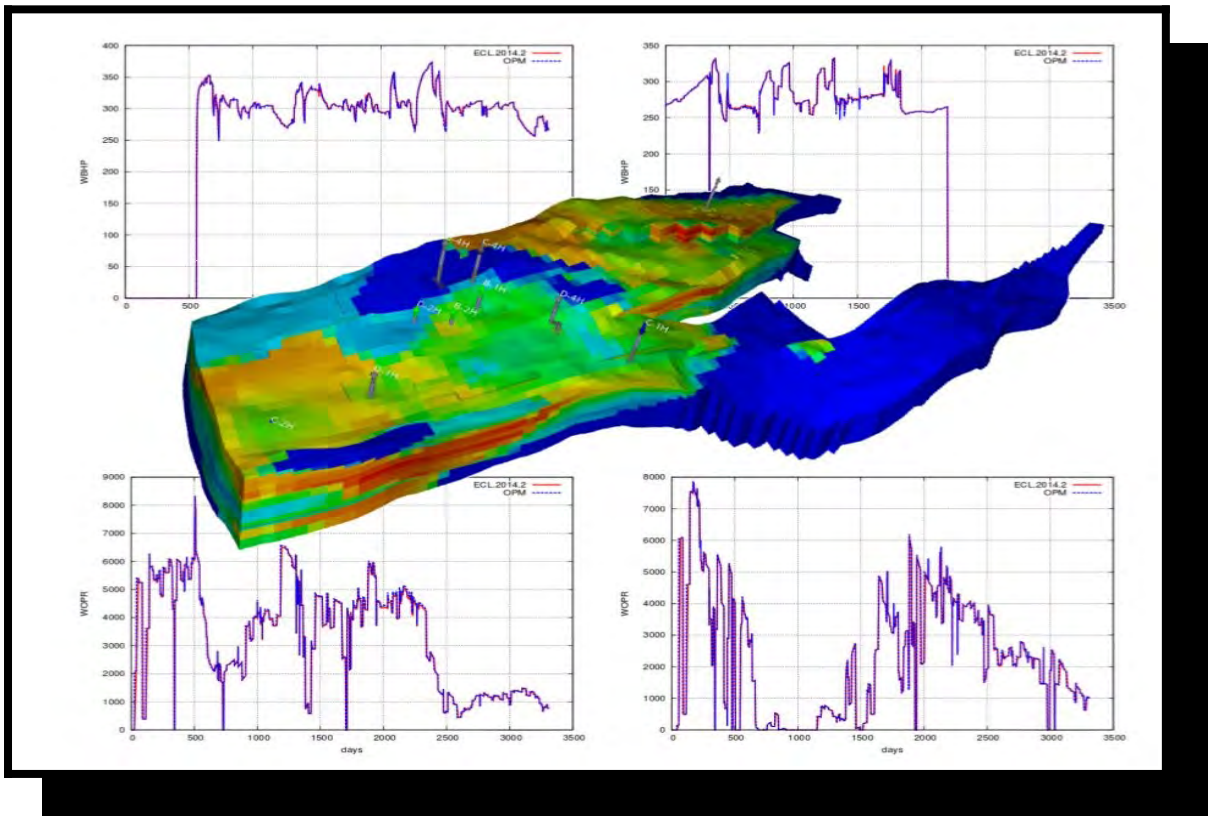
OPEN POROUS MEDIA

Flow Documentation Manual



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OPEN POROUS MEDIA
FLOW DOCUMENTATION MANUAL
(2019-04)

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1 INTRODUCTION

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.

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).

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 separte 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.

Description of Geology:

- Rectilinear and fully-unstructured grid.
- Corner-point grids from Eclipse input, including fault and region multipliers, minpv/pinch, etc.

Well and Group Controls:

- Bottom-hole pressure and surface/reservoir rate.
- Group controls.
- Shut/stop/open individual completions.
- History-matching wells.

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.

2 INSTALLING AND RUNNING FLOW

2.1 INSTALLING 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 2019-04 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.

Note

There is an issue with the Ubuntu Linux 18.04 LTS (64-bit version only) release that prevents mpirun working with OPM Flow under this version of the operating system. Either use another version of Unbuntu for mpi support, or run OPM Flow in sequential mode.

A list of command line options for this release is outlined in Table 2.1 and pass 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 2018-10 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.

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

[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 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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 *5.2.37 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
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 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
	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
33	--ignore-keywords	A character string that defines a list of keywords which should be ignored by OPM Flow. The keyword string should be 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

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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.	""
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

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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[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 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
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 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

[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 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
	VTK Graphics Command Line Parameters[3]		
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
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

[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 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 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2019-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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

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
#
ecl-output-dir=OPM
#
# ------------------------------------------------------------------------
# NEWTON SOLVER PARAMETER
# ------------------------------------------------------------------------
#
# Define Numerical Tolerances
#
flow-tolerance-mb=1e-5
flow-tolerance-cnv=1e-2
flow-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 18.04 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.

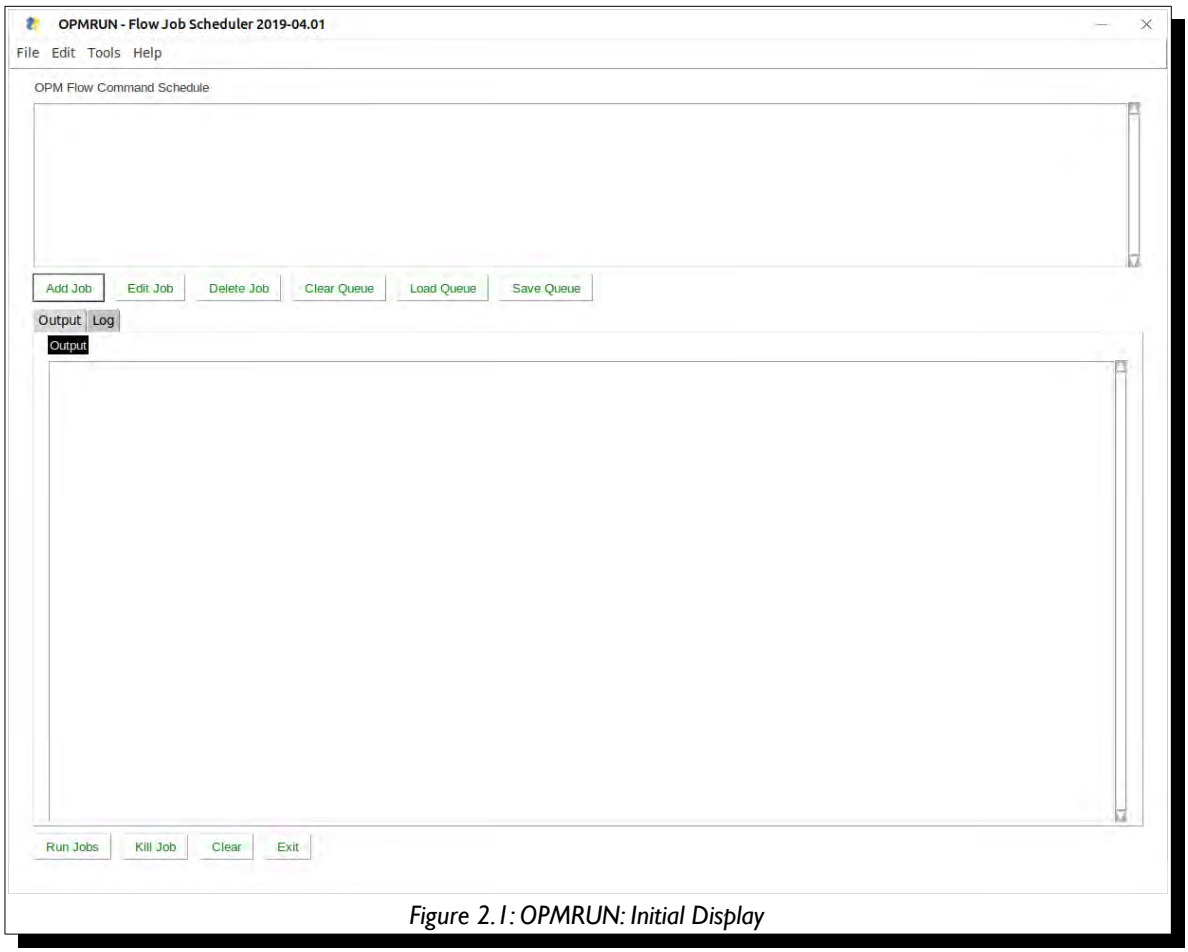

Figure 2.1: OPMRUN: Initial Display

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.

