect and the values entered on the keyword will be applied to the named array.

3) For the Brine model the SALTVD is active in this release; however, the values entered via the keyword are ignored and reset to zero. A fix is ongoing but did not make it into the 2020-04 release.

4) The Tracer model is not working. In order to activate the Tracer model the command line variable *-enable-tracer-mode* should be set to "true"; the simulator will still issue a message saying *Warning: Keyword 'TRACERS' is not supported by flow* but will continue to run. However, the results from the tracer tracking appear to be incorrect and should not be relied upon. The standard results, rates, pressures, saturations, etc., are identical to the comparable no tracer run.

5) The OPERATE keyword EQUATION options of MAXLIM and MINLIM are currently not supported.

6) The RPTSCHED WELLS report does not print the FIELD group production data.

Developer Changes

1) For restart runs the commercial simulator does not consider the historical part of the SCHEDULE section in the input deck, as all necessary well and group information is obtained from the restart file, and the interpretation of the SCHEDULE keywords starts at the restart date in the input deck. Historically, OPM Flow has treated restart runs differently. OPM Flow users the SCHEDULE section data to initialize the wells and groups, combined with the solution arrays (PRESSURE, SWAT, etc.) from the restart file. There is an ongoing effort to duplicate the same behavior as the commercial simulator to further increase the compatibility between the commercial simulator and OPM Flow. This work is being done in stages to ensure existing models continue to work. See the *–sched-restart* command line parameter in section *2.2 Running OPM Flow 2020-04 From The Command Line*.

Joakim Hove (Release Manager), Cintia Goncalves Machado, Kai Bao, Tor Harald Sandve, and David Baxendale.

B.2 RELEASE 2019-10

New Features

An experimental foam module has been added to OPM Flow 2019-10 release. With this it is possible to simulate certain types of surfactant injection. Such injection stimulates formation of foam to change mobility ratios, and give better reservoir sweep. The implemented foam model treats surfactant transported in the gas phase, and reduces the mobility of that phase depending on the surfactant concentration. In addition to mobility reduction, adsorption to the reservoir rock is included in the model. To test the foam module use the keywords, FOAM, FOAMADS, FOAMMOB, FOAMOPTS, FOAMROCK and WFOAM. The model has not been tested on anything but artificial test cases so far, it is therefore likely to have omissions and bugs. If you try it out, please send feedback by the mailinglist (*opm-request@opm-project.org*), or by raising an issue on GitHub (*https://github.com/OPM*). A simple test case based on SPE1 has been added to the opm-tests repository, in the directory spe1_foam (*https://github.com/OPM/opm-tests/tree/master/spe1_foam*).

First implementation of the ACTIONX facility and associated keywords. The ACTIONX keyword defines a series of conditions that invoke run time processing of ACTION functions and is similar to executing a run time script. This is the general purpose version of the ACTION series of keywords that can apply Boolean conditional tests to variables at the field, group, region, well segment and well levels. The ACTION, ACTIONG, ACTIONR, ACTIONS and ACTIONW keywords are not implemented in OPM Flow and are unlikely to be so, as the ACTIONX keyword implements their functionality with greater flexibility. As this is the first release with this functionality, users should exercise caution using this functionality.

Rock compaction has been implemented via the OVERBURD, ROCK2D, ROCK2DTR, ROCKCOMP, and the ROCKNUM keywords. The facility is activated by the ROCKCOMP keyword in the RUNSPEC section.

OPM Flow now supports output of a common subset of end-point arrays to OPM Flow's *.INIT file. Specifically, OPM Flow outputs the drainage and imbibition curve end-points but does not currently support directionally dependent end-points (e.g., SGCRX-). This version also supports the FILLEPS keyword to output the actual end-points, whether taken from direct assignment in the deck or derived from the corresponding saturation function table. Note that OPM Flow does not currently support the TOLCRIT keyword which will affect *CR end-points derived from the tables. This version also activates the pertinent flags in the *.INIT file's LOGIHEAD vector which means that the ResInsight relative permeability plot is now able to distinguish the scaled from the unscaled curves in a cell even for result sets generated by OPM Flow.

Initial implementation of the well list facility via the WLIST keyword for static well lists has been incorporated into this release. In addition, improve support for the WTEST keyword has been added and the WECON keyword now supports GOR checking.

The issue with the Ubuntu Linux 18.04 LTS (64-bit version only) release that prevented mpirun working with OPM Flow under this version of the operating system has been resolved in this release of OPM Flow.

There is an on going effort to recognize all known "black-oil" keywords by the OPM Flow input deck parser, and to document all these keywords with varying level of detail depending on the functionality implemented in OPM Flow.

In addition the following new keywords are now recognized with varying functionality as described by the comments in Table B.2.

No.	Keyword	Comment
1	ACTION	Define Action Conditions and Command Processing (Field).
2	ACTIONG	Define Action Conditions and Command Processing (Groups).
3	ACTIONR	Define Action Conditions and Command Processing (Regions).
4	ACTIONS	Define Action Conditions and Command Processing (Well Segments).
5	ACTIONW	Define Action Conditions and Command Processing (Wells).

No.	Keyword	Comment
6	ACTIONX	Define Action Conditions and Command Processing.
7	ACTPARAM	Define Action Facility Target and Tolerance Parameters.
8	ENDACTIO	End the Definition of ACTION Commands.
9	UDADIMS	Define the Dimensions of the User Defined Arguments.
10	UDQ	Declare User Define Quantities ("UDQ").
11	UDQDIMS	Define the Dimensions of the User Defined UDQ Feature.
12	UDQPARAM	Define Parameters for the User Defined Quantity Feature.
13	UDT	Declare User Define Tables ("UDT").
14	UDTDIMS	Define the Dimensions of the User Defined Tables.
15	FILLEPS	Activate Saturation End Point Export to INIT File.
16	FOAM	Activate the Foam Phase and Model.
17	FOAMADS	Define Foam Rock Adsorption Tables.
18	FOAMDCYO	Define Foam Decay versus Oil Saturation Tables.
19	FOAMDCYW	Define Foam Decay versus Water Saturation Tables.
20	FOAMFCN	Define Foam Gas Mobility Reduction versus Capillary Number.
21	FOAMFRM	Define Foam Gas Mobility Reduction versus Reference Mobility.
22	FOAMFSC	Define Foam Gas Mobility versus Surfactant Concentration Functions.
23	FOAMFSO	Define Foam Gas Mobility Reduction versus Oil Saturation.
24	FOAMFST	Define Foam Gas-Water Surface Tension versus Surfactant Concentration.
25	FOAMFST	Define Foam Gas-Water Surface Tension versus Surfactant Concentration.
26	FOAMMOB	Define Foam Gas Mobility versus Foam Concentration Tables.
27	FOAMMOBP	Define Foam Mobility Reduction versus Oil Pressure.
28	FOAMMOBS	Define Foam Mobility Reduction versus Shear.
29	FOAMOPTS	Define Foam Model Options.
30	FOAMROCK	Define Foam Rock Properties.
31	OVERBURD	Define Rock Overburden Pressure versus Depth Tables.
32	ROCK2D	Pore Volume Compaction versus Pressure and Sw Tables.
33	ROCK2DTR	Transmissibility Compaction versus Pressure and Sw Tables
34	ROCKCOMP	Activate Rock Compaction.
35	ROCKFRAC	Define the Rock Volume to Bulk Volume Fraction for All the Cells.
36	ROCKNUM	Define Rock Compaction Table Region Numbers.
37	ROCKOPTS	Define Rock Compaction and Compressibility Options.
38	ROCKPAMA	Define Coal Palmer-Mansorri Rock Model Parameters.
39	ROCKTAB	Rock Compaction Tables.

No.	Keyword	Comment
40	ROCKTABH	Rock Compaction Hysteresis Tables.
41	ROCKTABW	Rock Compaction Tables (Water Induced).
42	ROCKWNOD	Water Saturation Values for Compaction Pressure-Sw Tables.
43	WFOAM	Define Well Foam Injection Concentrations.
44	WLIST	Define Well Lists (Static).
45	WLISTARG	Modify Well List Target and Constraint Values (Static).
46	WLISTNAM	Define Well Lists (WLISTARG).

Notes:

1) Cells colored in green in the "No." column indicate that the keyword is recognized by the input deck parser and fully or partially supported by OPM Flow.
2) Cells colored in orange in the "No." column indicate that the keyword is recognized by the input deck parser but not supported by OPM Flow.
3) Cells colored in red in the "No." column indicate that the keyword is not recognized by the input deck parser and OPM Flow.

Table B.2: New Keywords for the 2019-10 Release

Bug Fixes

The following bug fixes and improvements have been incorporated into this release.

1) Restart values on the RESTART file are now only read once, previously this was done twice.
2) Fixed several bugs concerning the input and output of RESTART files.
3) EBOS now logs output to both the *.PRT and *.DBG files.
4) OPM Flow now abort a run without reading the deck if the command line parameters are incorrect.
5) Use grid region mapping from opm-grid.
6) Fixed a bug related to negative THP values when extrapolating values from VFP tables.
7) Printing of logging information from Well Testing is now written to both the *.PRT and *.LOG files.
8) Several bug fixes to multi-segement well model have been implemented.
9) Both the *.INIT and *.GRID files are now written out on a restart run.
10) OPM Flow now does not update RESV variable for producers in prediction mode.
11) Fixed an issue with the simulator over writing the FPR summary vector instead of writing out the FPRP summary vector instead..
12) The simulator now always writes out the transmissibilities between vertical neighbors to TRANZ (even for non-neighbor connections).

Developer Changes

For the 2019-10 release, the module "ewoms" has been renamed "opm-models". The repository on github has been renamed, but the old name will continue to work for some time. The figure below shows the current module structure for the 2019.10 release.

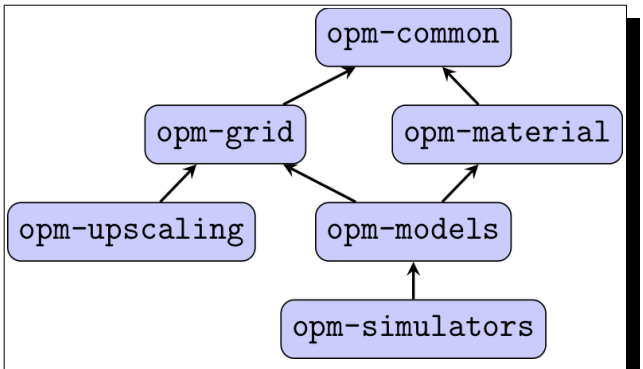


Figure B.1: Module Structure for 2019-10 Release

Most files/header that were located in directory opm/autodiff in opm-simulators have been moved to opm/simulators/aquifers, opm/simulators/linalg, opm/simulators/utils, or opm/simulators/wells depending on their content.

Markus Blatt, Atgeirr Flø Rasmussen, Bård Skaflestad, Tor Harald Sandve, Arne Morten Kvarving and David Baxendale.

B.3 RELEASE 2019-04

Error message reporting has been significantly improved for this release. Previously, when OPM Flow found an error in the input deck, an exception was thrown immediately and the program terminated after writing out an error message. In many cases there are multiple errors in an input deck, but only the first will be reported. In this release all errors are collected and OPM Flow continues until the input deck has been completely assembled. If there have been errors during processing all error messages are now written to the standard output files, after which the program will terminate. This should greatly improve debugging of OPM Flow input deck. The feature is activated by the command line option:

```
flow --strict-mode=true CASE.DATA
```

See section *2.2Running OPM Flow 2020-04 From The Command Line* for additional information.

In addition the following new keywords are now recognized with varying functionality as described by the comments in Table B.3.

No.	Keyword	Comment
1	AQUFETP	The AQUFETP keyword defines Fetkovich Analytical aquifers and the aquifer properties.
2	DRSDTR	DRSDTR defines the maximum rate at which the solution gas-oil ratio (Rs) can be increased in a grid cell for various regions in the model.
3	DRVDTR	DRVDTR defines the maximum rate at which the solution oil-gas ratio or condensate-gas ratio (Rv) can be increased in a grid cell for various regions in the model.
4	FILEUNIT	The FILEUNIT keyword defines the units of the of the data set, and is used to verify that the units in the input deck and any associated include files are consistent grid data.
	GDFILE	The GDFILE keyword loads a GRID file that contains the structural data for the grid as a set of topological cuboidal cells, and EGRID files that contain structural and property data. Added in 2018-10 but didn't work, this has been fixed in 2019-04 and is fully functional.
5	FLUXTYPE	Recognized by the input deck parser only.
6	ISGLPC	ISGLPC defines the imbibition connate gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked. Recognized by the input deck parser, and internalised into OPM Flow's 3D property representations. Missing Some Functionality - Use with Caution.
7	ISWLPC	ISWLPC defines the imbibition connate water saturation for all the cells in the model via an array when the end-point scaling option has been invoked. Recognized by the input deck parser, and internalised into OPM Flow's 3D property representations. Missing some functionality. Use with caution.
8	MULTIN	This keyword switches on the Multiple Input Files option for all input files.
8	MULTOUT	This keyword switches on the Multiple Output Files option for all output files.
9	OVERBURD	Recognized by the input deck parser and simulator support is available in the experimental "ebos" simulator.
10	ROCK2D	Recognized by the input deck parser and simulator support is available in the experimental "ebos" simulator.
11	ROCK2DTR	Recognized by the input deck parser and simulator support is available in the experimental "ebos" simulator

No.	Keyword	Comment
12	ROCKWNOD	Recognized by the input deck parser and simulator support is available in the experimental "ebos" simulator.
13	SGLPC	SGLPC defines the connate gas saturation for all the cells in the model via an array when the end-point scaling option has been invoked. Recognized by the input deck parser, and internalised into OPM Flow's 3D property representations. Missing some functionality. Use with caution.
14	STONE	This keyword is an alias for STONE2 keyword that activates Stone's second three phase oil relative permeability model as modified by Aziz and Settai. Keyword was previously supported by OPM Flow but not recognized by the input deck parser. This has now been fixed and the keyword is fully functional as per the documentation in the manual.
15	STONE2	This keyword activates Stone's second three phase oil relative permeability model as modified by Aziz and Settar. Keyword was previously supported by OPM Flow but not recognized by the input deck parser. This has now been fixed and the keyword is fully functional as per the documentation in the manual.
16	SWLPC	SWLPC defines the connate water saturation for all the cells in the model via an array when the end-point scaling option has been invoked. Recognized by the input deck parser, and internalised into OPM Flow's 3D property representations. Missing some functionality. Use with caution.
17	TBLK	Recognized by the input deck parser and simulator support is available in the experimental "ebos" simulator
18	THPRESFT	Recognized by the input deck parser and simulator support is available in the experimental "ebos" simulator.
19	WLIST	WLIST declares a group of wells to belong to a named well list.

Notes:

1) Cells colored in green in the "No." column indicate that the keyword is recognized by the input deck parser and fully or partially supported by OPM Flow.
2) Cells colored in orange in the "No." column indicate that the keyword is recognized by the input deck parser but not supported by OPM Flow.
3) Cells colored in red in the "No." column indicate that the keyword is not recognized by the input deck parser and OPM Flow.

Table B.3: New Keywords for the 2019-04 Release

Bård Skaflestad, Tor Harald Sandve, and David Baxendale.

B.4 RELEASE 2018-10

The Open Porous Media project is please to announce that version 2018.10 of the OPM suite of simulation software has been released. Binary packages for Red-Hat Enterprise Linux 6 and 7 and Ubuntu 16.04 and 18.04 are available for download at the OPM website download page *https://opm-project.org/?page_id=36.* Installation instructions can also be found at the download page as well as in section *CHAPTER 2: INSTALLING AND RUNNING FLOW* of this manual.

In addition to the usual list of fixes and improvements two significant improvements include:

1) OPM Flow can now write restart files which can be used to restart runs using the commercial simulator.

2) Performance has been improved significantly, on selected field models, where OPM Flow is significantly faster than the commercial simulator.

Due to problems with the Zoltan package we have unfortunately been forced to disable MPI for the Ubuntu 18.04 package. We are looking into this, and if possible we will make updated packages at a later stage.

In terms of new features OPM Flow now includes an option for thermal modeling. The energy "black-oil" implementation in OPM Flow is a mixture of the commercial simulators "black-oil" and the commercial simulators "compositional thermal" keywords, as well as some OPM Flow specific keywords. The temperature option (TEMP keyword) and the thermal option (THERMAL keyword) are two separate modeling facilities in the commercial simulator. OPM Flow's thermal implementation is based on solving the energy equation fully coupled with the "black-oil" equations so the results are not directly equivalent to commercial simulator's "black-oil" TEMP or compositional THERMAL formulations. See the *5.2.115 THERMAL– Activate the Thermal Modeling Option* keyword in the RUNSPEC section outlining the available keywords.

Apart form the new thermal keywords summarized in section *5.2.115 THERMAL– Activate the Thermal Modeling Option*, the following new keywords have been incorporated in this release and are active:

No.	Keyword	Comment
1	GDFILE	The GDFILE keyword loads a GRID file that contains the structural data for the grid as a set of topological cuboidal cells, and EGRID files that contain structural and property data. Fully functional – Not Working in this Release
2	PLMIXNUM	The PLMIXNUM keyword defines the polymer region number for each grid block that is used to assign the mixing tables as well as the maximum polymer and salt concentrations, for when the polymer option has been activated.
3	TOLCRIT	This keyword defines the Critical Saturation Tolerance.
4	ISGLPC	The WSEGSICD keyword defines a multi-segment well segment to be a spiral Inflow Control Device. ("ICD") as part of a completion for a multi-segment well.

Notes:

1) Cells colored in green in the "No." column indicate that the keyword is recognized by the input deck parser and fully or partially supported by OPM Flow.

2) Cells colored in orange in the "No." column indicate that the keyword is recognized by the input deck parser but not supported by OPM Flow.

3) Cells colored in red in the "No." column indicate that the keyword is not recognized by the input deck parser and OPM Flow.

Table B.4: New Keywords for the 2018-10 Release

Joakim Hove

B.5 RELEASE 2018-04

The Open Porous Media project is please to announce that version 2018.04 of the OPM suite of simulation software has been release. Installation instructions can found on OPM website download page *https://opm-project.org/?page_id=36* and in section *CHAPTER 2: INSTALLING AND RUNNING FLOW* of this manual. Packages for Ubuntu 16.04 and Red-Hat Enterprise Linux 6 and 7 is prepared. New in this release is that also the Red-Hat packages are shipped with mpi support.

In addition to various minor bug-fixes and a reorganization of the code, the release contains new functionality for the OPM Flow simulator like DRSDT support, experimental CPR preconditioning and enhanced output capability. Note that number of modules are reduced to simplify the build process and the code maintenance. The new module organization is shown opposite.

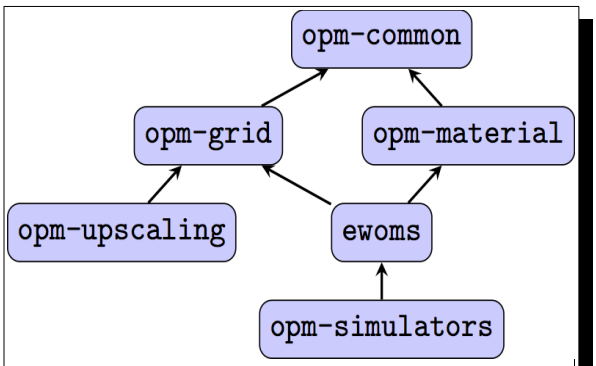


Figure B.2: Module Structure for 2018-04 Release

Since the 2017.10 release the opm-core module has been removed, and the modules opm-parser and opm-output have been folded into opm-common.

In terms of new features OPM Flow now includes analytical aquifers using the Carter-Tracy analytical aquifer and the ability model multi-segment wells. The following new keywords have been incorporated in this release and are active:

No.	Keyword	Comment
1	AQUANCON	AQUANCON keyword defines how analytical aquifers are connected to the simulation grid., this includes Carter-Tracy and Fetkovich analytical aquifers.
2	AQUCT	The AQUCT keyword defines Carter-Tracy aquifers, the properties of the aquifer, including the Carter-Tracy aquifer influence function associated with the aquifer.
3	AQUDIMS	The AQUDIMS keyword defines the dimensions of the various aquifer property data.
4	AQUTAB	AQUTAB keyword defines additional Carter-Tracy aquifer functions to be used in the model.
5	COMSEGS	The COMSEGS keyword defines how a multi-segment well is connected to the reservoir by defining or modifying existing well connections..
6	DRSDT	DRSDT defines the maximum rate at which the solution gas-oil ratio (Rs) can be increased in a grid cell.
7	DRVDT	DRVDT defines the maximum rate at which the solution oil-gas ratio or condensate-gas ratio (Rv) can be increased in a grid cell.
8	WELSEGS	The WELSEGS keyword defines a well to be a multi-segment well and defines the well's segment structure.
9	WSEGSDIMS	The WSEGSDIMS keyword defines the multi-segment well dimensions for the multi-segment well model.

No.	Keyword	Comment

Notes:

1) Cells colored in green in the "No." column indicate that the keyword is recognized by the input deck parser and fully or partially supported by OPM Flow.
2) Cells colored in orange in the "No." column indicate that the keyword is recognized by the input deck parser but not supported by OPM Flow.
3) Cells colored in red in the "No." column indicate that the keyword is not recognized by the input deck parser and OPM Flow.

Table B.5: New Keywords for the 2018-04 Release

Tor Harald Sandve

B.6 RELEASE 2017-10 UPDATE 1

We have created an update for the 2017.10 release. It fixes a few bugs in Flow that could affect simulation results slightly and also lead to very bad performance when running Flow in parallel using MPI. The effect was most pronounced when running with more than 4 MPI processes.

Binary packages for Ubuntu 16.04 and Red Hat Enterprise Linux 6 and 7 have been updated, and for most users your systems will ask to install the updated version or do it automatically.

For those who compile OPM from source, the release branches on GitHub have been updated and tagged with

```
release/2017.10/update1
```

The master branch of course includes the same fixes.

Atgeirr Flø Rasmussen

B.7 RELEASE 2017-10

On behalf of the OPM project, I'm happy to announce that version 2017.10 has been released. Packages for Ubuntu 16.04 and Red-Hat Enterprise Linux 6 and 7 have been prepared or should be available soon.

As usual, this release contains a multitude of new features and improvements. Most notable are probably that the Flow simulator is now considerably faster than in the 2017.04 release, Flow now supports the solvent and polymer black-oil extensions and that there now is freely available documentation for the file format that is used to specify the input.

Finally, as the release manager, I'd take the opportunity and thank everyone involved in making the release process for 2017.10 go as smoothly as it did.

Andreas Lauser

B.8 RELEASE 2017-04

The Open Porous Media project is glad to announce that version 2017.04 of the OPM suite of simulation software has been released! Installation instructions can found on our download page.

Certainly the most significant change of this release is the introduction of the "flow_ebos" simulator. Compared to the previous "flow" simulators, "flow_ebos" uses a different approach to linearize the non-linear system of partial differential equations and as a result exhibits significantly better performance. The new simulator is intended to eventually fully replace the current family of "flow" simulators (i.e., "flow", "flow_mpi", "flow_solvent", "flow_polymer", etc.) and should already provide a proper superset of the capabilities of the "flow" simulator of previous OPM releases. For this reason, the name "flow" has been made an alias for "flow_ebos" in OPM 2017.04. If, for some reason, the previous "flow" simulator must be used, it is still shipped under the name "flow_legacy", but we strongly encourage you to send us bug reports if you encounter any case that can be simulated using "flow_legacy" but not using "flow_ebos".

Besides the introduction of "flow_ebos", plenty unit tests have been added, a plethora of bugs has been fixed, well handling has been considerably improved and now supports e.g. top-hole pressure controls and vertical flow performance tables, ECL output and restart capabilities have been made much more comprehensive, and all grid related functionality of opm-core has been moved to the opm-grid module in preparation of the former module's eventual retirement. In addition, a Docker container has been uploaded to Docker Hub to ease deployment for people who are into container technologies.

Last but not least, I would like to thank everyone who contributed to making the many changes of this release happen so smoothly.

Modules involved in the release (maintainers are given in parenthesis):

- opm-data (Alf Birger Rustad)
- opm-common (Atgeirr Rasmussen, Bård Skaflestad, Arne Morten Kvarving, Joakim Hove, Robert Klöfkorn, Tor Harald Sandve, and Andreas Lauser)
- opm-parser (Joakim Hove)
- opm-output (Joakim Hove)
- opm-grid (Atgeirr Rasmussen, Robert Klöfkorn, and Bård Skaflestad)
- opm-material (Andreas Lauser, Robert Klöfkorn, and Tor Harald Sandve)
- opm-core (Atgeirr Rasmussen, Robert Klöfkorn, and Bård Skaflestad)
- ewoms (Andreas Lauser, Robert Klöfkorn, and Tor Harald Sandve)
- opm-simulators (Atgeirr Rasmussen, Robert Klöfkorn, Tor Harald Sandve, and Andreas Lauser)
- opm-upscaling (Arne Morten Kvarving, Atgeirr Rasmussen, and Bård Skaflestad)

Andreas Lauser

APPENDIX C: RUNNING PREVIOUS RELEASES OF OPM FLOW

C.1 RUNNING OPM FLOW 2019-10

The command line syntax for running OPM Flow is:

```
flow [OPTIONS] CASENAME
```

and typing the following command from your terminal:

```
flow CASENAME
```

will start the simulator and run the case specified by CASENAME.DATA.

OPM Flow accepts command line options to control various aspects of the simulator's run time behavior, as described in the table below. To give a command line option use "key=value" syntax, with no spaces around the equals sign. It is also possible to put multiple options together in a parameter file. To do so, put one option on each line of the file with ".param" as the extension and pass that filename as a command line parameter to OPM Flow using:

```
flow --parameter-file=CASENAME.PARAM
```

to instruct OPM Flow to read the parameter file. The available command line options for this release are listed in Table C.1.

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
	General eWoms/ebos Command Line Parameters		
1	-h or --help	A character string that causes OPM Flow to print a help message that gives a brief description of the available command line parameters.	N/A
2	--continue-on-convergence-error	A Boolean value set to true or false that that instructs the simulator to continue (true) with a non-converged solution instead of giving up (false) if it encounter a time step size smaller than the minimum time step size.	false
3	--cpr-ell-solvetype	A positive integer that defines the solver type of the elliptic pressure solver: 1) 0: bicgstab, 2) 1: cg, 3) 2: only amg preconditioner)	0
4	--cpr-max-ell-iter	A positive integer that sets the maximum number of Iterations for the elliptic pressure part of the Constrained Pressure Residual ("CPR") solver.	20
5	--cpr-reuse-setup	A positive integer that defines if the CPR solver should re-use the Amg setup.	0
6	--cpr-solver-verbose	A defined positive integer value that defines the output from CPR solver: 1) 0: no output 2) 1: output summary of inner linear solver 3) 2: output extensive information about inner linear solve, including setup information	0

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
7	--cpr-use-drs	A Boolean value set to true or false that switches on (true) or off (false) the use of dynamic row sum weights in the CPR solver.	false
8	--dbph-max-rel	A real positive value that sets maximum relative change of the bottom-hole pressure in a single iteration	1.0
9	--dp-max-rel	A real positive double precision value that sets the maximum allowed relative change of pressure per iteration.	0.3
10	--ds-max	A real positive double precision value that sets the maximum allowed change in saturation per iteration.	0.2
11	--dwell-fraction-max	A real positive double precision value that sets the maximum allowed change in well's volume fraction per iteration.	0.2
12	--ecl-deck-file-name	A character string that defines the name of the OPM Flow input file which contains the simulator's ECLIPSE formatted input deck to be simulated.	“”
13	--ecl-enable-drift-compensation	A Boolean value set to true or false that enables (true) or disables (false) partial compensation of systematic mass losses via the source term of the next time step.	false
14	--ecl-output-double-precision	A Boolean value set to true or false that switches on (true) or off (false) double precision in restart files. Useful for 'perfect' restarts.	false
15	--ecl-output-interval	An integer value defining the number of report steps that ought to be skipped between two writes of restart files results.	-1
16	--ecl-strict-parsing	A Boolean value set to true or false that switches on (true) or off (false) strict parsing mode for parsing - all errors are collected before the application exists. Useful for debugging initial runs.	false
17	--edge-weights-method	A defined positive integer value that defines the edge-weighing strategy: 1) 0: for uniform, 2) 1: for trans, 0r 3) 2” for log(trans).	1
18	--enable-adaptive-time-stepping	A Boolean value set to true or false that turns on (true) or off (false) adaptive time stepping. If set to false the report time steps provided by the input deck are used.	true
19	--enable-async-ecl-output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to restart and summary files in the commercial simulators format.	true

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
20	--enable-async-vtk-output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to the VTK output files.	true
21	--enable-dry-run	A Boolean value set to true or false that specifies if the simulation should actually run, (true) or just check the input deck (false). This option is equivalent to activating the NOSIM keyword in the RUNSPEC section of the input deck (see section *5.2.78 NOSIM – Activate the No Simulation Mode for Data File Checking*).	true
22	--enable-ecl-output	A Boolean value set to true or false that specifies if the binary output files (restart, summary files, etc.) should be written in the commercial simulator's format (true), or OPM Flow's format (false).	true
23	--enable-logging-fallout-warning	A Boolean value set to true or false that sets the developer option to see whether logging was on non-root processors (true). If set to true output will be appended to the *.DBG or *.PRT files.	false
24	--enable-opm-rst-file	A Boolean value set to true or false to write OPM specific data sets to the commercial simulators restart file to enable restart of an OPM Flow runs (true), or not to write the data (false).	true
25	--enable-storage-cache	A Boolean value set to true or false that turns on (true) or off (false) storing previous storage terms and avoid re-calculating them.	true
26	--enable-terminal-output	A Boolean value set to true or false that turns on (true) or off (false) high-level information about the simulation's progress to the terminal	true
27	--enable-tracer-mode	A Boolean value set to true or false that turns on (true) or off (false) transport tracer calculations for when tracers have been declared in the input deck. **Experimental - use with caution.**	false
28	--enable-tuning	A Boolean value set to true or false that instructs OPM Flow to read the time stepping parameters from the *TUNING - Numerical Tuning Control* keyword in the input deck, if set to true. Note that only the first record of the TUNING keyword is processed.	false
29	--enable-vtk-output	A Boolean value set to true or false that turns on (true) or off (false) a global switch for writing VTK files.	false
30	--enable-well-operability-check	A Boolean value set to true or false that enables (true) checking of a well's operating status, or disables (false) the checking.	true
31	--enable-write-all-solutions	A Boolean value set to true or false that turns on (true) or off (false) the writing of all solutions to disk instead of only the ones for the report steps.	false
	OPM Flow Specific Command Line Parameters		

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
32	--flow-linear-solver-verbosity	A positive integer value that defines the output from linear solver: 1) 0: no extra output 2) 1: output per solution iteration 3) >1: output per iteration	0
33	--flow-newton-max-iterations	A positive integer that defines the maximum number of Newton iterations per time step used by the simulator.	20
34	--flow-newton-min-iterations	A real positive value that sets the minimum number of Newton iterations per time step used by the simulator.	1
	General eWoms/ebos Command Line Parameters		
35	--force-disable-fluid-in-place-output	A Boolean value set to true or false that instructs OPM Flow to not to print the Fluid In-Place report after each report time step (true) or not (false).	false
36	--full-time-step-initially	A Boolean value set to true or false that instructs OPM Flow to always attempt to finish a report step using a single time step (true) or not (false).	false
37	--ignore-keywords	A character string that defines a list of keywords which should be ignored by OPM Flow. The keyword string should be enclosed in quotes and each keyword separated by a colon, that is ':' .	“”
38	--ilu-fillin-level	A positive integer value that sets the fill in level for the ILU pre-conditioner.	0
39	--ilu-redblack	A Boolean value set to true or false that instructs OPM Flow to use red-black partitioning for the ILU pre-conditioner. (true) or not (false).	false
40	--ilu-relaxation	A real positive double precision value that sets the relaxation factor of the linear solver's ILU pre-conditioner	0.9
41	--ilu-reorder-spheres	A Boolean value set to true or false specifies OPM Flow to reorder the entries of the matrix in the red-black ILU pre-conditioner in spheres starting at an edge (true) or not (false) If false the original ordering is preserved in each color. Otherwise try to ensure D4 ordering (in a 2D structured grid, the diagonal elements are consecutive).	false
42	--initial-time-step-in-days	A real double precision value that sets the size of initial time step in days.	1.0
43	--linear-solver-configuration-json-file	A character string enclosed in quotes that defines the filename of a JSON configuration file for the flexible linear solver system.	none
44	--linear-solver-ignore-convergence-failure	A Boolean value set to true or false that if set to true convergences failures in the linear solver are ignored. This option should be used with care, as the results may be unreliable.	false

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
45	--linear-solver-max-iter	A positive integer value that defines the maximum number of linear iterations.	200
46	--linear-solver-reduction	A real positive double precision value that sets the tolerance for the linear solver. The linear solver convergences when the residual is reduced sufficiently.	0.01
47	--linear-solver-require-full-sparsity-pattern	A Boolean value set to true or false that if set to true the simulator will produce the full sparsity pattern for the linear solver.	false
48	--linear-solver-restart	A positive integer value that sets the number of iterations after which GMRES is restarted.	40
49	--matrix-add-well-contributions	A Boolean value set to true or false that if set to true explicitly specifies the influences of wells between cells in the Jacobian and pre-conditioner matrices.	false
50	--max-inner-iter-ms-wells	A positive integer value that defines the maximum number of inner iterations for multi-segment wells.	100
51	--max-pressure-change-ms-wells	A real positive value that defines the maximum relative pressure change for a single iteration of the multi-segment well model.	1.0×10^6
52	--max-residual-allowed	A real positive value that sets the absolute maximum tolerance for residuals without cutting the time step size.	1.0×10^7
53	--max-single-precision-days	A real positive value that set the maximum time step size where single precision floating point arithmetic can be used solving for the linear systems of equations.	20.0
54	--max-strict-iter	A positive integer that sets the maximum number of Newton iterations before relaxed tolerances are used for the CNV convergence criterion.	8
55	--max-welleq-iter	A positive integer that defines the maximum number of iterations to determine the solution to the well equations.	30
56	--milu-variant	A defined character string that specifies which variant of the modified-ILU preconditioner ought to be used. Possible variants are: 1) ILU (default, plain ILU), 2) MILU_1 (lump diagonal with dropped row entries), 3) MILU_2 (lump diagonal with the sum of the absolute values of the dropped row entries), 4) MILU_3 (if diagonal is positive add sum of dropped row entries. Otherwise subtract them), 5) MILU_4 (if diagonal is positive add sum of dropped row entries. Otherwise do nothing. The default is ILU	ILU
57	--newton-max-relax	A real positive value that sets the maximum relaxation factor of a Newton iteration used by the simulator.	0.5

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
58	--newton-relaxation-type	A character string that defines the type of relaxation used in Newton's method, default is dampen.	dampen
59	--output-dir	A character string that defines the directory to which OPM Flow is to write the commercial simulator compatible output files (restart, summary files etc.). The default value results in the files be written to the same directory as the input file.	“”
60	--output-interval	A positive integer that specifies the number of report steps between two consecutive writes of restart data.	1
61	--output-mode	A character string that defines the output to the *.PRT and *.DEBUG files: 1) none: No output to the files. 2) log or false: Output logging information only. 3) all or true: Output everything. For example to just output logging information use: `--output-mode=log or --output-mode=false`	all
62	--parameter-file	A character string that defines the name of a parameter file which contains the simulator's set of run-time parameters, as listed in this table.	“”
63	--pri-var-oscilation-threshold	A real positive vale that defines the threshold value for the primary variable switching conditions after its meaning has switched to hinder oscillations.	1×10^{-5}
64	--print-parameters	A positive integer value that request that the run time parameters be printed at the start of the run: 1) 0: No output to the files. 2) 1: Output *.DBG file 3) 2: Output to *.DBG and *.PRT files (default)	2
65	--print-properties	A positive integer value that request that the compile time parameters be printed at the start of the run: 1) 0: No output to the files. 2) 1: Output *.DBG file 3) 2: Output to *.DBG and *.PRT files (default)	2
66	--scale-linear-system	A Boolean value set to true or false that switches on (true) or off (false) the scaling of linear system of equations according to the equation scale and primary variable types.	false
67	--solve-welleq-initially	A Boolean value set to true or false that switches on (true) or off (false) the solving of the well equations as a pre-processing step. Note that the well equations are always added to the full system and solved until converged.	true

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
68	--solver-growth-factor	A real positive value that specifies the allowed value a time step can be increased by, subject to the maximum allowable time step size set by the *–flow-solver-max-time-step-in-days* parameter. For example, if the current time step has converged at 10 days and *–flow-solver-growth-factor* is set to the default value, then the next time step will be 2.0 * 10 days, that is at 20 days.	2.0
69	--solver-max-growth	A real positive value that specifies the maximum allowed value a time step can be increased by after a report time step. subject to the maximum allowable time step size set by the *–flow-solver-max-time-step-in-days* parameter.	3.0
70	--solver-max-restarts	A positive integer that defines the number of allowed consecutive restarts (or time step chops) before the simulation is terminated.	10
71	--solver-max-time-step-in-days	A real positive double precision value that specifies the maximum allowed time step size in days.	365
72	--solver-restart-factor	A real positive double precision value that sets the time step chop factor of the time step after a convergence failure. For example, if the current non-convergent time step is 30 days and *–flow-solver-restart-factor* is set to the default value, then the time step will be repeated using 0.33 * 30 days as the time step, that is 9.9 days.	0.33
73	--solver-verbosity	A positive integer that specifies the "chattiness" of the non-linear solver.	1
74	--system-strategy	A character string that defines the strategy for reformulating and scaling linear system of equations and is set to one of the following: 1) none: No scaling - should not be used with the CPR solver. 2) original: Use weights that are equivalent to no scaling - should not be used with the CPR solver. 3) simple: Form pressure equation as simple sum of conservation equations. 4) quasiimpes: Form pressure equation based on diagonal block. 5) trueimpes: Form pressure equation based on linearization of the accumulation term.	none
75	--threads-per-process	A positive integer value that stipulates the maximum number of threads to be instantiated per process ('-1' means 'automatic').	-1
76	--time-step-after-event-in-days	A real double precision value that sets maximum allowed time step after an event; for example, when a well is open or closed etc. The default value of -1 means that events to do effect the time stepping.	-1