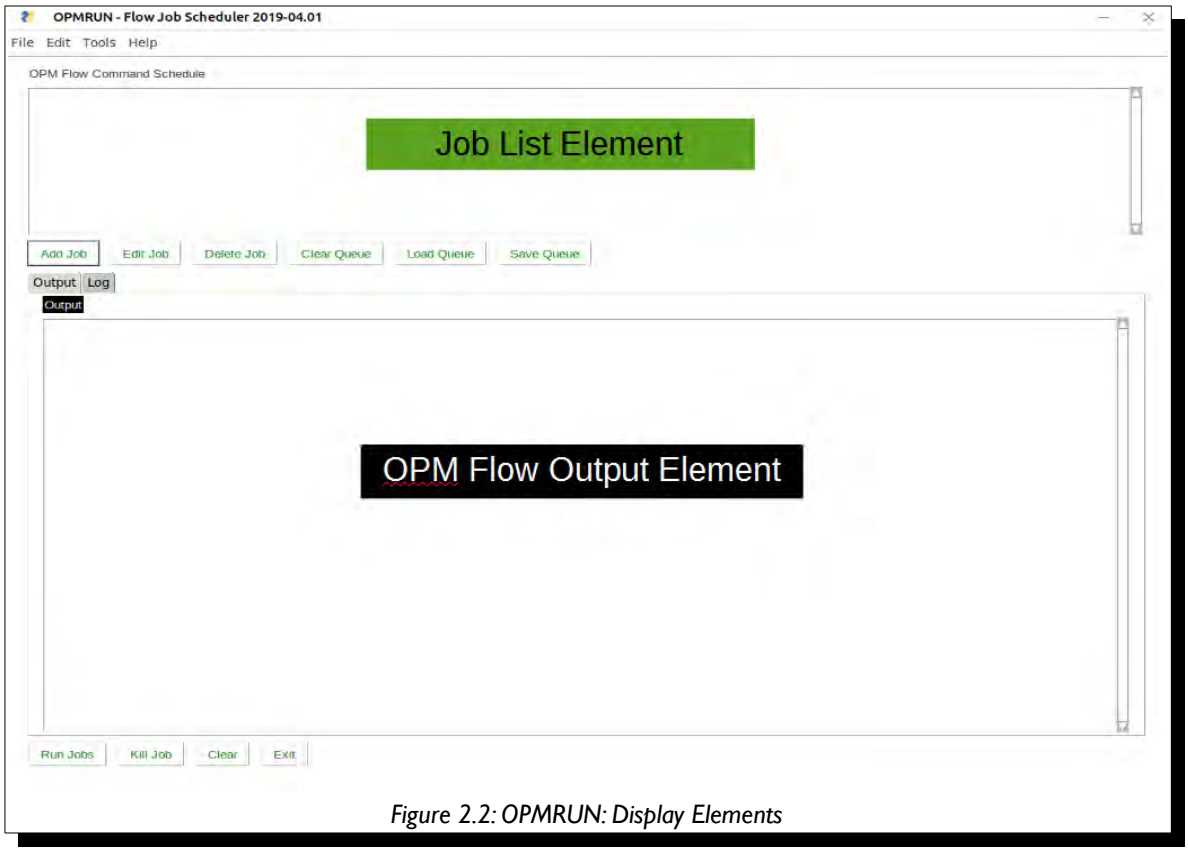

Figure 2.2: OPMRUN: Display Elements

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:

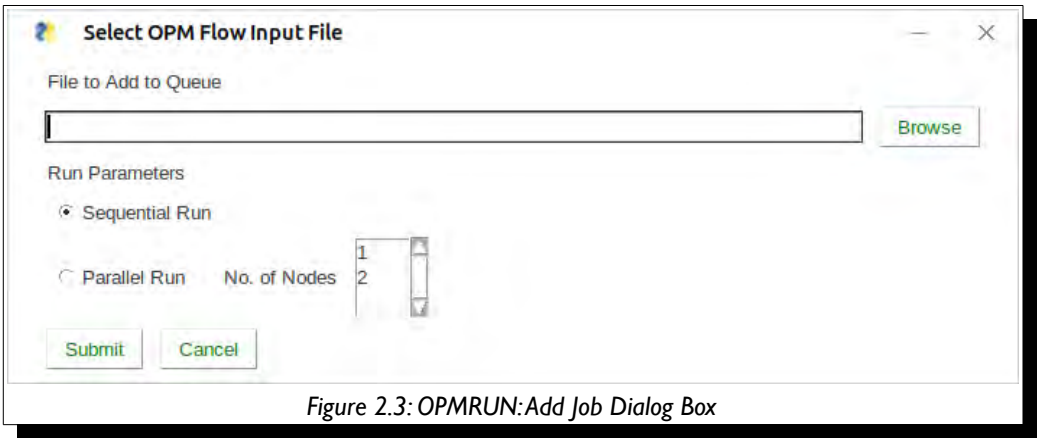

Figure 2.3: OPMRUN: Add Job Dialog Box

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.

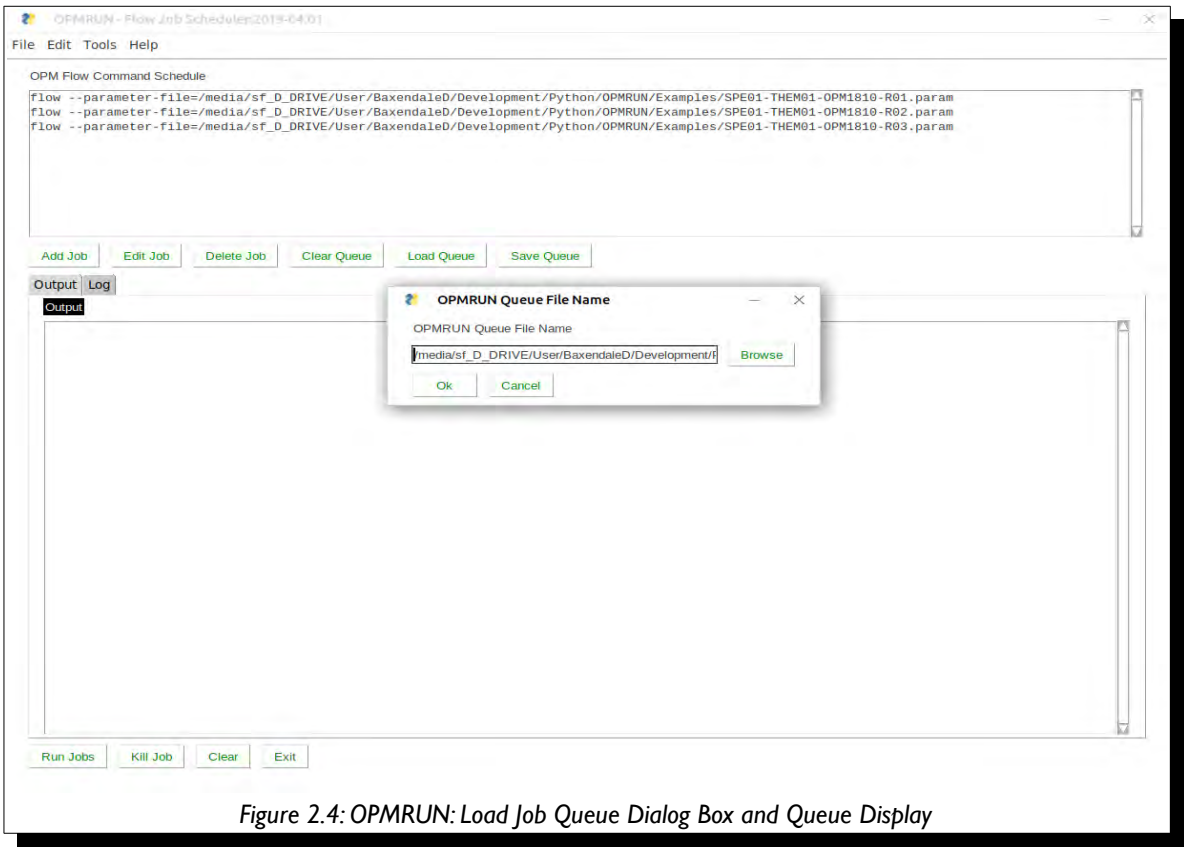

Figure 2.4: OPMRUN: Load Job Queue Dialog Box and Queue Display

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).

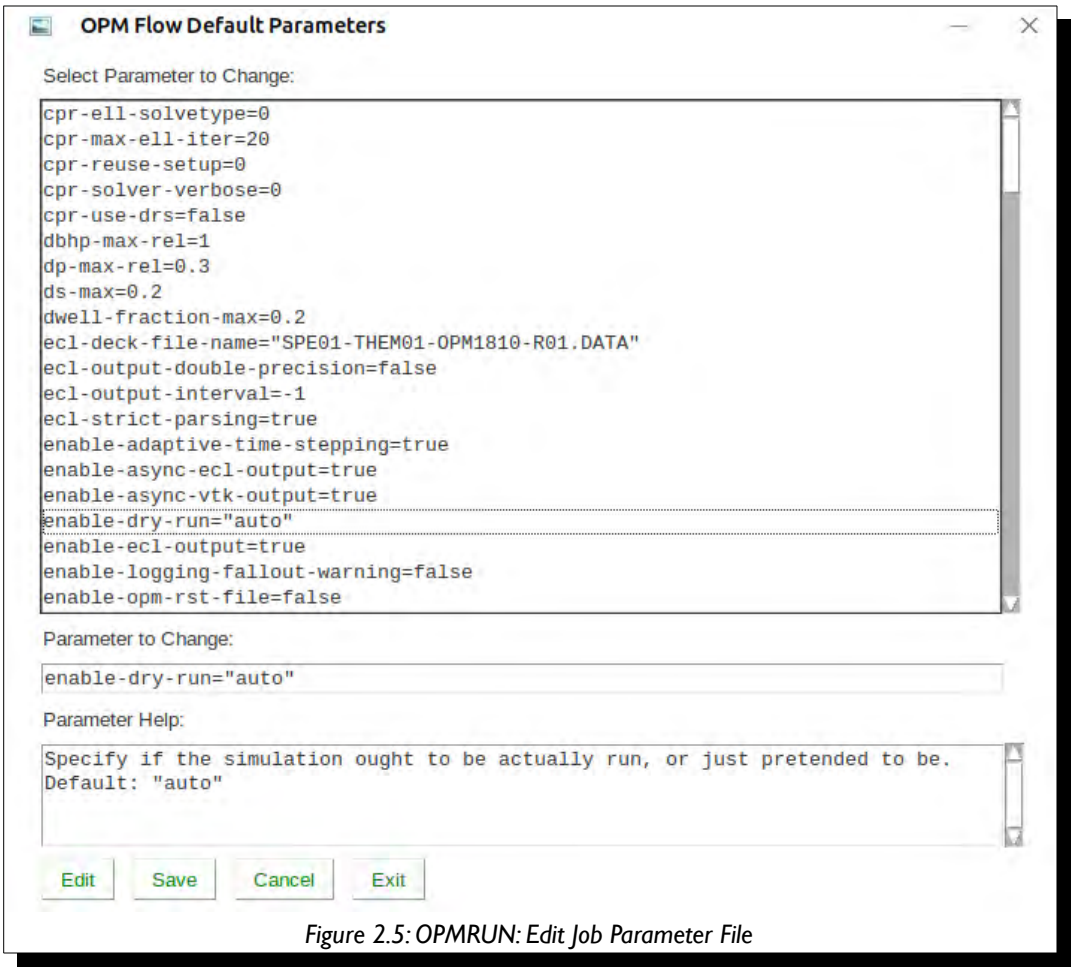

Figure 2.5: OPMRUN: Edit Job Parameter File

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

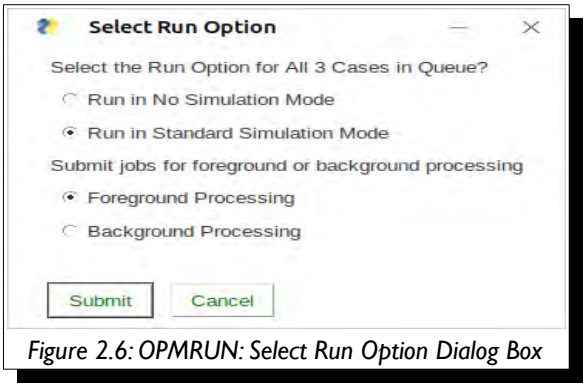

Figure 2.6: OPMRUN: Select Run Option Dialog Box

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 *5.2.37 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.