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
77	--time-step-control	A character string that defines the time stepping control algorithm and is set to one of the following: 1) pid: PID controller based adaptive time step control as suggested by Turek and Kuzmin[171]. 2) pid+iteration: Use PID and linear iteration numbers to guide the time step. 3) pid+newtoniteration: Use PID and non-linear iterations numbers to guide the time step. 4) Hardcoded: Use time steps supplied by user via the time-step-control-filename parameter.	pid
78	--time-step-control-decay-rate	A real positive value that specifies the decay rate a time step can be decreased by after the number of target iterations has been exceeded	0.75
79	--time-step-control-file-name	A character string enclosed in quotes that specifies a filename where time steps are specified. The default is the character string timesteps For instance time steps can be generated by the ecl_summary application in libecl as per the following UNIX command line: `path_to_libecl_applications/ ecl_summary DECK TIME > filename` Where: DECK is the name of the data deck you want to get the time steps from, TIME tells the application to return the timing for the run, and "filename" is the name of the file the times are piped to.	timesteps
80	--time-step-control-growth-rate	A real positive value that specifies the growth rate of the time step size of the number of target iterations is undercut.	1.25
81	--time-step-control-target-iterations	A positive integer that defines the number of linear iterations which the time step control scheme should aim for (if applicable).	30
82	--time-step-control-target-newton-iterations	A positive integer that specifies the number of Newtonian iterations which the time step control scheme should aim for (if applicable).	8
83	--time-step-control-tolerance	A real double precision value that sets the tolerance for PID (only used with the pid and pid+ options defined by the *–time-step-control* option).	0.1
84	--time-step-verbosity	A positive integer that specifies the "chattiness" during the time integration.	1
85	--tolerance-cnv	A real positive double precision value that specifies the maximum non-linear tolerance error. This is the local convergence tolerance (maximum of local saturation errors).	0.01

[171] *Algebraic Flux Correction III. Incompressible Flow Problems. Uni Dortmund, Turek and Kuzmin, January, 2006 (DOI: 10.1007/3-540-27206-2_8)*

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
86	--tolerance-cnv-relaxed	A real positive value that defines the relaxed local convergence tolerance that applies for iterations after the iterations with the strict tolerance.	1.0×10^{9}
87	--tolerance-mb	A real positive double precision value that sets the maximum mass balance error, that is the tolerated mass balance error relative to total mass present.	1.0×10^{6}
88	--tolerance-pressure-ms-wells	A real positive double precision value that specifies the tolerance for the pressure equations for multi-segment wells.	1000
89	--tolerance-well-control	A real positive double precision value that sets the maximum tolerance for the well control equations.	1.0×10^{-7}
90	--tolerance-wells	A real positive double precision value that defines the maximum non-linear error for the well equations.	0.0001
91	-update-equations-scaling	A Boolean value set to true or false that switches on (true) or off (false) the updating of the scaling factors for mass balance equations during the simulation.	false
92	--use-amg	A Boolean value set to true or false that if set to true OPM Flow will use AMG as the linear solver's pre-conditioner	false
93	--use-cpr	A Boolean value set to true or false that when set to true OPM Flow will use CPR as the linear solver's pre-conditioner	false
94	--use-gmres	A Boolean value set to true or false that when set to true OPM Flow will use Generalized Minimal Residual ("GMRES") solver instead of Biconjugate Gradient Stabilized ("BiCGSTAB") as the linear solver within the Newton iterations.	false
95	--use-inner-iterations-ms-wells	A Boolean value set to true or false that when set to true the simulator will use nested iterations for multi-segment wells.	true
96	--use-multisegment-well	A Boolean value set to true or false that when set to true the simulator will use the well model for multi-segment wells instead of the one for single-segment wells.	false
97	--use-update-stabilization	A Boolean value set to true or false that switches on (true) or off (false) the stabilized Newton option. This option may improve convergence for some cases.	true
	VTK Graphics Command Line Parameters[172]		
98	--vtk-write-average-molar-masses	A Boolean value set to true or false that turns on (true) or off (false) the output of the average phase mass in the VTK output files.	false

[172] *Virtualization ToolKit ("VTK") files used to visualize the 3D results from the model using ParaView, an open-source, multi-platform general purpose data analysis and visualization application (https://www.paraview.org/overview/). For the commercial simulator's compatible output files OPM's ResInsight 3D visualization package can be used instead and is specifically tailored for OPM Flow and the commercial simulator.*

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
99	--vtk-write-densities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase densities to the VTK output files	true
100	--vtk-write-dof-index	A Boolean value set to true or false that turns on (true) or off (false) the output of the tracer concentrations to the VTK output files.	false
101	--vtk-write-ecl-tracer-concentration	A Boolean value set to true or false that turns on (true) or off (false) the output of the index of the degrees of freedom to the VTK output files.	false
102	--vtk-write-extrusion-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the of the extrusion factor of the degrees of freedom to the VTK output files.	false
103	--vtk-write-filter-velocities	A Boolean value set to true or false that turns on (true) or off (false) the output of the filter velocities of the phases in the VTK output files.	false
104	--vtk-write-fugacities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component fugacities to the VTK output files.	false
105	--vtk-write-fugacity-coeffs	A Boolean value set to true or false that turns on (true) or off (false) the output of the component fugacity coefficients to the VTK output files.	false
106	--vtk-write-gas-dissolution-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas dissolution factor (Rs) of the observed oil to the VTK output files.	false
107	--vtk-write-gas-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas formation volume factor (Bg) to the VTK output files.	false
108	--vtk-write-gas-saturation-pressure	A Boolean value set to true or false that turns on (true) or off (false) the output of the saturation pressure of gas (Pg,sat) to the VTK output files'	false
109	--vtk-write-intrinsic-permeabilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the intrinsic permeability to the VTK output files.	false
110	--vtk-write-mass-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the mass fractions to the VTK output files.	false
111	--vtk-write-mobilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase mobilities to the VTK output files.	false
112	--vtk-write-molarities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component molarities to the VTK output files.	false
113	--vtk-write-mole-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the mole fractions to the VTK output files.	true

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
114	--vtk-write-oil-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil formation volume factor (Bo) to the VTK output files.	false
115	--vtk-write-oil-saturation-pressure	A Boolean value set to true or false that turns on (true) or off (false) the output of the saturation pressure of oil (Po,sat) to the VTK output files.	false
116	--vtk-write-oil-vaporization-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil vaporization factor (Rv) of the observed gas to the VTK output files.	false
117	--vtk-write-porosity	A Boolean value set to true or false that turns on (true) or off (false) the output of the porosity array to the VTK output files.	true
118	--vtk-write-potential-gradients	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase pressure potential gradients to the VTK output files.	false
119	--vtk-write-pressures	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase pressures to the VTK output files.	true
120	--vtk-write-primary-vars	A Boolean value set to true or false that turns on (true) or off (false) the output of the primary variables to the VTK output files.	false
121	--vtk-write-primary-vars-meaning	A Boolean value set to true or false that turns on (true) or off (false) the output of the how the primary variables should be interpreted to the VTK output files.	false
122	--vtk-write-process-rank	A Boolean value set to true or false that turns on (true) or off (false) the output of the MPI process rank to the VTK output files.	false
123	--vtk-write-relative-permeabilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase relative permeabilities to the VTK output files.	true
124	--vtk-write-saturated-gas-oil-vaporization-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil vaporization factor (Rv,sat) of oil saturated gas to the VTK output files.	false
125	--vtk-write-saturated-oil-gas-dissolution-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas dissolution factor (Rs,sat) of gas saturated oil to the VTK output files.	false
126	--vtk-write-saturation-ratios	A Boolean value set to true or false that turns on (true) or off (false) the output of the ratio of the actually and maximum dissolved component of the mixture to the VTK output files	false
127	--vtk-write-saturations	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase saturations to the VTK output files.	true

OPM Flow 2019-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
128	--vtk-write-temperature	A Boolean value set to true or false that turns on (true) or off (false) the output of the temperature array to the VTK output files.	true
129	--vtk-write-total-mass-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the total mass fractions to the VTK output files.	false
130	--vtk-write-total-mole-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the total mole fractions to the VTK output files.	false
131	--vtk-write-viscosities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component phase viscosities to the VTK output files.	false
132	--vtk-write-water-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil formation volume factor (Bo) to the VTK output files.	false

Notes:

1) Cells colored green in the No. column are new command line parameters for this release.
2) Items shaded in gray are considered to be developer options that should be used with caution as the values associated with these command line parameters are subject to change.
3) The --preconditioner-add-well-contributions parameter option that switches on (true) or off (false) the influences of wells between cells for the pre-conditioner matrix only, has been retired in the 2019-10 release.
4) As per all UNIX and LINUX based system the input is case dependent.
5) If a parameter file is used to set one of the above parameters, the leading "--" should not be incorporated in the parameter file.

Table C.1: OPM Flow 2019-10 Command Line Options

C.2 RUNNING OPM FLOW 2019-04

The command line syntax for running OPM Flow is:

```
flow [OPTIONS] CASENAME
```

and typing the following command from your terminal:

```
flow CASENAME
```

will start the simulator and run the case specified by CASENAME.DATA.

OPM Flow accepts command line options to control various aspects of the simulator's run time behavior, as described in the table below. To give a command line option use "key=value" syntax, with no spaces around the equals sign. It is also possible to put multiple options together in a parameter file. To do so, put one option on each line of the file with ".param" as the extension and pass that filename as a command line parameter to OPM Flow using:

```
flow --parameter-file=CASENAME.PARAM
```

to instruct OPM Flow to read the parameter file. The available command line options for this release are listed in Table C.2.

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
	General eWoms/ebos Command Line Parameters		
1	-h or --help	A character string that causes OPM Flow to print a help message that gives a brief description of the available command line parameters.	N/A
2	--cpr-ell-solvetype	A positive integer that defines the solver type of the elliptic pressure solver: 1) 0: bicgstab, 2) 1: cg, 3) 2: only amg preconditioner)	0
3	--cpr-max-ell-iter	A positive integer that sets the maximum number of Iterations for the elliptic pressure part of the Constrained Pressure Residual ("CPR") solver.	20
4	--cpr-reuse-setup	A positive integer that that defines if the CPR solver should re-use the Amg setup.	0
5	--cpr-solver-verbose	A positive integer value that defines the output from CPR solver: 1) 0: no output 2) 1: output summary of inner linear solver 3) 2: output extensive information about inner linear solve, including setup information	0
6	--cpr-use-drs	A Boolean value set to true or false that switches on (true) or off (false) the use of dynamic row sum weights in the CPR solver.	false
7	--dbph-max-rel	A real positive value that sets maximum relative change of the bottom-hole pressure in a single iteration	1.0

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
8	--dp-max-rel	A real positive double precision value that sets the maximum allowed relative change of pressure per iteration.	0.3
9	--ds-max	A real positive double precision value that sets the maximum allowed change in saturation per iteration.	0.2
10	--dwell-fraction-max	A real positive double precision value that sets the maximum allowed change in well's volume fraction per iteration.	0.2
11	--ecl-deck-file-name	A character string that defines the name of the OPM Flow input file which contains the simulator's ECLIPSE formatted input deck to be simulated.	“”
12	--ecl-output-double-precision	A Boolean value set to true or false that switches on (true) or off (false) double precision in restart files. Useful for 'perfect' restarts.	false
13	--ecl-output-interval	An integer value defining the number of report steps that ought to be skipped between two writes of restart files results.	-1
14	--ecl-strict-parsing	A Boolean value set to true or false that switches on (true) or off (false) strict parsing mode for parsing - all errors are collected before the application exists. Useful for debugging initial runs.	false
15	--enable-adaptive-time-stepping	A Boolean value set to true or false that that turns on (true) or off (false) adaptive time stepping. If set to false the report time steps provided by the input deck are used.	true
16	--enable-async-ecl-output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to restart and summary files in the commercial simulators format.	true
17	--enable-async-vtk-output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to the VTK output files.	true
18	--enable-dry-run	A Boolean value set to true or false that specifies if the simulation should actually run, (true) or just check the input deck (false). This option is equivalent to activating the NOSIM keyword in the RUNSPEC section of the input deck (see section *5.2.78 NOSIM – Activate the No Simulation Mode for Data File Checking*).	true
19	--enable-ecl-output	A Boolean value set to true or false that specifies if the binary output files (restart, summary files, etc.) should be written in the commercial simulator's format (true), or OPM Flow's format (false).	true
20	--enable-logging-fallout-warning	A Boolean value set to true or false that sets the developer option to see whether logging was on non-root processors (true). If set to true output will be appended to the *.DBG or *.PRT files.	false

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
21	--enable-opm-rst-file	A Boolean value set to true or false to write OPM specific data sets to the commercial simulators restart file to enable restart of an OPM Flow runs (true), or not to write the data (false).	true
22	--enable-storage-cache	A Boolean value set to true or false that turns on (true) or off (false) storing previous storage terms and avoid re-calculating them.	true
23	--enable-terminal-output	A Boolean value set to true or false that turns on (true) or off (false) high-level information about the simulation's progress to the terminal	true
24	--enable-tracer-mode	A Boolean value set to true or false that turns on (true) or off (false) transport tracer calculations for when tracers have been declared in the input deck. **Experimental - use with caution.**	false
25	--enable-tuning	A Boolean value set to true or false that that instructs OPM Flow to read the time stepping parameters from the *TUNING - Numerical Tuning Control* keyword in the input deck, if set to true. Note that only the first record of the TUNING keyword is processed.	false
26	--enable-vtk-output	A Boolean value set to true or false that turns on (true) or off (false) a global switch for writing VTK files.	false
27	--enable-write-all-solutions	A Boolean value set to true or false that turns on (true) or off (false) the writing of all solutions to disk instead of only the ones for the report steps.	false
	OPM Flow Specific Command Line Parameters		
28	--flow-linear-solver-verbosity	A positive integer value that defines the output from linear solver: 1) 0: no extra output 2) 1: output per solution iteration 3) >1: output per iteration	0
29	--flow-newton-max-iterations	A positive integer that defines the maximum number of Newton iterations per time step used by the simulator.	20
30	--flow-newton-min-iterations	A real positive value that sets the minimum number of Newton iterations per time step used by the simulator.	1
	General eWoms/ebos Command Line Parameters		
31	--force-disable-fluid-in-place-output	A Boolean value set to true or false that instructs OPM Flow to not to print the Fluid In-Place report after each report time step (true) or not (false).	false
32	--full-time-step-initially	A Boolean value set to true or false that instructs OPM Flow to always attempt to finish a report step using a single time step (true) or not (false).	false

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
33	--ignore-keywords	A character string that defines a list of keywords which should be ignored by OPM Flow. The keyword string should be enclosed in quotes and each keyword separated by a colon, that is ':' .	“”
34	--ilu-fillin-level	A positive integer value that sets the fill in level for the ILU pre-conditioner.	0
35	--ilu-redblack	A Boolean value set to true or false that instructs OPM Flow to use red-black partitioning for the ILU pre-conditioner. (true) or not (false).	false
36	--ilu-relaxation	A real positive double precision value that sets the relaxation factor of the linear solver's ILU pre-conditioner	0.9
37	--ilu-reorder-spheres	A Boolean value set to true or false specifies OPM Flow to reorder the entries of the matrix in the red-black ILU pre-conditioner in spheres starting at an edge (true) or not (false) If false the original ordering is preserved in each color. Otherwise try to ensure D4 ordering (in a 2D structured grid, the diagonal elements are consecutive).	false
38	--initial-time-step-in-days	A real double precision value that sets the size of initial time step in days.	1.0
39	--linear-solver-ignore-convergence-failure	A Boolean value set to true or false that if set to true convergences failures in the linear solver are ignored. This option should be used with care, as the results may be unreliable.	false
40	--linear-solver-max-iter	A positive integer value that defines the maximum number of linear iterations.	200
41	--linear-solver-reduction	A real positive double precision value that sets the tolerance for the linear solver. The linear solver convergences when the residual is reduced sufficiently.	0.01
42	--linear-solver-require-full-sparsity-pattern	A Boolean value set to true or false that if set to true the simulator will produce the full sparsity pattern for the linear solver.	false
43	--linear-solver-restart	A positive integer value that sets the number of iterations after which GMRES is restarted.	40
44	--matrix-add-well-contributions	A Boolean value set to true or false that if set to true explicitly specifies the influences of wells between cells in the Jacobian and pre-conditioner matrices.	false
45	--max-inner-iter-ms-wells	A positive integer value that defines the maximum number of inner iterations for multi-segment wells.	10
46	--max-pressure-change-ms-wells	A real positive value that defines the maximum relative pressure change for a single iteration of the multi-segment well model.	200000
47	--max-residual-allowed	A real positive value that sets the absolute maximum tolerance for residuals without cutting the time step size.	1.0×10^7

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
48	--max-single-precision-days	A real positive value that set the maximum time step size where single precision floating point arithmetic can be used solving for the linear systems of equations.	20.0
49	--max-strict-iter	A positive integer that sets the maximum number of Newton iterations before relaxed tolerances are used for the CNV convergence criterion.	8
50	--max-welleq-iter	A positive integer that defines the maximum number of iterations to determine the solution to the well equations.	30
51	--milu-variant	A defined character string that specifies which variant of the modified-ILU preconditioner ought to be used. Possible variants are: 1) ILU (default, plain ILU), 2) MILU_1 (lump diagonal with dropped row entries), 3) MILU_2 (lump diagonal with the sum of the absolute values of the dropped row entries), 4) MILU_3 (if diagonal is positive add sum of dropped row entrires. Otherwise substract them), 5) MILU_4 (if diagonal is positive add sum of dropped row entrires. Otherwise do nothing. The default is ILU	ILU
52	--newton-max-relax	A real positive value that sets the maximum relaxation factor of a Newton iteration used by the simulator.	0.5
53	--newton-relaxation-type	A character string that defines the type of relaxation used in Newton's method., default is dampen.	dampen
54	--output-dir	A character string that defines the directory to which OPM Flow is to write the commercial simulator compatible output files (restart, summary files etc.). The default value results in the files be written to the same directory as the input file.	“”
55	--output-interval	A positive integer that specifies the number of report steps between two consecutive writes of restart data.	1
56	--output-mode	A character string that defines the output to *.PRT and *.DEBUG files: 1) none: No output to the files. 2) log or false: Output logging information only. 3) all or true: Output everything. For example to just output logging information use: `--output-mode=log or --output-mode=false`	all
57	--parameter-file	A character string that defines the name of a parameter file which contains the simulator's set of run-time parameters, as listed in this table.	“”

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
58	--preconditioner-add-well-contributions	A Boolean value set to true or false that switches on (true) or off (false) the influences of wells between cells for the pre-conditioner matrix only. **Note this parameter is missing from the help when executing:** `flow -h`	false
59	--pri-var-oscilation-threshold	A real positive vale that defines the threshold value for the primary variable switching conditions after its meaning has switched to hinder oscillations.	1×10^{-5}
60	--print-parameters	A positive integer value that request that the run time parameters be printed at the start of the run: 1) 0: No output to the files. 2) 1: Output *.DBG file 3) 2: Output to *.DBG and *.PRT files (default)	2
61	--print-properties	A positive integer value that request that the compile time parameters be printed at the start of the run: 1) 0: No output to the files. 2) 1: Output *.DBG file 3) 2: Output to *.DBG and *.PRT files (default)	2
62	--scale-linear-system	A Boolean value set to true or false that switches on (true) or off (false) the scaling of linear system of equations according to the equation scale and primary variable types.	false
63	--solve-welleq-initially	A Boolean value set to true or false that switches on (true) or off (false) the solving of the well equations as a pre-processing step. Note that the well equations are always added to the full system and solved until converged.	true
64	--solver-growth-factor	A real positive value that specifies the allowed value a time step can be increased by, subject to the maximum allowable time step size set by the *–flow-solver-max-time-step-in-days* parameter. For example, if the current time step has converged at 10 days and *–flow-solver-growth-factor* is set to the default value, then the next time step will be 2.0 * 10 days, that is at 20 days.	2.0
65	--solver-max-growth	A real positive value that specifies the maximum allowed value a time step can be increased by after a report time step. subject to the maximum allowable time step size set by the *–flow-solver-max-time-step-in-days* parameter.	3.0
66	--solver-max-restarts	A positive integer that defines the number of allowed consecutive restarts (or time step chops) before the simulation is terminated.	10
67	--solver-max-time-step-in-days	A real positive double precision value that specifies the maximum allowed time step size in days.	365

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
68	--solver-restart-factor	A real positive double precision value that sets the time step chop factor of the time step after a convergence failure. For example, if the current non-convergent time step is 30 days and *--flow-solver-restart-factor* is set to the default value, then the time step will be repeated using 0.33 * 30 days as the time step, that is 9.9 days.	0.33
69	--solver-verbosity	A positive integer that specifies the "chattiness" of the non-linear solver.	1
70	--system-strategy	A character string that defines the strategy for reformulating and scaling linear system of equations and is set to one of the following: 1) none: No scaling - should not be used with the CPR solver. 2) original: Use weights that are equivalent to no scaling - should not be used with the CPR solver. 3) simple: Form pressure equation as simple sum of conservation equations. 4) quasiimpes: Form pressure equation based on diagonal block. 5) trueimpes: Form pressure equation based on linearization of the accumulation term.	none
71	--threads-per-process	A positive integer value that stipulates the maximum number of threads to be instantiated per process ('-1' means 'automatic').	1
72	--time-step-after-event-in-days	A real double precision value that sets maximum allowed time step after an event; for example, when a well is open or closed etc. The default value of -1 means that events to do effect the time stepping.	-1
73	--time-step-control	A character string that defines the time stepping control algorithm and is set to one of the following: 1) pid: PID controller based adaptive time step control as suggested by Turek and Kuzmin[173]. 2) pid+iteration: Use PID and linear iteration numbers to guide the time step. 3) pid+newtoniteration: Use PID and non-linear iterations numbers to guide the time step. 4) Hardcoded: Use time steps supplied by user. Via timestep.control.filename	pid
74	--time-step-control-decay-rate	A real positive value that specifies the decay rate a time step can be decreased by after the number of target iterations has been exceeded	0.75

[173] *Algebraic Flux Correction III. Incompressible Flow Problems. Uni Dortmund, Turek and Kuzmin, January, 2006 (DOI: 10.1007/3-540-27206-2_8)*

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
75	--time-step-control-file-name	A character string that specifies a filename where time steps are specified. The default is the character string timesteps For instance time steps can be generated by the ecl_summary application in libecl as per the following UNIX command line: `path_to_libecl_applications/ ecl_summary DECK TIME > filename` Where: DECK is the name of the data deck you want to get the time steps from, TIME tells the application to return the timing for the run, and "filename" is the name of the file the times are piped to.	timesteps
76	--time-step-control-growth-rate	A real positive value that specifies the growth rate of the time step size of the number of target iterations is undercut.	1.25
77	--time-step-control-target-iterations	A positive integer that defines the number of linear iterations which the time step control scheme should aim for (if applicable).	30
78	--time-step-control-target-newton-iterations	A positive integer that specifies the number of Newtonian iterations which the time step control scheme should aim for (if applicable).	8
79	--time-step-control-tolerance	A real double precision value that sets the tolerance for PID (only used with the pid and pid+ options defined by the *–time-step-control* option).	0.1
80	--time-step-verbosity	A positive integer that specifies the "chattiness" during the time integration.	1
81	--tolerance-cnv	A real positive double precision value that specifies the maximum non-linear tolerance error. This is the local convergence tolerance (maximum of local saturation errors).	0.01
82	--tolerance-cnv-relaxed	A real positive value that defines the relaxed local convergence tolerance that applies for iterations after the iterations with the strict tolerance.	1.0×10^{9}
83	--tolerance-mb	A real positive double precision value that sets the maximum mass balance error, that is the tolerated mass balance error relative to total mass present.	1.0×10^{6}
84	--tolerance-pressure-ms-wells	A real positive double precision value that specifies the tolerance for the pressure equations for multi-segment wells.	1000
85	--tolerance-well-control	A real positive double precision value that sets the maximum tolerance for the well control equations.	1.0×10^{-7}
86	--tolerance-wells	A real positive double precision value that defines the maximum non-linear error for the well equations.	0.0001

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
87	-update-equations-scaling	A Boolean value set to true or false that switches on (true) or off (false) the updating of the scaling factors for mass balance equations during the simulation.	false
88	--use-amg	A Boolean value set to true or false that if set to true OPM Flow will use AMG as the linear solver's pre-conditioner	false
89	--use-cpr	A Boolean value set to true or false that when set to true OPM Flow will use CPR as the linear solver's pre-conditioner	false
90	--use-gmres	A Boolean value set to true or false that when set to true OPM Flow will use Generalized Minimal Residual ("GMRES") solver instead of Biconjugate Gradient Stabilized ("BiCGSTAB") as the linear solver within the Newton iterations.	false
91	--use-inner-iterations-ms-wells	A Boolean value set to true or false that when set to true the simulator will use nested iterations for multi-segment wells.	true
92	--use-multisegment-well	A Boolean value set to true or false that when set to true the simulator will use the well model for multi-segment wells instead of the one for single-segment wells.	false
93	--use-update-stabilization	A Boolean value set to true or false that switches on (true) or off (false) the stabilized Newton option. This option may improve convergence for some cases.	true
	VTK Graphics Command Line Parameters[174]		
94	--vtk-write-average-molar-masses	A Boolean value set to true or false that turns on (true) or off (false) the output of the average phase mass in the VTK output files.	false
95	--vtk-write-densities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase densities to the VTK output files	true
96	--vtk-write-dof-index	A Boolean value set to true or false that turns on (true) or off (false) the output of the tracer concentrations to the VTK output files.	false
97	--vtk-write-ecl-tracer-concentration	A Boolean value set to true or false that turns on (true) or off (false) the output of the index of the degrees of freedom to the VTK output files.	false
98	--vtk-write-extrusion-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the of the extrusion factor of the degrees of freedom to the VTK output files.	false
99	--vtk-write-filter-velocities	A Boolean value set to true or false that turns on (true) or off (false) the output of the filter velocities of the phases in the VTK output files.	false

[174] *Virtualization ToolKit ("VTK") files used to visualize the 3D results from the model using ParaView, an open-source, multi-platform general purpose data analysis and visualization application (https://www.paraview.org/overview/). For the commercial simulator's compatible output files OPM's ResInsight 3D visualization package can be used instead and is specifically tailored for OPM Flow and the commercial simulator.*

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
100	--vtk-write-fugacities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component fugacities to the VTK output files.	false
101	--vtk-write-fugacity-coeffs	A Boolean value set to true or false that turns on (true) or off (false) the output of the component fugacity coefficients to the VTK output files.	false
102	--vtk-write-gas-dissolution-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas dissolution factor (Rs) of the observed oil to the VTK output files.	false
103	--vtk-write-gas-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas formation volume factor (Bg) to the VTK output files.	false
104	--vtk-write-gas-saturation-pressure	A Boolean value set to true or false that turns on (true) or off (false) the output of the saturation pressure of gas (Pg,sat) to the VTK output files'	false
105	--vtk-write-intrinsic-permeabilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the intrinsic permeability to the VTK output files.	false
106	--vtk-write-mass-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the mass fractions to the VTK output files.	false
107	--vtk-write-mobilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase mobilities to the VTK output files.	false
108	--vtk-write-molarities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component molarities to the VTK output files.	false
109	--vtk-write-mole-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the mole fractions to the VTK output files.	true
110	--vtk-write-oil-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil formation volume factor (Bo) to the VTK output files.	false
111	--vtk-write-oil-saturation-pressure	A Boolean value set to true or false that turns on (true) or off (false) the output of the saturation pressure of oil (Po,sat) to the VTK output files.	false
112	--vtk-write-oil-vaporization-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil vaporization factor (Rv) of the observed gas to the VTK output files.	false
113	--vtk-write-porosity	A Boolean value set to true or false that turns on (true) or off (false) the output of the porosity array to the VTK output files.	true
114	--vtk-write-potential-gradients	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase pressure potential gradients to the VTK output files.	false

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
115	--vtk-write-pressures	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase pressures to the VTK output files.	true
116	--vtk-write-primary-vars	A Boolean value set to true or false that turns on (true) or off (false) the output of the primary variables to the VTK output files.	false
117	--vtk-write-primary-vars-meaning	A Boolean value set to true or false that turns on (true) or off (false) the output of the how the primary variables should be interpreted to the VTK output files.	false
118	--vtk-write-process-rank	A Boolean value set to true or false that turns on (true) or off (false) the output of the MPI process rank to the VTK output files.	false
119	--vtk-write-relative-permeabilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase relative permeabilities to the VTK output files.	true
120	--vtk-write-saturated-gas-oil-vaporization-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil vaporization factor (Rv,sat) of oil saturated gas to the VTK output files.	false
121	--vtk-write-saturated-oil-gas-dissolution-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas dissolution factor (Rs,sat) of gas saturated oil to the VTK output files.	false
122	--vtk-write-saturation-ratios	A Boolean value set to true or false that turns on (true) or off (false) the output of the ratio of the actually and maximum dissolved component of the mixture to the VTK output files	false
123	--vtk-write-saturations	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase saturations to the VTK output files.	true
124	--vtk-write-temperature	A Boolean value set to true or false that turns on (true) or off (false) the output of the temperature array to the VTK output files.	true
125	--vtk-write-total-mass-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the total mass fractions to the VTK output files.	false
126	--vtk-write-total-mole-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the total mole fractions to the VTK output files.	false
127	--vtk-write-viscosities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component phase viscosities to the VTK output files.	false
128	--vtk-write-water-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil formation volume factor (Bo) to the VTK output files.	false

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**

Notes:

1) Cells colored green in the No. column are new command line parameters for this release.
2) Items shaded in gray are considered to be developer options that should be used with caution as the values associated with these command line parameters are subject to change.
3) As per all UNIX and LINUX based system the input is case dependent.
4) If a parameter file is used to set one of the above parameters, the leading "--" should not be incorporated in the parameter file.

Table C.2: OPM Flow 2019-04 Command Line Options

C.3 RUNNING OPM FLOW 2018-10

OPM Flow release 2018-10 and beyond have switched to the eWoms/ebos[175] command line interface. Previously the simulator used only OPM Flow specific command line parameters which were internally translated to the equivalent eWoms/ebos command line parameters. The pre 2018-10 set of command line parameters are now depreciated but are still documented in this section for backward compatibility with previous releases of the simulator.

The command line syntax for running OPM Flow is:

```
flow [OPTIONS] CASENAME
```

and typing the following command from your terminal:

```
flow CASENAME
```

will start the simulator and run the case specified by CASENAME.DATA.

OPM Flow accepts command line options to control various aspects of the simulator's run time behavior, as described in the table below. To give a command line option use "key=value" syntax, with no spaces around the equals sign.

```
flow --ecl-deck-file-name=path_to_data/CASENAME
```

It is also possible to put multiple options together in a parameter file. To do so, put one option on each line of the file with ".param" as the extension and pass that filename as a command line parameter to OPM Flow using:

```
flow --parameter-file=CASENAME.PARAM
```

to instruct OPM Flow to read the parameter file. The available command line options for this release are depicted in Table C.3.

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
	General eWoms/ebos Command Line Parameters		
1	-h or --help	A character string that causes OPM Flow to print a help message that gives a brief description of the available command line parameters.	N/A
2	--dbph-max-rel	A real positive value that sets maximum relative change of the bottom-hole pressure in a single iteration	1.0
3	--dp-max-rel	A real positive double precision value that sets the maximum allowed relative change of pressure per iteration.	0.3
4	--ds-max	A real positive double precision value that sets the maximum allowed change in saturation per iteration.	0.2
5	--dwell-fraction-max	A real positive double precision value that sets the maximum allowed change in well's volume fraction per iteration.	0.2

[175] *eWorms is a C++ software framework concerned with fully-implicit numerical models for flow and transport in porous media. It it is developed as an integral part of the Open Porous Media (OPM) initiative.*

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
6	--ecl-deck-file-name	A character string that defines the name of the OPM Flow input file which contains the simulator's ECLIPSE formatted input deck to be simulated.	N/A
7	--ecl-output-double-precision	A Boolean value set to true or false that switches on (true) or off (false) double precision in restart files. Useful for 'perfect' restarts.	false
8	--ecl-output-interval	An integer value defining the number of report steps that ought to be skipped between two writes of restart files results.	-1
9	--enable-adaptive-time-stepping	A Boolean value set to true or false that that turns on (true) or off (false) adaptive time stepping. If set to false the report time steps provided by the input deck are used.	true
10	--enable-async-ecl-output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to restart and summary files.	true
11	--enable-async-vtk-output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to the VTK output files.	true
12	--enable-dry-run	A Boolean value set to true or false that specifies if the simulation should actually run, (true) or just check the input deck (false). This option is equivalent to activating the NOSIM keyword in the RUNSPEC section of the input deck (see section *5.2.78 NOSIM – Activate the No Simulation Mode for Data File Checking*).	true
13	--enable-ecl-output	A Boolean value set to true or false to write the binary output which is compatible with the ECLIPSE commercial simulator (restart and summary files).	true
14	--enable-opm-rst-file	A Boolean value set to true or false to write OPM specific data sets to the commercial simulators restart file to enable restart of an OPM Flow run (true), or not to write the data (false).	true
15	--enable-storage-cache	A Boolean value set to true or false that turns on (true) or off (false) storing previous storage terms and avoid re-calculating them.	true
16	--enable-terminal-output	A Boolean value set to true or false that turns on (true) or off (false) high-level information about the simulation's progress to the terminal	true
17	--enable-tuning	A Boolean value set to true or false that that instructs OPM Flow to read the time stepping parameters from the *TUNING - Numerical Tuning Control* keyword in the input deck, if set to true. Note that only the first record of the TUNING keyword is processed.	false

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
18	--enable-vtk-output	A Boolean value set to true or false that turns on (true) or off (false) a global switch for writing VTK files.	false
19	--enable-write-all-solutions	A Boolean value set to true or false that turns on (true) or off (false) the writing of all solutions to disk instead of only the ones for the report steps.	false
	OPM Flow Specific Command Line Parameters		
20	--flow-linear-solver-verbosity	A positive integer value that defines the output from linear solver: 1) 0: no extra output 2) 1: output per solution iteration 3) >1: output per iteration	0
21	--flow-newton-max-iterations	A positive integer that defines the maximum number of Newton iterations per time step used by the simulator.	20
22	--flow-newton-min-iterations	A real positive value that sets the minimum number of Newton iterations per time step used by the simulator.	1
	General eWoms/ebos Command Line Parameters		
23	--force-disable-fluid-in-place-output	A Boolean value set to true or false that instructs OPM Flow to not to print the Fluid In-Place report after each report time step (true) or not (false).	false
24	--full-time-step-initially	A Boolean value set to true or false that instructs OPM Flow to always attempt to finish a report step using a single time step (true) or not (false).	false
25	--ilu-fillin-level	A positive integer value that sets the fill in level for the ILU pre-conditioner.	0
26	--ilu-redblack	A Boolean value set to true or false that instructs OPM Flow to use red-black partitioning for the ILU pre-conditioner. (true) or not (false).	false
27	--ilu-relaxation	A real positive double precision value that sets the relaxation factor of the linear solver's ILU pre-conditioner	0.9
28	--ilu-reorder-spheres	A Boolean value set to true or false specifies OPM Flow to reorder the entries of the matrix in the red-black ILU pre-conditioner in spheres starting at an edge (true) or not (false) If false the original ordering is preserved in each color. Otherwise try to ensure D4 ordering (in a 2D structured grid, the diagonal elements are consecutive).	false
29	--initial-time-step-in-days	A real double precision value that sets the size of initial time step in days.	1.0

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
30	--linear-solver-ignore-convergence-failure	A Boolean value set to true or false that if set to true convergences failures in the linear solver are ignored. This option should be used with care, as the results may be unreliable.	false
31	--linear-solver-max-iter	A positive integer value that defines the maximum number of linear iterations.	200
32	--linear-solver-reduction	A real positive double precision value that sets the tolerance for the linear solver. The linear solver convergences when the residual is reduced sufficiently.	0.01
33	--linear-solver-require-full-sparsity-pattern	A Boolean value set to true or false that if set to true the simulator will produce the full sparsity pattern for the linear solver.	false
34	--linear-solver-restart	A positive integer value that sets the number of iterations after which GMRES is restarted.	40
35	--matrix-add-well-contributions	A Boolean value set to true or false that if set to true explicitly specifies the influences of wells between cells in the Jacobian and pre-conditioner matrices.	false
36	--max-inner-iter-ms-wells	A positive integer value that defines the maximum number of inner iterations for multi-segment wells.	10
37	--max-pressure-change-ms-wells	A real positive value that defines the maximum relative pressure change for a single iteration of the multi-segment well model.	200000
38	--max-residual-allowed	A real positive value that sets the absolute maximum tolerance for residuals without cutting the time step size.	1.0×10^7
39	--max-single-precision-days	A real positive value that set the maximum time step size where single precision floating point arithmetic can be used solving for the linear systems of equations.	20.0
40	--max-strict-iter	A positive integer that sets the maximum number of Newton iterations before relaxed tolerances are used for the CNV convergence criterion.	8
41	--max-welleq-iter	A positive integer that defines the maximum number of iterations to determine the solution to the well equations.	15

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
42	--milu-variant	A defined character string that specifies which variant of the modified-ILU preconditioner ought to be used. Possible variants are: 1) ILU (default, plain ILU), 2) MILU_1 (lump diagonal with dropped row entries), 3) MILU_2 (lump diagonal with the sum of the absolute values of the dropped row entries), 4) MILU_3 (if diagonal is positive add sum of dropped row entrires. Otherwise substract them), 5) MILU_4 (if diagonal is positive add sum of dropped row entrires. Otherwise do nothing. The default is ILU	ILU
43	--newton-max-relax	A real positive value that sets the maximum relaxation factor of a Newton iteration used by the simulator.	0.5
44	--newton-relaxation-type	A character string that defines the type of relaxation used in Newton's method., default is dampen.	dampen
45	--output-dir	A character string that defines the directory to which OPM Flow to write the ECLIPSE compatible output files (restart and summary files).	N/A
46	--output-interval	A positive integer that specifies the number of report steps between two consecutive writes of restart data.	1
47	--output-mode	A character string that defines the output to *.PRT and *.DEBUG files: 1) none: No output to the files. 2) log or false: Output logging information only. 3) all or true: Output everything. For example to just output logging information use: `--output-mode=log` or `--output-mode=false`	all
48	--parameter-file	A character string that defines the name of a parameter file which contains the simulator's set of run-time parameters, as listed in this table.	N/A
49	--preconditioner-add-well-contributions	A Boolean value set to true or false that switches on (true) or off (false) the influences of wells between cells for the pre-conditioner matrix only.	false
50	--pri-var-oscilation-threshold	A real positive vale that defines the threshold value for the primary variable switching conditions after its meaning has switched to hinder oscilations.	1×10^{-5}
51	--print-parameters	A positive integer value that request that the run time parameters be printed at the start of the run: 1) 0: No output to the files. 2) 1: Output *.DBG file 3) 2: Output to *.DBG and *.PRT files (default)	2