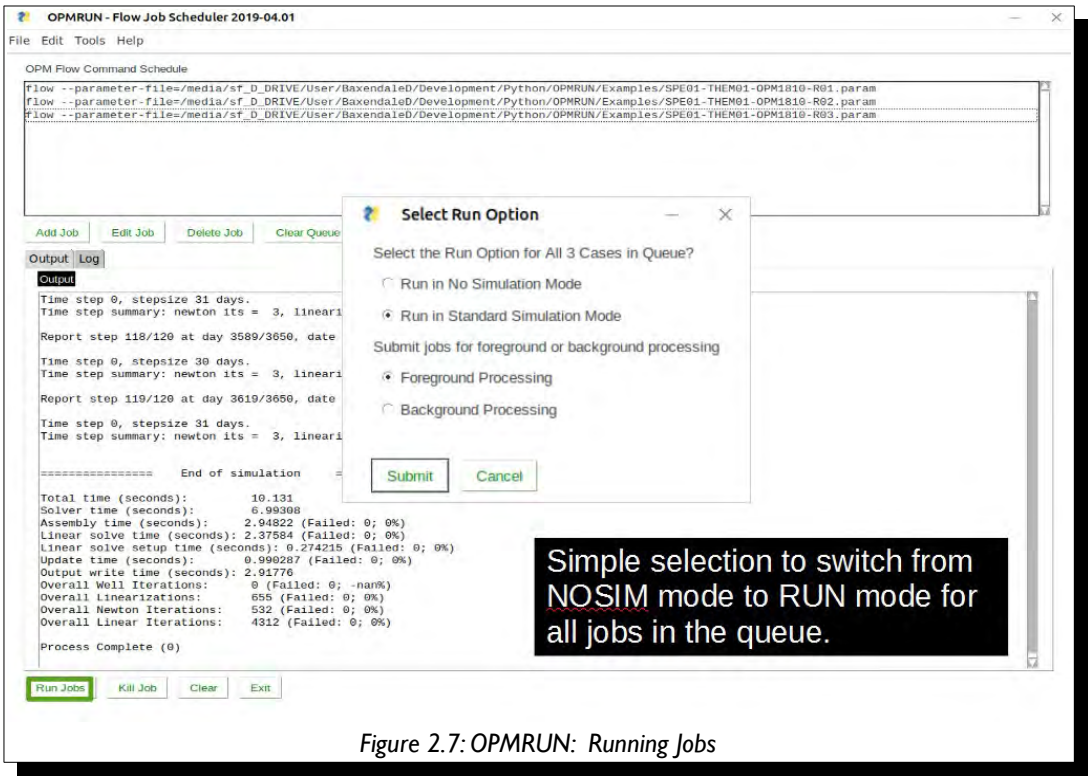

Figure 2.7: OPMRUN: Running Jobs

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.

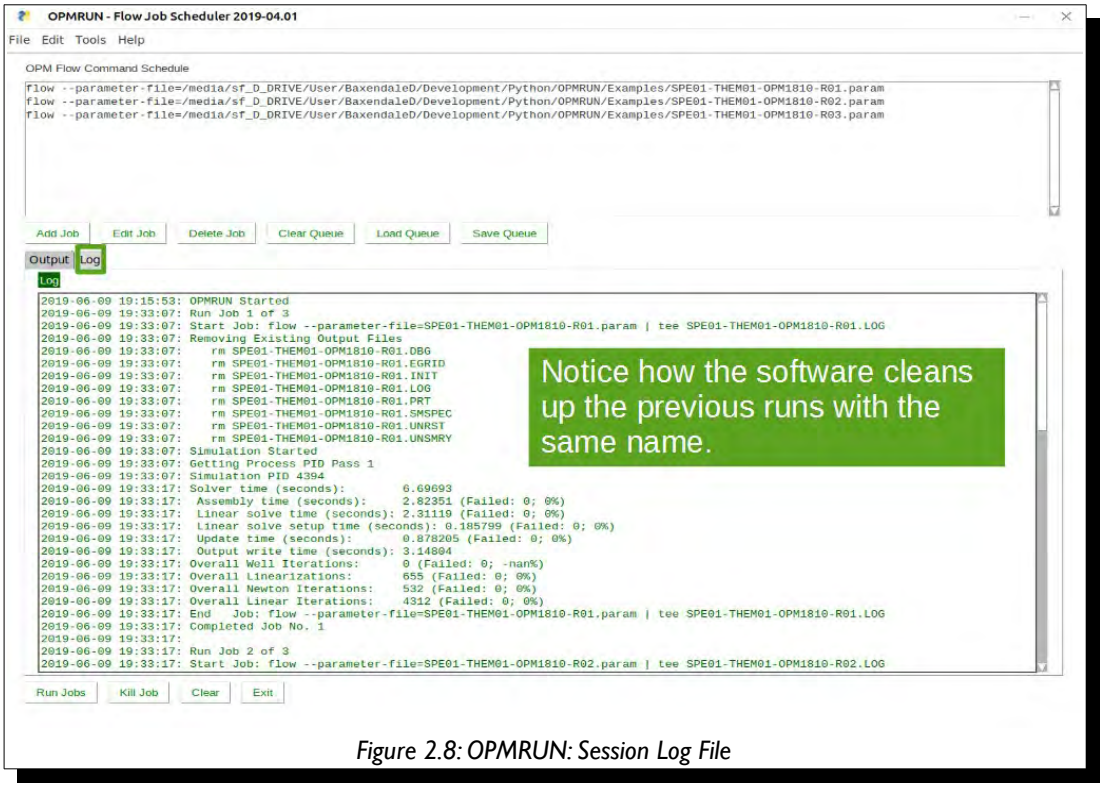

Figure 2.8: OPMRUN: Session Log File

3 KEYWORD DOCUMENTATION STRUCTURE

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.

3.1 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, or only part of the keyword's function is implemented. 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..

3.2 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.

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.

3.3 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.

3.3.1 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
/
```

3.3.2 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.

3.3.3 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 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 for 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.

Examples

```
--
--        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 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

Examples

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.

3.3.4 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.			
		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 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.

3.3.5 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 for 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.

Examples

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

3.4 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 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.*

4 GLOBAL SECTION KEYWORDS

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

4.1 KEYWORD DEFINITIONS

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

4.1.2 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.

4.1.3 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.

4.1.4 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.

4.1.5 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.

4.1.6 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: 0) 0 – No warning messages are give (the default). 1) 1 – PVT table extrapolation warnings are printed. 2) 2 – VFP table extrapolation warnings are printed. 3) 3 – PVT and VFP table extrapolation warnings are printed. 4) 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.

Examples

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

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

4.1.7 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 is encountered, 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	FILEINC	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 4.2: 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'  /
```

4.1.8 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 4.3.

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 4.3: MESSAGES Keyword Description

Examples

```
--       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.

4.1.9 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 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.

4.1.10 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 examples 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.

4.1.11 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.

4.1.12 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 examples 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.

4.1.13 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 examples 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.

4.1.14 WARN – ACTIVATE WARNING MESSAGES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns on warning messages to be printed to the print file; 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 examples 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.

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

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 calculation to the simulation run based on the how the simulation run is proceeding.

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 aborting.

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.

Examples

```
--        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 AITS - INTELLIGENT TIME STEPPING ACTIVATION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

Turns on ECLIPSES intelligent time stepping.

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

5.2.3 API – ACTIVATE API TRACKING

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.

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

Example

```
--
--       ACTVATE THE API TRACKING OPTION
--
API
```

The above example switches on the API tracking facility.

5.2.4 AQUDIMS – AQUIFER DIMENSIONS

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 5.2: AQUDIMS Keyword Description

Examples

```
--        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.

5.2.5 BLACKOIL – ACTIVATE BLACK OIL PHASES

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.

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.

5.2.6 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 2019-04 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.

5.2.7 DEADOIL – ACTIVATE THE DEAD OIL PHASE (NO FREE OR DISSOLVED GAS)

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword deactivates free and dissolved gas in the model and therefore makes the oil phase dead oil[5] in the "black-oil" formulation, and is equivalent to setting the phases present in the model to be oil 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 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.

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 DEAD-OIL PHASE
--
DEADOIL
```

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

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

The above example switches on the oil and water phases 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.*

5.2.8 DIMENS – DEFINE THE DIMENSION OF THE MODEL

Description

DIMENS defines the dimensions of the model entered as integer vector. The keyword can be used for 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 5.3: 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.

Examples

```
--
--       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 cells in the z direction.

5.2.9 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[6] 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 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[7], 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.

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.

[6] *"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.*

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

5.2.10 ENDSCALE – ACTIVATE RELATIVE PERMEABILITY END-POINT SCALING OPTION

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 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 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 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 5.4: ENDSCALE Keyword Description

Examples

```
--        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.

5.2.11 EQLDIMS – DEFINE THE EQUILIBRATION DATA DIMENSIONS

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 5.5: 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.

5.2.12 EQLOPTS – ACTIVATE THE EQUILIBRATION OPTIONS

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 5.6: EQLOPTS Keyword Description

Examples

```
--       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.

5.2.13 FAULTDIM – DEFINE THE NUMBER OF FAULT SEGMENTS

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 5.7: FAULTDIM Keyword Description

Examples

```
--        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.

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

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.

5.2.15 FMTIN – ACTIVATE THE FORMAT INPUT FILE OPTION

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 5.8.

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 5.8: FMTOUT 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.

5.2.16 FMTOUT – ACTIVATE THE FORMAT OUTPUT FILE OPTION

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 5.9.

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 5.9: 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.

5.2.17 FULLIMP – ACTIVATE FULLY IMPLICIT SOLUTION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

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.

There is no data required for this keyword.

See section *2.2 Running OPM Flow 2019-04 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.

5.2.18 GAS – ACTIVATE THE GAS PHASE IN THE MODEL

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.

5.2.19 GRIDOPTS - GRID PROCESSING OPTIONS

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 5.10: 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.

5.2.20 IMPES – ACTIVATE IMPLICIT PRESSURE EXPLICIT SATURATION SOLUTION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

IMPES keyword activates on 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.

Example

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

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

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

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.

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.

5.2.22 LICENSES – DEFINE REQUIRED LICENSES FOR RUN

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.

5.2.23 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[8] 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.

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 DEAD-OIL PHASE
--
LIVEDOIL
```

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.

[8] *"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.*

5.2.24 LGR – DEFINE LOCAL GRID REFINEMENT PARAMETERS

Description

This keyword defines various parameters for the local grid refinement option.

Currently, OPM Flow does not support the local grid refinement feature.

5.2.25 MEMORY – DEFINE ALLOCATED MEMORY

Description

This keyword defines the memory allocation for the run.

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

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

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.

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.

5.2.27 MISCIBLE – DEFINE MISCIBILITY TODD-LONGSTAFF PARAMETERS

Description

The MISCIBLE keyword defines the options associated with the Todd-Longstaff[9] 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 5.11: 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.

[9] *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.*

5.2.28 MONITOR – ACTIVATE OUTPUT OF THE MONITORING DATA AND FILE

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.

Example

```
--
--       ACTIVATEMONITORING 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.

5.2.29 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 5.12: MSGFILE Keyword Description

Example

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

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

5.2.30 MULTIN – ACTIVATE THE UNIFIED INPUT FILE OPTION

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 5.13.

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 5.13: 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

```
--
--       SWITCH ON THE MULTIPLE INPUT FILES OPTION
--
MULTIN
```

The above example switches on the multiple input file option.

5.2.31 MULTOUT – ACTIVATE THE MULTIPLE OUTPUT FILE OPTION

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 5.14.

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 5.14: 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

```
--
--       SWITCH ON THE MULTIPLE OUTPUT FILES OPTION
--
MULTOUT
```

The above example switches on the multiple output file option.

5.2.32 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.

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.

5.2.33 NOINSPEC – DEACTIVATE OUTPUT OF THE INIT INDEX FILE

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 i(*.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.

Example

```
--
--       DEACTIVATEOUTPUT 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.

5.2.34 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.

Example

```
--
--       DEACTIVATEMONITORING 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.

5.2.35 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.

Example

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

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

5.2.36 NORSSPEC – DEACTIVATE OUTPUT OF THE RESTART INDEX FILE

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) is 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.

Example

```
--
--       DEACTIVATEOUTPUT 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.

5.2.37 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.

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

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; hence, OPM Flow ignores this keyword. It 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 5.15: 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.

5.2.39 NUMRES – DEFINE THE NUMBER OF RESERVOIR GRIDS

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 5.16: 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.

5.2.40 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.

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 2019-04 From The Command Line* on how to set the 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.	3

Notes:

1) The keyword is terminated by "/".

Table 5.17: NUPCOL Keyword Description

Example

```
--
--       DEFINE THE NUMBER OF ITERATIONS TO UPDATE WELL FLOW TARGETS
--
NUPCOL
        3                                                                  /
```

The above example sets the default NUPCOL value; however, this has no effect in OPM Flow input decks.

5.2.41 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.

Example

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

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

5.2.42 OPTIONS – ACTIVATE VARIOUS PROGRAM OPTIONS

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.

No.	Description	Default
1 - 273	Undefined.	0

Notes:

1) The keyword is terminated by "/".

Table 5.18: OPTIONS Keyword Description

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

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.

5.2.43 PARALLEL – DEFINE 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 Error: Reference source not found on how to run OPM Flow in parallel.

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 5.19: 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.

See section *2.2 Running OPM Flow 2019-04 From The Command Line* on how to run OPM Flow in parallel mode.

Example

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

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

5.2.44 PATHS – DEFINE FILENAME DIRECTORY PATH ALIASES

Description

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

OPM Flow currently does not support this feature and ignores this keyword. It is documented here for completeness.

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 5.20: 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.

5.2.45 POLYMER – ACTIVATE THE POLYMER PHASE IN THE MODEL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword indicate that the polymer phase is present in the model and to activate the polymer flooding mode. l 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.

Example

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

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

5.2.46 PIMTDIMS – DEFINE WELL PRODUCTIVITY SCALING TABLE DIMENSIONS

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 5.21: 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.

5.2.47 RADIAL – RADIAL GRID ACTIVATION OPTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RADIAL[10] 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.

[10] *Radial grids are not currently implemented in this version of OPM Flow but are expected to be incorporated in a future release.*

5.2.48 REGDIMS – DEFINE THE MAXIMUM NUMBER OF REGIONS FOR A REGION ARRAY

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 5.22: 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.

5.2.49 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[11]. 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[12] 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). Only the default option is supported by OPM Flow	NO

[11] *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.*

[12] *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[13, 14 and 15] porosity-transmissibility relationship should be used. This option is currently ignored by OPM Flow.	1*
Notes: 1) The keyword is terminated by "/".			

Table 5.23: 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.

[13] *J. Kozeny, "Ueber kapillare Leitung des Wassers im Boden." Sitzungsber Akad.Wiss.,Wien, 136(2a): 271-306, 1927.*

[14] *P.C. Carman, "Fluid flow through granular beds." Transactions, Institution of Chemical Engineers, London, 15: 150-166, 1937.*

[15] *P.C. Carman, "Flow of gases through porous media." Butterworths, London, 1956*

5.2.50 RPTRUNSP – ACTIVATE RUNSPEC REPORTING

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

```
--
--       SWITCH ON RUNSPEC SECTION REPORTING
--
RPTRUNSP
```

The above example switches on RUNSPEC reporting; however, this has no effect in OPM Flow input decks.

5.2.51 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 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.

5.2.52 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[16] is used to describe relative permeability hysteresis and the Killough[17] 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 5.25 for the various relative permeability table allocation keywords for the various combination of DIRECT, IRREVERS and HYSTER command options.

[16] *Carlson, F. M. (1981) SPE 10157, presented at the 56th Annual SPE Fall Meeting, San Antonio, 1981*

[17] *Killough, J. E. "Reservoir Simulation with History-dependent Saturation Functions," paper SPE 5106, Society of Petroleum Engineers Journal (1976) 16, No. 1, 37-48.*

The keyword should be followed by one or more of the following keyword options.

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	SURFTENSA	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 5.25 for the various relative permeability table allocation keywords. 2) The keyword is terminated by "/".			