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
52	--print-properties	A positive integer value that request that the compile time parameters be printed at the start of the run: 1) 0: No output to the files. 2) 1: Output *.DBG file 3) 2: Output to *.DBG and *.PRT files (default)	2
53	--solve-welleq-initially	A Boolean value set to true or false that switches on (true) or off (false) the solving of the well equations as a pre-processing step. Note that the well equations are always added to the full system and solved until converged.	true
54	--solver-growth-factor	A real positive value that specifies the allowed value a time step can be increased by, subject to the maximum allowable time step size set by the *–flow-solver-max-time-step-in-days* parameter. For example, if the current time step has converged at 10 days and *–flow-solver-growth-factor* is set to the default value, then the next time step will be 2.0 * 10 days, that is at 20 days.	2.0
55	--solver-max-growth	A real positive value that specifies the maximum allowed value a time step can be increased by after a report time step. subject to the maximum allowable time step size set by the *–flow-solver-max-time-step-in-days* parameter.	3.0
56	--solver-max-restarts	A positive integer that defines the number of allowed consecutive restarts (or time step chops) before the simulation is terminated.	10
57	--solver-max-time-step-in-days	A real positive double precision value that specifies the maximum allowed time step size in days.	365
58	--solver-restart-factor	A real positive double precision value that sets the time step chop factor of the time step after a convergence failure. For example, if the current non-convergent time step is 30 days and *–flow-solver-restart-factor* is set to the default value, then the time step will be repeated using 0.33 * 30 days as the time step, that is 9.9 days.	0.33
59	--solver-verbosity	A positive integer that specifies the "chattiness" of the non-linear solver.	1
60	--threads-per-process	A positive integer value that stipulates the maximum number of threads to be instantiated per process ('-1' means 'automatic').	1
61	--time-step-after-event-in-days	A real double precision value that sets maximum allowed time step after an event; for example, when a well is open or closed etc. The default value of -1 means that events to do effect the time stepping.	-1

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
62	--time-step-control	A character string that defines the time stepping control algorithm and is set to one of the following: 1) pid: PID controller based adaptive time step control as suggested by Turek and Kuzmin[176]. 2) pid+iteration: Use PID and linear iteration numbers to guide the time step. 3) pid+newtoniteration: Use PID and non-linear iterations numbers to guide the time step. 4) Hardcoded: Use time steps supplied by user. Via timestep.control.filename	pid
63	--time-step-control-decay-rate	A real positive value that specifies the decay rate a time step can be decreased by after the number of target iterations has been exceeded	0.75
64	--time-step-control-file-name	A character string that specifies a filename where time steps are specified. The default is the character string timesteps For instance generated by the ecl_summary application in libecl as per the following UNIX command line: `path_to_libecl_applications/ ecl_summary DECK TIME > filename` Where: DECK is the name of the data deck you want to get the time steps from, TIME tells the application to return the timing for the run, and "filename" is the name of the file the times are piped to.	timesteps
65	--time-step-control-growth-rate	A real positive value that specifies the growth rate of the time step size of the number of target iterations is undercut.	1.25
66	--time-step-control-target-iterations	A positive integer that defines the number of linear iterations which the time step control scheme should aim for (if applicable).	30
67	--time-step-control-target-newton-iterations	A positive integer that specifies the number of Newtonian iterations which the time step control scheme should aim for (if applicable).	8
68	--time-step-control-tolerance	A real double precision value that sets the tolerance for PID (only used with the pid and pid+ options defined by the *–flow-timestep.control* option).	0.1
69	--time-step-verbosity	A positive integer that specifies the "chattiness" during the time integration.	1
70	--tolerance-cnv	A real positive double precision value that specifies the maximum non-linear tolerance error. This is the local convergence tolerance (maximum of local saturation errors).	0.01

[176] *Algebraic Flux Correction III. Incompressible Flow Problems. Uni Dortmund, Turek and Kuzmin, January, 2006 (DOI: 10.1007/3-540-27206-2_8)*

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
71	--tolerance-cnv-relaxed	A real positive value that defines the relaxed local convergence tolerance that applies for iterations after the iterations with the strict tolerance.	1.0×10^{9}
72	--tolerance-mb	A real positive double precision value that sets the maximum mass balance error, that is the tolerated mass balance error relative to total mass present.	1.0×10^{5}
73	--tolerance-pressure-ms-wells	A real positive double precision value that specifies the tolerance for the pressure equations for multi-segment wells.	1000
74	--tolerance-well-control	A real positive double precision value that sets the maximum tolerance for the well control equations.	1.0×10^{-7}
75	--tolerance-wells	A real positive double precision value that defines the maximum non-linear error for the well equations.	0.0001
76	-update-equations-scaling	A Boolean value set to true or false that switches on (true) or off (false) the updating of the scaling factors for mass balance equations during the simulation.	false
77	--use-amg	A Boolean value set to true or false that if set to true OPM Flow will use AMG as the linear solver's preconditioner	false
78	--use-cpr	A Boolean value set to true or false that when set to true OPM Flow will use CPR as the linear solver's pre-conditioner	false
79	--use-gmres	A Boolean value set to true or false that when set to true OPM Flow will use GMRes instead of BiCGStab as linear solver within the Newton iterations.	false
80	--use-inner-iterations-ms-wells	A Boolean value set to true or false that when set to true the simulator will use nested iterations for multi-segment wells.	true
81	--use-multisegment-well	A Boolean value set to true or false that when set to true the simulator will use the well model for multi-segment wells instead of the one for single-segment wells.	false
82	--use-update-stabilization	A Boolean value set to true or false that switches on (true) or off (false) the stabilized Newton option. This option may improve convergence for some cases.	true
	VTK Graphics Command Line Parameters[177]		
83	--vtk-write-average-molar-masses	A Boolean value set to true or false that turns on (true) or off (false) the output of the average phase mass in the VTK output files.	false
84	--vtk-write-densities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase densities to the VTK output files	true

[177] *Virtualization ToolKit ("VTK") files used to visualize the 3D results from the model using ParaView, an open-source, multi-platform general purpose data analysis and visualization application (https://www.paraview.org/overview/). For ECLIPSE compatible output files OPMS's ResInsight 3D visualization package can be used which is specifically tailored for OPM Flow and the commercial simulator.*

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
85	--vtk-write-dof-index	A Boolean value set to true or false that turns on (true) or off (false) the output of the index of the degrees of freedom to the VTK output files.	false
86	--vtk-write-extrusion-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the of the extrusion factor of the degrees of freedom to the VTK output files.	false
87	--vtk-write-filter-velocities	A Boolean value set to true or false that turns on (true) or off (false) the output of the filter velocities of the phases in the VTK output files.	false
88	--vtk-write-fugacities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component fugacities to the VTK output files.	false
89	--vtk-write-fugacity-coeffs	A Boolean value set to true or false that turns on (true) or off (false) the output of the component fugacity coefficients to the VTK output files.	false
90	--vtk-write-gas-dissolution-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas dissolution factor (Rs) of the observed oil to the VTK output files.	false
91	--vtk-write-gas-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas formation volume factor (Bg) to the VTK output files.	false
92	--vtk-write-gas-saturation-pressure	A Boolean value set to true or false that turns on (true) or off (false) the output of the saturation pressure of gas (Pg,sat) to the VTK output files'	false
93	--vtk-write-intrinsic-permeabilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the intrinsic permeability to the VTK output files.	false
94	--vtk-write-mass-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the mass fractions to the VTK output files.	false
95	--vtk-write-mobilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase mobilities to the VTK output files.	false
96	--vtk-write-molarities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component molarities to the VTK output files.	false
97	--vtk-write-mole-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the mole fractions to the VTK output files.	true
98	--vtk-write-oil-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil formation volume factor (Bo) to the VTK output files.	false
99	--vtk-write-oil-saturation-pressure	A Boolean value set to true or false that turns on (true) or off (false) the output of the saturation pressure of oil (Po,sat) to the VTK output files.	false

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
100	--vtk-write-oil-vaporization-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil vaporization factor (Rv) of the observed gas to the VTK output files.	false
101	--vtk-write-porosity	A Boolean value set to true or false that turns on (true) or off (false) the output of the porosity array to the VTK output files.	true
102	--vtk-write-potential-gradients	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase pressure potential gradients to the VTK output files.	false
103	--vtk-write-pressures	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase pressures to the VTK output files.	true
104	--vtk-write-primary-vars	A Boolean value set to true or false that turns on (true) or off (false) the output of the primary variables to the VTK output files.	false
105	--vtk-write-primary-vars-meaning	A Boolean value set to true or false that turns on (true) or off (false) the output of the how the primary variables should be interpreted to the VTK output files.	false
106	--vtk-write-process-rank	A Boolean value set to true or false that turns on (true) or off (false) the output of the MPI process rank to the VTK output files.	false
107	--vtk-write-relative-permeabilities	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase relative permeabilities to the VTK output files.	true
108	--vtk-write-saturated-gas-oil-vaporization-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil vaporization factor (Rv,sat) of oil saturated gas to the VTK output files.	false
109	--vtk-write-saturated-oil-gas-dissolution-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the gas dissolution factor (Rs,sat) of gas saturated oil to the VTK output files.	false
110	--vtk-write-saturation-ratios	A Boolean value set to true or false that turns on (true) or off (false) the output of the ratio of the actually and maximum dissolved component of the mixture to the VTK output files	false
111	--vtk-write-saturations	A Boolean value set to true or false that turns on (true) or off (false) the output of the phase saturations to the VTK output files.	true
112	--vtk-write-temperature	A Boolean value set to true or false that turns on (true) or off (false) the output of the temperature array to the VTK output files.	true
113	--vtk-write-total-mass-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the total mass fractions to the VTK output files.	false

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
114	--vtk-write-total-mole-fractions	A Boolean value set to true or false that turns on (true) or off (false) the output of the total mole fractions to the VTK output files.	false
115	--vtk-write-viscosities	A Boolean value set to true or false that turns on (true) or off (false) the output of the component phase viscosities to the VTK output files.	false
116	--vtk-write-water-formation-volume-factor	A Boolean value set to true or false that turns on (true) or off (false) the output of the oil formation volume factor (Bo) to the VTK output files.	false

Notes:

1) Items shaded in gray are considered to be developer options that should be used with caution as the values associated with these command line parameters are subject to change.
2) As per all UNIX and LINUX based system the input is case dependent.
3) If a parameter file is used to set one of the above parameters, the leading "--" should not be incorporated in the parameter file.

Table C.3: OPM Flow 2018-10 Command Line Options

C.4 RUNNING OPM FLOW 2018-04

This section describes the command line options up to the 2018-04 release of OPM Flow, post this release the command line options were changed to be the same as eWoms/ebos[178] command line parameters. It is anticipated that this section will be removed from the manual once the 2018-10 and later versions are firmly established.

The command line syntax for running OPM Flow is:

```
flow [OPTIONS] CASENAME
```

and typing the following command from your terminal:

```
flow CASENAME
```

will start the simulator and run the case specified by CASENAME.DATA.

OPM Flow accepts command line options to control various aspects of the simulator's run time behavior, as described in the table below. To give a command line option use "key=value" syntax, with no spaces around the equals sign. It is also possible to put multiple options together in a parameter file. To do so, put one option on each line of the file with ".param" as the extension and pass that filename as a command line parameter to OPM Flow using:

```
flow --parameter-file=CASENAME.PARAM
```

to instruct OPM Flow to read the parameter file. The available command line options for this release are listed in Table C.4.

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
1	deck_filename	A character string that defines the name of the OPM Flow input file which contains the simulator's ECLIPSE formatted input deck to be simulated.	N/A
2	output_ecl	A Boolean value set to true or false that turns on (true) or off (false) output to the .*RST and .*SMRY files.	true
3	output	A character string that defines the output to *.PRT and *.DEBUG files: 1) none: No output to the files. 2) log or false: Output logging information only. 3) all or true: Output everything. For example to just output logging information use: `output=log` or `output=false`	all
4	output_dir	Set the directory to which output files are written.	deck location

[178] *eWorms is a C++ software framework concerned with fully-implicit numerical models for flow and transport in porous media. It it is developed as an integral part of the Open Porous Media (OPM) initiative.*

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
5	restart_double_si	A Boolean value set to true or false that switches on (true) or off (false) double precision in restart files and stores all restart data in SI units rather than using the unit family (METRIC, FIELD etc.) used in the input deck. The option improves the quality of the restart.	false
6	async_output	A Boolean value set to true or false that sets the output mode to be asynchronously (true), letting the simulator continue computing the next time step while writing results to restart and summary files.	true
7	newton_use_gmres	A Boolean value set to true or false that when set to true OPM Flow will use GMRes instead of BiCGStab as linear solver within the Newton iterations.	false
8	linear_solver_reduction	A real positive double precision value that sets the tolerance for the linear solver. The linear solver convergences when the residual is reduced sufficiently.	0.01
9	linear_solver_maxiter	A positive integer value that defines the maximum number of linear iterations.	150
10	linear_solver_verbosity	A positive integer value that defines the output from linear solver: 1) 0: no extra output 2) 1: output per solution iteration 3) >1: output per iteration	0
11	linear_solver_ignoreconvergencefailure	A Boolean value set to true or false that if set to true convergences failures in the linear solver are ignored. This option should be used with care, as the results may be unreliable.	false
12	linear_solver_use_amg	A Boolean value set to true or false that if set to true OPM Flow will use amg as the pre-conditioner instead of ilu.	false
13	ilu_relaxation	A real positive double precision value that sets the relaxation parameter for the ILU pre-conditioner.	0.9
14	ilu_fillin_level	A positive integer value that sets the fill in level for the ILU pre-conditioner.	0
15	dp_max_rel	A real positive double precision value that sets the maximum allowed relative change of pressure per iteration.	0.3
16	ds_max	A real positive double precision value that sets the maximum allowed change in saturation per iteration.	0.2
17	dr_max_rel	A real positive double precision value that sets the maximum allowed relative change in dissolved gas and vaporized oil per iteration	1e+09

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
18	dbhp_max_rel	A real positive double precision value that sets the maximum allowed relative change in BHP per iteration.	1
19	dwell_fraction_max	A real positive double precision value that sets the maximum allowed change in well's volume per iteration.	1e+07
20	tolerance_mb	A real positive double precision value that sets the maximum mass balance error.	1e-05
21	tolerance_cnv	A real positive double precision value that specifies the maximum non-linear tolerance error.	0.01
22	tolerance_wells	A real positive double precision value that defines the maximum non-linear error for the well equations.	0.0001
23	max_strict_iter	A positive integer value that sets the maximum number of non-linear iterations. After this maximum value has been exceeded only the mass balance error is checked.	8
24	solve_welleq_initially	A Boolean value set to true or false that switches on (true) or off (false) the solving of the well equations as a pre-processing step. Note that the well equations are always added to the full system and solved until converged.	true
25	use_update_stabilization	A Boolean value set to true or false that switches on (true) or off (false) the stabilized Newton option. This option may improve convergence for some cases.	true
26	relax_max	A real positive double precision value that is used to tune the stabilized Newton option.	0.5
27	relax_type	A character string that sets relaxation type of the stabilized Newton option.	dampen
28	max_iter	A positive integer that sets the maximum number of non-linear iterations.	10
29	min_iter	A positive integer that sets the minimum number of non-linear iterations.	1
30	output_terminal	A Boolean value set to true or false that turns on (true) or off (false) output to terminal.	true
31	use_TUNING	A Boolean value set to true or false that that instructs OPM Flow to read the time stepping parameters from the *TUNING - Numerical Tuning Control* keyword in the input deck, if set to true. Note that only the first record of the TUNING keyword is processed.	false
32	timestep.adaptive	A Boolean value set to true or false that that turns on (true) or off (false) adaptive time stepping. If set to false the report time steps provided by the input deck are used.	true

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
33	solver.restartfactor	A real positive double precision value that sets the time step chop factor of the time step after convergence failure. For example, if the current non-convergent time step is 30 days and *solver.restartfactor* is set to the default value, then the time step will be repeated using 0.33 * 30 days as the time step, that is 9.9 days.	0.33
34	timestep.control.maxgrowth	A real positive double precision value that sets the maximum allowed value a time step can be increased by, subject to the maximum allowable time step size set by the *timestep.max_timestep_in_days* parameter. For example, if the current time step has converged at 10 days and *solver.restartfactor* is set to the default value, then the next time step will be 3.0 * 10 days, that is at 30 days.	3
35	timestep.max_timestep_in_days	A real positive double precision value that sets the maximum allowed time step size in days.	365
36	solver.restart	A positive integer that defines the number of allowed consecutive restarts (or time step chops) before the simulation is terminated.	10
37	solver.verbose	A Boolean value set to true or false that switches on (true) or off (false) solver specific output.	true
38	timestep.verbose	A Boolean value set to true or false that switches on (true) or off (false) time step specific output.	true
39	timestep.initial_timestep_in_days	A real double precision value that sets the size of initial time step in days. The default value of -1 sets the initial time step to be *solver.restartfactor* * the length of the first report step.	-1
40	full_timestep_initially	Try to use the report steps as time steps.	false
41	timestep.timestep_in_days_after_event	A real double precision value that sets maximum allowed time step after an event; for example, when a well is open or closed etc. The default value of -1 means that events to do effect the time stepping.	-1

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
42	timestep.control	A character string that defines the time stepping control algorithm and is set to one of the following: 1) pid: PID controller based adaptive time step control as suggested by Turek and Kuzmin[179]. 2) pid+iteration: Use PID and linear iteration numbers to guide the time step. 3) pid+newtoniteration: Use PID and non-linear iterations numbers to guide the time step. 4) Hardcoded: Use time steps supplied by user. Via timestep.control.filename	pid
43	timestep.control.tol	A real double precision value that sets the tolerance for PID (only used with the pid and pid+ options defined by the *timestep.control* option).	0.1
44	timestep.control.targetiteration	A positive integer that sets the target number of linear / non-linear iterations. This option can only be only used by pid+iterations and pid+newtoniteration defined by the *timestep.control* option.	8
45	timestep.control.filename	A character string that specifies a file name where time steps are specified. For instance generated by the ecl_summary application in libecl as per the following UNIX command line: `path_to_libecl_applications/ecl_summary DECK TIME > filename` Where: DECK is the name of the data deck you want to get the time steps from, TIME tells the application to return the timing for the run, and "filename" is the name of the file the times are piped to.	

Notes:

1) As per all UNIX and LINUX based system the input is case dependent.

Table C.4: OPM Flow 2018-04 Command Line Options

[179] *Algebraic Flux Correction III. Incompressible Flow Problems. Uni Dortmund, Turek and Kuzmin, January, 2006 (DOI: 10.1007/3-540-27206-2_8)*

APPENDIX D: OPM FLOW OUTPUT FILE FORMATS

D.1 OVERVIEW

This section of the manual describes the various output files generated by OPM Flow and attempts to outline the format of the various files, in order for third party software to read and write these type of files. From the 2019-04 release a substantial effort has been undertaken to make OPM Flow's output files compatible with the commercial simulator's output files. This compatibility enables OMP Flow to "restart" from the commercial simulator's generated RESTART files as well as the commercial simulator to "restart" from the OPM Flow's RESTART files. Although, this might not be the case for all models, as restarting a simulation model from another simulators restart file is complicated and may not be possible in all cases.

Where applicable, files written by OPM Flow can be loaded into OPM ResInsight post processing software for further analysis and for displaying the results. Please see section *2.2 Running OPM Flow 2020-04 From The Command Line* for the various command line options for setting the output format type.

D.1.1 FILE TYPES

OPM Flow, similar to the commercial simulator, writes out various files, some of which are used by post processing software (OPM ResInsight) and some that are directly used by the user, for example the *.PRT file that contains various reports. Table D.1 summaries the various file formats and the status of the file formats currently supported by OPM Flow.

File Type	Data Type	Description	OPM Flow Status
DATA	Input Data	DATA files contain the input data in ASCII format used to run OPM Flow.	Fully Supported, as outlined in the manual
DBG	Debug Data	This file contains ASCII developer debug output specific to OPM Flow, that is there no compatibility with the commercial simulator's DBG file.	OPM Flow Specific
EGRID	Structure Data	EGRID files contain the structural information for the model via the COORD and ZCORN etc., keywords, and employs the extensible GRID format, which is more compact than the GRID formatted files and is the only format supported by OPM Flow. The output for this file type must be requested via the *GRIDFILE – Set the Grid File Output Options* in the GRID section. The data is used in post-processing software to view the grid and is not in itself used by OPM Flow.	Fully Supported
GRID	Structure Data	This file type contains the structural information for the model via the COORD and ZCORN etc., keywords, and consists of two data formats: 1) The standard GRID file format that contains only the active global cells. 2) The extended GRID file format that contains (1) plus local grid refinements and local coarsening grid specifications. Neither of these two formats are currently supported by OPM Flow.	Not Supported
INIT Index	Static Property Index	The INIT index file type specifies and defines the format and data type written to the INIT Data file. This file is not required by OPM Flow or OPM ResInsight to be able to read and write the INIT data file.	Not Supported and Not Required

File Type	Data Type	Description	OPM Flow Status
INIT Data	Static Property Data	This file type contains static model properties, that is, 1) Grid property data: porosity (PORO array), permeability (PERMX, PERMY, and PERMZ), net-to-gross (NTG), etc. 2) Region allocation array data: EQLUM, FIPNUM, PVTNUM, SATNUM, etc. 3) Fluid and rock property static data, including end-point scaling arrays: SGC, SGL, SOWCR, PCW etc. 4) Fluid and rock property tables: PVDG, PVTO, PCW, SGFN, SWFN, etc. In order to request this type of output see the *INIT – Activate the INIT File Option* in the GRID section. Activating this keyword results in both the INIT static property index and data files being written out by the commercial simulator. OPM Flow only writes out this file as the index file is not required by OPM ResInsight. The data is used in post-processing software to view the grid property data and is not in itself used by OPM Flow.	Fully Supported
LOG	Output File	The LOG file for the commercial simulator contains an ASCII copy of the output from the terminal. The file itself is not generated by the commercial simulator but by an auxiliary program, ECLRUN, that is used to call and execute all the commercial simulators. OPM Flow does not generate a LOG file; however, the file can be generated by using the Linux `tee` command, for example: `flow CASENAME | tee CASENAME.LOG` Which will copy the terminal output to the CASENAME.LOG file. Alternatively, one can use the OPMRUN, the Graphical User Interface ("GUI") program for OPM Flow, that provides similar functionality to the commercial simulator's auxiliary program.	OPM Flow Specific
PRT	Output File	This file contains ASCII user output reports specific to OPM Flow, although there is a strong desire to make the OPM Flow reports similar to those that are produced by the commercial simulator.	OPM Flow Specific
RESTART Index	Dynamic Solution Index	The RESTART index file type specifies and defines the format and data type written to the RESTART Data file. This file is not required by OPM Flow or OPM ResInsight to be able to read and write the RESTART data file.	Not Supported and Not Required

File Type	Data Type	Description	OPM Flow Status
RESTART Data	Dynamic Solution Data	This file type contains dynamic solution data for each active cell in the model at the user requested time steps, that is, 1) Grid solution pressure and saturation data (PRESSURE, SGAS, SOIL, and SWAT). Note that Ternary saturations are normally computed by the post-processing software. 2) Grid solution fluid property data (GAS_DEN, GAS_VISC, OIL-DENS, etc.). The *RPTRST – Define Data to be Written to the RESTART File* and the *RPTSCHED – Define SCHEDULE Section Reporting* keywords in the SCHEDULE defines the data and frequency of the data to be written to the RESTART file at each requested restart point. Activating this keyword results in both the RESTART index and data files being written out by the commercial simulator; OPM Flow only writes this file. In addition to the solution data, this file type also includes group and well configuration data (number of connections, connections open and closed etc.) This information is required to ensure that the correct group and well configuration is available at a given time in order to be able to restart the simulation at a restart point. The data is used to visualize the simulation results of the model in two and three dimensional space using post-processing software. The file is also used by OPM Flow to "restart" from a previous simulation case.	Fully Supported
RFT	Dynamic Wellbore Vector Data	Data written to the RFT file consists of wellbore vector data, for example, pressure and saturation versus wellbore depth at various time steps. The data written out is not restricted to just Repeat Formation Tester ("RFT") data, but can contain any Production Logging Tool ("PLT") data made available in the simulator. Note that only the RFT data set is currently supported by OPM Flow. The keywords *WRFT – Activate Well RFT Reporting to the RFT File* and *WRFTPLT – Activate Well RFT and PLT Reporting to the RFT File* in the SCHEDULE section are used to define the wells, data and time step at which the data should be written to the RFT file. The data is used in post-processing software to compare the actual wire line logging data with the simulation derived results. The file is not in itself used by OPM Flow.	Fully Supported (RFT)
RSM	Output File	The RSM file contains the variables requested to be written to the SUMMARY file via the keywords described in the *SUMMARY SECTION*, in a tabulated ASCII output format. The format of the file enables the data to be easily loaded into the LibreOffice Calc program for further processing, as each vector represents one column. The report is written at the end of the simulation run by parsing the SUMMARY Index and SUMMARY Data files.	Fully Supported
SAVE	Staic and Dynamic Data	SAVE files are basically a combination of both the INIT and RESTART files, except for the static initialization data that also includes the processed data, that is the PORV and TRANX, TRANY and TRANZ arrays etc. This enables "fast restarts" as the pore volumes and transmissibility arrays do not have to be re-calculated in a "restart" run. This file type is currently not supported by OPM Flow.	Not Supported
SUMMARY Index	Dynamic Vector Index	The SUMMARY index file type specifies and defines the format and data type written to the SUMMARY Data file.	Fully Supported

File Type	Data Type	Description	OPM Flow Status
SUMMARY Data	Dynamic Vector Data	The SUMMARY data file contains the variables requested to be written to the file via the keywords described in the *SUMMARY SECTION*. The data consists of vectors that are used to generate line graphs of properties such as oil flow rate versus time, grid plot pressure versus time, etc. The properties to be stored on the SUMMARY file are written to the summary file at the end of each successful time step. The data can be used to compare actual production data with the simulation derived results in post processing software. Note that although the file format is fully supported, not all of the SUMMARY variables are are available.	Fully Supported

Notes:

1) All files can be written out in either ASCII or binary formats, except for DBG , LOG. PRT and RSM files that are always written in ASCII format.
2) In addition, SUMMARY and RESTART files can be loaded or written out in either unified or non-unified formats.
3) File Type cells colored in gray indicate the output may be different to the commercial simulators equivalent file type. File Type cells colored in orange represent file types that are not currently supported by OPM Flow.

Table D.1: OPM Flow Output File Types Summary

As mentioned in Table D.1 all files can be written out in either ASCII or binary formats and in addition the SUMMARY and RESTART files can be loaded or written out in either unified or non-unified formats. The file type (ASCII or binary) and file structure format (unified or non-unified formats) are set via various keywords in the RUNSPEC section, as outlined in Table D.2.

Process	RUNSPEC Keyword	Description	Files
Input	FMTIN	The keyword defines the input files to be formatted as ASCII i.e. text files, as oppose to binary files. The input deck file is always of this type. The option relates to the OPM Flow derived files that used as input, for for example when restarting from another case. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTIN	A character string that defines the input files to be non-unified multiple files, as opposed to unified files. In this case, one file is read in per reporting time step, as opposed to all time steps reports being read from one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001
	UNIFIN	UNIFIN defines the input files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. For this option a single summary file and a single restart file will be read. If the keyword is omitted then the default is for one file per report time step.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY

Process	RUNSPEC Keyword	Description	Files
Output	FMTOUT	The keyword sets all output files to be formatted as ASCII i.e. text files, as opposed to binary files. The *.DBG, *.LOG, *.PRT and *.RSM files are always of this type. The option relates to the OPM Flow output files only. In this case the files will be portable across operating systems, but will also be very large in terms of hard disk space. For this reason it is recommend that the default option is used so that only binary files are written out. If the keyword is omitted then the default is for binary file input.	*.FEGRID *.FINSPEC *.FINIT *.FRSSPEC *.FUNRST *.FSMSPEC *.FUNSMRY
	MULTOUT	A character string that defines the output files to be non-unified multiple files, as opposed to unified files. In this case, one file is written for each reporting time step, as opposed to all time steps reports being written in one file. If the keyword is omitted then the default is for one file per reporting time step.	*.RSSPEC *.X0001 *.SMSPEC *.S0001
	UNIFOUT	UNIFOUT defines the output files to be unified files, as opposed to non-unified multiple files. A unified file is a single file containing output for each reporting time step. Here a single summary file and a single restart file will be generated, as opposed to one file per report time step. If the keyword is omitted then the default is for one file per report time step input.	*.RSSPEC *.UNRST *.SMSPEC *.UNSMRY

Notes:

1) A binary file is computer-readable but not human-readable. All executable programs are stored in binary files, as are most numeric data files. In contrast, text files are stored in a form (usually ASCII) that is human-readable.
2) For unified files if the run terminates unexpectedly, or there is sufficient disk space, then the last report output is not stored. The main advantage of unified files is that if a number of simulation cases reside in one directory, the number of output files per case is minimum compared to using non-unified multiple files. There is no limit on the number of reporting steps that a unified file can store.

Table D.2: RUNSPEC Input and Output File Format Keywords

D.1.2 FILE NAMING CONVENTIONS

OPM Flow automatically generates the file names based on the input file name and the output options selected via the keywords in the RUNSPEC summarized in in Table D.2. For example, the command line syntax for running OPM Flow is:

```
flow [OPTIONS] CASENAME
```

and typing the following command from the terminal:

```
flow CASENAME
```

will start the simulator and run the case specified by CASENAME.DATA. Here CASENAME is the "root" of the filename and DATA is the extension of the filename. OPM Flow will generate the output files based on the CASENAME with the extension based on the type (ASCII or binary) and file structure format (unified or non-unified formats), as outlined in Table D.3. Note that if If CASENAME includes a relative or absolute path to the data file, run directory will be set so that all output files are generated in the directory holding the data file.

File Type	Unformatted Extension	Description	Formatted Extension
DATA		Input data file.	*.DATA
DBG		Output debug file.	*.DBG
EGRID	*.EGRID	EGRID files containing the structural grid data and is the only format supported by OPM Flow. This output for this file type must be requested via the *GRIDFILE – Set the Grid File Output Options* in the GRID section.	*.FEGRID
GRID	*.GRID	Grid file in either the standard GRID file format or the extended GRID file format Neither of these two formats are currently supported by OPM Flow.	*.FGRID
INIT Index	*.INSPEC	The INIT index file for both unified and non-unified formats	*.FINSPEC
INIT	*.INIT	This file type contains static model properties.	*.FINIT
LOG		Output log file that contains a copy of the output from the terminal. The file itself is not generated by the commercial simulator but by an auxiliary program, ECLRUN, that is used to call and execute all the commercial simulators.	*.LOG
PRT		Output print file.	*.PRT
RESTART Index	*.RSSPEC	The RESTART index file for both unified and non-unified formats. This file is not required by OPM Flow or OPM ResInsight to be able to read and write the RESTART data file.	*.FRSSPEC

RESTART Data Non-Unified	*.Xnnnn	The RESTART data files containing the solution arrays requested to be written to the RESTART files. For example:
		`CASENAME.X0001`
		`CASENAME.X0002`
		`CASENAME.X0003`
		`etc.`
		`CASENAME.RSSPEC`
			*.Fnnnn

RESTART Data Unified	*.UNRST	The RESTART data file containing the solution arrays requested to be written to the RESTART file. For example:
		`CASENAME.UNRST`
		`CASENAME.RSSPEC`
			*.FUNRST

RFT	*.RFT	The RFT data file containing wellbore vector data requested to be written to the RFT file. For example: `CASENAME.RFT`	*.FRFT
RSM		Output RSM file.	*.RSM
SAVE	*.SAVE	The SAVE file type is currently not supported by OPM Flow.	*.FSAVE
SUMMARY Index	*.SMSPEC	The SUMMARY index file for both unified and non-unified formats.	*.FSMSPEC

SUMMARY Data Non-Unified	*.Snnnn	The SUMMARY data files containing the variables requested to be written to the SUMMARY files. For example:
		`CASENAME.S0001`
		`CASENAME.S0002`
		`CASENAME.S0003`
		`etc.`
		`CASENAME.SMSPEC`
			*.Annnn

File Type	Unformatted Extension	Description	Formatted Extension
SUMMARY Data Unified	*.UNSMRY	The SUMMARY data file containing the variables requested to be written to the SUMMARY file. For example: `CASENAME.UNSMRY` `CASENAME.SMSPEC`	*.FUNSMRY

Notes:

1) The above file naming convention is for Linux type operating systems, as OPM Flow is currently only officially supported for Linux distributions.
2) File Type cells colored in gray indicate the output may be different to the commercial simulators equivalent file type. File Type cells colored in orange represent file types that are not supported by OPM Flow.
3) Unformatted Extension cells colored in gray indicate the format is not available.

Table D.3: OPM Flow File Naming Conventions

D.1.3 UNFORMATTED FILE FORMAT CONSIDERATIONS

Originally the commercial simulator was written in FORTRAN 77 and the current version is still written in a version of FORTRAN. FORTRAN unformatted file output is dependent on the FORTRAN compiler used to generated the executable program. Typically an unformatted record consists of a four byte prefix outlining the length of the record in bytes, then the actual data record, followed by suffix containing the length of the record in bytes, Most but not all compilers use four bytes. This aids in reading records, for example, the four byte record size at the end of the record assists with a backspace operation. If the record size is greater than two Gigabytes (2^{31} bytes), the record is divide into sub-records. In this case the sign bit of the prefix inform that the record is continued by a sub-record or not and the sign bit of the suffix indicate whether or not there is a preceding sub record.

OPM Flow unformatted files are written using the big-endian mode, that is the most significant value in the sequence is stored at the lowest storage address, that is first. This is opposite to the little-endian mode, where the least significant value in the sequence is stored first. For example, consider the number 1025 (2 to the tenth power plus one) stored in a for byte integer:

```
00000000 00000000 00000100 00000001
```

Address	Big-Endian Representation Of 1025	Little-Endian Representation Of 1025
00	00000000	00000001
01	00000000	00000100
02	00000100	00000000
03	00000001	00000000

Table D.4: Big-Endian and Little-Endian Representation

OPM Flow is written in C++ using the open source GNU C++ compiler and therefore developers using C++ to need to ensure that unformatted files are read or written using the correct big-endian mode.

D.1.4 FILE OUTPUT FORMAT

All the files consist of a series of "header" keywords that defined various parameters based on their format type: integer, real, Boolean, double precision and character. For example for the INT and RESTART files the header keywords are:

1) SEQNUM: Report time step keyword (RESTART file only).
2) INTEHEAD: Integer (four byte) keyword that contains constant values for example, the dimensions of the model, as well as the location and length of data contained in the subsequent property keywords.
3) LOGIHEAD: Boolean or logical (four byte) keyword that consists of a set of either T (true) or F (false) character strings, for example, if dissolved gas is present in the model then set to T for true or F for false.
4) DOUBHEAD: Real double precision keyword (eight byte) that contain real values, for example, the current time step SCHEDULE section TUNING keyword parameter real values. Note that the integer parameters on the TUNING keyword are stored in the INTEHEAD keyword data array.

These are then followed by a series of "property" keywords that that outline the various additional data. For the RESTART files the header keywords are repeated for each time step a RESTART record is written. There are also additional header keywords for Local Grid Refinements ("LGR") that are repeated for each LGR and for time step.

All the keywords follow the same format, including the property keywords, as outlined in Table D.5, which shows a portion of the INTEHEAD header keyword definition for the RESTART file.

No.	Description	Output File Keyword Format			Status Or Value
		Keyword	No. of Entries	Data Type	
	INTEHEAD	Global grid header keyword for the RESTART Data file that defines the integer variables for this time step. NIHEAD is the number of entries associated with this keyword, and is dependent on the features being used in the model. Undefined values should be set to zero.			Required
1-1	Format	INTEHEAD	NIHEAD	INTE	
2-1	Data	An encoded integer corresponding to the time the file was created. For files not originating from the commercial simulator, this value may be set to zero.			ISNUM
2-2	Data	Simulator version, should be set to zero.			VERSION
2-3	Data	Unit system used in the simulation, set to 1 for metric, 2 for field, and 3 for laboratory			
2-4	Data	Undefined.			0
Notes: 1) Rows shaded in gray indicate the start of a keyword. 2) Cells colored red in the No. column indicate that this item is either "Not Used" or "Undefined".					

Table D.5: Output File Keyword Format

The row colored gray in the table specifies the start of a keyword definition and shows the format for the keyword (INTEHEAD) together with a description of the keyword. The next row, item 1-1 in the No. column, outlines the format of the keyword, that is the keyword name (INITHEAD), the number of data entries for the keyword (NIHEAD) and the type of entries (INTE for integers). The next set of rows specify the individual data entries, for example, item 2-3 in the No. column is the third integer value that declares the unit system for the file. Note that Cells colored red in the No. column indicate that this item is either "Not Used" or "Undefined".

Note

Under the No. column in Table D.5 the count base is one (offset one), as per FORTRAN; however, in C++ the base is zero (offset zero) and therefore C++ programmers must subtract one from this column to obtain the correct reference.

This reference adjustment should be applied to all references in this Appendix.

OPM Flow is written in C++ developers should use offset zero in reviewing or modifying the code.

The Data Type variable in row 1-1 in Table D.5 should have one of the following values:

1) CHAR for eight character words enclosed in single quotes (ASCII character decimal 39) for formatted output.
2) DOUB for double precision eight byte real values.
3) INTE for standard four byte integers.
4) LOGI for standard four byte Boolean (logical) values.
5) MESS keyword that has no associated data.
6) REAL for single precision four byte reals values.