Table 5.24: 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.	KRNUMX, KRNUMY KRNUMZ		KRNUMR KRNUMT KRNUMZ	
Flow in the i to i -1 directions.	KRNUMX- KRNUMY- 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.	**Drainage** KRNUMX KRNUMY KRNUMZ	**Imbibition** IMBNUMX IMBNUMY IMBNUMZ	**Drainage** KRNUMR KRNUMT KRNUMZ	**Imbibition** IMBNUMR IMBNUMT IMBNUMZ
Flow in the i to i -1 directions.	KRNUMX-, KRNUMY- KRNUMZ-	IMBNUMX- IMBNUMY- IMBNUMZ-	KRNUMR- KRNUMT- KRNUMZ-	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 5.25: 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.

5.2.53 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.

5.2.54 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 5.26: 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.

5.2.55 SOLVENT – ACTIVATE THE SOLVENT PHASE IN THE MODEL

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.

Example

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

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

5.2.56 START – SIMULATION START DATE

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 5.27: 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.

5.2.57 TABDIMS – DEFINE THE NUMBER OF TABLES AND THE TABLE DIMENSIONS

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 notr 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 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 5.28:TABDIMS Keyword Description

Examples

```
--
--        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 or rows of 40, and the maximum number of PVT tables to be nine with a maximum number or rows of 30.

5.2.58 TEMP – ACTIVATE THE TEMPERATURE MODELING OPTION

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 5.29: 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
--
TEMP
```

The above example activates the temperature modeling option, although the keyword is ignored by OPM Flow and has no effect on the simulation.

5.2.59 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 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 5.30 for easy of reference.

Section	Keyword	Function	OPM Flow	Commercial	
			THERMAL	**TEMP**	THERMAL
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			
	SPECROCK	Specific Heat of the Reservoir Rock			
	WATDENT	Oil Density Temperature Coefficients.			

Section	Keyword	Function	OPM Flow	Commercial	
			THERMAL	TEMP	THERMAL
	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) 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 keywords.

Table 5.30:THERMAL Option Associated Keywords

Example

```
--
--       ACTIVATE THE THERMAL MODELING OPTION
--
THERMAL
```

The above example activates the thermal modeling option.

5.2.60 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 5.31: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.

Examples

```
--
--       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*".

5.2.61 TRACERS – ACTIVATE TRACER OPTIONS AND SET TRACER ARRAY DIMENSIONS

Description

The TRACER keyword defines the number of tracers in the model and the various passive tracer tracking options.

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 5.32:TRACERS Keyword Description

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

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.

5.2.62 UDADIMS – DEFINE THE DIMENSIONS OF THE USER DEFINED ARGUMENTS

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, 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 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 5.33: 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 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.

5.2.63 UDQDIMS – DEFINE THE DIMENSIONS OF THE USER DEFINED UDQ FEATURE

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, 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 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

No.	Name	Description	Default
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 5.34: 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).

5.2.64 UDQPARAM – DEFINE PARAMETERS FOR THE USER DEFINED QUANTITY FEATURE

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, 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 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 5.35: 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}.

5.2.65 UNIFIN – ACTIVATE THE UNIFIED INPUT FILE OPTION

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 5.36.

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 5.36: UNIFIN 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 UNIFIED INPUT FILES OPTION
--
UNIFIN
```

The above example switches on the unified input file option.

5.2.66 UNIFOUT – ACTIVATE THE UNIFIED OUTPUT FILE OPTION

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 5.37.

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 5.37: UNIFOUT 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 UNIFIED OUTPUT FILES OPTION
--
UNIFOUT
```

The above example switches on the unified output file option.

5.2.67 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[18] 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 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[19], 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.

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.

[18] *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.*

[19] *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.*

5.2.68 VFPIDIMS – INJECTION VERTICAL FLOW PERFORMANCE TABLE DIMENSIONS

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 5.38: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.

5.2.69 VFPPDIMS – PRODUCTION VERTICAL FLOW PERFORMANCE TABLE DIMENSIONS

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 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 5.39: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.

5.2.70 WATER – ACTIVATE THE WATER PHASE IN THE MODEL

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.

Example

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

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

5.2.71 WELLDIMS – DEFINE THE WELLS AND GROUP DIMENSIONS

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.	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
13	MXWSECD	A positive integer defining the maximum number of secondary wells for this model. This option is ignored by OPM Flow.	10

No.	Name	Description	Default
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 5.40: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.

5.2.72 WSEGDIMS – DEFINE MULTI-SEGMENT WELL DIMENSIONS

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 branch. 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 5.41: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.

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[20]). 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.

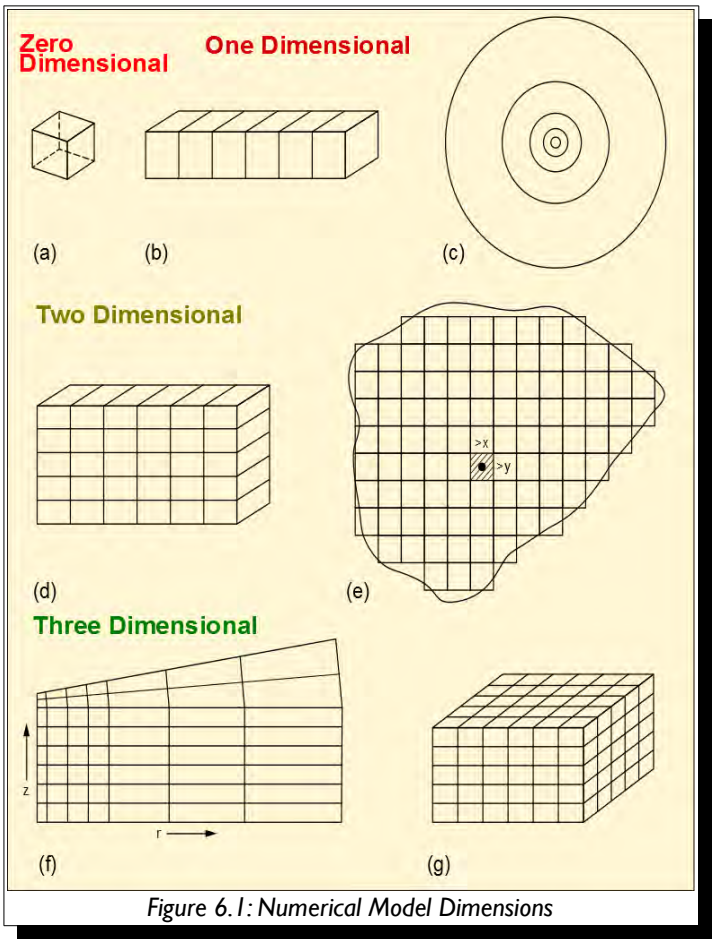

Figure 6.1: Numerical Model Dimensions

OPM Flow enables the user to define 1D, 2D and 3D models using three types of grids: Cartesian Regular Grid, Radial Grid[21], 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.

[20] *Mattax, C.C. and Dalton R.L. 1990. Reservoir Simulation. Society of Petroleum Engineers, Henry L. Doherty Series, Monograph Vol. 13*

[21] *Radial grids are not currently implemented in OPM Flow version 2018-04 but is expected to be incorporated in the next 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[22].

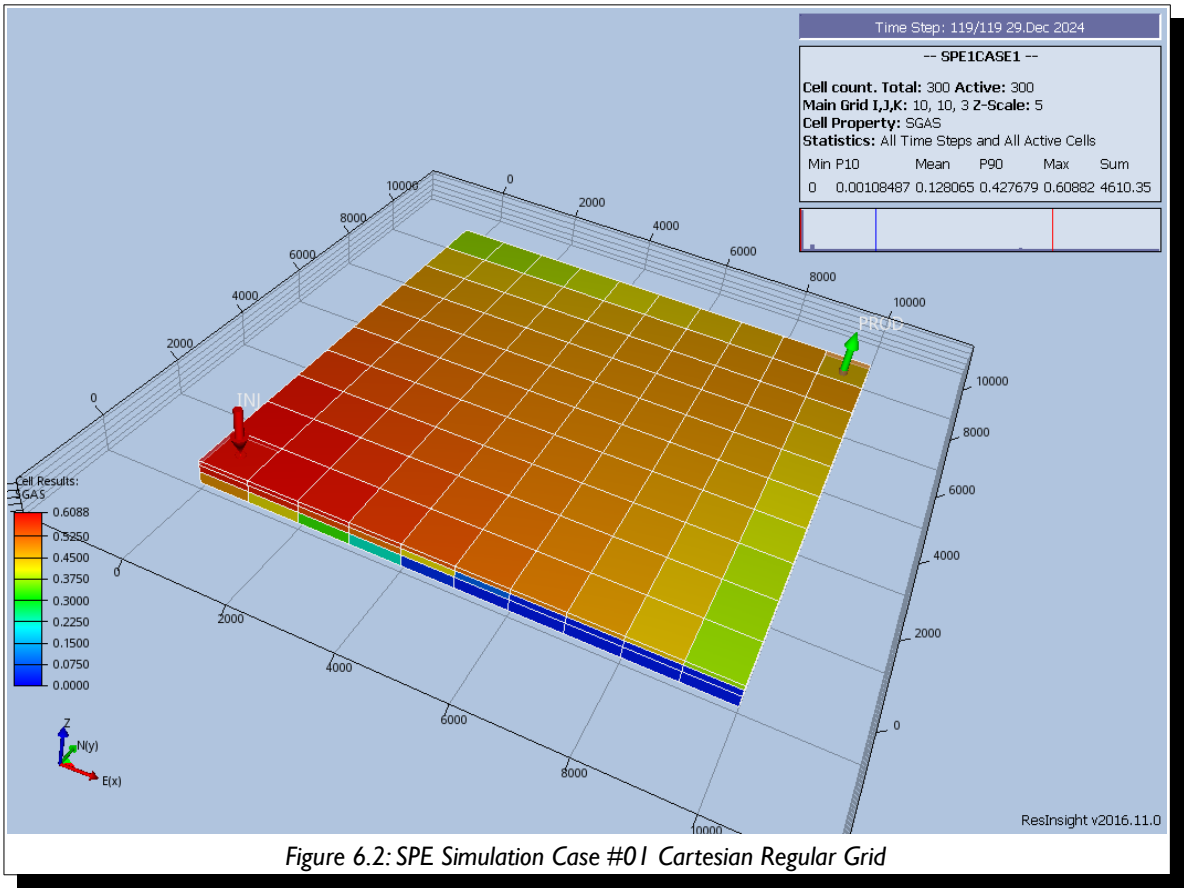

Figure 6.2: SPE Simulation Case #01 Cartesian Regular Grid

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                                         /
```