All keywords follow the same format including the property array like PORO and PRESSURE. So for example, the INTEHEAD keyword would be like this in a typical formatted RESTART file:

```
 'INTEHEAD'          249 'INTE'
  -955283513      200400           2       -2345       -2345       -2345
       -2345       -2345          10          10           1         100
          10       -2345           7       -2345           0           1
           0           2           2           0           0           0
         110         108         109           3          97          93
       -2345       -2345          19          38          53       -2345
          97          93         146           5           0           1
          15          24           8           5           2           4
 ..............................................
```

And the pressure and water saturation arrays would be of the same form in a typical formatted RESTART file:

```
 'PRESSURE'        44431 'REAL'
   0.26889725E+03   0.26838983E+03   0.26826810E+03   0.26820352E+03
   0.26814493E+03   0.26809378E+03   0.26807767E+03   0.26806363E+03
   0.26802625E+03   0.26798474E+03   0.26795001E+03   0.26791434E+03
   0.26787915E+03   0.26783920E+03   0.26777118E+03   0.26769208E+03
..............................................
 'SWAT    '        44431 'REAL'
   0.10500000E+00   0.10500000E+00   0.10500000E+00   0.10500000E+00
   0.10500000E+00   0.10500000E+00   0.10500000E+00   0.14000000E+00
   0.14000000E+00   0.14500000E+00   0.14500000E+00   0.14500000E+00
   0.14500000E+00   0.14500000E+00   0.16000000E+00   0.16000000E+00
..............................................
```

Secondly, the No. Entries is the number of values following the keyword and as such cannot be used to determine the size of an array that is not associated with the grid, say for example the number of active connections in a well. Instead, the array size is given in another property keyword. In this case, the number of elements for each well in the IWEL property array is given in the INTEHEAD keyword as shown in Table D.6 (see Table D.20 for a full description of the RESTART INTEHEAD keyword).

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	INTEHEAD	Global grid header keyword for the RESTART Data file.			Required
1-1	Format	INTEHEAD	NIHEAD	INTE	
2-17	Data	Number of wells in the model.			NWELLS
2-25	Data	Number of values per well in the IWEL array (default value is 97)			NIWELZ

Table D.6: INTEHEAD Keyword - IWEL Example

Now if INTEHEAD(17) was equal to three and INTEHEAD(5) was equal to five then the IWEL property array for the three wells would have the data arranged as shown in Figure D.1.

IWEL Property Array Data Layout
INTEHEAD(17) = 3 and INTEHEAD(25)= 5

Well-1					Well-2					Well-3				
Item 1	Item 2	Item 3	Item 4	Item 5	Item 1	Item 2	Item 3	Item 4	Item 5	Item 1	Item 2	Item 3	Item 4	Item 5
Pos 1	Pos 2	Pos 3	Pos 4	Pos 5	Pos 6	Pos 7	Pos 8	Pos 9	Pos 10	Pos 11	Pos 12	Pos 13	Pos 14	Pos 15

Figure D.1: IWEL Property Keyword Example

Here the Items are the values affiliated with a specific well and Pos(ition) is the actual position in the IWEL property array, shown as gray boxes in Figure D.1.

Similarly for well connections and completions. In this case the maximum number of connections for all the wells is given in INTEHEAD(18) element and a well's current number of connections is given via the IWEL(5) element in the IWEL property array (see Table D.26 for a detailed description of the IWEL keyword).

Now if the number of wells equal two (INTEHEAD(17)) and INTEHEAD(18) is equal to four, that is the maximum number of connections is set to four, together with IWEL(5) equal to three for the first well and four for the second well, the ICON property array for the two wells would have the data arranged as shown in Figure D.2.

ICON Property Array Data Layout
INTEHEAD(17) = 2 and INTEHEAD(18) = 4
Well-1 with IWEL(5) = 3 and Well-2 with IWEL(5) = 4

ICON Array																							
Well-1												Well-2											
Conn-1			Conn-2			Conn-3			Conn-4			Conn-1			Conn-2			Conn-3			Conn-4		
I	J	K	I	J	K	I	J	K	0	0	0	I	J	K	I	J	K	I	J	K	I	J	K
Position																							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Figure D.2: ICON Property Keyword Example

Here the connection co-ordinates are given by (I, J, K) and the actual position in the ICON array is shown in the gray colored boxes. Notice that Well-1 has the required maximum number of connections but the fourth connection has the default values of zero, as the IWEL(5) value for this well only has three active connections.

Note also that the number of data elements per connection in the ICON vector is given by NICONZ which is given by INTEHEAD(33) and that the size of the ICON vector is NICONZ * NCWMAX * NWELLS, where NCWMAX is set by INTEHEAD (18) and NWELLS by INTEHEAD(17). In the example, NICONZ was assumed to be three for illustrative purposes, while the actual value is a constant 25 in the most recent versions of the commercial simulator. These arbitrary constants, like NICONZ, use to determine vector lengths, appear to be constant for various versions of the commercial simulator.

The following sections outline the format of the various individual files supported by OPM Flow, except for the DBG, LOG, PRT, and RSM ASCII format files.

D.2 EGRID - MODEL STRUCTURAL DATA FOR IRREGULAR CORNER-POINT GRIDS FILE

EGRID files contain the structural information for the model via the COORD and ZCORN etc., keywords, and employs the extensible GRID format, which is more compact than the GRID formatted files and is the only format supported by OPM Flow.

The output for this file type must be requested via the *GRIDFILE – Set the Grid File Output Options* in the GRID section, as shown below:

```
--
--        GRID FILE OUTPUT OPTIONS
--        GRID     EGRID
--        OPTN     OPTN
GRIDFILE
          0        1                                                    /
```

The above example defines that no GRID file will be written out and that the extensible GRID (that is the EGRID geometry format) file will be produced. This is the only configuration that OPM Flow supports.

The FMTIN and FMTOUT keywords in the RUNSPEC section defines the input and output files to be formatted as ASCII i.e. text files, (*.FEGRID), as oppose to unformatted binary files (*.EGRID). If these keywords are omitted then the default is for unformatted binary file input.

The EGRID file structure consists of a series header keywords that define the header keyword data type, the number of data entries, and then the associated header keyword data. There are a total of four major keyword header types for this file type (1) File Header, (2) Global Grid Header, (3) Local Grid Refinement Header[180] (repeated for each local grid refinement in the model), and (4) Non-Neighbor Connection Header.

In addition to the structural data, this file type also contains information describing the geometry relationship between the global grid and any Local Grid Refinements ("LGR") that are present in the model, together with the Non-Neighbor Connections ("NNC") that may be present due to structural discontinuities. The overall structure of this file is is outlined in Table D.7

Reference Section	Global Section Keywords	Global Data Keywords	LGR Section Keywords	LGR Data Keywords	Notes
D.2.1	FILEHEAD MAPUNITS MAPAXES GRIDUNIT GDORIENT				EGRID header keyword that defines various Global Grid grid properties
D.2.2	GRIDHEAD	COORD ZCORN etc.			EGRID global irregular corner point grid keyword that defines the grid geometry
D.2.2	ENDGRID				Marks the end of the EGRID global irregular corner point grid keyword
D.2.3			LGR LGRPARNT LGRSGRID		EGRID LGR irregular corner point grid keyword that defines the LGR name and optionally the nested or parent LGRs associated with this LGR.

[180] *Several keywords are used for both global and LGR grids, for example the GRIDHEAD, COORD, ZCORN keywords.*

Reference Section	Global Section Keywords	Global Data Keywords	LGR Section Keywords	LGR Data Keywords	Notes
D.2.3			GRIDHEAD	COORD ZCORN etc.	EGRID LGR irregular corner point grid keyword that defines the grid geometry
D.2.3			ENDGRID		Marks the end of the EGRID LGR irregular corner point grid keyword
D.2.3			ENDLGR		Sets the end of current LGR section.
D.2.3			LGR LGRPARNT LGRSGRID		EGRID LGR irregular corner point grid keyword that defines the LGR name and optionally the nested or parent LGRs associated with this LGR
D.2.3			GRIDHEAD	COORD ZCORN etc.	EGRID LGR irregular corner point grid keyword that defines the grid geometry
D.2.3			ENDGRID		End of the EGRID LGR grid section.
D.2.3			ENDLGR		Sets the end of current LGR section.
D.2.4	NNCHEAD	NNC1 NNC2			EGRID Global Non-Neighbor Connections for Irregular Corner Point Grid keywords.
D.2.4			NNCHEAD	NNC1 NNC2 NNCL NNCG	First LGR EGRID global and local non-neighbor connections for irregular corner point grid keywords.
D.2.4			NNCHEAD	NNC1 NNC2 NNCL NNCG	Second LGR EGRID global and local non-neighbor connections for irregular corner point grid keywords.
D.2.4			NNCHEADA	NNA1 NNA2	EGRID amalgamated and local non-neighbor connections for irregular corner point grid keywords.

Notes:

1) Cells shaded in gray indicate the combination is not applicable and cells colored orange indicate that this item is not currently supported by OPM Flow.

Table D.7: EGRID - Model Structural Data for Irregular Corner-Point Grids

Each major header keyword is subdivided into a series of sub-header keywords that define a particular data set. The general format for a header keyword is the keyword (enclosed in single quotes), followed by the number of data entries (an integer value), followed by the data type which is set to CHAR, INTE, or REAL (enclosed in quotes). This will then be followed by the data for the keyword.

The following sections describe the format of the various keywords and the associated data sets.

D.2.1 EGRID HEADER KEYWORDS

The FILEHEAD keyword defines the key attributes of the file via a series of integer constants, this is then followed by the MAPUNITS, MAPAXES, GRIDUNIT and GDORIENT keywords and their data sets. Note that some keywords are optional and are not used by OPM Flow per se, but are used by pre- and post processing software. Secondly, some features are not supported by OPM Flow, for example local grid refinements, and thus OPM will not write out the data associated with these features.

Table D.8 outlines the structure of the EGRID Header Keywords and their affiliated data.

No.	Keyword Name	EGRID Header Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
	FILEHEAD	This keyword marks the start of the EGRID file and defines various parameters associated with this file type.			Required
1-1	Format	FILEHEAD	100	INTE	
2-1	Data	Version number for this file type, for example 3.			3
2-2	Data	The year this version of the file format was released, for example 2004.			2004
2-3	Data	Not used.			
2-4	Data	Version number of earliest this file format is supported, normally set to 0.			0
2-5	Data	Type of grid, set to 0 for Irregular Corner-Point Grids, 1 for Unstructured Grids, or 2 for a mixture of Irregular Corner-Point and Unstructured Grids (Mixed Grids).			0
2-6	Data	Type of rock model, set to 0 for a single porosity/permeability rock model, 1 for dual porosity rock model, or 3 for a dual permeability rock model.			0
2-7	Data	Original grid format, set to 0 for unknown, 1 for Irregular Corner-Point Grids, or 2 for Cartesian Regular Grids.			
2-8 to 2-100	Data	Not used			0
	MAPUNITS	This keyword defines the MAPUNITS.			Optional
1-1	Format	MAPUNITS	1	CHAR	
2-1	Data	The units of the map data, normally set to FEET or METRES.			
	MAPAXES	The MAPAXES keyword defines the grid position relative to the map coordinates. The six values in the data fields define the relative map (x, y) coordinates for three locations to enable conversion from grid to map coordinate in pre- and post processing software.			Optional
1-1	Format	MAPAXES	6	REAL	
2-1	Data	X-coordinate on the y-axis located at the end of the y-axis.			
2-2	Data	Y-coordinate on the y-axis located at the end of the y-axis.			
2-3	Data	X-coordinate at the origin.			
2-4	Data	Y-coordinate at the origin.			
2-5	Data	X-coordinate on the x-axis located at the end of the x-axis.			
2-6	Data	Y-coordinate on the x-axis located at the end of the x-axis.			
	GRIDUNIT	The GRIDUNIT keyword defines units of the COORD and ZCORN arrays and the grid coordinate space			Required

No.	Keyword Name	EGRID Header Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
1-2	Format	GRIDUNIT	2	CHAR	
2-1	Data	The first entry defines units of the COORD and ZCORN arrays and should be normally set to FEET or METRES (enclosed in single quotes).			
2-2	Data	The second entry defines the grid coordinate space (MAP or MAPFT if COORD and ZCORN are defined in map coordinates, or blank if in grid coordinates (‘ ’).			
	GDORIENT	Grid orientation keyword defines the property ordering in the I, J, and K dimensions, the direction of the Z-direction, and the “handedness of the grid.			Optional
1-1	Format	GDORIENT	5	CHAR	
2-1	Data	Define the property ordering in the I dimension (set to either INC for increasing or DEC for decreasing).			
2-2	Data	Define the property ordering in the J dimension (set to either INC for increasing or DEC for decreasing).			
2-3	Data	Define the property ordering in the K dimension (set to either INC for increasing or DEC for decreasing).			
2-4	Data	Declare the direction of the Z-direction, should be set to either UP or DOWN.			
2-5	Data	Set the “handedness of the grid., should be set to either LEFT or RIGHT.			

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow and those colored red are either “Not Used” or “Undefined”.
3) For formatted output all character variables, including the keywords should be enclosed in single quotes, for example the FILEHEAD keyword should be written out as ‘FILEHEAD’.
4) GDORIENT keyword in the GRID section is not supported by OPM Flow.

Table D.8: EGRID Header Keywords

Example: EGRID Header Keywords

The following example shows a typical formatted file EGRID header keyword data set taken from the Norne model.

```
'FILEHEAD'         100 'INTE'
          3        2004           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0
'MAPAXES '            6 'REAL'
  0.00000000E+00   0.10000000E+03   0.00000000E+00   0.00000000E+00
  0.10000000E+03   0.00000000E+00
'GRIDUNIT'            2 'CHAR'
'METRES  ' '         '
```

Notice that the GDORIENT keyword is not written out.

D.2.2 EGRID GLOBAL IRREGULAR CORNER POINT GRID KEYWORDS

Following the EGRID Header Keyword data set, the EGRID Global Irregular Corner Point Grid Keywords should be read or written to the EGRID file. This data set includes the actual structural data for the model, that is the COORD and ZCORN keyword data, as well as the ACTNUM keyword data that defines if a given cell is active (set to 1), or inactive (set to zero). The structure for this type data is defined in Table D.9.

No.	Keyword Name	EGRID Global Irregular Corner Point Grid Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	GRIDHEAD	Global grid keyword that defines the start of this keyword type.			Required
1-1	Format	GRIDHEAD	100	INTE	
2-1	Data	Type of grid, set to 0 for a mixture of Irregular Corner-Point and Unstructured Grids, 1 for. Irregular Corner-Point Grids, and 2 for Unstructured Grids. Only the default value of one is supported by OPM Flow.			1
2-2	Data	The number of grid blocks in the x-direction (NX).			
2-3	Data	The number of grid blocks in the y-direction (NY).			
2-4	Data	The number of grid blocks in the z-direction (NZ).			
2-5	Data	The grid reference number set to zero for the global grid or a value greater than zero to represent a LGR. For example if there are five LGR's, then this complete data set is repeated six times, once for the global grid, and five times for the five LGRs., with the first LGR having a reference number of 1 and the last LGR having a reference number of 5.			
2-6 to 2-24	Data	Not used.			0
2-25	Data	NUMRES the number of reservoirs, that is the number COORD data sets to be processed by OPM Flow. This should be set to one as the only value supported by OPM Flow			1
2-26	Data	NSEG the number of coordinate line segments, should be set to 1.			1
2-27	Data	Cartesian/Radial grid indicator set to 0 for Cartesian girds and greater than zero for radial grids. Currently OPM Flow does not support radial geometries so this value should always be set to zero.			0
2-28	Data	The LGR location of the lower I-index LGR in the global grid. This value should be set to zero if there is no LGR grids.			0
2-29	Data	The LGR location of the lower J-index LGR in the global grid. This value should be set to zero if there is no LGR grids.			0
2-30	Data	The LGR location of the lower K-index LGR in the global grid. This value should be set to zero if there is no LGR grids.			0
2-31	Data	The LGR location of the upperI -index LGR in the global grid. This value should be set to zero if there is no LGR grids.			0
2-32	Data	The LGR location of the upper J-index LGR in the global grid. This value should be set to zero if there is no LGR grids.			0
2-33	Data	The LGR location of the uper K-index LGR in the global grid. This value should be set to zero if there is no LGR grids.			0

No.	Keyword Name	EGRID Global Irregular Corner Point Grid Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-34 to 2-100	Data	Not used by OPM Flow.			0
	BOXORIG	Not supported.			Optional
1-1	Format	BOXORIG	3	INTE	
2-1 to 2-3	Data	Ignored by OPM Flow.			
	COORD	Property keyword that defines the start of the COORD data set. The COORD data defines a set of coordinate lines or pillars for a reservoir grid via an array. The number of data values for this keyword should be 6 x (NX+1) x (NY+1) x NUMRES. Where NUMRES represents the number of separate coordinate lines (or reservoirs). In OPM Flow NUMRES can only be set to one.			Required
1-1	Format	COORD	6 x (NX+1) x (NY+1)	REAL	
2-1	Data	COORD data in the same format as the COORD keyword described in the GRID section of the manual.			
	COORDSYS	Coordinate definitions for each NUMRES reservoir. The number of data values for this keyword should be 6 x NUMRES. Where NUMRES represents the number of separate coordinate lines (or reservoirs). In OPM Flow NUMRES can only be set to one.			Optional
1-1	Format	COORDSYS	6	INTE	
2-1 to 2-6	Data	Ignored by OPM Flow.			
	ZCORN	Property keyword that defines the start of the ZCORN data set. ZCORN defines the depth of each corner point of a grid block on the pillars defining the reservoir grid. The number of data values for this keyword should be 8 x NX x NY x NZ.			Required
1-2	Format	ZCORN	8 x NX x NY x NZ	REAL	
1-3	Type	Type of data in the Data fields.			
2-1	Data	ZCORN data in the same format as the ZCORN keyword described in the GRID section of the manual.			
	ACTNUM	Property keyword that defines the start of the ACTNUM data set. ACTNUM specifies which grid blocks are active or inactive. A value of 1 indicates the block is active and a value of 0 indicates the block is inactive. Although this data set status is set to Optional, it is normally always written out by pre-processing software. The number of data values for this keyword should be NX x NY x NZ integer values.			Optional
1-1	Format	ACTNUM	NX x NY x NZ	INTE	
2-1	Data	ACTNUM data in the same format as the ACTNUM keyword described in the GRID section of the manual.			

No.	Keyword Name	EGRID Global Irregular Corner Point Grid Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	CORSNUM	Property keyword that defines the start of the CORSNUM data set for when the grid has been coarsened. The number of data values for this keyword should be NX x NY x NZ integer values. Grid coarsening is currently not supported in OPM Flow.			Optional
1-1	Format	CORSNUM	NX x NY x NZ	INTE	
2-1	Data	CORSNUM data set.			
1-1	ENDGRID	The ENDGRID keyword marks the end of the these set of keywords. Always set to 0 to indicate that there is no data section following this keyword.			Required
1-2	Format	ENDGRID	0	INTE	0

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keywords, should be enclosed in single quotes, for example the GRIDHEAD keyword should be written out as 'GRIDHEAD'.

Table D.9: EGRID Global Irregular Corner Point Grid Keywords

Example: EGRID Global Irregular Corner Point Grid Keywords

The following example shows a typical formatted EGRID Global Irregular Corner Point Grid Keywords data set, taken from the Norne model.

```
'GRIDHEAD'          100 'INTE'
           1           46          112           22            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           1            1            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0
 'COORD   '        31866 'REAL'
   0.45311400E+06   0.73199210E+07   0.30374729E+04   0.45311400E+06
   0.73199210E+07   0.31328311E+04   0.45315503E+06   0.73198400E+07
   0.29839331E+04   0.45314275E+06   0.73198640E+07   0.31735720E+04
   0.45319609E+06   0.73197590E+07   0.30059690E+04   0.45317150E+06
   0.73198075E+07   0.32158359E+04   0.45323716E+06   0.73196780E+07
   0.30002649E+04   0.45320025E+06   0.73197510E+07   0.32172500E+04
   0.45327819E+06   0.73195970E+07   0.29893479E+04   0.45322903E+06
   0.73196940E+07   0.32139509E+04   0.45331925E+06   0.73195165E+07
..............................................
 'ZCORN   '       906752 'REAL'
   0.30374729E+04   0.29839331E+04   0.29839331E+04   0.30059690E+04
   0.30059690E+04   0.30002649E+04   0.30002649E+04   0.29893479E+04
   0.29893479E+04   0.29956799E+04   0.29956799E+04   0.30008550E+04
   0.30008550E+04   0.30052520E+04   0.30052520E+04   0.30308621E+04
   0.30308621E+04   0.30368701E+04   0.30368701E+04   0.30380171E+04
   0.30380171E+04   0.30450271E+04   0.30450271E+04   0.30554099E+04
   0.30554099E+04   0.30665410E+04   0.30665410E+04   0.30766240E+04
   0.30766240E+04   0.30869380E+04   0.30869380E+04   0.30961531E+04
..............................................
 'ACTNUM  '       113344 'INTE'
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
           0            0            0            0            0            0
..............................................
 'ENDGRID '            0 'INTE'
```

End of Example

D.2.3 EGRID LGR IRREGULAR CORNER POINT GRID KEYWORDS

The data structure for Local Grid Refinement ("LGR") Irregular Corner Point Grids is similar to the global grid format described in the previous section. Additional data that the defines the LGR properties (LGR Name for example) are included in this definition and the LGR keywords are repeated for each LGR in the model. The keyword description is outlined in Table D.10.

Note that currently OPM Flow does not support LGR grids and therefore this series of keywords cannot be used by OPM Flow.

No.	Keyword Name	EGRID LGR Irregular Corner Point Grid Keywords (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. of Entries	Data Type	
	LGR	LGR keyword defines the start of the LGR section of keywords and is required when LGRs are in the model.			Required
1-1	Format	LGR	1	CHAR	
2-1	Data	Name of the LGR			
	LGRPARNT	Start of LGRPARNT keyword that defines the parent LGR for when nested LGR have been used.			Optional
1-1	Format	LGRPARNT	1	CHAR	
2-1	Data	Name of parent LGR			
	LGRSGRID	Start of the LGRSGRID keyword for LGRs parented from a sub-grid.			Optional
1-1	Format	LGRSGRID	1	CHAR	
2-1	Data	Name of parent LGR			
	GRIDHEAD	LGR grid keyword that defines the start of this keyword type for the LGR. The format is the same as the Global grid keyword - see Table D.9.			Required
	BOXORIG	Not supported. The format is the same as the Global grid keyword - see Table D.9.			Optional
	COORD	Property keyword that defines the start of the LGR COORD data set. The COORD data defines a set of coordinate lines or pillars for LGR grid via an array. The format is the same as the Global grid keyword - see Table D.9.			Required
	COORDSYS	Coordinate definitions for the LGR. The format is the same as the Global grid keyword - see Table D.9.			Optional
	ZCORN	Property keyword that defines the start of the LGR ZCORN data set. The format is the same as the Global grid keyword - see Table D.9.			Required
	ACTNUM	Property keyword that defines the start of the LGR ACTNUM data set. The format is the same as the Global grid keyword - see Table D.9.			Optional
	HOSTNUM	Property keyword that defines the start of the HOSTNUM data set. which is only applicable to LGR grids. Number of data values for this keyword should be NX x NY x NZ integer values.			Required
1-1	Format	HOSTNUM	NX x NY x NZ	INTE	
2-1	Data	HOSTNUM data set.			

No.	Keyword Name	EGRID LGR Irregular Corner Point Grid Keywords (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. of Entries	Data Type	
	ENDGRID	The ENDGRID keyword marks the end of the LGR Grid Header section. Always set to 0 to indicate that there is no Data section for this keyword.			Required
1-1	Format	ENDGRID	0	INTE	0
	ENDLGR	ENDLGR keyword marks the end of the LGR Header section. Always set to 0 to indicate that there is no Data section for this keyword.			Required
1-1	Format	ENDLGR	0	INTE	0

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow.
3) For formatted output all character variables, including the keywords, should be enclosed in single quotes, for example the LGR keyword should be written out as 'LGR '.

Table D.10: EGRID LGR Irregular Corner Point Grid Keywords

Note that this data set is repeated for each LGR in the model as demonstrated in the following example.

Example: EGRID LGR Irregular Corner Point Grid Keywords

The following example shows a typical formatted data set for this series of keywords with two Cartesian LGR grids, named LGR-1 and LGR-2 define via the following CARFIN keyword statements:

```
--
--       CARFIN LGR GRID COMMANDS
--
--       LGR        ----- FINE GRID ------   -- CARFIN GRID --  MAX     HOST
--       NAME       I1  I2  J1  J2  K1  K2     NX    NY    NZ   WELLS   NAME
CARFIN
        'LGR-1'      2   2   2   2   1   1      2     2     2     1    GLOBAL /
CARFIN LGR GRID PARAMETERS

--
--       CARFIN LGR GRID COMMANDS
--
--       LGR        ----- FINE GRID ------   -- CARFIN GRID --  MAX     HOST
--       NAME       I1  I2  J1  J2  K1  K2     NX    NY    NZ   WELLS   NAME
CARFIN
        'LGR-2'      9   9   9   9   1   1      2     2     2     1    GLOBAL /
CARFIN LGR GRID PARAMETERS

ENDFIN
```

The resulting keywords are as follows:

```
'LGR     '            1 'CHAR'
'LGR-1   '
'LGRPARNT'            1 'CHAR'
'        '
'GRIDHEAD'          100 'INTE'
          1           2           2           2           1           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
          1           1           0           2           2           1
 ..........................................
           0           0           0           0
'COORD   '           54 'REAL'
  0.10000000E+04   0.10000000E+04   0.00000000E+00   0.10000000E+04
  0.10000000E+04   0.10000000E+04   0.15000000E+04   0.10000000E+04
  0.00000000E+00   0.15000000E+04   0.10000000E+04   0.10000000E+04
  0.20000000E+04   0.10000000E+04   0.00000000E+00   0.20000000E+04
  0.10000000E+04   0.10000000E+04   0.10000000E+04   0.15000000E+04
 ..........................................
   0.20000000E+04   0.10000000E+04
'ZCORN   '           64 'REAL'
  0.83250000E+04   0.83250000E+04   0.83250000E+04   0.83250000E+04
  0.83250000E+04   0.83250000E+04   0.83250000E+04   0.83250000E+04
  0.83250000E+04   0.83250000E+04   0.83250000E+04   0.83250000E+04
  0.83250000E+04   0.83250000E+04   0.83250000E+04   0.83250000E+04
  0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
 ..........................................
   0.83450000E+04   0.83450000E+04   0.83450000E+04   0.83450000E+04
'ACTNUM  '            8 'INTE'
          1           1           1           1           1           1
          1           1
'HOSTNUM '            8 'INTE'
         12          12          12          12          12          12
         12          12
'ENDGRID '            0 'INTE'
'ENDLGR  '            0 'INTE'
'LGR     '            1 'CHAR'
'LGR-2   '
'LGRPARNT'            1 'CHAR'
'        '
'GRIDHEAD'          100 'INTE'
          1           2           2           2           2           0
  ..........................................
          0           0           0           0
'COORD   '           54 'REAL'
  0.80000000E+04   0.80000000E+04   0.00000000E+00   0.80000000E+04
  0.80000000E+04   0.10000000E+04   0.85000000E+04   0.80000000E+04
  ..........................................
  0.90000000E+04   0.10000000E+04
'ZCORN   '           64 'REAL'
  0.83250000E+04   0.83250000E+04   0.83250000E+04   0.83250000E+04
  ..........................................
  0.83450000E+04   0.83450000E+04   0.83450000E+04   0.83450000E+04
'ACTNUM  '            8 'INTE'
          1           1           1           1           1           1
          1           1
'HOSTNUM '            8 'INTE'
         89          89          89          89          89          89
         89          89
'ENDGRID '            0 'INTE'
'ENDLGR  '            0 'INTE'
```

End of Example

D.2.4 EGRID NON-NEIGHBOR CONNECTIONS FOR IRREGULAR CORNER POINT GRID KEYWORDS

The keywords in this section are used to define Non-Neighbor Connections ("NNC") for both the global grid and any LGR's included in the model. This data set is only written out if there are NNCs in the model and can be skipped if this is the case; however, apart from very simple models, nearly all full field models will have NNCs as a result of modeling the structural faults in the model. Likewise, the keywords affiliate with LGRs are also skipped if the there are no LGRs in the model.

Note that actual NNC transmissibility data for the NNCs (TRANX, TRANY and TRANZ) are stored in the INIT Data File and not in the EGRID File.

The keyword definitions are tabulated in Table D.11

No.	Keyword Name	EGRID Non-Neighbor Connections Keywords For Irregular Corner Point Grids			Status Or Value
		Keyword	No. of Entries	Data Type	
	NNCHEAD	This keyword marks the start of the non-neighbor keywords and defines the number of non-neighbor connections.			Required
1-1	Format	NNCHEAD	10	INTE	
2-1	Data	The number of non-neighbor connections (NUMNNC)			
2-2	Data	Grid identifier set to zero for the global grid, or a value greater than zero to represent a LGR.			
2-3 to 2-10	Data	Not used.			
	NNC1	NNC1 defines the cell numbers for the UPSTREAM non-neighbor connections, where NUMNNC is the number of non-neighbor connections.			Required
1-1	Format	NNC1	NUMNNC	INTE	
2-1	Data	NUMNNC integer values defining the cell numbers for the UPSTREAM non-neighbor connections.			
	NNC2	NNC2 defines the cell numbers for the DOWNSTREAM non-neighbor connections, where NUMNNC is the number of non-neighbor connections			Required
1-1	Format	NNC2	NUMNNC	INTE	
2-1	Data	NUMNNC integer values defining the cell numbers for the DOWNSTREAM non-neighbor connections.			
	NNCL	This keyword defines the local cells connected to the global grid, where NCONGL is the number of entries.			Optional
1-1	Format	NNCL	NCONCL	INTE	
2-1	Data	NCONCL integer values defining the local cells connected to the global grid.			
	NNCG	This keyword defines the global cells connected to the current local grid being defined by this section of keywords, where NCONGL is the number of entries.			Optional
1-1	Format	NNCG	NCONGL	INTE	

No.	Keyword Name	EGRID Non-Neighbor Connections Keywords For Irregular Corner Point Grids			Status Or Value
		Keyword	No. of Entries	Data Type	
2-1	Data	NCONGL integer values defining the global cells connected to the current local grid.			
	NNCHEADA	This keyword defines the connection between two LGRs that have been amalgamated.			Optional
1-1	Format	NNCHEADA	10	INTE	
2-1	Data	LGR index of the first LGR in the amalgamation (ILOC1).			
2-2	Data	LGR index of the second LGR in the amalgamation (ILOC2).			
2-3 to 2-10		Not used			
	NNA1	This keyword defines the ILOC1 cells connected in the amalgamation, where NUMNCA is the number of entries.			Optional
1-1	Format	NNA1	NUMNCA	INTE	
2-1	Data	NUMNCA integer values defining the ILOC1 cells connected in the amalgamation.			
	NNA2	This keyword defines the ILOC2 cells connected in the amalgamation, where NUMNCA is the number of entries.			
1-1	Format	NNA2	NUMNCA	INTE	
2-1	Data	NUMNCA integer values defining the ILOC2 cells connected in the amalgamation.			

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keywords, should be enclosed in single quotes, for example the NNCHEAD keyword should be written out as 'NNCHEAD'.
4) Local Grid Refinements are currently not supported by OPM Flow and neither therefore is LGR amalgamation of LGRs.

Table D.11: EGRID NNC Keywords for Irregular Corner Point Grids

Note that if LGR's are present in the model then the keywords relating to LGRs are repeated for each LGR in the model.

Example: EGRID Grid Keywords for Non-Neighbor Connections for Irregular Corner Point Grids

The example shows the NNCs for the global grid and two LGRs.

```
 'NNCHEAD '          10 'INTE'
       11363           0           0           0           0           0
           0           0           0           0
 'NNC1    '       11363 'INTE'
        5717        5717       21173       26325       31477       36629
       41781       46933       52085       57237       62389       67541
       72693       77845       82997       88149       93301      103605
..............................................
 'NNC2    '       11363 'INTE'
         566       10870       26326       31478       36630       41782
       46934       52086       57238       62390       67542       72694
       77846       82998       88150       93302       98454       98454
      103606         612        5764       26372       21220       31524
..............................................

 'NNCHEAD '          10 'INTE'
           0           1           0           0           0           0
           0           0           0           0
 'NNC1    '           0 'INTE'
 'NNC2    '           0 'INTE'
 'NNCL    '          16 'INTE'
           1           5           3           7           1           5
           2           6           2           6           4           8
           3           7           4           8
 'NNCG    '          16 'INTE'
          11          11          11          11           2           2
           2           2          13          13          13          13
          22          22          22          22
 'NNCHEAD '          10 'INTE'
           0           2           0           0           0           0
           0           0           0           0
 'NNC1    '           0 'INTE'
 'NNC2    '           0 'INTE'
 'NNCL    '          16 'INTE'
           1           5           3           7           1           5
           2           6           2           6           4           8
           3           7           4           8
 'NNCG    '          16 'INTE'
          88          88          88          88          79          79
          79          79          90          90          90          90
          99          99          99          99
```

End of Example

D.3 EGRID - Model Structural Data for Unstructured Grids File

This file format is currently not supported by OPM Flow.

D.4 EGRID - Model Structural Data for Mixed Grids File

This file format is currently not supported by OPM Flow.

D.5 GRID - Model Structural Data File

This file format is currently not supported by OPM Flow.

D.6 INIT – MODEL INITIALIZATION AND STATIC DATA FILE

The INIT files contain the static data specified in the GRID, PROPS and REGIONS sections. For example, the PORO, PERM and NTG arrays from the GRID section and the resulting PORV and TRANX, TRANY and TRANZ arrays. The data is used in post-processing software, for example OPM ResInsight, to visualize the static grid properties and the tabular PVT and relative permeability data, and is not used per se by the simulator.

The data is written to file if the INIT keyword in the GRID section has been activated (*INIT – Activate the INIT File Option)*. Similar to the EGRID file, the INIT file can either be written out in formatted form as ASCII i.e. text files, if the FMTOUT keyword has been activated, or binary format if the FMTOUT keyword has not been activated. Normally, this option is always activated by the user and when activated the binary form of the file is used.

There are two files types associated with the INIT data:

1) an index file (INIT Index) that contains a list of variables, the array type (character, integer, or real) and the size of the arrays that are written out to the initialization data file and,

2) the initialization data file (INIT Data) that contains the actual data written out at the beginning of the run once the model has been initialized.

The commercial simulator writes out both files, whereas OPM Flow only writes out the INIT Data file, as the data can be read by most post-processing software, including OPM ResInsight, using only the INIT Data file as input.

The following sections outline the format for these two file types.

D.6.1 INIT INDEX FILE

This file type is not supported or required by OPM Flow or OPM ResInsight to read or write the static data written to the INIT Data file.

D.6.2 INIT DATA FILE SPECIFICATION

This file type contains the global and any LGR grid property data present in the model[181], for example porosity (PORO) and permeability data arrays (PERMX,PERMY, and PERMZ) for properties allocated to each grid cell, as well as the fluid and rock property functions tabular data. The overall structure of this file is similar to the RESTART file with the individual keywords being structured as shown in Table D.12.

Reference Section	Global Section Keywords	Global Data Keywords	LGR Section Keywords	LGR Data Keywords	Notes
D.6.3	INTEHEAD LOGIHEAD DOUBHEAD				Global grid header keywords that defines the integer, logical and double precision variables for this header keyword.
D.6.4	Property Keywords	PORV PORO etc.			Global grid property keywords that defines the global grid property data defined in the GRID and Edit sections. For example, PORV, NTG, PERMX etc.)
D.6.5			LGR LGRHEADI LGRHEADQ LGRHEADD		Defines the start of an LGR section of keywords and the LGR header keywords
D.6.5			INTEHEAD LOGIHEAD DOUBHEAD		LGR grid header keywords defining the same data as the global keywords, except for the given LGR. This set of keywords are only written once for each LGR.
D.6.4			Property Keywords	PORV PORO etc.	LGR property keywords; same format as the global grid keywords.
D.6.5			LGR LGRHEADI LGRHEADQ LGRHEADD		The LGR header keywords
D.6.5			INTEHEAD LOGIHEAD DOUBHEA		The LGR header keywords which are only written once for each LGR.
D.6.4			Property Keywords	PORV PORO etc.	LGR property keywords
			etc.		Repeated for each LGR in the model.
D.6.5			LGRSGONE		Marks the end of LGR section of keywords.
D.6.7	TABDIMS				TABDIMS defines the tables dimensions, for the subsequent TAB keywords.
D.6.8	TAB				Rock and fluid tabular property data keywords.

[181] *Several keywords are used for both global and LGR grids, for example the INTEHEAD, LOGIHEAD, DOUBHEAD, PROPERTY and REGION keywords and arrays.*

Reference Section	Global Section Keywords	Global Data Keywords	LGR Section Keywords	LGR Data Keywords	Notes
D.6.8	CON				CON keyword defines the constant PVT dead oil data (the data associated with RSCONST, RSCONSTT, RVCONT and RVCONSTT keywords).
D.6.4	Region Keywords	PVTNUM SATNUM etc.			Region property data for the global grid as defined in the REGION section (PVTNUM, SATNUM etc.). The keyword is repeated to account for all region property data.
D.6.5			LGR LGRHEADI LGRHEADQ LGRHEADD		The LGR header keywords
D.6.4			Region Keywords	PVTNUM SATNUM etc.	LGR region property data for the LGR grid.
D.6.5			LGR LGRHEADI LGRHEADQ LGRHEADD		The LGR header keywords
D.6.4			Region Keywords	PVTNUM SATNUM etc.	LGR region property data for the LGR grid.
			etc.		Repeated for each LGR in the model.
D.6.5			LGRSGONE		Marks the end of LGR section of keywords.
D.6.4	End-Point Keywords	SWATINIT SWL etc.			Global grid saturation and end-point data keywords. The keyword users the same keywords outlined in the GRID and PROPS section, for example, the SWL, SWATINIT, KRG, PCW, etc. arrays
D.6.5			LGR LGRHEADI LGRHEADQ LGRHEADD		The LGR header keywords
D.6.4			End-Point Keywords	SWATINIT SWL etc.	LGR grid saturation and end-point data keywords.
D.6.5			LGR LGRHEADI LGRHEADQ LGRHEADD		The LGR header keywords
D.6.4			End-Point Keywords	SWATINIT SWL etc.	LGR grid saturation and end-point data keywords.