[22] *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.

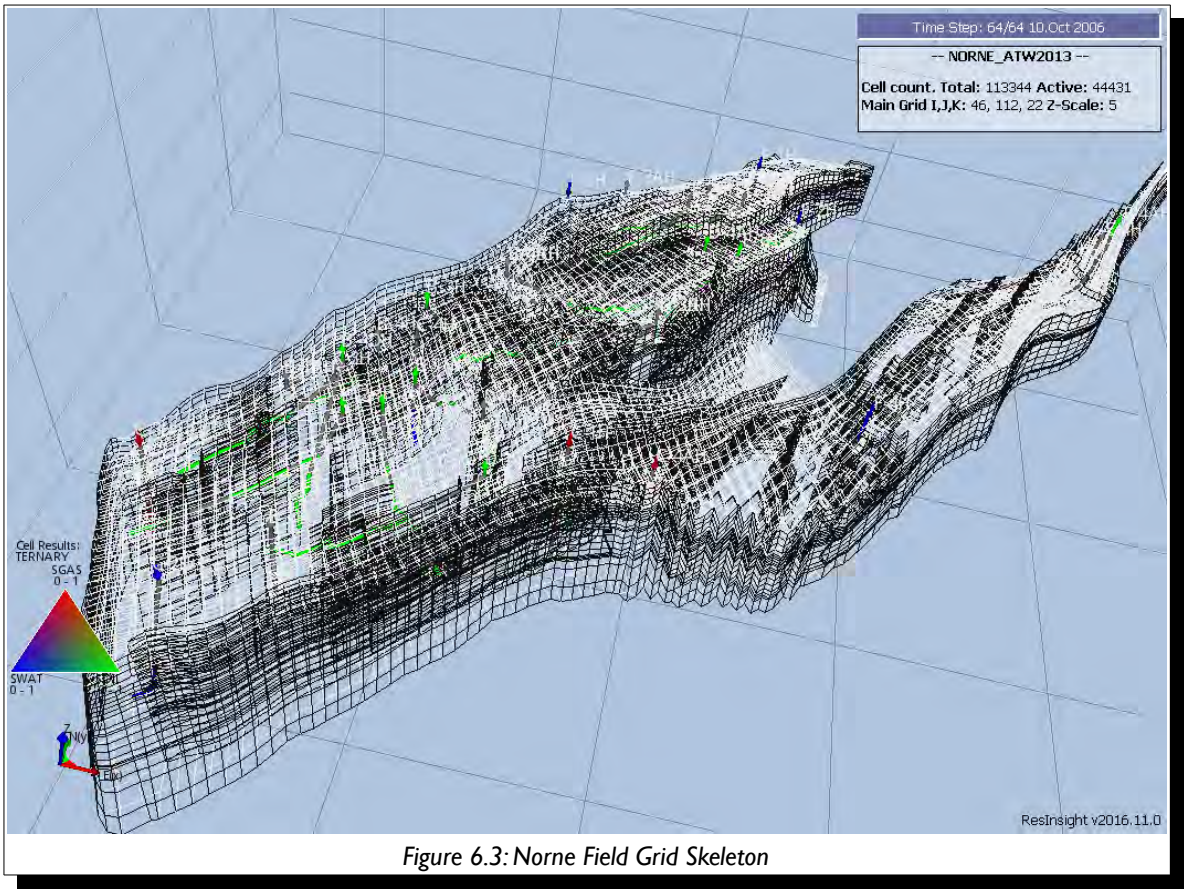

Figure 6.3: Norne Field Grid Skeleton

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.