Reference Section	Global Section Keywords	Global Data Keywords	LGR Section Keywords	LGR Data Keywords	Notes
			etc.		
D.6.5			LGRSGONE		Marks the end of LGR section of keywords.
D.6.4	NNC Keywords	TRANNC HEATNNC etc.			Non-neighbor connection property data ("NNC") for the global grid. The keyword is repeated to account for various NNC arrays.
D.6.5			LGR LGRHEADI LGRHEADQ LGRHEADD		The LGR header keywords
D.6.4			NNC Keywords	TRANNC TRANGL etc.	LGR NNC property data.
D.6.5			LGR LGRHEADI LGRHEADQ LGRHEADD		The LGR header keywords
D.6.4			NNC Keywords	TRANNC TRANGL etc.	LGR NNC property data.
			etc.		Repeated for each LGR in the model.
D.6.5			LGRSGONE		Marks the end of LGR section of keywords.

Notes:

1) Cells shaded in gray indicate the combination is not applicable and cells colored orange indicate that this item is not currently supported by OPM Flow.

Table D.12: INIT Data File Structure

D.6.3 INIT DATA – STATIC DATA HEADER KEYWORDS

The INIT Data – Static Data Header Keyword section is the first data set that should be read or written to the INIT Data file. This data set includes INTEHEAD, LOGIHEAD and DOUBHEAD keywords that define versus parameters used in subsequent keywords in the INIT Data file. This is then followed by a series of global grid PROPERTY data keywords that define the various global grid property arrays for each grid cell in the model, as well as the static tabular data (relative permeability tables and PVT tables), etc.

The structure for this set of keywords is defined in Table D.13.

No.	Keyword Name	INIT Data – Static Data Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	INTEHEAD	Global static header keyword for the INIT Data file that defines the start of INIT static data set, and contains the integer variables for this header keyword. NIHEAD is the number of entries associated with this keyword, and is dependent on the features being used in the model.			Required
1-1	Format	INTEHEAD	NIHEAD	INTE	
2-1		Undefined			0
2-2		Undefined			0
2-3	Data	Unit system used in the simulation, set to 1 for metric, 2 for field, and 3 for laboratory			
2-4 to 2-8		Undefined.			0
2-9	Data	DIMENS key word in the RUNSPEC section - the number of grid blocks in the x-direction.			NX
2-10	Data	DIMENS key word in the RUNSPEC section - the number of grid blocks in the y-direction.			NY
2-11	Data	DIMENS key word in the RUNSPEC section - the number of grid blocks in the z-direction.			NZ
2-12	Data	Number of global active cells in the model			NACTIV
2-13	Data	Not used.			0
2-14	Data	Type of grid, set to 0 for Irregular Corner-Point Grids, 1 for Unstructured Grids, or 2 for a mixture of Irregular Corner-Point, Unstructured Grids (Mixed Grids) and 3 for Cartesian grids.			1
2-15	Data	Type of phases in the model, set to 1 for oil, 2 for water, 3 for oil-water, 4 for gas, 5 for oil-gas, 6 for gas-water and 7 for oil-water-gas.			PHASE
2-16 to 2-64		Undefined.			0
2-65	Data	First part of start date of the run, DAY, the value should be greater than or equal to one and less than or equal to 31 for the calendar days.			DAY
2-66	Data	Second part of start date of the run, MONTH, the value should be greater than or equal to one and less than or equal to 12 for the calendar month.			MONTH
2-77	Data	Third part of start date of run, YEAR, a positive four digit integer value of the start year, which must be specified fully by four digits, that is 1986.			YEAR

No.	Keyword Name	INIT Data – Static Data Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-68 to 2-94					0
2-95	Data	Simulator code used to generate the file, set to 100 for Schlumberger's ECLIPSE 100, 300 for Schlumberger's ECLIPSE 300, 500 for Schlumberger's ECLIPSE 300 Thermal, 700 for Schlumberger's INTERSECT simulator, 800 for Schlumberger's FrontSim simulator, or a negative value for other simulators. OPM Flow users a value of 100.			IPROG
2-96 to 206		Undefined.			0
2-207	Data	The first part of the current simulation time in the form HH;MM:SS, that is HH for hours. The value should be greater than or equal to zero and less than or equal to 23.			IHOURZ
2-208	Data	The second part of the current simulation time in the form HH;MM:SS, that is MM for minutes. The value should be greater than or equal to zero and less than or equal to 59.			IMINTS
2-209 to 410		Undefined.			0
411	Data	The third part of the current simulation time in the form HH;MM:SS, that is SS for seconds. The value should be greater than or equal to zero and less than or equal to 59.			ISECND
	LOGIHEAD	Global static data keyword for the INIT Data file that defines the logical variables (T for true and F for false) for this keyword. NLHEAD is the number of entries associated with this keyword, and is dependent on the features being used in the model. Undefined items should be set to F (False).			Required
1-1	Format	LOGIHEAD	NLHEAD	LOGI	
2-1	Data	Dissolved gas is present in the model indicator, set to T if present in the model else set to F.			DISGAS
2-2	Data	Vaporized oil is present in the model indicator, set to T if present in the model else set to F.			VAPOIL
2-3	Data	SATOPTS in the RUNSPEC section - directional relative permeability curves are active in the model.			DIRECT
2-4	Data	SATOPTS keyword in the RUNSPEC section - reversible relative permeability (black-oil) are active in the model.			IRREVERS
		Radial grid geometry has been used for a compositional model indicator, set to T or F. Note that currently OPM Flow does not support radial grids and therefore this item should be set to F.			RADIAL

No.	Keyword Name	INIT Data – Static Data Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2.5	Data	Radial grid geometry has been used for a black-oil model indicator, set to T or F. Note that currently OPM Flow does not support radial grids and therefore this item should be set to F.			RADIAL
		Reversible relative permeability (compositional) are active in the model.			IRREVERS
2.6		Undefined.			F
2-7	Data	The hysteresis option has been activated in the model indicator, set to T or F.			HYSER
2-8 to 2-14	Data	Undefined.			F
2-15	Data	The dual porosity option has been activated in the model indicator, set to T or F. Note that currently OPM Flow does not support dual porosity grids and therefore this item should be set to F.			DUALPORO
2-16		Undefined.			F
2-17	Data	ENDSCALE keyword in the RUNSPEC section - enable end-point scaling indicator.			ENDSCALE
2-18	Data	ENDSCALE keyword in the RUNSPEC section - directional end-point scaling indicator.			DIRECT
2.19	Data	ENDSCALE keyword in the RUNSPEC section - reversible end-point scaling indicator.			IRREVERS
2-20	Data	SCALECRS keyword in the PROPS section - alternative three point end-point scaling indicator.			SCALECRS
2-21 to 2-35		Undefined.			F
2-36	Data	Miscible displacement has been activated in the model indicator, set to T or F. See the *MISCIBLE – Define Miscibility Todd-Longstaff Parameters* keyword in the RUNSPEC section for further information.			
2-37 to 2-55		Undefined.			F
2-56	Data	The scale water capillary pressure at maximum water saturation (that is minimum pressure) has been activated in the model, set to T or F.			
2-57	Data	The scale water capillary pressure at maximum water saturation (that is minimum pressure) has been activated in the model, set to T or F.			
2-58 to 2-127		Undefined.			0

No.	Keyword Name	INIT Data – Static Data Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-128	Data	Coal Bed Methane option has been activated in the compositional model indicator, set to T or F. Note that currently OPM Flow does not support the Coal Bed Methane option and therefore this item should be set to F.			F
	DOUBHEAD	Global static data keyword for the INIT Data file that defines the double precision REAL variables for this keyword. NDHEAD is the number of entries associated with this keyword, and is dependent on the features being used in the model.			Required
1-1	Format	DOUBHEAD	NDHEAD	DOUB	
2-1 to 2-185		Undefined			0.0

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keywords should be enclosed in single quotes, for example the SEQNUM should be written out as 'SEQNUM '.

Table D.13: INIT Data – Static Data Header Keywords

Example: INIT Data – Static Header Keywords

The following example shows a typical formatted INIT Data header set of keywords.

```
'INTEHEAD'          249 'INTE'
 -955283513      200400           2       -2345       -2345       -2345
      -2345       -2345          10          10           1         100
         10       -2345           7       -2345           0           1
          0           2           2           0           0           0
        110         108         109           3          97          93
      -2345       -2345          19          38          53       -2345
         97          93         146           5           0           1
         15          24           8           5           2           4
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0          19          10
       1982           0           0           0           1           0
          0           0           0           0           1          10
          0           0          12           1          25           1
 ..............................................
'LOGIHEAD'           79 'LOGI'
 T  F  F  T  F  F  F  F  T  F  F  F  F  F  F  F  T  F  T  F  F  F  F  F  F
 F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F
 F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F
 F  F  F  F
'DOUBHEAD'          185 'DOUB'
  0.00000000000000D+00   0.10000000000000D+01   0.36500000000000D+03
  0.10000000149012D+00   0.15000000596046D+00   0.30000000000000D+01
  0.30000001192093D+00   0.10000000149012D+00   0.10000000149012D+00
 -0.10000000200409D+21   0.10000000000000D+01   0.10000000000000D+01
  0.10000000000000D+01   0.00000000000000D+00   0.00000000000000D+00
  0.10000000000000D+01   0.10000000000000D-03
 ..............................................
```

End of Example

D.6.4 INIT DATA – STATIC GRID ARRAY DATA KEYWORDS

This series of keywords define various static global and LGR grid property arrays for each grid cell in the model. The grid array keywords use the same grid property keywords described in the GRID section of the manual. For example, the DEPTH, PORO, PERMX, PERMY, PERMZ, NTG, TOPS arrays etc. In addition, the keywords also include the calculated pore volumes (PORV) and transmissibility arrays (TRANX, TRANY and TRANZ) after processing the GRID and EDIT sections. Note the first property should always be the PORV array for both global and LGR grid types.

This format is also used to define the global grid REGION, NNC and ENPOINTS section arrays, with the keyword name corresponding to the array name. For example, for the REGION keywords the same keywords outlined in the REGION section of the manual; that is EQLNUM, FIPNUM, PVTNUM, ROCKNUM, SATNUM are utilized as the keywords in this section.

The structure for this type of data is defined in Table D.14 and the keywords.

No.	Keyword Name	INIT Data – Static Grid Array Data Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	PROPERTY	The PROPERTY keyword defines the start of a grid property array section of the INIT file. PROPERTY is the keyword name of the array being written out, as outlined in the GRID section. For example, DEPTH, PORO, PERMX, PERMY, PERMZ, NTG, TOPS keywords and the calculated PORV, TRANX, TRANY and TRANZ arrays. The PROPERTY keyword (items 1-1 and 2-1) is repeated for each grid property. The PORV property must be the first data set for this keyword type and is written out in full for each cell in the model (that is NXYZ = NX x NY x NZ values). Note the PORV array values for inactive cells are set to a constant value of zero. Subsequent grid property arrays can be in any order and only the active cells are written out (NACTIV).			Required
1-1	Format	PROPERTY	NXYZ or NACTIV	REAL	
2-1	Data	PROPERTY data set.			
LGR Property Data for Each LGR Keyword and Data					
Table and Constant Keywords (TABDIMS, TAB and CON)					
	REGION	The REGION keyword defines the start of grid region array section. REGION is the keyword name of the region array being written out, as outlined in the REGIONS section. For example, EQLNUM, FIPNUM, PVTNUM, ROCKNUM, SATNUM, etc. For analytical aquifers in the model, the AQUIFERA variable name is used to indicate which cells are connected to a given aquifer. If a cell is connected to an aquifer number N, then the cell value will be set to $2^{(N-1)}$ in the array. The REGION keyword (items 1-1 and 2-1) is repeated for each global region array and the arrays can be written out in any order.			Required
1-1	Format	REGION	NACTIV	INTE	
2-1	Data	REGION data set.			
LGR Region Keywords and Data for Each Grid					

No.	Keyword Name	INIT Data – Static Grid Array Data Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	ENDPOINT	The ENDPOINT keywords define the start of a grids saturation and end-point data arrays. ENDPOINT is the keyword name of the saturation (SWL, SWATINIT, etc.) array or end-point array (PWC, KROW, etc.) being written out, as described in the GRID and PROPS sections. The type of data for the keyword should be set to REAL for arrays with real values (SWL, SWATINIT, etc) or INTE for integer arrays (ENDNUM etc.). ENDPOINT arrays can be in any order and only the active cells are written out (NACTIV). This keyword (items 1-1 and 2-1) is repeated for each saturation and end-point array being written out. The data written out is dependent on the various options declared in the RUNSPEC section as well as the data declared in the GRID and PROPS sections.			Required
1-1	Keyword	ENDPOINTS	NACTIV	INTE or REAL	
2-1	Data	ENDPOINT data set.			
LGR Saturation End-Point Keywords and Data for Each LGR					
	NNC	The NNC keyword defines the start of a grids non-neighbor connection array data. NNC is the keyword name of the non-neighbor connection array being written out, and should be set to one of the following keywords: 1) TRANNNC: the non-neighbor connection transmissibilities within the grid. Always required even if there are no NNC, in which case NUMNCC is set to zero. 1) DIFFNNC: the non-neighbor connection diffusivities within the grid. Only required if the Diffusivity option has been activated by the DIFFUSE keyword in the RUNSPEC section. This option is currently not supported by OPM Flow 2) HEATNNC: the non-neighbor connection thermal transmissibilities within the grid. Only required if OPM Flow's THERMAL option has been activated by the THERMAL keyword in the RUNSPEC section. The following two additional NNC keywords are required for when the data for an LGR is being defined: 1) TRANCC: the non-neighbor connection transmissibilities within the LGR (always required for an LGR). 2) TRANGL: the non-neighbor connections transmissibilities between the LGR and the global grid (always required for an LGR). Number of data values for this keyword data set should set to the number of non-neighbor connection to be read or written out (NUMNNC) for the TRANNC, DIFFNNC, HEATNCC, TRANCC, and TRANGL arrays. The NNC keyword (items 1-1 and 2-1) are repeated for each non-neighbor connection array being written out.			Required
1-1	Format	NNC	NUMNCC	REAL	
2-1	Data	NNC data set.			
LGR Non-Neighbor Connection Keywords for Each LGR					

No.	Keyword Name	INIT Data – Static Grid Array Data Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	

Notes:

1) Rows shaded in gray indicate the start of a keyword and rows colored orange indicate the location of LGR data if LGRs are present in the model.

2) For formatted output all character variables, including the keyword should be enclosed in single quotes, for example the PORV and PROPERTY fields should be written out as 'PORV ' and 'DEPTH ', etc.

Table D.14: INIT Data – Static Grid Array Data Keywords

Example: INIT Data – Static Grid Array Data Keywords

The following example shows a typical formatted global grid property data keyword.

```
 'PORV    '          100 'REAL'
   0.10686456E+07   0.10686456E+07   0.10686456E+07   0.10686456E+07
   0.10686456E+07   0.10686456E+07   0.10686456E+07   0.10686456E+07
  ..............................................
   0.10686456E+07   0.10686456E+07   0.10686456E+07   0.10686456E+07
   0.10686456E+07   0.10686456E+07   0.10686456E+07   0.10686456E+07
 'DX      '          100 'REAL'
   0.10000000E+04   0.10000000E+04   0.10000000E+04   0.10000000E+04
   0.10000000E+04   0.10000000E+04   0.10000000E+04   0.10000000E+04
  ..............................................
   0.10000000E+04   0.10000000E+04   0.10000000E+04   0.10000000E+04
   0.10000000E+04   0.10000000E+04   0.10000000E+04   0.10000000E+04
 'DY      '          100 'REAL'
   0.10000000E+04   0.10000000E+04   0.10000000E+04   0.10000000E+04
   0.10000000E+04   0.10000000E+04   0.10000000E+04   0.10000000E+04
  ..............................................
   0.10000000E+04   0.10000000E+04   0.10000000E+04   0.10000000E+04
   0.10000000E+04   0.10000000E+04   0.10000000E+04   0.10000000E+04
 'DZ      '          100 'REAL'
   0.20000000E+02   0.20000000E+02   0.20000000E+02   0.20000000E+02
   0.20000000E+02   0.20000000E+02   0.20000000E+02   0.20000000E+02
   ..............................................
   0.20000000E+02   0.20000000E+02   0.20000000E+02   0.20000000E+02
   0.20000000E+02   0.20000000E+02   0.20000000E+02   0.20000000E+02
 'PERMX   '          100 'REAL'
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
   ..............................................
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
..............................................
TABULAR DATA
..............................................
 'PVTNUM  '          100 'INTE'
            1           1           1           1           1           1
            1           1           1           1           1           1
..............................................
            1           1           1           1           1           1
 'SATNUM  '          100 'INTE'
            1           1           1           1           1           2
            1           1           1           2           2           2
..............................................
            2           2           2           2           2           2
            2           2           2           2
 'EQLNUM  '          100 'INTE'
            1           1           1           1           1           1
            1           1           1           1           1           1
  ..............................................
```

End of Example

D.6.5 INIT DATA - LGR STATIC DATA HEADER KEYWORDS

The file structure for this series of keywords consists of two sets of keywords, the first set is repeated each time an LGR data set is written out and the second set, which is the same as global static header keywords in section INIT Data – Static Data Header Keywords, is only written once. The first set of keywords define an LGR's properties, LGR Name for example, and always proceeds an LGR data set for a given LGR; that is this series of keywords are repeated for each LGR data set in the model. This is then followed by the second set of static data header keywords, or the actual array or table keywords. Termination of the LGR data set occurs after the last LGR data set has been written out using the LGRSGONE keyword, which switches input back to the global grid properties. Table D.15 outlines the structure of the INIT Data - LGR Static Header Keywords and their affiliated data.

Note that currently OPM Flow does not support LGR grids and therefore this set of keywords cannot be used by OPM Flow.

No.	Keyword Name	INIT Data - LGR Static Header Keywords (Repeated Each Time An LGR Each Data Set Is Written Out)			Status Or Value
		Keyword	No. of Entries	Data Type	
	LGR	LGR static data header keyword for the INIT Data file that defines the name of the LGR.			Always Required
1-1	Keyword	LGR	1	CHAR	
2-1	Data	Name of the LGR			
	LGRHEADI	LGR that defines the integer variables for this keyword.			Always Required
1-1	Format	LGRHEADI	45	INTE	
2-1 to 2-45	Data	Undefined.			
	LGRHEADQ	LGR grid keyword for the INIT Data file that defines the logical variables (T for true and F for false) for this keyword.			Always Required
1-1	Format	LGRHEADQ	5	LOGI	
2-1 to 2-5	Data	Undefined			
	LGRHEADD	LGR grid keyword for the INIT Data file that defines the double precision REAL variables for this keyword.			Always Required
1-1	Format	LGRHEADD	5	DOUB	5
2-1 to 2-5	Data	Undefined.			
	LGRSGONE	The LGRSGONE keyword marks the end of the LGR section. Number of entries is always set to zero. There is no data set associated with this keyword.			Always Required
1-1	Format	LGRSGONE	0	MESG	

No.	Keyword Name	INIT Data - LGR Static Header Keywords (Repeated Each Time An LGR Each Data Set Is Written Out)			Status Or Value
		Keyword	No. of Entries	Data Type	
	INTEHEAD	The keywords are the same as the INIT Data Static Data Header keywords but the data pertains to the current LGR. See Table D.13 for a detailed description of this keyword type.			Required Only Once
	LOGIHEAD	See Table D.13 for a detailed description of this keyword type.			Required Only Once
	DOUBHEAD	See Table D.13 for a detailed description of this keyword type.			Required Only Once

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keyword name should be enclosed in single quotes, for example the LGR keyword should be written out as 'LGR '.

Table D.15: INIT Data - LGR Static Data Header Keywords

This series of keywords are repeated for each LGR in the model followed by the pertinent data and in the order outlined in Table D.12 and with the last LGR data set terminated by the LGSGONE keyword to mark the end of the LGR input section.

Note

The LGR, LGRHEADI, LGRHEADQ and LGRHEADD keywords always proceeds and LGR data sets and the LGRSGONE keyword terminates the end of the LGR data section, which causes the data to revert back to the global grid data.

Example: INIT Data - LGR Static Header Keywords

The following example shows a typical formatted INIT Data - LGR Grid Header Keyword data set for a single LGR grid named LGR-1. As this is the first time LGR data is being written out both sets of LGR header keywords are written out followed by the property array data.

```
 'LGR     '           1 'CHAR'
 'LGR-1   '
 'LGRHEADI'          45 'INTE'
           1         100       -2345       -2345       -2345       -2345
       -2345       -2345       -2345       -2345       -2345       -2345
       -2345       -2345       -2345       -2345       -2345       -2345
       -2345       -2345       -2345       -2345       -2345       -2345
       -2345       -2345       -2345       -2345       -2345       -2345
       -2345       -2345       -2345       -2345       -2345       -2345
       -2345       -2345       -2345       -2345       -2345       -2345
       -2345       -2345       -2345
 'LGRHEADQ'           5 'LOGI'
  F   F   F   F   F
 'LGRHEADD'           5 'DOUB'
   0.00000000000000D+00  -0.10000000200409D+21  -0.10000000200409D+21
  -0.10000000200409D+21  -0.10000000200409D+21
.............................................

 'INTEHEAD'         249 'INTE'
  -955283513      200400           2       -2345       -2345       -2345
       -2345       -2345           2           2           2           8
.............................................
            1           6           1          10           1          10
            1           1           1           0          30           3
           18          10           9
 'LOGIHEAD'          79 'LOGI'
  T   F   F   T   F   F   F   F   T   F   F   F   F   F   F   F   T   F   T   F   F   F   F   F   F
  F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F
  F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F
  F   F   F   F
 'DOUBHEAD'         185 'DOUB'
   0.00000000000000D+00   0.10000000000000D+01   0.36500000000000D+03
   0.10000000149012D+00   0.15000000596046D+00   0.30000000000000D+01
.............................................
   0.10000000000000D+01   0.00000000000000D+00   0.00000000000000D+00
   0.10000000000000D+01   0.10000000000000D-03
.............................................
 'PORV    '           8 'REAL'
   0.13358070E+06   0.13358070E+06   0.13358070E+06   0.13358070E+06
   0.13358070E+06   0.13358070E+06   0.13358070E+06   0.13358070E+06
 'DX      '           8 'REAL'
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
 'DY      '           8 'REAL'
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
 'DZ      '           8 'REAL'
   0.10000000E+02   0.10000000E+02   0.10000000E+02   0.10000000E+02
   0.10000000E+02   0.10000000E+02   0.10000000E+02   0.10000000E+02
 'PERMX   '           8 'REAL'
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
.............................................
```

End of Example

D.6.6 INIT DATA - LGR GRID ARRAY DATA KEYWORDS

The file structure for this set of keywords is identical to the Static Grid Array Data Keywords described in Table D.14, except that LGR header keywords prefix the actual data keywords. Both the LGR header and data keywords are repeated for each LGR in the model, and the last LGR data set is terminated by the LGSGONE keyword to mark the end of the LGR input section. The keyword description for this type of data set is outlined in Table D.16.

Note that currently OPM Flow does not support LGR grids and therefore this series of keywords cannot be used by OPM Flow.

No.	Keyword Name	INIT Data - LGR Grid Array Data Keywords (Repeated For Each LGR In The Model)	Status Or Value
1-1	LGR	LGR Header Keywords (see Table D.15)	Required
	LGRHEADI		
	LGRHEADQ		
	LGRHEADD		
1-2	INTEHEAD	LGR Header Keywords (see Table D.15)	Required Only Once
	LOGIHEAD		
	DOUBHEAD		
1-3	PROPERTY REGION NNC or ENPOINIT	LGR array data set for the current LGR – same format as the INIT Data - Grid Array Data Keywords (see Table D.14).	Required
1-4	LGRSGONE	LGR Header Section termination keyword (see Table D.15)	Required

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow.
3) For formatted output all character variables, including the keyword should be enclosed in single quotes, for example the LGR keyword should be written out as 'LGR '.

Table D.16: INIT Data - LGR Grid Array Data Keywords

This keyword data set is repeated for each LGR in the model with the last LGR data set terminated by the LGSGONE keyword to mark the end of the LGR data section.

Example: INIT Data - LGR Static Grid Array Data Keywords

The following example shows a typical formatted INIT Data - LGR Static Grid Array Data Keywords for the region data set with two LGR grids named LGR-1 and LGR-2.

```
'LGR     '           1 'CHAR'
'LGR-1   '
'LGRHEADI'          45 'INTE'
          1         100       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345
'LGRHEADQ'           5 'LOGI'
 F  F  F  F  F
'LGRHEADD'           5 'DOUB'
  0.00000000000000D+00  -0.10000000200409D+21  -0.10000000200409D+21
 -0.10000000200409D+21  -0.10000000200409D+21
'PVTNUM  '           8 'INTE'
          1           1           1           1           1           1
          1           1
'SATNUM  '           8 'INTE'
          1           1           1           1           2           2
          2           2
'EQLNUM  '           8 'INTE'
          1           1           1           1           1           1
          1           1
'FIPNUM  '           8 'INTE'
          1           1           1           1           1           1
          1           1
'LGR     '           1 'CHAR'
'LGR-2   '
'LGRHEADI'          45 'INTE'
          2         100       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345
'LGRHEADQ'           5 'LOGI'
 F  F  F  F  F
'LGRHEADD'           5 'DOUB'
  0.00000000000000D+00  -0.10000000200409D+21  -0.10000000200409D+21
 -0.10000000200409D+21  -0.10000000200409D+21
'PVTNUM  '           8 'INTE'
          1           1           1           1           1           1
          1           1
'SATNUM  '           8 'INTE'
          1           2           1           2           2           1
          2           1
'EQLNUM  '           8 'INTE'
          1           1           1           1           1           1
          1           1
'FIPNUM  '           8 'INTE'
          1           1           1           1           1           1
          1           1
'LGRSGONE'           0 'MESS'
```

End of Example

D.6.7 INIT DATA – STATIC TABULAR DATA HEADER KEYWORD

The INIT Data – Static Tabular Data Header Keyword precedes the TAB keyword and consists of just one keyword followed by a series of integer values that define the dimensions of the data in the TAB keyword. TABDIMS is then followed by the TAB keyword that contains the actual tabular data in one continuous array.

The structure for this keyword is defined in Table D.17.

No.	Keyword Name	INIT Data – Static Tabular Data Header Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
	TABDIMS	Tabular header keyword for the INIT Data file that defines the start of the tabular data and contains the base addresses and dimension of subsequent tabular array keyword TAB. Missing values should be defaulted to one.			Required
1-1	Format	TABDIMS	100	INTE	
2-1	Data	Total size of TAB data array, value should be the same as that on the TAB keyword.			NTABDA
2-2	Data	Location of the first entry in the TAB array for the rock property table.			IBROCK
2-3	Data	Maximum umber of rock property tables.			NTROCK
2-4	Data	Location of the first entry in the TAB array of rock compaction data.			IBROCC
2-5	Data	Maximum number of pressure nodes in rock compaction data table.			NPROCC
2-6	Data	Maximum number of rock compaction data tables.			NTROCC
2-7	Data	Location of the first entry in the TAB array for the oil PVT property tables.			IBPVTO
2-8	Data	Location of the first entry in the TAB array for the oil pressure nodes.			JBPVTO
2-9	Data	Maximum number of composition nodes in oil PVT tables.			NRPVTO
2-10	Data	Maximum number of pressure nodes in oil PVT tables.			NPPVTO
2-11	Data	Maximum number of oil PVT property tables.			NTPVTO
2-12	Data	Location of the first entry in the TAB array for water PVT property tables.			IBPVTW
2-13	Data	Maximum number of water property tables.			NTPVTW
2-14	Data	Location of the first entry in the TAB array for gas PVT property tables.			IBPVTG
2-15	Data	Location of the first entry in the TAB array for the gas pressure nodes.			JBPVTG
2-16	Data	Maximum number of composition nodes in the gas PVT tables.			NRPVTG
2-17	Data	Maximum number of pressure nodes in the gas PVT tables.			NPPVTG
2-18	Data	Maximum number of gas PVT property tables.			NTPVTG
2-19	Data	Location of the first entry in the TAB array for surface density tables.			IBDENS
2-20	Data	Maximum number of surface densities tables.			NTDENS
2-21	Data	Location of the first entry in the TAB array for water saturation tables.			IBSWFN
2-22	Data	Maximum number of saturation nodes in water saturation tables.			NSSWFN
2-23	Data	Maximum number of water saturation tables.			NTSWFN
2-24	Data	Location of the first entry in the TAB array for gas saturation tables .			IBSGFN
2-25	Data	Maximum number of saturation nodes in gas saturation tables.			NSSGFN

No.	Keyword Name	INIT Data – Static Tabular Data Header Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
2-26	Data	Maximum number of gas saturation tables.			NTSGFN
2-27	Data	Location of the first entry in the TAB array for oil saturation tables.			IBSOFN
2-28	Data	Location of the first entry in the TAB array for array of connate water saturations.			IBSWCO
2-29	Data	Maximum number of saturation nodes in the oil saturation tables.			NSSOFN
2-30	Data	Maximum number of oil saturation tables			NTSOFN
2-31 to 40		Undefined			1
2-41	Data	Location of the first entry in the TAB array to the VE table data.			IBVETB
2-42	Data	Maximum number of items in a VE table.			NSVETB
2-43	Data	Maximum number of VE tables.			NTVETB
2-44	Data	Location of the first entry in the TAB array to the threshold pressure array.			IBTHPR
2.45	Data	Location of the first entry in the TAB array to SCALELIM data			IBSLIM
2.46	Data	Maximum number of end-point versus depth nodes.			NSENDP
2.47	Data	Maximum number of end-point versus depth tables.			NTENDP
2.48	Data	Location of the first entry in the TAB array to the reference temperature RTEMP used in PVZG keyword in the PROPD section.			IBRTEM
2.49	Data	Location of the first entry in the TAB array to the value specified by the TOLCRIT keyword. Note that this is a single value applied to all the saturation tables.			IBCTOL
2.50		Undefined			1
2-51	Data	Location of the first entry in the TAB array to LANGMUIR table.			IBLANG
2-52	Data	Maximum number of columns in LANGMUIR tables.			NCLANG
2-53	Data	Maximum number of rows in the LANGMUIR tables			NSLANG
2-54	Data	Maximum number of LANGMUIR tables			NTLANG
2-55	Data	Location of the first entry in the TAB array to a LANGSOLV table.			IBLNG2
2-56	Data	Location of the first entry in the TAB array to a COALPP table.			IBCADP
2-57	Data	Location of the first entry in the TAB array to a COALADS table.			IBCADS
2-58	Data	Location of the first entry in the TAB array to a ROCKPAMA table.			IBROCP
2-59	Data	Maximum number of tables of ROCKPAMA tables			NTRPMA
2-60 to 2-100		Undefined			1

No.	Keyword Name	INIT Data – Static Tabular Data Header Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keywords should be enclosed in single quotes, for example the PORV and PROPERTY fields should be written out as 'PORV ' and 'DEPTH ', etc.

Table D.17: INIT Data – Static Tabular Data Header Keyword

Example: INIT Data – Static Tabular Data Header Keyword

The following example shows a typical formatted INIT Data – Static Tabular Data Header Keyword and the affiliated data.

```
'TABDIMS '          100 'INTE'
     77006            1            2            1           60            1
        17        36017           60           60            2        36799
         2        37139        73139           60           60            2
         5            2        36809           33            2        73259
        33            2        36137        36797           66            2
     73589            5        73644           20            5        74044
        20            5            0            0        74444           25
         2        74494        75835           20            1        77003
         0            0            0            0            0            0
         0            0            0            0            0            0
         0            0            0            0            0            0
         0            0            0            0            0            0
         0            0            0            0            0            0
         0            0            0            0            0            0
         0            0            0            0            0            0
         0            0            0            0            0            0
         0            0            0            0
```

End of Example

D.6.8 INIT DATA – STATIC TABULAR AND CONSTANT DATA ARRAY KEYWORDS

The INIT Data – Static Tabular and Constant Data Array Keyword section contains the actual tabular data in one continuous array, followed by the constant data array. The tabular array data is parse according to the phases present in the model and the location and dimension data given by the TABDIMS keyword.

The structure for this set of keywords is defined in Table D.18.

No.	Keyword Or Variable Name	INIT Data – Static Tabular And Constant Data Array Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
	TAB	Tabular data array keyword for the INIT Data file that defines the start of the tabular data array. The total number of entries is given by the NTABDA and the value should be the same as declared on the TABDIMS keyword.			Required
1-1	Format	TABDIMS	NTABDA	DOUB	
2-1	Data	Tabular data array. The data should be written out in double precision and missing data should be set to less than or equal to -10.0×10^{20} or greater than or equal to 10.0×10^{20}.			
	CON	Constant data array that contains the constant dead oil, dead vaporized oil, and saturation pressure PVT entered via the RSCONST/RSCONSTT and RVCONT/RVCONSTT keywords in the PROPS section.			Required
1-1	Format	CON	NPVT * 3	DOUB	
2-1	Data	The data consists of three values for each PVT data set (NPVT), RS, RV and the saturation pressure of the active phase in the model (bubble-point or dew point).			

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Note both TAB and CON keywords should be enclosed in single quotation marks, that is 'TAB ' and 'CON '.

Table D.18: INIT Data – Static Tabular and Constant Data Array Keywords

The phases present in the model are given on the INTEHEAD keyword (Table D.13) in location 2-15 where the type of phases in the model are set via an integer: 1 for oil, 2 for water, 3 for oil-water, 4 for gas, 5 for oil-gas, 6 for gas-water and 7 for oil-water-gas. This data is used to access the phase dependent data (PVT, saturation functions tables etc.) combine with the location (or base address) and the dimension data given on the TABDIMS keyword in Table D.17.

Note that data given in Table D.17 refers to the maximum values and therefore missing data should be set to the default value.

Example: INIT Data – Static Tabular and Constant Data Array Keywords

The following example shows a typical formatted data set for this type set of keywords and the affiliated data. Here the CON array has two PVT tables but the values are all set to zero indicating that dead oil and vaporized dead oil are not active phases in the model.

```
'TAB     '       73576 'DOUB'
   0.49700000000000D-05   0.24800000000000D-05   0.00000000000000D+00
  -0.20000000000000D+21  -0.20000000000000D+21  -0.20000000000000D+21
  -0.20000000000000D+21  -0.20000000000000D+21  -0.20000000000000D+21
 ..............................................
  -0.20000000000000D+21  -0.20000000000000D+21  -0.20000000000000D+21
   0.52100000000000D-05   0.26100000000000D-05   0.00000000000000D+00
  -0.20000000000000D+21  -0.20000000000000D+21  -0.20000000000000D+21
'CON     '            6 'DOUB'
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
 ..............................................
```

End of Example

D.7 RESTART FILES – SOLUTION DATA

RESTART files contain the solution data arrays for each active cell in the model, and represents a "snapshot" of the reservoir state at a reporting time step, for example the pressure (PRESSURE, PPCW, and PPCG), fluid saturations (SGAS, SOIL and SWAT), and fluid state (RS and RV) for all active cells. The PPCW and PPCG arrays are the water and capillary solution arrays and the RS and RV arrays are the gas-oil and vaporized-oil ratio (condensate-gas ratio) solution arrays. The data written to the RESTART file is dependent on the fluid phases and options invoked in the model, as well as any additional user requested solution data. The default arrays written out are always sufficient to enable the simulator to restart from a previous run[182]. This was the original purpose of the RESTART file, that is saving the reservoir state in such a manner, is to enable a "restart" of the simulation.

As of the OPM Flow 2019-04 release the simulator can "restart" from the commercial simulator's generated RESTART files as well as the commercial simulator being to "restart" from the OPM Flow's generated RESTART files. See section *2.2 Running OPM Flow 2020-04 From The Command Line* for additional information.

As RESTART files contain a complete description of the reservoir state, they are also used in post processing software to visualize the reservoir solutions through time, for example by OPM ResInsight. And as the functionality of the both OPM Flow and the commercial simulator have expanded over time additional solution arrays have been added to the RESTART file to enable "restarts" (POLYMER – polymer saturations), as well as to write out additional user specific solution arrays (FIPOIL - fluid in-place oil array), that are not necessary for a "restart", but are consider useful in understanding the reservoir performance.

The frequency and type of data written to the RESTART file is controlled via the RPTSCHED and RPTRST keywords in the SCHEDULE, with the latter having greater functionality and flexibility. For example, to request that the standard restart data be written out every month using the RPTRST keyword:

```
--
--        RESTART CONTROL BASIC = 4 (YEARLY) 5 (MONTHLY)
--
RPTRST
          BASIC=5                                                          /
```

The next example requests that the standard restart data be written at every report time step until this switch is reset and all the restarts are kept. In addition to the standard the data the gas, oil and water relative permeability data will also be written out at each report time step.

```
--
--        RESTART CONTROL BASIC = 4 (YEARLY) 5 (MONTHLY)
--
RPTRST
          BASIC=2  KRG   KRO   KRW                                         /
```

RESTART solution data is written out via two separate files; the RESTART Index file that specifies and defines the format and data type written to the RESTART Data file, and the RESTART Data file that contains the solution data for each active cell in the model for the requested report time steps. The commercial simulator writes out both files, where as OPM Flow only writes out the RESTART Data file, as the data can be read by most post-processing software, including OPM ResInsight, using only the RESTART Data file as input. Secondly, both the commercial simulator and OPM Flow can be "restarted" using just the RESTART Data file.

The following sections outline the format for these two file types.

D.7.1 RESTART INDEX FILES

This file type is not supported or required by OPM Flow or OPM ResInsight to read or write restart files.

[182] *For example in a three phase (oil, gas and water) runs only two phase saturations are needed for a "restart" run, as the third phase can be calculated in by summing two phases and subtracting from one.*

D.7.2 RESTART DATA FILE SPECIFICATION

This file type contains the global and LGR grid solution data property data[183] (PRESSURE, SGAS, SOIL and SWAT) and the group, well and connection data[184]. The overall structure of this file is similar to the INIT file, and the individual data keywords are structured as presented in Table D.19.

Reference Section	Global Section Keywords	Global Data Keywords	LGR Data Keywords	Global Section Keywords	Notes
D.7.3	SEQNUM				Global grid header keyword that defines the start of a RESTART global grid time step data set.
D.7.3	INTEHEAD LOGIHEAD DOUBHEAD				Global grid header keyword that defines the integer, logical and double precision variables for this header keyword.
D.7.4	IGRP SGRP etc.				Group, well, and connection data status keywords for this reporting time step.
D.7.5	IAAQ SAAQ ect.				Aquifer definition arrays.
D.7.6	HIDDEN				Defines HIDDEN solution data, that is a list of solution arrays NOT to be read by post processing software.
D.7.7	STARTSOL				This keyword marks the start of the solution variable section for the global grid.
D.7.7		PRESSURE SWAT etc.			Solution array section (PRESSURE, SGAS, SOIL, SWAT, etc.) for the Global grid.
D.7.7	LGRNAMES				A list of LGRs in this report step
D.7.7	ENDSOL				Marks the end of the solution variable section for the global grid.
D.7.8			LGR LGRHEADI LGRHEADQ LGRHEADD		LGR grid header keyword for that defines the start of a RESTART LGR data set.
D.7.3			INTEHEAD LOGIHEAD DOUBHEAD		LGR header keyword and defines the integer, logical and double precision variables for this header keyword.
D.7.4			IGRP SGRP etc.		Group, well, and connection data status keywords for this reporting time step.

[183] *Several keywords are used for both global and LGR grids, for example the INTEHEAD, LOGIHEAD, DOUBHEAD keywords and SOLUTION arrays.*

[184] *The group, well, and connection production data is not stored on the RESTART file, but is instead stored on the SUMMARY file. The RESTART file contains the group, well and connection configurations as the they change versus time. For example, the status of a well (OPEN or SHUT), or the connections open to flow in a well.*

Reference Section	Global Section Keywords	Global Data Keywords	LGR Data Keywords	Global Section Keywords	Notes
D.7.6			HIDDEN		Defines HIDDEN solution data section.
D.7.7			STARTSOL		Start of LGR solution array section.
D.7.7			Solution Keywords	PRESSURE SWAT etc.	LGR solution array section – same as global grid
D.7.7			ENDSOL		End of the solution variable section for the current LGR grid.
D.7.8			ENDLGR		End of current LGR section.
D.7.8			LGR LGRHEADI LGRHEADQ LGRHEADD		LGR grid header keywords
D.7.4			IGRP SGRP etc.		Group, well, and connection data status keywords for this reporting time step.
D.7.6			HIDDEN		Defines HIDDEN solution data section.
D.7.7			STARTSOL		Start of solution array section.
D.7.7			Solution Keywords	PRESSUE SWAT etc.	LGR solution array section.
D.7.7			ENDSOL		End of the solution variable section.
D.7.8			ENDLGR		End of current LGR section.
D.7.3	SEQNUM				Global grid header keyword that defines the start of a RESTART global grid time step data set.

Notes:

1) Cells shaded in gray indicate the combination is not applicable and cells colored orange indicate that this item is not currently supported by OPM Flow.

Table D.19: RESTART Data File Structure

The individual keywords are described in the following sections.

D.7.3 RESTART DATA - HEADER KEYWORDS

This set of keywords[185] are the first set of keywords that should be read or written to the RESTART file. This data set includes INTEHEAD, LOGIHEAD and DOUBHEAD keywords that define versus parameters used in subsequent keywords in the RESTART file for the global and LGR grids.

The structure for this type of keyword is defined in Table D.26.

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	SEQNUM	Global grid header keyword for the RESTART Data file that defines the start of a RESTART global grid time step data set for unified restart files only.			Optional
1-1	Format	SEQNUM	1	INTE	
2-1	Data	Report time step number.			0
	INTEHEAD	Global grid header keyword for the RESTART Data file that defines the integer variables for this time step. NIHEAD is the number of entries associated with this keyword, and is dependent on the features being used in the model. Undefined values should be set to zero.			Required
1-1	Format	INTEHEAD	NIHEAD	INTE	
2-1	Data	An encoded integer corresponding to the time the file was created. For files not originating from the commercial simulator, this value may be set to zero.			ISNUM
2-2	Data	Simulator version, should be set to zero.			VERSION
2-3	Data	Unit system used in the simulation, set to 1 for metric, 2 for field, and 3 for laboratory			
2-4 to 2-8	Data	Undefined.			0
2-9	Data	DIMENS key word in the RUNSPEC section - the number of grid blocks in the x-direction.			NX
2-10	Data	DIMENS key word in the RUNSPEC section - the number of grid blocks in the y-direction.			NY
2-11	Data	DIMENS key word in the RUNSPEC section - the number of grid blocks in the z-direction.			NZ
2-12	Data	Number of global active cells in the model			NACTIV
2-13	Data	Not used.			0
2-14	Data	Not used.			0
2-15	Data	Type of phases in the model, set to 1 for oil, 2 for water, 3 for oil-water, 4 for gas, 5 for oil-gas, 6 for gas-water and 7 for oil-water-gas.			PHASE
2-16	Data	Undefined.			0
2-17	Data	Number of wells in the model.			NWELLS
2-18	Data	Maximum number of grid block connections per well.			NCWMAX
2-19	Data	Actual number of groups.			NGRP
2-20	Data	Maximum number of wells belonging to a group in the model.			NWGMAX
2-21	Data	Maximum number of groups for this model.			NGMAXZ

[185] *The RESTART Data – Header keywords are used both for global and LGR grids with the global grid data for the global grid and the individual LGR data for the LGR grids. The LGR data is preceded by a series of LGR header keywords and terminated by an LGR termination keyword.*

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-22 to 2-24	Data	Not used.			
2-25	Data	Number of values per well in the IWEL array (default value is 97)			NIWELZ
2-26	Data	Number of values per well in the SWEL array.			NSWELZ
2.27	Data	Number of values per well in the XWEL array.			NXWELZ
2-28	Data	Number of eight character words per well in the ZWEL array.			NZWELZ
2-29 to 2-32	Data	Not used.			
2-33	Data	Number of values per completion in ICON array (default 19)			NICONZ
2-34	Data	Number of values per completion in SCON array			NSCONZ
2-35	Data	Number of values per completion in XCON array			NXCONZ
2-36		Not used.			0
2-37	Data	Number of values per group in IGRP array			NIGRPZ
2-38	Data	Number of values per group in SGRP array			NISGRPZ
2-39	Data	Number of values per group in XGRP array			NIXGRPZ
2-40	Data	Number of values per group in ZGRP array			NIZGRPZ
2-41		Not used.			
2-42	Data	Maximum number of analytical aquifer connections.			NCAMAX
2-43	Data	Number of values per aquifer in the IAAQ array			NIAAQZ
2-44	Data	Number of values per aquifer in the SAAQ array			NSAAQZ
2-45	Data	Number of values per aquifer in the XAAQ array			NXAAQZ
2-46	Data	Number of values per aquifer connection in the ICAQ array			NICAQZ
2-47	Data	Number of values per aquifer connection in the SCAQ array			NSCAQZ
2-48	Data	Number of values per aquifer connection in the ACAQ array			NXCAQZ
2-49 to 2-51		Not used.			
2-52	Data	Index indicating if group control is used or not (1 – for GCONPROD group control, 2 for GCONINJE control, or 0 if no group control)			NGCTRL
2-53 to 2.58		Undefined.			
2-59	Data	Parameter to determine the nominated phase for the guide rate.			NGRNPH
2-60 to 2-64		Undefined.			
2-65	Data	Calendar day of report step, the value should be greater than or equal to one and less than or equal to 31 for the calendar days.			DAY
2-66	Data	Calendar month of report step, the value should be greater than or equal to one and less than or equal to 12 for the calendar month.			MONTH

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-67	Data	Calendar year of report step, a positive four digit integer value of the start year, which must be specified fully by four digits, that is 2019.			YEAR
2-68	Data	Numerical solver step, that is the number of solver steps the simulator has performed so far.			NUM_SOLVER _STEP
2-69	Data	Report step.			REPORT_STEP
2-70 to 2-71		Undefined.			0
2-72	Data	Index for WHISTCTL keyword.			WHISTC
2-73 to 2-80		Undefined			
2-81	Data	TUNING keyword in the SCHEDULE section - the maximum number of Newtonian iterations for a time step.			NEWTMX
2-82	Data	TUNING keyword in the SCHEDULE section - the minimum number of Newtonian iterations for a time step			NEWTMN
2-83	Data	TUNING keyword in the SCHEDULE section - the maximum number of linear iterations within a Newtonian iteration.			LITMAX
2-84	Data	TUNING keyword in the SCHEDULE section - the minimum number of linear iterations within a Newtonian iteration.			LITMIN
2-85		Undefined			
2-86		Undefined.			
2-87	Data	TUNING keyword in the SCHEDULE section - the maximum number of iterations within a well flow calculation.			MXWSIT
2-88	Data	TUNING keyword in the SCHEDULE section - he maximum number of iterations for solving the bottom-hole pressure for wells under tubing head pressure control within a well flow calculation.			MXWPIT
2-89		Undefined			
2-90	Data	REGDIMS and TABDIMS keywords in the RUNSPEC section. The maximum number of regions in the FIPNUM region array. Note that this parameter may also be set on the TABDIMS keyword as well. If NTFIP is set in both places then the maximum value should be used.			NTFIP
2-91 to 2-94		Undefined.			
2-95	Data	Simulator code used to generate the file, set to 100 for Schlumberger's ECLIPSE 100, 300 for Schlumberger's ECLIPSE 300, 500 for Schlumberger's ECLIPSE 300 Thermal, 700 for Schlumberger's INTERSECT simulator, 800 for Schlumberger's FrontSim simulator, or a negative value for other simulators. OPM Flow users a value of 100.			IPROG
2-96 to 2-99		Undefined.			0

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-100	Data	REGDIMS keyword in the RUNSPEC section. The total maximum number of regions. The FIPNUM regions are defined by (2-90). if additional sets of fluid in-place regions are used, as per the FIPxxx series of fluid in-place region keywords, then NMFIPR is the sum of all FIP regions.			NMFIPR
2-101 to 2- 131					
2-132	Data	NETWORK keyword in the RUNSPEC section - maximum number of nodes in an extended network model or zero if the extended network option has not been activated.			NODMAX
2-133	Data	NETWORK keyword in the RUNSPEC section - maximum number of branches in an extended network model or zero if the extended network option has not been activated.			NBRMAX
2-134	Data	Number of items per branch in the IBRAN array when the extended network model is active, or zero if the extended network option has not been activated.			NIBRAN
2-135	Data	Number of items per branch in the RBRAN array when the extended network model is active, or zero if the extended network option has not been activated.			NRBRAN
2-136	Data	Number of items per node in the INODE array when the extended network model is active, or zero if the extended network option has not been activated.			NINODE
2-137	Data	Number of items per node in the RNODE array when the extended network model is active, or zero if the extended network option has not been activated.			NRNODE
2-138	Data	Number of items per node in the ZNODE array when the extended network model is active, or zero if the extended network option has not been activated.			NZNODE
2-139	Data	Number of items in the INOBR array.			NINOBR
2-140 to 2-156		Undefined.			0
2-157	Data	The number of actions in the data set			NO_ACT
2-158	Data	Maximum number of lines of schedule data for ACTION keyword - including ENDACTIO			MAX_LINES
2-159	Data	Maximum number of eight character strings per input line of Action data (rounded up from input deck)			MAXSPRLINE
2-160 to 2-162		Undefined.			
2-163	Data	Maximum number of aquifer connections actually used in the model.			NGCAUS
2-164	Data	Maximum number of wells in the model			NWMAXZ
2-165 to 2-174		Undefined.			0
2-175	Data	Number of multi-segmented wells defined with the WELSEG keyword in the SCHEDULE section, for when multi-segment wells have been activated, or zero otherwise.			NSEGWL

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-176	Data	WSEGDIMS keyword in the RUNSPEC section - maximum number of segments per multi-segment well, for when multi-segment wells have been activated, or zero otherwise.			NSWLMX
2-177	Data	WSEGDIMS keyword in the RUNSPEC section - maximum number of branches per multi-segment well, including the main branch. groups for the model, for when multi-segment wells have been activated, or zero otherwise.			NSEGMX
2-178	Data	WSEGDIMS keyword in the RUNSPEC section - number of entries per segment in the multi-segment well ISEG array, for when multi-segment wells have been activated, or zero otherwise.			NLBRMX
2-179	Data	Number of entries per segment in the multi-segment well ISEG array, for when multi-segment wells have been activated, or zero otherwise.			NISEGZ
2-180	Data	Number of entries per segment in the multi-segment well RSEG array, for when multi-segment wells have been activated, or zero otherwise.			NRSEGZ
2-181	Data	Number of entries per segment in the multi-segment well ILBR array, for when multi-segment wells have been activated, or zero otherwise.			NILBRZ
2-181 to 2-206		Undefined.			0
2-207	Data	The first part of the current simulation time in the form HH;MM:SS, that is HH for hours. The value should be greater than or equal to zero and less than or equal to 23.			IHOURZ
2-208	Data	The second part of the current simulation time in the form HH;MM:SS, that is MM for minutes. The value should be greater than or equal to zero and less than or equal to 59.			IMINTS
2-209 to 2-223		Undefined.			0
2-224	Data	Number of INTEGER lines in the AQUNUM data set.			NILAQN
2-225	Data	Number of REAL lines in the AQUNUM data set.			NIRAQN
2-226		Undefined.			0
2-227	Data	Number of entries in the AQUNUM data set.			NUMAQN
2-228 to 2-234		Undefined.			0
2-235	Data	Number of items in the ICOT array.			NICOTZ
2-236	Data	Number of items in the XCOT array.			NXCOTZ
2-237	Data	Number of items in the IWET array.			NIWETZ
2-238	Data	Number of items in the XWET array.			NXWETZ
2-239	Data	Number of items in the IGRT array.			NIGRTZ
2-240	Data	Number of items in the XGRT array.			NXGRTZ
2-241	Data	Number of tracers in the model plus two.			NSTRA2
2-242 to 2-245		Undefined.			0

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-246	Data	Maximum number of conditions per action.			MAXACTC
2-253	Data	Maximum umber of analytical aquifers in the model.			MAAQID
2.254 to 2-262		Undefined.			0
2-263	Data	No of Field UDQ data (parameters)			NOFUDQS
2-264	Data	No of Group UDQ data (parameters)			NOGUDQS
2-265		Undefined.			
2-266		Undefined.			
2-267	Data	No of Well UDQ data (parameters)			NOWUDQS
2-268	Data	Integer seed value for the RAND			UDQPAR_1
2-269		Undefined.			
2-270		Undefined.			
2.271	Data	Maximum number of Chord segment links per multi-segment well for when multi-segment wells have been activated, or zero otherwise.			NCRDMX
2-272 to 2-290		Undefined.			0
2-291		Number of integer IUADs			NOIUADS
2-292		Number of integer IUAPs			NOIUAPS
2-293 to 2-296		Undefined.			
2-297	Data				RSEED
2-298 to 2-410		Undefined.			
2-411	Data	The third part of the current simulation time in the form HH;MM:SS, that is SS for seconds. The value should be greater than or equal to zero and less than or equal to 59.			ISECND
	LOGIHEAD	Global grid keyword for the RESTART Data file that defines the logical variables (T for true and F for false) for this time step. NLHEAD is the number of entries associated with this keyword, and is dependent on the features being used in the model. Undefined items should be set to F (False).			Required
1-1	Format	LOGIHEAD	NLHEAD	LOGI	
2-1	Data	Dissolved gas is present in the model indicator, set to T if present in the model else set to F.			DISGAS
2-2	Data	Vaporized oil is present in the model indicator, set to T if present in the model else set to F.			VAPOIL
2-3	Data	SATOPTS in the RUNSPEC section - directional relative permeability curves are active in the model.			DIRECT
2-4	Data	SATOPTS keyword in the RUNSPEC section - reversible relative permeability curves (black-oil) are active in the model.			IRREVERS

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
		Radial grid geometry has been used for a compositional model indicator, set to T or F. Note that currently OPM Flow does not support radial grids and therefore this item should be set to F.			RADIAL
2-5	Data	Radial grid geometry has been used for a black-oil model indicator, set to T or F. Note that currently OPM Flow does not support radial grids and therefore this item should be set to F.			RADIAL
		Reversible relative permeability (compositional) are active in the model.			IRREVERS
2-6		Undefined.			
2-7	Data	Enable hysteresis indicator.			HYSER
2.8 to 2-14					F
2-15	Data	The dual porosity option has been activated in the model indicator, set to T or F. Note that currently OPM Flow does not support dual porosity grids and therefore this item should be set to F.			DUALPORO
2-16		Undefined.			F
2-17	Data	ENDSCALE keyword in the RUNSPEC section - enable end-point scaling indicator.			ENDSCALE
2-18	Data	ENDSCALE keyword in the RUNSPEC section - directional end-point scaling indicator.			DIRECT
2-19	Data	ENDSCALE keyword in the RUNSPEC section - reversible end-point scaling indicator.			IRREVERS
2-20	Data	SCALECRS keyword in the PROPS section - alternative three point end-point scaling indicator.			SCALECRS
2-21 to 2-30					F
2-31	Data	Coal Bed Methane option has been activated in the "black-oil" model indicator, set to T or F. Note that currently OPM Flow does not support the Coal Bed Methane option and therefore this item should be set to F.			F
2-32 to 2-38		Undefined.			F
2-39	Data	Constant oil compressibility (PVCDO) indicator.			ConstCo
2-40 to 2-75		Undefined.			
2-76	Data	Multi-segment wells are present in the model indicator.			HasMSWells
2-77 to 2-127					

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-128		Coal Bed Methane option has been activated in the compositional model indicator, set to T or F. Note that currently OPM Flow does not support the Coal Bed Methane option and therefore this item should be set to F.			F
	DOUBHEAD	Global grid keyword for the RESTART Data file that defines the double precision REAL variables for this time step. NDHEAD is the number of entries associated with this keyword, and is dependent on the features being used in the model. Undefined values should be set to zero.			Required
1-1	Format	DOUBHEAD	NDHEAD	DOUB	
2-1	Data	The simulation REPORT TIME STEP, expressed in days for all units, except for the LAB system of units which should be expressed in hours.			
2-2	Data	TUNING keyword in the SCHEDULE section - maximum length of next time step.			TSINIT
2-3	Data	TUNING keyword in the SCHEDULE section - maximum length of time step after next.			TSMAXZ
2-4	Data	TUNING keyword in the SCHEDULE section - minimum length of all time steps.			TSMINZ
2-5	Data	TUNING keyword in the SCHEDULE section - minimum length of all chopped time steps.			TSMCHP
2-6	Data	TUNING keyword in the SCHEDULE section - maximum growth rate a time step can be increased by, subject to the maximum allowable time step size set by TSMAXZ.			TSFMAX
2-7	Data	TUNING keyword in the SCHEDULE section - minimum decay rate a time step can be decreased by, subject to the minimum allowable time step size set by TSMINZ.			TSFMIN
2-8	Data	TUNING keyword in the SCHEDULE section - the decay rate a time step can be decreased by after the number of target iterations has been exceeded.			TSFCNV
2-9	Data	TUNING keyword in the SCHEDULE section - the time truncation error target.			TRGTTE
2-10	Data	TUNING keyword in the SCHEDULE section - thee non-linear convergence error.			TRGCNV
2-11	Data	TUNING keyword in the SCHEDULE section - the target material balance error.			TRGMBE
2-12	Data	TUNING keyword in the SCHEDULE section - the linear convergence error target.			TRGLCV
2-13 to 2-16		Undefined			
2-17	Data	TUNING keyword in the SCHEDULE section - the maximum time truncation error.			XXXTTE
2-18	Data	TUNING keyword in the SCHEDULE section - the maximum non-linear convergence error.			XXXCNV
2-19	Data	TUNING keyword in the SCHEDULE section - the maximum mass balance error.			XXXMBE
2-20	Data	TUNING keyword in the SCHEDULE section - the maximum linear convergence error.			XXXLCV

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-21	Data	TUNING keyword in the SCHEDULE section - the maximum well flow convergence error.			XXXWFL
2-22 to 2-82		Undefined			
2-83	Data	TUNING keyword in the SCHEDULE section - target pressure change within a time step.			TRGDPR
2-84	Data	TUNING keyword in the SCHEDULE section - time step growth factor of the time step after a convergence failure.			TFDIFF
2-85	Data	TUNING keyword in the SCHEDULE section - the maximum pressure change at the last Newtonian iteration.			DDPLIM
2.86	Data	TUNING keyword in the SCHEDULE section - the maximum saturation change at the last Newtonian iteration.			DDSLIM
2.87		Undefined			
2-88	Data	GUIDERAT keyword in the SCHEDULE section - guide rate parameter A.			GRPAR_A
2-89	Data	GUIDERAT keyword in the SCHEDULE section - guide rate parameter B.			GRPAR_B
2-90	Data	GUIDERAT keyword in the SCHEDULE section - guide rate parameter C.			GRPAR_C
2-91	Data	GUIDERAT keyword in the SCHEDULE section - guide rate parameter D.			GRPAR_D
2-92	Data	GUIDERAT keyword in the SCHEDULE section - guide rate parameter E.			GRPAR_E
2-93	Data	GUIDERAT keyword in the SCHEDULE section - guide rate parameter F.			GRPAR_F
2-94 to 2-97		Undefined			
2.98	Data	Guide rate parameter delay interval.			GRPAR_INT
2-99					
2-100	Data	TUNING keyword in the SCHEDULE section - the maximum throughput ratio over a time step.			THRURPT
2-101	Data	TUNING keyword in the SCHEDULE section - maximum tolerable pressure change within a time step.			XXXDPR
2-102	Data	TUNING keyword in the SCHEDULE section - the target fluid in-place error in Local Grid Refinements.			TRGFIP
2-103	Data	TUNING keyword in the SCHEDULE section - target surfactant change when the Surfactant Model is active in the run.			TRGSFT
2-104 to 2-144		Undefined			
2-145	Data	Guide rate parameter damping factor			GRPAR_DAMP
2-146 to 2-161		Undefined			
2-161	Data	The simulation START time, expressed in days for all units, except for the LAB system of units which should expressed in hours.			

No.	Keyword Name	RESTART Data - Header Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-162	Data	Cumulative time from the start of the simulation, expressed in days for all units, except for the LAB system of units which should expressed in hours. That is the sum of values (2-1) and (2-161).			
2-163 to 2-212		Undefined.			0
2-213	Data	UDQPARAM item number 2 (Permitted range (+/-) of user-defined quantities).			UDQPAR_2
2-214	Data	UDQPARAM item number 3 (Value given to undefined elements when outputting data).			UDQPAR_3
2-215	Data	UDQPARAM item number 4 (fractional equality tolerance used in == <= etc. functions).			UDQPAR_4

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored red in the No. column indicate that this item is either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keyword should be enclosed in single quotes, for example the DOUBHEAD keyword should be written out as 'DOUBHEAD'.

Table D.20: RESTART Data - Header Keywords

Example: RESTART Data - Header Keywords

The following example shows a typical formatted RESTART Data - Header keywords.

```
'INTEHEAD'          249 'INTE'
 -955283513      200400           2       -2345       -2345       -2345
      -2345       -2345          10          10           1         100
         10       -2345           7       -2345           0           1
          0           2           2           0           0           0
        110         108         109           3          97          93
      -2345       -2345          19          38          53       -2345
         97          93         146           5           0           1
         15          24           8           5           2           4
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0          19          10
       1982           0           0           0           1           0
          0           0           0           0           1          10
          0           0          12           1          25           1
      -2345       -2345           8           8           5           1
          2           1           2           0         100           2
          7           0         -11           1           0           1
          0           0           0          10          10           1
        100           1           1           1           1          10
         10           1          19           1           0           0
          0           0           0           1           1           1
          0           0           0           0           0           0
          0          14          10          10          16           1
          1           1           1           1           2           1
          1           1           1           1           1          31
        108           0           0           0           0           0
          0          50          10           4           5           9
          0           2           8           8          12           1
         25           1      -32767      -32767      -32767      -32767
          0           1           1           1          18          86
          5           1           1           1           1          18
         86      -32767      -32767           0           0         109
         53         146           8           0          19         110
          0           0           1           1          86           0
          0           0           0           0           0           1
          0           0           0           0           1           0
          0           1           0          -1          12           0
          0          10          13           1           0           0
          0           0           2           0           0        3600
          1           6           1          10           1          10
          1           1           1           0          30           3
         18          10           9
'LOGIHEAD'           79 'LOGI'
 T  F  F  T  F  F  F  F  T  F  F  F  F  F  F  F  T  F  T  F  F  F  F  F  F
 F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F
 F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F
 F  F  F  F
'DOUBHEAD'          185 'DOUB'
  0.00000000000000D+00   0.10000000000000D+01   0.36500000000000D+03
  0.10000000149012D+00   0.15000000596046D+00   0.30000000000000D+01
  0.30000001192093D+00   0.10000000149012D+00   0.10000000149012D+00
 ..........................................
 -0.10000000200409D+21   0.10000000000000D+01   0.10000000000000D+01
  0.10000000000000D+01   0.00000000000000D+00   0.00000000000000D+00
  0.10000000000000D+01   0.10000000000000D-03
```

End of Example

D.7.4 RESTART DATA – GROUP, WELL AND CONNECTION DATA KEYWORDS

The Restart Data – Well and Group Completion Keywords[186] define various parameters associated with groups, wells and connection keywords in the RESTART file for both global and LGR grids.

The structure for this type of keyword is based on the data type as summarized below:

1) The group data set keywords are specified in Table D.21 and consists of the IGRP, SGRP, XGRP, and ZGRP keywords.
2) Table D.22 contains the multi-segment well keywords that consist of the ISEG, RSEG, ILBS, ILBR and ICRD keywords.
3) For wells the keywords are IWEL, SWEL, XWEL and ZWEL and Table D.23 describes these keywords.
4) Well connection keywords are specified in Table D.24 and consist of the ICON, SCON, and XCON keywords.
5) Tracer keywords are listed in Table D.25 and consists of the ICOT, XCOT, IWET, XWET, IGRT, and XGRT keywords.
6) Finally, the network keywords INODE, IBRAN, INOBR, RNODE, RBRAN, and ZNODE are specified in Table D.26.

Note that if multi-segment wells, tracers and networks are absent from the simulation deck then this data will not be written to the RESTART Data file.

The following table outlines the keywords for groups.

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Group Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	IGRP	Keyword defines the integer Group, well, and connection data for this time step. Undefined values should be set to zero.			Required
1-1	Format	IGRP	NSGRPZ x NGMAXZ	DOUB	
2-1	Data	Integer group data array IGRP(NIGRPZ,NGMAXZ) where NIGRPZ and NGMAXZ are defined on the INTEHEAD keyword. 1) Entries 1 to NWGMAX define the index of each well in the group, if this is a well group, or the index of each child group in this group if it is a node group. 2) Entries (NWGMAX + 1) define the number of wells or child groups belonging to this group. 3) Entries (NWGMAX + 27) define the group type: with 0 for a well group, 1 for a node group, 2 for a satellite group, and 3 for a slave group. 4) Entries (NWGMAX + 28) define the level of the group, with 0 representing the Field group. 5) Entries (NWGMAX + 29) define the index of the parent group Note that undefined items in this array may be set to zero.			
	SGRP	Keyword defines the real group data array SGRP(NIGRPZ,NGMAXZ) where NIGRPZ and NGMAXZ are defined on the INTEHEAD keyword.			Required

[186] *The RESTART Data – Group, Well and Connection keywords are used both for global and LGR grids with groups, well and connection dats for the global grid, and wells and connection data for wells contained in the individual LGRs for the LGR grids. The LGR data is preceded by a series of LGR header keywords and terminated by an LGR termination keyword.*

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Group Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
1-1	Format	SGRP	NSGRPZ x NGMAXZ	REAL	
2-1 to 2-6		Undefined.			
2-7	Data	Group's oil production target/limit			
2-8	Data	Group's water production target/limit			
2-9	Data	Group's gas production target/limit			
2-10	Data	Group's liquid production target/limit			
2-11	Data	Group's oil surface volume injection rate target/limit			
2-12	Data	Group's oil reservoir volume injection rate target/limi			
2-13	Data	Group's oil re-injection fraction target/limit			
2-14	Data	Group's oil voidage injection fraction target/limit			
2-15		Undefined.			
2-16	Data	Group's water surface volume injection rate target/limit			
2-17	Data	Group's water reservoir volume injection rate target/limit			
2-18	Data	Group's water re-injection fraction target/limit			
2-19	Data	Group's water voidage injection fraction target/limit			
2-20		Undefined			
2-21	Data	Group's gas surface volume injection rate target/limit			
2-22	Data	Group's gas reservoir volume injection rate target/limit			
2-23	Data	Group's gas re-injection fraction target/limit			
2-24	Data	Group's gas voidage injection fraction target/limit			
	XGRP	Keyword defines the double precision group data array XGRP(NIGRPZ,NGMAXZ) where NIGRPZ and NGMAXZ are defined on the INTEHEAD keyword.			Required
1-1	Format	XGRP	NSGRPZ x NGMAXZ	DOUB	
2-1	Data	Group's oil production rate			
2-2	Data	Group's water production rate			
2-3	Data	Group's gas production rate			
2-4	Data	Group's liquid production rate			
2-5		Undefined.			
2-6	Data	Group's water injection rate			
2-7	Data	Group's gas injection rate			
2-8		Undefined			
2-9	Data	Group's producing water cut			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Group Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-10	Data	Group's producing gas/oil ratio			
2-11	Data	Group's total cumulative oil production			
2-12	Data	Group's total cumulative water production			
2-13	Data	Group's total cumulative gas production			
2-14	Data	Group's total cumulative reservoir voidage production			
2-15	Data	Undefined			
2-16	Data	Group's total cumulative water injection			
2-17	Data	Group's total cumulative gas injection			
2-18	Data	Group's total cumulative reservoir volume injection			
2-19		Undefined			
2-20		Undefined			
2-21		Undefined			
2-22		Undefined			
2-23	Data	Group's oil production potential			
2-24	Data	Group's water production potential			
2-25 to 2-86		Undefined			
2-86	Data	Group's producer guide rate for oil.			
2-87	Data	Group's producer guide rate for water.			
2-88	Data	Group's producer guide rate for gas.			
2-89	Data	Group's producer guide rate for reservoir voidage volume.			
2-90	Data	Group's injection guide rate for oil.			
2-91		Undefined			
2-92	Data	Group's injection guide rate for water.			
2-93	Data	Second copy of group's injection guide rate for water. Not fully characterized.			
2-94	Data	Groups injection guide rate for gas.			
2-95 to 2-127		Undefined			
2-128	Data	Second copy of group's producer guide rate for oil. Not fully characterized.			
2-129	Data	Second copy of group's producer guide rate for water. Not fully characterized.			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Group Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-130	Data	Second copy of group's producer guide rate for gas. Not fully characterized.			
2-131	Data	Second copy of group's producer guide rate for reservoir voidage volume. Not fully characterized.			
2-132 to 2-135		Undefined			
2-136	Data	Group's total cumulative oil production (observed/historical rates)			
2-137		Undefined			
2-138		Undefined			
2-139		Undefined			
2-140	Data	Group's total cumulative water production (observed/historical rates)			
2-141	Data	Group's total cumulative water injection (observed/historical rates)			
2-142		Undefined			
2-143		Undefined			
2-144	Data	Group's total cumulative gas production (observed/historical rates)			
2-145	Data	Group's total cumulative gas injection (observed/historical rates)			
	ZGRP	Keyword defines the character GROUP data for this keyword.			Required
1-1	Format	ZGRP	NSGRPZ x NGMAXZ	CHAR	
2-1	Data	Character group data array ZGRP(NIGRPZ,NGMAXZ) where NIGRPZ and NGMAXZ are defined on the INTEHEAD keyword.			

Table D.21: RESTART Data – Group, Well and Connection Keywords (Groups)

The next table (Table D.22) contains the multi-segment well keywords that consist of the ISEG, RSEG, ILBS, ILBR and ICRD keywords.

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Multi-Segment Well Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	ISEG	Integer multi-segment well data array ISEG (NISEGZ, NSEGMX, NSWLMX) where NISEGZ, NSEGMX, and NSWLMX are defined on the INTEHEAD keyword.			Optional
1-1	Format	ISEG	NISEGZ x NSEGMX x NSWLMX	INTE	
2-1	Data	Segment number (one-based).			
2-2	Data	Outlet segment (one-based). Defines the multi-segment outlet segment number starting with 0 for the segment nearest wellhead (NISEGZ = 2)			
2-3	Data	Inflow segment current branch (one-based).			
2-4	Data	Branch number (one-based). Defines the multi-segment branch for this segment number 1 for main stem and 0 if not active (NISEGZ = 4).			
2-5 to 2-11		Undefined			
2-12	Data	Segment type.			
2-123 to 2-18		Undefined			
2-19	Data	ICD scaling mode.			
2-20	Data	ICD open/shut flag.			
	RSEG	Double precision multi-segment well data array RSEG (NISEGZ, NSEGMX, NSWLMX) where NISEGZ, NSEGMX, and NSWLMX are defined on the INTEHEAD keyword.			Optional
1-1	Format	RSEG	NISEGZ x NSEGMX x NSWLMX	DOUB	
2-1	Data	Segment's distance to outlet.			
2-2	Data	Segment's depth differential to outlet.			
2-3	Data	Internal diameter of segment.			
2-4	Data	Roughness parameter of segment.			
2-5	Data	Cross-sectional area of segment.			
2-6	Data	Physical volume of segment.			
2-7	Data	Segment's distance to BHP reference node.			
2-8	Data	Segment's depth differential to BHP reference node.			
2-9	Data	Normalized total segment flow rate.			
2-10	Data	Normalized Water flow rate fraction.			
2-11	Data	Normalized Gas flow rate fraction.			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Multi-Segment Well Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-12	Data	Segment pressure.			
2-13 to 2-30		Undefined.			
2-31	Data	Very close to normalized water flow rate fraction.			
2-32 to 2-39		Undefined.			
2-40	Data	Unknown			
2-41	Data	Length of valve			
2-42	Data	Cross-sectional area of valve			
2-43	Data	Valve's dimensionless flow coefficient			
2-44	Data	Maximal cross-sectional valve area			
2-45 to 2-86		Undefined.			
2-87	Data	Device base strength.			
2-88		Undefined			
2-89	Data	Calibrated fluid density.			
2-90	Data	Calibrated fluid viscosity.			
2-91	Data	Critical water fraction.			
2-92	Data	Transition region width.			
2-93	Data	Maximum emulsion ratio.			
2-94 to 2-97		Undefined.			
2-98	Data	Maximum valid flow rate.			
2-99 to 2-102		Undefined.			
2-103	Data	ICD length.			
2-104	Data	Valve area fraction.			
2-105 to 2-111		Unknown.			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Multi-Segment Well Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	ILBS	Integer multi-segment well data array for lateral branches ILBR (NLBRMX,NSWLMX) where NLBRMX and NSWLMX are defined on the INTEHEAD keyword.			Optional
1-1	Format	ILBS	NLBRMX x NSWLMX	INTE	
2-1	Data	ILBR (NLBRMX,NSWLMX) array.			
	ILBR	Integer multi-segment well data array for chords ILBR (NILBRZ, NLBRMX, NSWLMX) where NILBRZ, NLBRMX, and NSWLMX are defined on the INTEHEAD keyword.			Optional
1-1	Format	ILBR	NILBRZ x NLBRMX x NSWLMX	INTE	
2-1	Data	ILBR (NILBRZ, NLBRMX, NSWLMX) array.			
	ICRD	Integer multi-segment well data array for chords ICRD (2, NCRDMX, NSWLMX) where NCRDMX, and NSWLMX are defined on the INTEHEAD keyword.			Optional
1-1	Format	ILBR	2 x NCRDMX x NSWLMX	INTE	
2-1	Data	ICRD (2, NCRDMX, NSWLMX) array.			

Table D.22: RESTART Data – Group, Well and Connection Keywords (Multi-Segment Wells)

The wells keywords are IWEL, SWEL, XWEL and ZWEL and Table D.23 below describes these keywords in detail.

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Well Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	IWEL	Well integer data array IWEL(NIWELZ, NWELLS) where NIWELX and NWELS are defined on the INTEHEAD keyword. Undefined values should be set to zero.			
1-1	Format	IWEL	NIWELZ*NWELLS	INTE	Required
2-1	Data	Defines the location of the wellhead in the grid for the I dimension (NIWELZ = 1).			
2-2	Data	Defines the location of the wellhead in the grid for the J dimension (NIWELZ = 2).			
2-3	Data	Layer ID (one-based) of top/first connection.			
2-4	Data	Layer ID (one-based) of bottom/last connection.			
2-5	Data	Number of active cells connected to a well.			
2-6	Data	Index (one-based) of well's current group.			
2-7	Data	Defines the well type, set 1 for a production well, 2 for an oil injection well, 3 for a water injection well or 4 for a gas injection well (NIWELZ = 7).			
2-8	Data	Well's active target control mode (constraint).			
2-9		Unknown			
2-10		Unknown			
2-11	Data	Defines the well status, set to greater than zero for producing and less than or equal to zero for being shut (NIWELZ =11).			
2-12	Data	ID (one-based) of well's current VFP table.			
2-13		Undefined			
2-14		Undefined			
2-15		Undefined			
2-16	Data	Well's requested control mode from simulation deck (WCONINJE, WCONPROD).			
2-17 to 2-22		Unknown			
2-23	Data	Cross flow indicator.			
2-24 to 2-42					
2-43	Data	Defines the LGR index for a well with local completions in a LGR (NIWELZ = 43).			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Well Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-44 to 2-48					
2-49	Data	Defines the well friction indicator, set to non-zero for horizontal wells (NIWELZ = 49).			
2-50	Data	Well's requested control mode from simulation deck (WCONHIST, WCONINJH)			
2-51 to 2-70		Undefined			
2-71	Data	Multi-segment well ID; value of one for regular wells, or zero for mult-segment wells.			
2-72	Data	Number of well segments: value of one for regular wells, or the number of segments for multi-segment wells.			
2-73 to 2-98		Undefined.			
2-99	Data	Well's completion ordering scheme, set to: 0) Connections ordered along well track (increasing MD) 1) Connections ordered by increasing true vertical depth. Not really supported in OPM Flow. 2) Connections listed in order of appearance in simulation model's COMPDAT keyword.			
	SWEL	Well real data array SWEL(NSWELZ, NWELLS) where NSWELX and NWELS are defined on the INTEHEAD record.			
1-1	Format	SWEL	NSWELZ*NWELLS	REAL	Required
2-1	Data	Well's current oil rate production target.			
2-2	Data	Well's current water rate production target.			
2-3	Data	Well's current gas rate production target.			
2-4	Data	Well's current liquid rate production target.			
2-5	Data	Well's current reservoir voidage rate production target.			
2-6	Data	Well's tubing head pressure target.			
2-7	Data	Well's bottom hole pressure target.			
2-8		Undefined.			
2-9		Undefined.			
2-10		Well's reference depth for BHP.			
2-11		Well's artificial lift quantity.			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Well Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-12 to 2-17		Undefined.			
2-18		Well's drainage radius - item seven from the WELSPECS keyword.			
2-19 to 2-20		Undefined.			
2-25		Item two from WEFAC; this value is repeated at two locations.			
2-26 to 2-31		Undefined.			
2-32		Item two from WEFAC keyword.			
2-33		Undefined.			
2-34		Well's historical/observed liquid rate target/limit.			
2-35 to 2-54		Undefined.			
2-55		Well's historical/observed gas rate target/limit.			
2-56		Well's historical/observed bottom hole pressure target/limit.			
	XWEL	Well's injection and production data array XWEL(NXWELZ, NWELLS).			
1-1	Format	XWEL	NSWELZ*NWELLS	DOUB	Required
2-1	Data	Well's oil production rate.			
2-2	Data	Well's water production rate.			
2-3	Data	Well's gas production rate.			
2-4	Data	Well's liquid production rate.			
2-5	Data	Well's reservoir voidage production rate.			
2-6	Data	Well's tubing head pressure.			
2-7	Data	Well's flowing/producing bottom hole pressure.			
2-8	Data	Well's producing water cut.			
2-9	Data	Well's producing gas/oil ratio.			
2-10 to 2-18					
2-19	Data	Well's total cumulative oil production.			
2-20	Data	Well's total cumulative water production.			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Well Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-21	Data	Well's total cumulative gas production.			
2-22	Data	Well's total cumulative reservoir voidage production.			
2-23		Undefined.			
2-24	Data	Well's total cumulative water injection.			
2-25	Data	Well's total cumulative gas injection.			
2-26	Data	Well's total cumulative reservoir volume injection.			
2-27 to 2-34		Undefined.			
2-35	Data	Well's producing gas formation volume factor.			
2-36		Undefined.			
2-37		Unknown.			
2-38		Unknown.			
2-39 to 2-41		Undefined.			
2-42	Data	Well's current BHP Target/Limit.			
2-43 to 2-48		Undefined.			
2-49	Data	Well's "primary" guide rate (oil for producers, preferred phase for injectors).			
2-50	Data	Well's producer guide rate for water.			
2-51	Data	Well's producer guide rate for gas.			
2-52 to 2-68	Data	Undefined.			
2-69	Data	Well's producer guide rate for reservoir voidage volume.			
2-70 to 2-75		Undefined.			
2-76	Data	Well's total cumulative oil production (observed/historical rates).			
2-77	Data	Well's total cumulative water production observed/historical rates).			
2-78	Data	Well's total cumulative gas production (observed(historical rates).			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Well Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-79 to 2-81		Undefined.			
2-82	Data	Well's total cumulative water injection (observed/historical rates).			
2-83	Data	Well's total cumulative gas injection (observed/historical rates).			
2-84 to 2-91		Undefined.			
2-92		Second copy of well's primary guide rate. Not fully characterized.			
2-93	Data	Second copy of well's producer guide rate for water. Not fully characterized.			
2-94	Data	Second copy of well's producer guide rate for gas. Not fully characterized.			
2-95	Data	Second copy of well's producer guide rate for reservoir voidage. Not fully characterized.			
2-96 to 2-122		Undefined.			
2-123	Data	Well's voidage production rate.			
2-124	Data	Well's voidage production rate.			
	ZWEL	Well character data array ZWEL(NXWELZ, NWELLS) where NXWELX and NWELS are defined on the INTEHEAD keyword. All strings are eight characters in length.			
1-1	Format	ZWEL	NSWELZ*NWELLS	CHAR	Required
2-1	Data	Defines the well name consisting of eight characters (NXWELZ = 1).			
2-2	Data	Defines the name of the Well List the well belongs to, set to "blank" for the well does not belong to Well List (NXWELZ = 2), that is the ACTIONX name.			
2-3	Data	Defines the end of time step action for the well (NXWELZ = 3).			

Table D.23: RESTART Data – Group, Well and Connection Keywords (Wells)

The well connection keywords are specified in Table D.24 and consist of the ICON, SCON, and XCON keywords.

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Connection Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	ICON	Connection integer data array ICON(NICONZ, NCWMAX, NWELLS) where NICONZ, NCWMAX, and NWELLS are defined on the INTEHEAD keyword. Data keywords are required for each completion in the well and the number of data items, N, should be NICONZ x NCWMAX x NWELLS. Undefined values should be set to zero..			
1-1	Format	ICON	N	INTE	
2-1	Data	Defines the well connect index (NICONZ = 1).			0
2-2	Data	Defines the location of connection in the grid for the I dimension (NICONZ = 2).			0
2-3	Data	Defines the location of connection in the grid for the J dimension (NICONZ = 3).			0
2-4	Data	Defines the location of connection in the grid for the K dimension (NICONZ = 4).			0
2-5		Undefined.			0
2-6	Data	Defines the status of the connection, set to less than or equal to zero for being shut or greater than zero for being open (NICONZ = 5).			0
2-7		Drainage saturation function table number.			0
2-8		Undefined.			0
2-9		Undefined.			0
2-10		Imbibition saturation function table number.			0
2-11		Undefined.			0
2-12		Undefined.			0
2-13		Completion ID (1-based)			0
2-14	Data	Defines the direction of connection, set to one for the x-direction, two for the y-direction, three for the z-direction. The default value of zero indicates the z-direction (NICONZ = 14).			0
2-15	Data	Defines, for multi-segment wells, the segment number the connect belongs to, for conventional wells the default value of zero should be used (NICONZ = 15).			
	SCON	Connection real data array SCON(NSCONZ, NCWMAX, NWELLS) where NSCONZ, NCWMAX, and NWELLS are defined on the INTEHEAD keyword. Data are required for each completion in the well and the number of data items, N, should be NSCONZ x NCWMAX x NWELLS.			Required
1-1	Format	ICON	N	REAL	
2-1	Data	Connection transmissibility factor NSCONZ = 1 in the SCON array.			
2-2	Data	Connection center depth.			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Connection Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-3	Data	Connection diameter.			
2-4	Data	Connection KH, that is the net thickness times the permeability, NSCONZ = 4 in the SCON array.			
2-5	Data	Skin factor - item 'SKIN' from COMPDAT keyword in the SCHEDULE section.			
2-6 to 2-11		Undefined.			
2-12	Data	Connection transmissibility factor.			
2-13 to 2-20		Undefined.			
2-21	Data	Distance to end of connection in segment.			
2-22	Data	Distance to start of connection in segment.			
2-23 to 2-29		Undefined.			
2-30	Data	Unknown			
2-31	Data	Unknown			
2-32 to 2-40		Undefined.			
2-41	Data	Connection factor defined in input deck (set to one), or zero for undefined in input deck.			
	XCON	Connection double precision data array XCON(NXCONZ, NCWMAX, NWELLS) where NXCONZ, NCWMAX, and NWELLS are defined on the INTEHEAD keyword. The number of data items, N, should be NXCONZ x NCWMAX x NWELLS			Required
1-1	Format	ICON	N	DOUB	
2-1	Data	Oil surface rate.			
2-2	Data	Water surface rate.			
2-3	Data	Gas surface rate.			
2-4 to 2-34					
2-35		Connection pressure value.			

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Connection Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
2-36 to 2-49					
2-50		Reservoir voidage rate.			

Table D.24: RESTART Data – Group, Well and Connection Keywords (Connections)

The tracer keywords are listed in Table D.25 and consists of the ICOT, XCOT, IWET, XWET, IGRT, and XGRT keywords. Not this series of keywords are only available if tracers are present in the run.

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Tracer Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	ICOT	Tracer connection integer data array ICOT(NICOTZ, NSTRA2, NCWMAX, NWELLS) where NICOTZ, NSTRA2, NCWMAX, and NWELLS are defined on the INTEHEAD keyword. The number of data items, N, should be NICONZ x NSTRA2 x NCWMAX x NWELLS.			Optional
1-1	Format	ICOT	N	INTE	
2-1	Data	ICOT(NICOTZ, NSTRA2, NCWMAX, NWELLS) array.			
	XCOT	Tracer connection double precision data array ICOT(NICOTZ, NSTRA2, NCWMAX, NWELLS) where NICOTZ, NSTRA2, NCWMAX, and NWELLS are defined on the INTEHEAD keyword. The number of data items, N, should be NICONZ x NSTRA2 x NCWMAX x NWELLS.			Optional
1-1	Format	XCOT	N	DOUB	
2-1	Data	XCOT(NICOTZ, NSTRA2, NCWMAX, NWELLS) array.			
	IWET	Tracer well integer data array IWET(NIWETZ, NSTRA2, NWMAXZ, NWELLS) where NIWETZ, NSTRA2, and NWMAXZ are defined on the INTEHEAD keyword. The number of items, N, should be NIWETNZ x NSTRA2 x NWMAXZ.			Optional
1-1	Format	IWET	N	INTE	
2-1	Data	IWET(NIWETZ, NSTRA2, NWMAXZ, NWELLS) array.			
	XWET	Tracer connection double precision data array XWET(NXWETZ, NSTRA2, NWMAXZ) where NXWETZ, NSTRA2, and NWMAXZ are defined on the INTEHEAD keyword. The number of items, N, should be NXWETNZ x NSTRA2 x NWMAXZ.			Optional
1-1	Format	XWET	N	DOUB	
2-1	Data	XWET(NXWETZ, NSTRA2, NWMAXZ) array.			
	IGRT	Tracer well integer data array IGRT(NIGRTZ, NSTRA2, NWMAXZ, NWELLS) where NIGRTZ, NSTRA2, and NWMAXZ are defined on the INTEHEAD keyword. The number of elements, N, should be NIGRTNZ x NSTRA2 x NWMAXZ.			Optional
1-1	Format	IGRT	N	INTE	
2-1	Data	IGRT(NIGRTZ, NSTRA2, NWMAXZ, NWELLS) array.			
	XGRT	Tracer connection double precision data array XGRT(NXGRTZ, NSTRA2, NWMAXZ) where NXGRTZ, NSTRA2, and NWMAXZ are defined in the INTEHEAD keyword. The number of data items, N, should be NXGRTNZ x NSTRA2 x NWMAXZ.			Optional
1-1	Format	XGRT	N	DOUB	
2-1	Data	XWET(NXWETZ, NSTRA2, NWMAXZ) array.			

Table D.25: RESTART Data – Group, Well and Connection Keywords (Tracers)

Finally, the network keywords INODE, IBRAN, INOBR, RNODE, RBRAN, and ZNODE are specified in Table D.26. Again, this series of keywords are only available if networks are present in the run.

No.	Keyword Name	RESTART Data – Group, Well And Connection Keywords Network Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	INODE	Network node integer data array INODE(NINODE, NODMAX) where NINODE and NODMAX are defined in the INTEHEAD keyword.			Optional
1-1	Format	INODE	NINODE x NODMAX	INTE	
2-1	Data	INODE(NINODE, NODMAX) array			
	IBRAN	Network node branch integer data array IBRAN(NIBRAN, NBRMAX) where NIBRAN and NBRMAX are defined in the INTEHEAD keyword.			Optional
1-1	Format	IBRAN	NIBRAN x NBRMAX	INTE	
2-1	Data	IBRAN(NIBRAN, NBRMAX)			
	INOBR	Network node-branch integer data array INOBR(NIOBR) where NIOBR are defined in the INTEHEAD keyword.			Optional
1-1		INOBR	NIOBR	INTE	
2-1		INOBR(NIOBR) array.			
	RNODE	Network node double precision data array RNODE(NRNODE, NODMAX) where NRNODE and NODMAX are defined in the INTEHEAD keyword.			Optional
1-1	Format	RNODE	NRNODE x NODMAX	DOUB	
2-1	Data	RNODE(NRNODE, NODMAX) array			
	RBRAN	Network node branch integer data array RBRAN(NRBRAN, NBRMAX) where NRBRAN and NBRMAX are defined in the INTEHEAD keyword.			Optional
1-1	Format	RBRAN	NRBRAN x NBRMAX	DOUB	
2-1	Data	RBRAN(NRBRAN, NBRMAX) array.			
	ZNODE	Network node character data array ZNODE(NZNODE, NODMAX) where NZNODE and NODMAX are defined in the INTEHEAD keyword.			Optional
1-1	Format	ZNODE	NZNODE x NODMAX	CHAR	
2-1	Data	ZNODE(NZNODE, NODMAX) array.			

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored red in the No. column indicate that this item is either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the ZNODE keyword should be written out as 'ZNODE '.

Table D.26: RESTART Data – Group, Well and Connection Keywords (Network)

Example: RESTART Data – Group, Well and Connection Keywords

The following example shows a typical formatted RESTART Data – Group, Well and Connection keyword data set, showing the IGRP, SGRP, XGRP and ZGRP keywords.

```
 'IGRP    '         2864 'INTE'
          1            0           0           0           0           0
          0            0           0           0           0           0
          0            0           0           0           0           0
          0            0           0           0           0           0
 ..............................................
          0            0           0           0           0           0
          0            0           0           0           0           0
          0            0           0           0           0           0
          0            0           0           0           0          16
         16            0           0           0           0           0
'SGRP    '         1488 'REAL'
  0.10000000E+21   0.10000000E+21  -0.10000000E+21   0.10000000E+21
  0.00000000E+00   0.00000000E+00   0.10000000E+21   0.10000000E+21
  0.10000000E+21   0.10000000E+21   0.10000000E+21   0.10000000E+21
 ..............................................
  0.00000000E+00   0.00000000E+00   0.10000000E+21   0.10000000E+21
  0.00000000E+00   0.10000000E+21   0.00000000E+00   0.00000000E+00
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.10000000E+01
'XGRP    '         2784 'DOUB'
  0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
  0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
  0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
 ..............................................
  0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
  0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
  0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
  0.00000000000000D+00
'ZGRP    '           80 'CHAR'
'MANI-C  ' '         ' '         ' '         ' 'B1-DUMMY' '         '
'        ' '         ' '         ' 'MANI-D1 ' '         ' '         '
'        ' 'INJE     ' '         ' '         ' '         ' 'PROD     '
'        ' '         ' 'MANI-B1 ' '         ' 'MANI-B2 ' '         '
'MANI-D2 ' '         ' '         ' '         ' '         ' 'MANI-E1 ' '         '
'        ' '         ' '         ' 'MANI-E2 ' '         ' '         '
'        ' 'MANI-K1 ' '         ' '         ' '         ' 'MANI-K2 '
'        ' '         ' '         ' '         ' 'MANI-F  ' '         ' '         '
'        ' '         ' 'WI-GSEG ' '         ' '         ' '         ' '         '
'D2-DUMMY' '         ' '         ' '         ' '         ' 'FIELD   ' '         '
'        ' '         ' '         '
```

End of Example

D.7.5 RESTART DATA – AQUIFER DATA KEYWORDS

This set of keywords are used to define the various aquifer arrays written out by OPM Flow. If there are no aquifers in the model then this set of keywords are skipped. If an analytical or numerical model aquifer is present in the model, a complete set of keywords, for a given aquifer type, should be written out. For example, if a numerical model is defined in the model then the IAQN and RAQN keywords should be written to the file.

The structure for this set of keywords is dependent on the aquifer type, for analytical aquifers the format is outlined in Table D.27 and numerical aquifers are characterized in Table D.28.

No.	Keyword Name	RESTART Data – Aquifer Data Keywords Analytical Aquifer Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	IAAQ	Analytical aquifers integer data array IAAQ(NIAAQZ, MAAQID) where NIAAQZ and MAAQIDR are defined in the INTEHEAD keyword.			Optional
1-1	Format	IAAQ	NIAAQZ x MAAQID	INTE	
2-1	Data	Aquifer Connection Number			
2-2	Data	Water Property Table			PVTW
2-3 to 2-9		Undefined.			
2-10	Data	Type Related 1			
2-11	Data	Type Related 2			
	SAAQ	Analytical aquifers real data array SAAQ(NSAAQZ, MAAQID) where NSAAQZ and MAAQIDR are defined in the INTEHEAD keyword.			Optional
1-1	Format	SAAQ	NSAAQZ x MAAQID	REAL	
2-1	Data	Total Compressibility			COMP
2-2	Data	Fetkovich analytical aquifer pore volume.			PORV
		Carter-Tracy aquifer external radius.			RE
2-3	Data	Fetkovich analytical aquifer productivity index.			PI
		Carter-Tracy aquifer permeability.			PERM
2-4	Data	Fetkovich analytical aquifer time constant			
		Carter-Tracy aquifer porosity.			PORO
2-5	Data	Analytical aquifer pressure.			PRESS
2-6	Data	Analytical aquifer datum depth.			DATUM
2-7	Data	Carter-Tracy aquifer thickness			DZ
2-8	Data	Carter-Tracy aquifer influence angle.			ANGLE
2-9	Data	Carter-Tracy aquifer mass density of water.			
2-10	Data	Carter-Tracy aquifer water viscosity.			

No.	Keyword Name	RESTART Data – Aquifer Data Keywords Analytical Aquifer Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	XAAQ	Analytical aquifers double precision data array XAAQ(NXAAQZ, MAAQID) where NXAAQZ and MAAQIDR are defined in the INTEHEAD keyword.			Optional
1-1	Format	XAAQ	NXAAQZ x MAAQID	DOUB	
2-1	Data	Aquifer flow rate.			
2-2	Data	Dynamic aquifer pressure.			
2-3	Data	Liquid volume produced from the aquifer into the reservoir.			
2-4	Data	Total area of the aquifer.			
	IAQL	Analytical aquifers integer aquifer list data array IAQL(NIAQLX, MXNALI, MXAAQL) where NIAQLX, MXNALI, and MXAAQL are defined in the INTEHEAD keyword.			Optional
1-1	Format	IAQL	NIAQLX x MXNALI x MXAAQL	INTE	
2-1	Data	IAQL(NIAQLX, MXNALI, MXAAQL) array.			
	ZAQL	Analytical aquifers character aquifer list data array ZAQL(NZAQLX, MXNALI) where NZAQLX, and MXNALI are defined in the INTEHEAD keyword.			Optional
1-1	Format	ZAQL	NZAQLX x MXNALI	CHAR	
2-1	Data	ZAQL(NZAQLX, MXNALI) array.			
	ICAQ	Analytical aquifers integer aquifer connection data array MAAQID arrays, each of size ICAQ (NICAQZ, NGCAUS) where NICAQZ, NGCAUS, and MAAQID are defined in the INTEHEAD keyword.			Optional
1-1	Format	ICAQ	NICAQZ x NGCAUS x MAAQID	INTE	
2-1	Data	ICAQ(NICAQZ, NGCAUS, MAAQID) array.			
	SCAQ	Analytical aquifers real aquifer connection data array MAAQID arrays, each of size SCAQ (NSCAQZ, NGCAUS) where NSCAQZ, NGCAUS, and MAAQID are defined in the INTEHEAD keyword.			Optional
1-1	Format	SCAQ	NICAQZ x NGCAUS x MAAQID	REAL	
2-1	Data	SCAQ(NSCAQZ, NGCAUS, MAAQID) array.			
	ACAQ	Analytical aquifers double precision aquifer connection data array MAAQID arrays, each of size aCAQ (NACAQZ, NGCAUS) where NACAQZ, NGCAUS, and MAAQID are defined in the INTEHEAD keyword.			Optional
1-1	Format	ACAQ	NACAQZ x NGCAUS x MAAQID	DOUB	
2-1	Data	ACAQ(NSCAQZ, NGCAUS, MAAQID) array.			

No.	Keyword Name	RESTART Data – Aquifer Data Keywords Analytical Aquifer Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) For formatted output all character variables, including the keywords should be enclosed in single quotes, for example the ACAQ keyword should be written out as 'ACAQ '.

Table D.27: RESTART Data – Analytical Aquifer Data Keywords

And for numerical aquifers the format is outlined in Table D.28.

No.	Keyword Name	RESTART Data – Aquifer Data Keywords Numerical Aquifer keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	IAQN	Numerical aquifers integer data array IAQN (NIIAQN, NUMAQN) where NIIAQN and NUMAQN are defined in the INTEHEAD keyword.			Optional
1-1	Format	IAAQ	NIIAQN x NUMAQN	INTE	
2-1	Data	IAQN (NIIAQN, NUMAQN) array.			
	RAQN	Numerical aquifers doubl eprecision data array RAQN (NIRAQN, NUMAQN) where NIIAQN and NUMAQN are defined in the INTEHEAD keyword.			Optional
1-1	Format	RAAQ	NIRAQN x NUMAQN	REAL	
2-1	Data	RAQN (NIIAQN, NUMAQN) array.			

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the RAQN keyword should be written out as 'RAQN '.

Table D.28: RESTART Data – Numerical Aquifer Data Keywords

Example: RESTART Data – Aquifer Data Keywords

The following example shows a typical formatted RESTART Data – Aquifer Data keyword data set for an analytical aquifer.

```
 'IAAQ    '          15 'INTE'
          3           1           0           0           0           0
          0           0           0           1           1           1
          0           0           0
'SAAQ    '          24 'REAL'
  0.29999999E-04   0.24000000E+04   0.20000000E+02   0.10000000E+00
  0.49619409E+04   0.54000000E+04   0.14000000E+03   0.13333334E-01
  0.63151001E+02   0.31000000E+00   0.00000000E+00   0.43846342E+00
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
'XAAQ    '           8 'DOUB'
  0.63857101611063D+03   0.49619408179004D+04   0.26831697328212D+05
  0.15000000000000D+06   0.23624684055200D-01   0.36097145428688D+02
  0.00000000000000D+00   0.00000000000000D+00
'ICAQNUM '           1 'INTE'
          1
'ICAQ    '          15 'INTE'
          5           1           1          13           2           5
          1           2          14           2           5           1
          3          15           2
'SCAQNUM '           1 'INTE'
          1
'SCAQ    '           6 'REAL'
  0.33333334E+00   0.33333334E+00   0.33333334E+00   0.33333334E+00
  0.33333334E+00   0.33333334E+00
```

End of Example

D.7.6 RESTART DATA – HIDDEN KEYWORD

This keyword[187] defines solution arrays that have been exported by OPM Flow that should not be processed by post-processing software.

The structure for this type of keyword is defined in Table D.29.

No.	Keyword Name	RESTART Data – Hidden Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
	HIDDEN	The keyword defines the solution arrays that have not been exported by the simulator, where N is the number of solution variable names that have been "hidden", each enclosed in single quotes and of eight characters in length.			Required
1-1	Format	HIDDEN	N	CHAR	
2-1	Data	Character list of solution arrays to be hidden from post processing software.			

Notes:

1) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the HIDDEN keyword should be written out as 'HIDDEN '.

Table D.29: RESTART Data – Hidden Keyword

Example: RESTART Data – Hidden Keyword

The following example shows a typical formatted hidden data set, showing 51 Solution arrays that should be hidden.

```
'HIDDEN  '          51 'CHAR'
'ISTHGGI ' 'SWMAX   ' 'SWHY1   ' 'SWHY2   ' 'SWHY3   ' 'ISTHW   ' 'SOMAX   '
'SGHY1   ' 'SGHY2   ' 'SGHY3   ' 'ISTHG   ' 'SGMAX   ' 'SHMAX   ' 'WATQUIES'
'GASQUIES' 'PRESROCC' 'SPDOIL  ' 'SPDWATER' 'SPDGAS  ' 'SWINIT  ' 'SGINIT  '
'POLYMAX ' 'EIP0    ' 'EIP     ' 'TINIT   ' 'IOCN    ' 'SGMIN   ' 'SGSTRD  '
'SWSTRD  ' 'RISTRD  ' 'SGSTRI  ' 'SWSTRI  ' 'RISTRI  ' 'SGTRPD  ' 'SGSTRWD '
'SGSTRWI ' 'SWMIN   ' 'SGSTRWS ' 'RPTHMW  ' 'PPCW    ' 'GRADWELL' 'GRADCONN'
'SWHY4   ' 'SGHY4   ' 'GRADGRUP' 'GRADRESV' 'GRADFIP ' 'GRADSOL ' 'GRADEXP '
'IAQN    ' 'RAQN    '
```

End of Example

[187] *The RESTART Data – Hidden keyword format is used both for global and LGR grids.*

D.7.7 RESTART DATA - SOLUTION DATA KEYWORD

The solution data keywords[188] define the solution for each active cell for both global and LGR grids. This is then followed by a series of global data for a global entry or LGR data for a LGR entry.

The structure for this type of keyword is defined in Table D.30 and a list of solution names is tabulated in Table D.32.

No.	Keyword Name	RESTART Data - Solution Data Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
	STARTSOL	This keyword marks the start of the solution variable section for both global and local grids. Note that there is no data associated with this keyword.			Required
1-1	Format	STARTSOL	0	MESG	
	LGRNAMES	This keyword defines a list of LGR names for the reporting time step, where N is the number of LGR names.			
1-1	Format	LGRNAMES	N	CHAR	
2-1	Data	A character list of LGR names with each name enclosed in single quotes and each having a length of eight characters.			
	SOLUTION	The SOLUTION keyword defines the start of a SOLUTION array data set, where SOLUTION is the name of the array being written out, as outlined in Table D.32. For example, PRESSURE, SWAT, SGAS, RS, RV etc. The SOLUTION keyword (items 1-1 and 2-1) is repeated for each SOLUTION array being written out. SOLUTION arrays can be in any order and only the active cells are written out (NACTIV).			Required
1-1	Format	SOLUTION	NACTIV	REAL	
2-1	Data	SOLUTION data set.			
	ENDSOL	This keyword marks the end of the solution variable section for both global and local grids. Note that there is no data associated with this keyword.			Required
1-1	Format	ENDSOL	0	MESG	

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the SOLUTION array for PRESSURE should be written out as 'PRESSURE '.

Table D.30: RESTART Data - Solution Data keyword

For SOLUTION tracer concentration arrays the ZTRACER keyword must precede the SOLUTION tracer data array – see Table D.31 for a description of ZTRACER keyword.

[188] *The RESTART Data - Solution Data keywords are used both for global and LGR grids SOLUTION arrays. The LGR data is preceded by a series of LGR head keywords and terminated by an LGR termination keyword.*

No.	Keyword Name	RESTART Data – Solution Data Keyword For Tracer Concentration Name			Status Or Value
		Keyword	No. of Entries	Data Type	
	ZTRACER	This keyword marks the start of the solution variable section for both global and local grids. The TRACER in the Data field is the name of the tracer concentration being processed.			Optional
1-1	Format	ZTRACER	2	CHAR	
2-1	Data	TRACER	‘ ‘		
	TRACER	TRACER is the name of the tracer concentration that is contained on the next keyword. Tracer arrays can be in any order and only the active cells are written out (NACTIV).			
1-1	Format	TRACER	NACTIV	REAL	
2-1	Data	Tracer solution data array.			

Notes:

1) The ZTRACER and the TRACER keywords are repeated for each tracer.
2) For formatted output all character variables, including the keyword, should be enclosed in single quotes, including the tracer name.

Table D.31: RESTART Data – Solution Data Keyword for Tracer Concentration Name

The SOLUTION keywords are listed in Table D.32.

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		STANDARD	1OVERBO	Reciprocal of oil formation volume factor.	
		STANDARD	1OVERBW	Reciprocal of water formation volume factor.	
		STANDARD	CNV_DGAS	Worst cells depending on the gas saturation increment / Rv increment / Rs increment.	
		STANDARD	CNV_DPRE	Worst cells depending on the pressure increment.	
		STANDARD	CNV_DWAT	Worst cells depending on the water saturation increment.	
		STANDARD	CNV_GAS	Worst cells depending on the residual of gas equation.	
		STANDARD	CNV_OIL	Worst cells depending on the residual of the oil equation.	
		STANDARD	CNV_WAT	Worst cells depending on the residual of the water equation.	
		STANDARD	CONV_NEW	Number of Newtons required by each cell in order to satisfy the solution change convergence criteria at the last time step.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		STANDARD	CONV_PRU	Worst cells depending on the pressure update.	
		STANDARD	CONV_VBR	Worst cells depending on the volume balance residual.	
		STANDARD	DRAINAGE	Drainage region numbers.	
		STANDARD	DRAINMIN	Drainage sink indicator.	
		STANDARD	FIPGAS	Gas fluid-in-place.	
		STANDARD	FIPOIL	Oil fluid-in-place.	
		STANDARD	FIPWAT	Water fluid-in-place.	
		STANDARD	GAS-DEN	Gas density.	
		STANDARD	GAS-POTN	Gas potential.	
		STANDARD	GAS-PRES	Gas phase pressure.	
		STANDARD	GAS-VISC	Gas viscosity.	
		STANDARD	IOVERBG	Reciprocal of gas formation volume factor.	
		STANDARD	ISTHG	Gas capillary pressure state.	
		STANDARD	ISTHW	Water capillary pressure state.	
		STANDARD	OIL-DEN	Oil density.	
		STANDARD	OIL-POTN	Oil potential.	
		STANDARD	OIL-VISC	Oil viscosity.	
		STANDARD	PBUB	Bubble point pressure.	
		STANDARD	PCOG	Oil-gas capillary pressure.	
		STANDARD	PCOW	Oil-water capillary pressure.	
		STANDARD	PDEW	Dew point pressure.	
		STANDARD	PORV	Pore volume at surface conditions.	
		STANDARD	PRESSURE	Pressure.	
		STANDARD	RFIPGAS	Gas fluid-in-place at reservoir conditions.	
		STANDARD	RFIPOIL	Oil fluid-in-place at reservoir conditions.	
		STANDARD	RFIPWAT	Water fluid-in-place at reservoir conditions.	
		STANDARD	RPORV	Pore volume at reservoir conditions.	
		STANDARD	RS	Gas-oil ratio.	
		STANDARD	RSSAT	Saturated gas-oil ratio.	
		STANDARD	RV	Oil-gas ratio.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		STANDARD	RVSAT	Saturated oil-gas ratio.	
		STANDARD	SFIPGAS	Gas fluid-in-place at surface/separator conditions.	
		STANDARD	SFIPOIL	Oil fluid-in-place at surface/separator conditions.	
		STANDARD	SFIPWAT	Water fluid-in-place at surface/separator conditions.	
		STANDARD	SGAS	Gas saturation.	
		STANDARD	SGMAX	Maximum gas saturation.	
		STANDARD	SGMIN	Minimum gas saturation.	
		STANDARD	SOIL	Oil saturation.	
		STANDARD	SOMAX	Maximum oil saturation.	
		STANDARD	SSOL	Solvent saturation.	
		STANDARD	STATES	Gas-oil state indicator.	
		STANDARD	SWAT	Water saturation.	
		STANDARD	SWMAX	Maximum water saturation.	
		STANDARD	SWMIN	Minimum water saturation.	
		STANDARD	WAT-DEN	Water density.	
		STANDARD	WAT-POTN	Water potential.	
		STANDARD	WAT-PRES	Water phase pressure.	
		STANDARD	WAT-VISC	Water viscosity.	
		STANDARD	XMF	Liquid mole fractions.	
		STANDARD	YMF	Vapor mole fractions.	
		STANDARD	ZMF	Total mole fractions.	
		ALKALINE	ALKADS	Alkaline adsorption.	
		ALKALINE	ALKALINE	Alkaline concentration.	
		ALKALINE	ALKMAX	Alkaline maximum historic concentration.	
		ALKALINE	PADMAX	Alkaline polymer maximum historic adsorption.	
		ALKALINE	PLADALK	Alkaline polymer adsorption multipliers.	
		ALKALINE	SFADALK	Alkaline surfactant adsorption multipliers.	
		ALKALINE	STMALK	Alkaline water/oil surface tension multipliers.	
		API	SDENO	Oil surface densities.	
		API	OILAPI	Oil API values.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		AQUIFER	HYDH	Hydraulic head aquifer.	
		AQUIFER	HYDHFW	Fresh water hydraulic head aquifer.	
		BRINE	CNV_DSAL	Worst cells depending on the brine concentration increment.	
		BRINE	CNV_SAL	Worst cells depending on the residual of the brine equation (BRINEoption when used with polymer).	
		BRINE	ESALSUR	Effective salinity for surfactant.	
		BRINE	SALT	Brine concentration.	
		COAL	COALGAS	Coal gas concentration for coal bed methane option.	
		COAL	COALSOLV	Solvent concentration for coal bed methane option.	
		COAL	GASSATC	Initial coal gas saturated content for coal bed methane option.	
		COAL	MLANG	Langmuir scaling factors for coal bed methane option.	
		COAL	MLANGSLV	Langmuir scaling factors for solvent in coal bed methane option.	
		ENDSCALE	GASKR	Gas relative permeability.	
		ENDSCALE	OILKR	Oil relative permeability.	
		ENDSCALE	WATKR	Water relative permeability.	
		EXCAVATE	EXCAVNUM	Excavation status identifier.	
		EXCAVATE	TRANEXX/Y/Z	Transmissibilities in excavation runs.	
		FOAM	FOAM	Foam concentration.	
		FOAM	FOAM_HL	Foam half-life.	
		FOAM	FOAMADS	Foam adsorption.	
		FOAM	FOAMCNM	Foam capillary numbers.	
		FOAM	FOAMDCY	Foam decay.	
		FOAM	FOAMMAX	Foam maximum historic concentration.	
		FOAM	FOAMMOB	Foam mobility multiplier.	
		GIMODEL	CNV_DGGI	Worst cells depending on the dry injection gas parameter (Gi) increment.	
		GIMODEL	CNV_GGI	Worst cells depending on the residual of the Gi Pseudo-Compositional modeL.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		GIMODEL	GGI	GI injected gas ratio.	
		GIMODEL	RFIPGGI	Dry injection gas in place at reservoir conditions.	
		GIMODEL	SFIPGGI	Dry injection gas in place at surface conditions.	
		POLYMER	CABINnnn	This is for use with the PLYTRRFA keyword only.	
		POLYMER	CNV_DPLY	Worst cells depending on the polymer concentration increment.	
		POLYMER	CNV_PLY	Worst cells depending on the residual of the polymer equation.	
		POLYMER	PADS	Adsorbed polymer concentrations.	
		POLYMER	POLYMAX	Maximum historic polymer concentration.	
		POLYMER	POLYMER	Polymer concentrations.	
		POLYMER	SFIPPLY,RFIPPLY	Polymer-in-place.	
		POLYMER	SFIPSAL,RFIPSAL	Salt-in-place (BRINE option when used with polymer).	
		ROCKCOMP	PRESROCC	Rock pressure values used for rock compaction model.	
		SOLVENT	CNV_DSOL	Worst cells depending on the solvent concentration increment.	
		SOLVENT	CNV_SOL	Worst cells depending on the residual of the solvent equation.	
		SOLVENT	RFIPSOL	Solvent-in-place at reservoir conditions.	
		SOLVENT	SFIPSOL	Solvent-in-place at surface conditions.	
		SURFACT	CATROCK	Divalent cation concentration associated with rock.	
		SURFACT	CATSURF	Divalent cation concentration associated with surfactant.	
		SURFACT	SURFACT	Surface interactions.	
		SURFACT	SURFADS	Adsorbed surfactant concentrations.	
		SURFACT	SURFCNM	Surfactant capillary numbers.	
		SURFACT	SURFMAX	Maximum surfactant concentrations.	
		SURFACT	SURFST	Surface tension in surfactant runs.	
		TEMP	TEMP	Temperature.	
OPM		THERMAL	TEMP	Temperature.	
		VE	EOGC	Maximum oil-gas contact.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		VE	EOWC	Minimum oil-water contact.	
		VE	GWC	Gas-water contact.	
		VE	OGC	Oil-gas contact.	
		VE	OWC	Oil-water contact.	
		VE	POT_CORR	Initial contact corrected potential.	

Notes:

1) The Model Type columns indicate if the solution keyword applies to a black-oil model, a compositional model or both. Since OPM Flow is a black-oil model the compositional keywords are not valid, as shown by the orange cells under the Compositional column.

2) The Model Option column states the model option the solution keyword is associated with and a green cell in the Model Type column indicates that OPM Flow has this option.

3) Finally, the OPM Output Status column indicates if the current version of OPM Flow writes out the data associated with the solution keyword, with a green cell indicating it does and orange it does not.

Table D.32: RESTART Data - Solution Data Keywords

Example: RESTART Data – Solution Data Keyword

The following example shows a typical formatted global grid data set for this keyword set.

```
 'STARTSOL'           0 'MESS'
 'PRESSURE'       44431 'REAL'
   0.26889725E+03   0.26838983E+03   0.26826810E+03   0.26820352E+03
   0.26814493E+03   0.26809378E+03   0.26807767E+03   0.26806363E+03
   0.26802625E+03   0.26798474E+03   0.26795001E+03   0.26791434E+03
   0.26787915E+03   0.26783920E+03   0.26777118E+03   0.26769208E+03
……………………………………..
 'SWAT    '       44431 'REAL'
   0.10500000E+00   0.10500000E+00   0.10500000E+00   0.10500000E+00
   0.10500000E+00   0.10500000E+00   0.10500000E+00   0.14000000E+00
   0.14000000E+00   0.14500000E+00   0.14500000E+00   0.14500000E+00
   0.14500000E+00   0.14500000E+00   0.16000000E+00   0.16000000E+00
……………………………………..
 'SGAS    '       44431 'REAL'
   0.00000000E+00   0.89499998E+00   0.89499998E+00   0.89499998E+00
   0.89499998E+00   0.89499998E+00   0.89499998E+00   0.86000001E+00
   0.86000001E+00   0.85500002E+00   0.85500002E+00   0.85500002E+00
……………………………………..
 'RS      '       44431 'REAL'
   0.11697504E+03   0.12030303E+03   0.12023456E+03   0.12019825E+03
   0.12016528E+03   0.12013654E+03   0.12012746E+03   0.12011956E+03
   0.12009855E+03   0.12007520E+03   0.12005566E+03   0.12003561E+03
   0.12001582E+03   0.11999335E+03   0.11995509E+03   0.11991060E+03
   0.11987761E+03   0.11985194E+03   0.11983020E+03   0.11981972E+03
   0.11980798E+03   0.11977385E+03   0.11970672E+03   0.11963727E+03
  ……………………………………..
 'RV      '       44431 'REAL'
   0.57879315E-04   0.57552861E-04   0.57483696E-04   0.57447018E-04
   0.57413723E-04   0.57384681E-04   0.57375513E-04   0.57367535E-04
   0.57346311E-04   0.57322733E-04   0.57302990E-04   0.57282738E-04
   0.57262747E-04   0.57240050E-04   0.57201407E-04   0.57156467E-04
   0.57123143E-04   0.57097215E-04   0.57075260E-04   0.57064670E-04
   0.57052810E-04   0.57018340E-04   0.56950528E-04   0.56880377E-04
……………………………………..
 'TRFIELD '          28 'DOUB'
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00
 'ZTRACER '           2 'CHAR'
 'SEAF    ' '         '
 'SEAF    '       44431 'REAL'
   0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
   0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
   0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
   0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
   0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
   0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
   0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
……………………………………..
```

End of Example

D.7.8 RESTART DATA - LGR GRID HEADER KEYWORDS

Ththis set of keywords define an LGR's properties, LGR Name for example, and always proceeds an LGR data set for a given LGR; that is the keywords are repeated for each LGR data set in the model and each time step. Note that a given LGR data set is terminated by the ENDLGR keyword and the SEQNUM keyword terminates the input for a time step, which switches the input back to the global grid properties. The keyword description is outlined in Table D.33.

Note that currently OPM Flow does not support LGR grids and therefore this set of keywords cannot be used by OPM Flow.

No.	Keyword Name	RESTART Data - LGR Grid Header Keywords (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. Of Entries	Data Type	
	LGR	LGR grid header keyword that defines the name of the LGR.			Always Required
1-1	Keyword	LGR	1	CHAR	
2-1	Data	Name of the LGR			
	LGRHEADI	LGR that defines the integer variables for this time step.			Always Required
1-1	Format	LGRHEADI	45	INTE	
2-1 to 2-45	Data	Undefined.			
	LGRHEADQ	LGR grid keyword that defines the logical variables (T for true and F for false) for this time step.			Always Required
1-1	Format	LGRHEADQ	5	LOGI	
2-1 to 2-5	Data	Undefined			
	LGRHEADD	LGR grid keyword that defines the double precision REAL variables for this time step.			Always Required
1-1	Format	LGRHEADD	5	DOUB	5
2-1 to 2-5	Data	Undefined.			
	ENDLGR	The ENDLGR keyword marks the end of an LGR section for a given LGR.			Always Required
1-1	Format	ENDLGR	1	MESG	
	Data	LGR number.			

No.	Keyword Name	RESTART Data - LGR Grid Header Keywords (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. Of Entries	Data Type	

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the LGR keyword should be written out as 'LGR '.

Table D.33: RESTART Data - LGR Grid Header Keywords

This keyword type is repeated for each LGR in the model with the last LGR data set terminated by the LGSGONE keyword to mark the end of the LGR input.

Note

The LGR, LGRHEADI, LGRHEADQ and LGRHEADD always proceed LGR data sets and the ENDLGR keyword terminates the end of a data section of LGR data.

Example: RESTART Data - LGR Grid Header Keywords

The following example shows a typical formatted LGR grid header data set for a single LGR grid named LGR-1.

```
'LGR     '           1 'CHAR'
'LGR-1   '
'LGRHEADI'          45 'INTE'
          1         100       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345       -2345       -2345       -2345
      -2345       -2345       -2345
'LGRHEADQ'           5 'LOGI'
 F  F  F  F  F
'LGRHEADD'           5 'DOUB'
  0.00000000000000D+00  -0.10000000200409D+21  -0.10000000200409D+21
 -0.10000000200409D+21  -0.10000000200409D+21
```

End of Example

D.7.9 RESTART DATA - LGR SOLUTION DATA KEYWORDS

The file structure for this series of keywords is similar to the global grid RESTART Data keywords described previously. However, additional data that the defines the LGR properties (LGR Name for example) are included in this keyword definition and the LGR keyword is repeated for each LGR in the model. The keyword description is outlined in Table D.34.

Note that currently OPM Flow does not support LGR grids and therefore this keyword format cannot be used by OPM Flow.

No.	Keyword Name	RESTART Data - LGR Grid Property Data Keyword (Repeated For Each LGR In The Model)	Status Or Value
	LGR	LGR Grid Header keyword See section D.7.8 RESTART Data - LGR Grid Header Keywords	Required
	LGRHEADI		
	LGRHEADQ		
	LGRHEADD		
	INTEHEAD	Header keyword See section D.7.3 RESTART Data - Header Keywords	
	LOGIHEAD		
	DOUBHEAD		
	IGRP SGRP etc.	Group, well, and connection data status keywords for this reporting time step. See section D.7.4 RESTART Data – Group, Well and Connection Data Keywords	Required
	IAAQ SAAQ ect.	Aquifer definition arrays, only applicable if an aquifer is connected to an LGR. See section D.7.5 RESTART Data – Aquifer Data Keywords	Optional
	HIDDEN	HIDDEN solution data, that is a list of solution arrays NOT to be read by post processing software. See section D.7.6 RESTART Data – Hidden Keyword	Required
	SOLUTION	LGR SOLUTION array section (PRESSURE, SGAS, SOILS, WAT, etc.) . See section D.7.7 RESTART Data - Solution Data keyword	Required
	ENDSOL	LGR SOLUTION section termination keyword. See section D.7.7 RESTART Data - Solution Data keyword	Required
	ENDLGR	LGR grid header section termination keywords See section D.7.8 RESTART Data - LGR Grid Header Keywords	Required

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow.
3) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the LGR keyword should be written out as 'LGR '.

Table D.34: RESTART Data – LGR Solution Data Keywords

This set of keywords are repeated for each LGR in the model with the last LGR data set terminated by the ENDSOL and ENDLGR keywords to mark the end of the LGR input - see the example.

Example: RESTART Data - LGR Solution Data Keywords

The following example shows a typical formatted data set with two LGR grids named LGR-1 and LGR-2.

```
 'LGR     '           1 'CHAR'
 'LGR-1   '
 'LGRHEADI'          45 'INTE'
           1         100       -2345       -2345       -2345       -2345
……………………………………..
       -2345       -2345       -2345
 'LGRHEADQ'           5 'LOGI'
  F  F  F  F  F
 'LGRHEADD'           5 'DOUB'
   0.00000000000000D+00  -0.10000000200409D+21  -0.10000000200409D+21
  -0.10000000200409D+21  -0.10000000200409D+21
 'INTEHEAD'         249 'INTE'
……………………………………..
 'LOGIHEAD'          79 'LOGI'
……………………………………..
 'DOUBHEAD'         185 'DOUB'
……………………………………..
 'IGRP    '         358 'INTE'
           0           0           0           0           0           0
……………………………………..
           0           0           0           0
 'SGRP    '         186 'REAL'
   0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
……………………………………..
   0.00000000E+00   0.10000000E+01
 'XGRP    '         348 'DOUB'
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
……………………………………..
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
 'ZGRP    '          10 'CHAR'
 '        ' '        ' '        ' '        ' 'FIELD   ' '        '
 '        ' '        ' '        '
 'ICOT    '           0 'INTE'
 'XCOT    '           0 'DOUB'
 'IWET    '           0 'INTE'
 'XWET    '           0 'DOUB'
 'IGRT    '          18 'INTE'
……………………………………..
 'XGRT    '         180 'DOUB'
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
……………………………………..
   0.10000000200409D+21   0.10000000200409D+21   0.10000000200409D+21
 'DLYTIM  '          30 'DOUB'
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
……………………………………..
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
 'HIDDEN  '          51 'CHAR'
 'ISTHGGI ' 'SWMAX   ' 'SWHY1   ' 'SWHY2   ' 'SWHY3   ' 'ISTHW   ' 'SOMAX
'……………………………………..
 'IAQN    ' 'RAQN    '
 'STARTSOL'           0 'MESS'
 'PRESSURE'           9 'REAL'
   0.26823886E+03   0.26824997E+03   0.26826108E+03   0.26822879E+03
……………………………………..
 'SWAT    '           9 'REAL'
   0.10500000E+00   0.10500000E+00   0.10500000E+00   0.10500000E+00
……………………………………..
 'SGAS    '           9 'REAL'
   0.89499998E+00   0.89499998E+00   0.89499998E+00   0.89499998E+00
……………………………………..
```

```
 'RS      '           9 'REAL'
   0.12021812E+03   0.12022437E+03   0.12023062E+03   0.12021246E+03
…………………….……….
 'RV      '           9 'REAL'
   0.57467099E-04   0.57473411E-04   0.57479720E-04   0.57461380E-04
…………………….……….
 'ENDSOL  '           0 'MESS'
 'ENDLGR  '           1 'INTE'
           1
 'LGR     '           1 'CHAR'
 'LGR-2   '
 'LGRHEADI'          45 'INTE'
…………………….……….
 'LGRHEADQ'           5 'LOGI'
…………………….……….
 'LGRHEADD'           5 'DOUB'
…………………….……….
 'INTEHEAD'         249 'INTE'
…………………….……….
 'LOGIHEAD'          79 'LOGI'
…………………….……….
 'DOUBHEAD'         185 'DOUB'
…………………….……….
 'IGRP    '         358 'INTE'
…………………….……….
 'SGRP    '         186 'REAL'
…………………….……….
 'XGRP    '         348 'DOUB'
…………………….……….
 'ZGRP    '          10 'CHAR'
…………………….……….
 'ICOT    '           0 'INTE'
 'XCOT    '           0 'DOUB'
 'IWET    '           0 'INTE'
 'XWET    '           0 'DOUB'
 'IGRT    '          18 'INTE'
…………………….……….
 'XGRT    '         180 'DOUB'
…………………….……….
 'DLYTIM  '          30 'DOUB'
…………………….……….
 'HIDDEN  '          51 'CHAR'
…………………….……….
 'STARTSOL'           0 'MESS'
 'PRESSURE'           9 'REAL'
…………………….……….
 'SWAT    '           9 'REAL'
…………………….……….
 'SGAS    '           9 'REAL'
…………………….……….
 'RS      '           9 'REAL'
…………………….……….
 'RV      '           9 'REAL'
…………………….……….
 'ENDSOL  '           0 'MESS'
 'ENDLGR  '           1 'INTE'
           2
 'SEQNUM  '           1 'INTE'
           4
```

End of Example

D.8 RFT FILES – PRESSURE, SATURATION AND PRODUCTION LOG DATA

The Repeat Formation Tester ("RFT") file contains a well's depth pressure profile at the time the data is requested using the WRFT or WRFTPLT keywords in the SCHEDULE section. The data is meant to be used to compare the simulator's pressure profile with the field measured data collected from one of the open hole wire line logging tools: Formation Interval Tester ("FIT"), Repeat Formation Tester ("RFT") tool, Modular Dynamics Tester ("MDT"), or similar tool. The keywords also export the fluid saturations for the well connections at the same time.

In addition to the pressure and saturation data, the WRFTPLT keyword can also active the writing out of each well connection's fluid rates, connection factors and KH data, etc., collectively known as the Production Logging Tool ("PLT") data. The PLT data is used to compare with measured data from wire line production logging tools. Currently, output of the PLT data is not supported by OPM Flow.

D.8.1 RFT DATA FILE SPECIFICATION

The file structure for the RFT Data File consists of various keywords: a Time and Date keyword, a Well and Connection keyword followed by the requested optional keywords of RFT, PLT, Multi-Segment Well, and River keywords, that are written out depending on the data requested. A brief description of the keywords is given in Table D.35. A complete RFT data set is written to file for each well and time step as requested on the WRFT and WRFTPLT keywords.

Reference Section	Keyword Name	Keyword Type	Description
D.8.2	TIME	Time and Date Date	This data set contains the simulated time and date information that the date was written out.
	DATE		
D.8.3	WELLETC	Well and Connection Data	The Well and Connection keywords outlines the type and units being written out, the type of well and the well connections at the simulated time the data is written out to the RFT file.
	CONIPOS		
	CONJPOS		
	CONKPOS		
	HOSTGRID		
D.8.4	DEPTH	RFT Solution Data	RFT keyword data consists of the pressure and saturations for each declared connection in the well at the simulated time the data is written out to file.
	PRESSURE		
	SWAT		
	SGAS		
	CPLY		
	CPLAD		
	CBRI		
D.8.5		PLT Solution Data	PLT series of keywords contain the production logging data which consists of the mid-point depth of each connection, the tubing length for the connection from the bottom-hole reference depth, the pressures and fluid rates for the connections. In addition, this data also includes the well pressures, fluid rates, connection transmissibility and KH vales, for the given simulated time. Currently this data set is not supported.

Reference Section	Keyword Name	Keyword Type	Description
D.8.6		Multi-Segment Well Data	The Multi-Segment Well data set consists of pressure and flow rate data for segments and branches, currently this data set is not supported.
D.8.7		River Data	Data pertaining to the Rivers option, this option is not supported by OPM Flow.

Notes:

1) Reference Section cells colored orange indicate that this item is not supported by OPM Flow.

Table D.35: RFT Data File Format

D.8.2 RFT DATA FILE – TIME AND DATE KEYWORDS

The time and date keywords define the start of an RFT data set and declares the time and date for the subsequent property data written to file. The structure for these two keywords is summarized in Table D.36.

No.	Keyword Name	RFT Data File – Time And Date Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	TIME	This keyword marks the start of of an RFT file data set.			Required
1-1	Format	TIME	1	REAL	
2-1	Data	Simulation time the data is being written to file.			
	DATE	Three integer values representing the date of the data being written out.			Required
1-1	Format	DATE	3	INTE	
2-1	Data	Calendar day and should range between one and 31			DAY
2-2	Data	Calendar month and should range between one and 12			MONTH
2-3	Data	Calendar year in four digits, that is 2020.			YEAR

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) For formatted output all character variables, including the keyword should be enclosed in single quotes, for example the TIME should be written out as 'TIME '.

Table D.36: RFT Data File – Time and Date Keywords

The DATE keyword is immediate followed by the well and connection keywords.

D.8.3 RFT DATA FILE – WELL AND CONNECTION DATA KEYWORD

The well and connection data set of keywords specify the well and the well connection data as well as the system of units for the pressure and flow data being written to the RFT file. The structure for this set of keywords is outlined in Table D.37 and consists of WELLETC, CONIPOS, CONJPOS, CONKPOS and HOSTGRID keywords.

No.	Keyword Name	RFT Data File – Well And Connection Data Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
	WELLETC	This keyword marks the start of the well and connection data set and comprises of 16 character variables all enclose in single quotes.			Required
1-1	Format	WELLETC	16	CHAR	
2-1	Data	Time units.			
2-2	Data	Well name.			
2-3	Data	Local Grid Refinement ("LGR") name or left blank if the well is not in an LGR. LGRs are not currently supported by OPM Flow.			Blank
2-4	Data	Depth units.			
2-5	Data	Pressure units.			
2-6	Data	Type of data being written out in subsequent keywords and should be set to R for RFT data, P for PLT data, or S for Segment data. The Segment data option is not currently supported in OPM Flow			
2.7	Data	Well type data set to STANDARD for a standard well, FRICTION for a wellbore friction well, and MULTSEG for a multi-segment well. Only the STANDARD well option is currently supported by OPM Flow.			
2-8	Data	Liquid flow rate units.			
2-9	Data	Gas flow rate units.			
2-10	Data	Local volumetric flow rate units.			
2-11	Data	Flow velocity units.			
2-12	Data	Not used and should be a blank character string.			Blank
2-13	Data	Liquid and gas viscosity units.			
2-14	Data	Polymer and Brine concentration units.			
2-15	Data	Polymer and Brine flow rate units.			
2-16	Data	Adsorbed Polymer concentration units.			
	CONIPOS	This keyword defines the grid index in the x direction (I direction) for all NCON connections in the well associated with the RFT data set.			Required
1-1	Format	CONIPOS	NCON	INTE	
2-1	Data	Grid index in the I direction for each connection.			
	CONJPOS	This keyword defines the grid index in the y direction (J direction) for all NCON connections in the well associated with the RFT data set.			Required
1-1	Format	CONJPOS	NCON	INTE	
2-1	Data	Grid index in the J direction for each connection.			

No.	Keyword Name	RFT Data File – Well And Connection Data Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
	CONKPOS	This keyword defines the grid index in the z direction (K direction) for all NCON connections in the well associated with the RFT data set.			Required
1-1	Format	CONKPOS	NCON	INTE	
2-1	Data	Grid index in the K direction for each connection.			
	HOSTGRID	Defines the LGR name for each of the NCON connections. LGR's have not been implemented in OPM Flow and therefore this keyword should contain NCON blank character strings.			Blank
1-1	Format	HOSTGRID	NCON	CHAR	Blank
2-1	Data	Connections host LGR grid name.			

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the WELLETC should be written out as 'WELLETC '.

Table D.37: RFT Data File – Well and Connection Data Keyword

This series of keywords are immediate followed by the RFT solution keywords: DEPTH, PRESSURE, SWAT, and SGAS.

D.8.4 RFT DATA FILE – RFT SOLUTION DATA KEYWORD

The RFT solution keywords specify the actual solution data (pressure, saturation etc.) for each connection in the well, as described in Table D.38.

No.	Keyword Name	RESTART Data - Solution Data Keyword			Status Or Value
		Keyword	No. of Entries	Data Type	
1-1	DEPTH	Connection gird block depth.			Required
1-1	Format	DEPTH	NCON	REAL	
2-1	Data	Depth data for each connection.			
	PRESSURE	Connection grid block pressure at the requested time.			Required
1-1	Format	PRESSURE	NCON	REAL	
2-1	Data	Pressure data for each connection.			
	SWAT	Connection grid block water saturation at the requested time.			Required
1-1	Format	SWAT	NCON	REAL	
2-1	Data	Water saturation data for each connection.			
2-4	SGAS	Connection grid block gas saturation at the requested time.			Required
1-1	Format	SGAS	NCON	REAL	
2-1	Data	Gas saturation data for each connection.			
	CPLY	Connection grid block polymer concentration at the requested time.			Optional
1-1	Format	CPLY	NCON	REAL	
2-1	Data	Polymer concentration data for each connection.			
	CPLAD	Connection grid block adsorbed polymer concentration at the requested time.			Optional
1-1	Format	CPLAD	NCON	REAL	
2-1	Data	Adsorbed polymer concentration data for each connection.			
	CBRI	Connection grid block brine concentration at the requested time.			Optional
1-1	Format	CBRI	NCON	REAL	
2-1	Data	Brine concentration data for each connection.			

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow.
3) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the PRESSURE keyword should be written out as 'PRESSURE '.

Table D.38: RFT Data File – RFT Solution Data Keywords

A complete standard RFT example showing the TIME, DATE, WELLECT, CONIPOS, CONJPOS, CONKPOS, DEPTH, PRESSURE, SWAT, and SGAS keywords, for one well at one time step is shown on the following page.

Example

The example shows all the keywords required to define a standard RFT data set for well B-4H which has 20 connection as of March 29, 1998. The units declared on the WELLETC keyword indicate the standard metric unit system.

```
'TIME    '           1 'REAL'
  0.14300000E+03
'DATE    '           3 'INTE'
         29           3        1998
'WELLETC '          16 'CHAR'
'   DAYS  ' 'B-4H    ' ' '         ' ' METRES ' '   BARSA ' 'R        ' 'STANDARD'
' SM3/DAY' ' SM3/DAY' ' RM3/DAY' ' M/SEC  ' ' '         ' '    CP    ' ' KG/SM3 '
' KG/DAY ' '   KG/KG '
'CONIPOS '          20 'INTE'
         10          10          10          10          10          10
         10          10          10           9           9           9
          9           9           9           9           9           9
          9           9
'CONJPOS '          20 'INTE'
         32          32          32          32          32          32
         32          32          32          32          32          32
         32          32          32          32          32          31
         31          31
'CONKPOS '          20 'INTE'
          1           2           3           5           6           7
          8           9          10          13          14          15
         16          17          18          19          20          20
         21          22
'HOSTGRID'          20 'CHAR'
'        ' '        ' '        ' '        ' '        ' '        ' '        '
'        ' '        ' '        ' '        ' '        ' '        ' '        '
'        ' '        ' '        ' '        ' '        ' '        '
'DEPTH   '          20 'REAL'
  0.25333979E+04   0.25452786E+04   0.25577705E+04   0.25742898E+04
  0.25797493E+04   0.25855930E+04   0.25918203E+04   0.25966951E+04
  0.26071150E+04   0.26206902E+04   0.26333235E+04   0.26461284E+04
  0.26576768E+04   0.26637878E+04   0.26665945E+04   0.26786790E+04
  0.27012888E+04   0.27033108E+04   0.27381892E+04   0.27746746E+04
'PRESSURE'          20 'REAL'
  0.27384171E+03   0.27406891E+03   0.27430649E+03   0.25063243E+03
  0.25072800E+03   0.25085713E+03   0.25126656E+03   0.25138820E+03
  0.25212048E+03   0.25290869E+03   0.25380568E+03   0.25471658E+03
  0.25669318E+03   0.25713290E+03   0.25733768E+03   0.26151834E+03
  0.26378452E+03   0.26398804E+03   0.28049472E+03   0.28405634E+03
'SWAT    '          20 'REAL'
  0.79952940E-01   0.10493817E+00   0.16989987E+00   0.10517924E+00
  0.10518920E+00   0.14012721E+00   0.14357868E+00   0.80211885E-01
  0.80138676E-01   0.80140039E-01   0.90355128E-01   0.19185907E+00
  0.12343995E+00   0.29019111E+00   0.14448708E+00   0.32566309E+00
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'SGAS    '          20 'REAL'
  0.92004704E+00   0.89506185E+00   0.83010012E+00   0.89231288E+00
  0.89236671E+00   0.14750090E+00   0.17341191E-01   0.64456672E-02
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
```

End of Example

D.8.5 RFT Data File – Solution PLT Data Keywords

This data set is currently not supported.

D.8.6 RFT Data File – Solution Multi-Segment Well Keywords

This data set is currently not supported.

D.8.7 RFT Data File – Solution River Keywords

This data set is currently not supported.

D.9 SUMMARY FILES – TIME BASED VECTOR DATA

The SUMMARY files contain the variables requested to be written to the summary files via the keywords declared in the SUMMARY section. The data are used to generate line graphs of properties such as oil flow rate versus time, grid block pressure versus time, etc. See sections *11.2 Data Requirements* and *11.3 Keyword Definitions* that declare the variables to be written out to the SUMMARY files. The default behavior is write out the requested variables at each time step. As this can lead to large files, especially for full field simulation models, the *RPTONLY - Activate the Report Time Steps Only Option for the SUMMARY File* keyword allows one to write out the data only at a report time step instead.

There are two files types associated with the time based vector data, an index file (SUMMARY Index) that contains a list of variables and objects (wells, groups, connections etc.) that are to be written out to summary data file, and the summary data file (SUMMARY Data) that contains the actual data written out at the required time steps. The commercial simulator users the term "MINISTEP" to describe the time the data is written, and as mentioned above, "MINISTEP" may be either a time step or a reporting time step.

D.9.1 SUMMARY INDEX FILE KEYWORDS

The structure for this series of keywords is outlined in Table D.39, Table D.40, and Table D.41 and depends on the data requested to be written out to the SUMMARY Data File.

No.	Keyword Name	SUMMARY Index File Keywords (Global)			Status Or Value
		Keyword	No. of Entries	Data Type	
	INTEHEAD	The integer header keyword contains two values indicating the units system and the simulator used to generate the file.			Required
1-1	Format	INTEHEAD	2	INTE	
2-1	Data	Unit system used in the simulation, set to 1 for metric, 2 for field, and 3 for laboratory			
2-2	Data	Simulator code used to generate the file, set to: 100 for Schlumberger's ECLIPSE 100, 300 for Schlumberger's ECLIPSE 300, 500 for Schlumberger's ECLIPSE 300 Thermal, 700 for Schlumberger's INTERSECT simulator, 800 for Schlumberger's FrontSim simulator, or a negative value for other simulators. OPM Flow users a value of 100.			100
	RESTART	Contains the root file name of the case which this run was restarted from, if this was a restart run, other wise blank.			Required
1-1	Format	RESTART	9	CHAR	

2-1	Data	Maximum of 72 characters divided into eight character words. For example, if the data file is restarted from NOR01-PRED01-OPM2004-R00, then this data will be of the form:
		`'NOR01-PR' 'ED01-OPM' '2010-R00' '  '`
		`'  ' '  ' '  ' '  '`
		`'  '`			

	DIMENS	This keyword contains the number of vectors and objects written to the SUMMARY Data file at each time step.			Required
1-1	Format	DIMENS	6	REAL	
2-1	Data	NLIST is the number of values stored at each time step on the SUMMARY Data File.			
2-2	Data	The number of grid blocks in the x-direction (NX).			
2-3	Data	The number of grid blocks in the y-direction (NY).			

No.	Keyword Name	SUMMARY Index File Keywords (Global)			Status Or Value
		Keyword	No. of Entries	Data Type	
2-4	Data	The number of grid blocks in the z-direction (NZ).			
2-5	Data	Not Used			0
2-6	Data	Report time step of the case which this run was restated from, if this was a restart run.			0
	KEYWORDS	A list of all the summary variable mnemonics written to the SUMMARY Data file at each time step.			Required
1-1	Format	KEYWORDS	NLIST	CHAR	
2-1	Data	Each mnemonic string should be enclosed in quotes.			
	WGNAMES	A list of all well and group objects associated with summary variable mnemonics			Required
1-1	Format	WGNAMES	NLIST	CHAR	
2-1	Data	Each well and group name should be enclosed in quotes			
	NUMS	Integer grid cell or region number associated with the summary variable mnemonics.			Required
1-1	Format	NUMS	NLIST	INTE	
2-1	Data	Integer values.			
	LENGTHS	Horizontal well length.			Optional
1-1	Format	LENGTHS	NLIST	REAL	
2-1	Data	The distance from the bottom-hole reference depth to the completion depth for the associated summary variable mnemonics for horizontal wells			
	LENUNITS	Horizontal well length units.			Optional
1-1	Format	LENUNITS	1	CHAR	
2-1	Data	Horizontal well length units.			
	MEASRMNT	Measurements associated with each summary variable mnemonic.			Optional
1-1	Format	MEASRMNT	NBLOCK * NLIST	CHAR	
2-1	Data	NBLOCK is equal to the number of elements provided by this keyword divided by NLIST.			
	UNITS	Units			Required
1-1	Format	UNITS	NLIST	CHAR	
2-1	Data	Units for the associated summary variable mnemonics.			
	STARTDAT	Three integer values representing the date of the data being written out., and three integers representing the hour, minutes and micro seconds the data is being written out.			Required
1-1	Format	STARTDAT	3	INTE	
2-1	Data	Calendar day and should range between one and 31			DAY
2-2	Data	Calendar month should range between one and 12			MONTH
2-3	Data	Calendar year in four digits, that is 2020.			YEAR

No.	Keyword Name	SUMMARY Index File Keywords (Global)			Status Or Value
		Keyword	No. of Entries	Data Type	
2-4	Data	Hour			HOUR
2-5	Data	Minutes			MINUTE
2-6	Data	Seconds in micro seconds, 0-59:999:999			SECOND

Notes:

1) Keywords up to including the NUMS keyword are order dependent, after the NUMS keyword the keywords may be in any order.
1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the INTEHEAD and DIMENS keywords should be written out as 'INTEHEAD ' and 'DIMENS '.

Table D.39: SUMMARY Index File Keywords (Global)

In addition, Table D.40 summarizes the SUMMARY Index File keywords associated with Local Grid Refinements.

No.	Keyword Name	SUMMARY Index File Keywords (LGR)			Status Or Value
		Keyword	No. of Entries	Data Type	
	LGRS	Local Grid Refinement names associated summary variable mnemonic for LGR grids			Optional
1-1	Format	LGRS	NLIST	CHAR	
2-1	Data	Name of the LGRs			
	NUMLX	This keyword defines the LGR grid index in the x direction (I direction) for the associated summary variable mnemonic for LGR grids.			Optional
1-1	Format	NUMLX	NLIST	INTE	
2-1	Data	LGR I location of local grid block data or the connection data.			
	NUMLY	This keyword defines the LGR grid index in the y direction (J direction) for the associated summary variable mnemonic for LGR grids.			Optional
1-1	Format	NUMLY	NLIST	INTE	
2-1	Data	LGR J location of local grid block data or the connection data.			
	NUMLZ	This keyword defines the LGR grid index in the z direction (K direction) for the associated summary variable mnemonic for LGR grids.			Optional
1-1	Format	NUMLX	NLIST	INTE	
2-1	Data	LGR K location of local grid block data or the connection data.			
	LGRNAMES	The names of all the LGRs in this case with the number of of LGRs in the case given by NLGR.			Optional
1-1	Format	LGRNAMES	NLGR	CHAR	
2-1	Data	List of LGR names.			
	LGRVEC	Integer list of the number of summary variable mnemonics for each LGR.			Optional
1-1	Format	LGRVEC	NLGR	INTE	

No.	Keyword Name	SUMMARY Index File Keywords (LGR)			Status Or Value
		Keyword	No. of Entries	Data Type	
2-1	Data	Number of summary variable mnemonics for each LGR			
	LGRTIMES	A list of the total number of local time steps for each LGR.			
1-1	Format	LGRTIMES	NLGR	INTE	
2-1	Data	Number of local time steps for each LGR.			

Notes:

1) The LGR keywords may be in any order but must come after the NUMS keyword in Table D.39.
2) Rows shaded in gray indicate the start of a keyword.
3) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow
4) For formatted output all character variables, including the keyword, should be enclosed in single quotes, for example the LGRTIMES keyword should be written out as 'LGRTIMES'.

Table D.40: SUMMARY Index File Keywords (LGR)

Finally, Table D.41 summarizes the SUMMARY Index File keywords specific to the commercial simulator and are therefore not described in any detail.

No.	Keyword Name	SUMMARY Index File Keywords (Commercial Simulator)	Status Or Value
	RUNTIMEI	Run time monitoring – not supported	
	RUNTIMED	Run time monitoring – not supported	
	STEPRESN	Run time monitoring – not supported	
	XCOORD	OFM Data – not supported	
	YCOORD	OFM – not supported	
	TIMESTMP	Not supported	

Notes:

1) Rows shaded in gray indicate the start of a keyword.
2) Cells colored orange in the No. column indicate that this item is not supported by OPM Flow.
3) For formatted output all character variables, including the keyword should be enclosed in single quotes.

Table D.41: SUMMARY Index File Keywords (Commercial Simulator)

Example: SUMMARY Index File Keywords

The following example shows a typical formatted SUMMARY Index file set of keywords.

```
 'INTEHEAD'           2 'INTE'
          1         100
 'RESTART '           9 'CHAR'
 '        ' '        ' '        ' '        ' '        ' '        ' '        '
 '        ' '        '
 'DIMENS  '           6 'INTE'
        164          10          10          10           0           0
 'KEYWORDS'         164 'CHAR'
 'TIME    ' 'YEARS   ' 'FGIP    ' 'FGIPG   ' 'FGIPL   ' 'FGIR    ' 'FGIT    '
 'FGOR    ' 'FGPR    ' 'FGPT    ' 'FOIP    ' 'FOIPG   ' 'FOIPL   ' 'FOIR    '
 'FOIT    ' 'FOPR    ' 'FOPT    ' 'FPR     ' 'FVIR    ' 'FVIT    ' 'FVPR    '
 'FVPT    ' 'FWCT    ' 'FWIP    ' 'FWIR    ' 'FWIT    ' 'FWPR    ' 'FWPT    '
 'GGIR    ' 'GGIT    ' 'GGOR    ' 'GGPR    ' 'GGPT    ' 'GOIR    ' 'GOIT    '
 'GOPR    ' 'GOPT    ' 'GVIR    ' 'GVIT    ' 'GVPR    ' 'GVPT    ' 'GWCT    '
 'GWIR    ' 'GWIT    ' 'GWPR    ' 'GWPT    ' 'SPR     ' 'SPR     ' 'SPR     '
 'SPR     ' 'SPR     ' 'SPR     ' 'SPR     ' 'SPR     ' 'SPR     ' 'SPR     '
 ..............................................

 'WWCT    ' 'WWCT    ' 'WWIR    ' 'WWIR    ' 'WWIT    ' 'WWIT    ' 'WWPR    '
 'WWPR    ' 'WWPT    ' 'WWPT    '
 'WGNAMES '         164 'CHAR'
 ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+'
 ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+'
 ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+'
 ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+' ':+:+:+:+'
 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM'
 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM'
 'PLATFORM' 'PLATFORM' 'PLATFORM' 'PLATFORM' 'OP01    ' 'OP01    ' 'OP01    '
 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    '
 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    '
 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    '
 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    '
 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    '
 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    ' 'OP01    '
..............................................

 'WI01    ' 'OP01    ' 'WI01    '
 'NUMS    '         164 'INTE'
           0           0           0           0           0           0
           0           0           0           0           0           0
           0           0           0           0           0           0
           0           0           0           0           0           0
           0           0           0           0           0           0
           0           0           0           0           0           0
           0           0           0           0           0           0
           0           0           0           0           1           2
           3           4           5           6           7           8
           9          10          11          12          13          14
..............................................
          0           0
 'UNITS   '         164 'CHAR'
 'DAYS    ' 'YEARS   ' 'SM3     ' 'SM3     ' 'SM3     ' 'SM3/DAY ' 'SM3     '
 'SM3/SM3 ' 'SM3/DAY ' 'SM3     ' 'SM3     ' 'SM3     ' 'SM3     ' 'SM3/DAY '
 'SM3     ' 'SM3/DAY ' 'SM3     ' 'BARSA   ' 'RM3/DAY ' 'RM3     ' 'RM3/DAY '
 'RM3     ' 'SM3/SM3 ' 'SM3     ' 'SM3/DAY ' 'SM3     ' 'SM3/DAY ' 'SM3     '
..............................................
 'SM3/DAY ' 'SM3     ' 'SM3     '
 'STARTDAT'           6 'INTE'
           1           1        2020           0           0           0
```

End of Example

D.9.2 SUMMARY DATA FILE KEYWORDS

The structure for this series of keywords is relatively simple compared to the SUMMARY Index file, in that it only consists of four keyword types that are written out at the requested time steps, as outlined in Table D.26.

No.	Keyword Name	SUMMARY Data File Keywords			Status Or Value
		Keyword	No. of Entries	Data Type	
	SEQNUM	This keyword contains a sequence data value corresponding to an encoded integer representing the time the file was created. Although required the data is not used. Secondly, this keyword is written at each report step only and not for each inter leaving mini step, that is the file format is of the following format: SEQNUM Report step n MINISTEP PARAMS MINISTEP PARAMS MINISTEP PARAMS INISTEP PARAMS SEQNUM Report step n + 1 MINISTEP PARAMS MINISTEP PARAMS			Required
1-1	Format	SEQNUM	1	INTE	
2-1	Data	The value entered is not used by either OPM Flow or OPM ResInsight			0
	MINSTEP	The time step number starting from zero and incremented by one for each subsequent time step.			Required
1-1	Format	MINISTEP	1	INTE	
2-1	Data	Time step			
	PARAMS	This keyword contains the actual data for all the vectors and objects specified in the index file.			Required
1-1	Format	PARAMS	NLIST	REAL	
2-1	Data	There should be NLIST values corresponding to the variable list declared on the corresponding SUMMARY Index file.			

Notes:

1) Rows shaded in gray indicate the start of a keyword.

Table D.42: SUMMARY Data File Keywords

For LGRs, the global cell data is written to the standard SUMMARY Data file containing an additional keyword that states the LGR name, as depicted in Table D.43.

No.	Keyword Name	SUMMARY Data File Keywords (LGR)			Status Or Value
		Keyword	No. of Entries	Data Type	
	SEQNUM	As per Table D.42			Required
	LGRNAME	Name of Local Grid Refinement			Required
	Format	LGRNAME	1	CHAR	
	Data	LGR name enclosed in single quotes.			
	MINSTEP	As per Table D.42			Required
	PARAMS	As per Table D.42			Required

Notes:

1) Rows shaded in gray indicate the start of a keyword.

Table D.43: SUMMARY Data File Keywords (LGR)

The data for the LGR time steps, as opposed to the global time step, are written out to a separate SUMMARY Data File, with the suffix of LGR or FLG for fixed format output. In this case, the MINSTEP keyword states the "local" time step and the keyword is repeated for each local grid in the model.

Example: SUMMARY Data Data File keyword

The following example shows a typical formatted SUMMARY Data File keyword data set for one complete report time step and part of a second report time step.

```
'SEQHDR  '           1 'INTE'
          1
'MINISTEP'           1 'INTE'
          0
'PARAMS  '         164 'REAL'
  0.50000000E+00   0.13689254E-02   0.18381236E+11   0.51459348E+10
  0.13235301E+11   0.00000000E+00   0.00000000E+00   0.37649313E+03
  0.95391960E+07   0.47695980E+07   0.10947282E+09   0.30000488E+06
  0.10917282E+09   0.00000000E+00   0.00000000E+00   0.25336973E+05
  0.12668486E+05   0.27468176E+03   0.15571577E+05   0.77857886E+04
  0.63867320E+05   0.31933660E+05   0.12643164E-02   0.60474832E+08
  0.15000000E+05   0.75000000E+04   0.32074501E+02   0.16037251E+02
  0.00000000E+00   0.00000000E+00   0.37649313E+03   0.95391960E+07
  0.47695980E+07   0.00000000E+00   0.00000000E+00   0.25336973E+05
  0.12668486E+05   0.15571577E+05   0.77857886E+04   0.63867320E+05
  0.31933660E+05   0.12643164E-02   0.15000000E+05   0.75000000E+04
  0.32074501E+02   0.16037251E+02   0.26000000E+03   0.26172531E+03
  0.26362421E+03   0.26596732E+03   0.26747589E+03   0.26896045E+03
  0.26282996E+03   0.26332187E+03   0.26378699E+03   0.26365936E+03
 ..............................................
'SEQHDR  '           1 'INTE'
          2
'MINISTEP'           1 'INTE'
          1
'PARAMS  '         164 'REAL'
  0.10000000E+01   0.27378509E-02   0.18377710E+11   0.51453399E+10
  0.13232370E+11   0.00000000E+00   0.00000000E+00   0.32637939E+03
 ..............................................
```

End of Example

D.10 SAVE Files - Initialization and Solution Data

This file format is currently not supported by OPM Flow.

End of Document