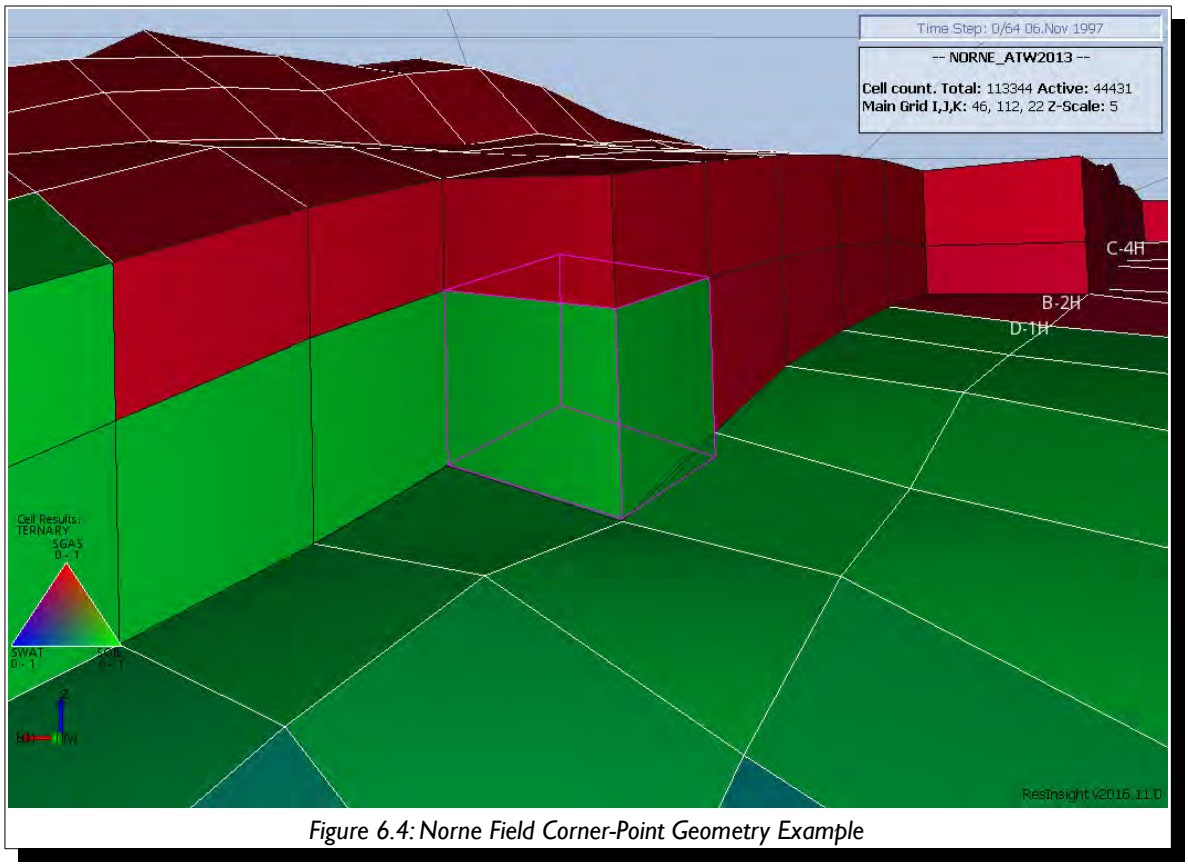

Figure 6.4: Norne Field Corner-Point Geometry Example

```
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.

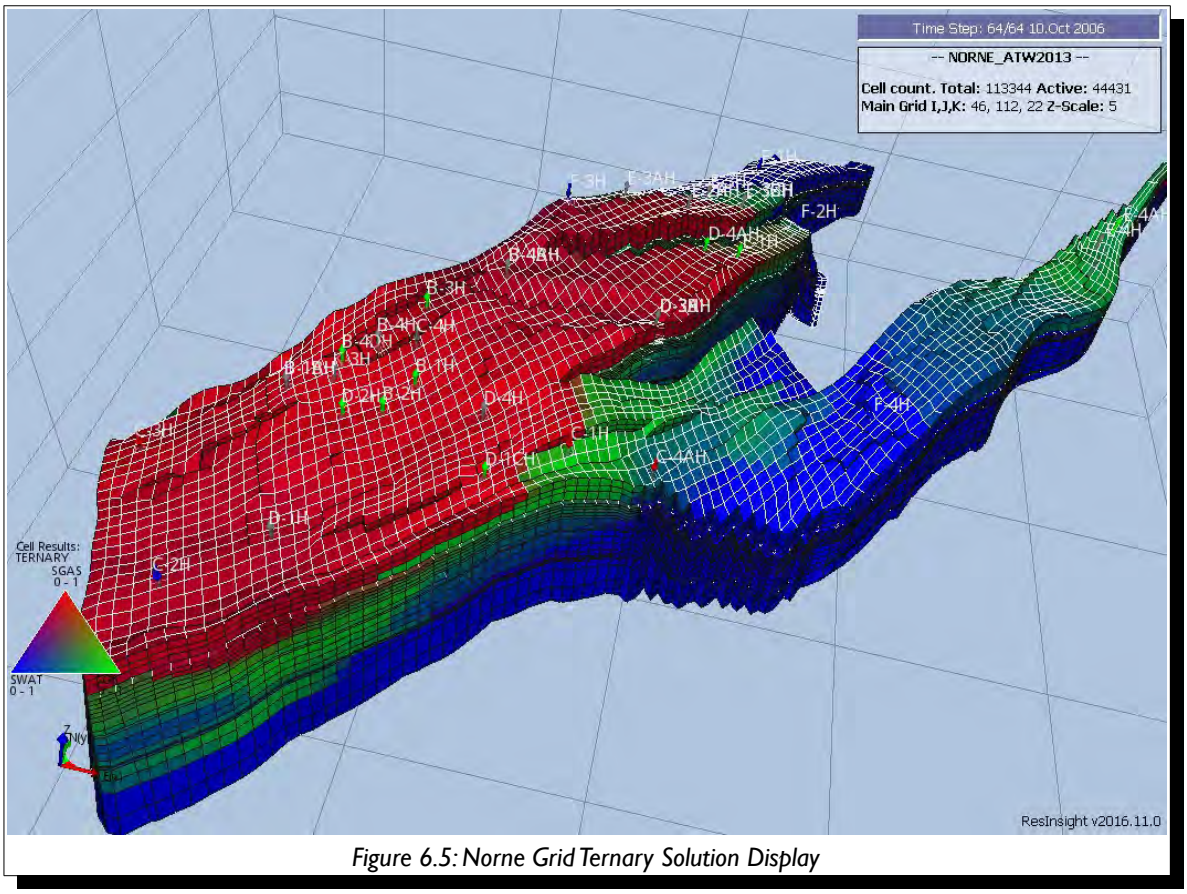

Figure 6.5: Norne Grid Ternary Solution Display

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 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:

$$T_{x_{i+\frac{1}{2},\ j}} = \left[\frac{k_x\ h\ (\Delta y)}{\mu\ (\Delta x)}\right]_{i+\frac{1}{2},\ j} \tag{6.2}$$

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

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 the 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

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		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.6: ADDREG Keyword Applicable Arrays by Section

Examples

```
--
-- 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 AQUANCON – DEFINE ANALYTICAL CONNECTIONS TO THE GRID

Description

AQUANCON keyword defines how analytical aquifers are connected to the simulation grid., this includes Carter-Tracy and Fetkovich analytical aquifers, although the Carter-Tracy aquifer is the only aquifer currently 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 grid 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 grid 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 grid 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 grid 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 grid 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 grid 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.

6.3.5 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 but is documented here for completeness.

6.3.6 AQUCT – DEFINE CARTER-TRACY ANALYTICAL AQUIFERS

Description

The AQUCT keyword defines Carter-Tracy 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

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:

```
--
--                        CARTER-TRACY AQUIFER DESCRIPTION
--
--       ID   DATUM   AQF    AQF    AQF    AQF     AQF   AQF   INFL   PVT  AQU
--       NUM  DEPTH   PRESS  PERM   PORO   RCOMP   RET   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.

6.3.7 AQUNUM – NUMERICAL AQUIFER ASSIGNMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

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

6.3.8 BOX - DEFINE A RANGE OF GRID BLOCKS TO ENTER PROPERTY DATA

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 data elements 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.

6.3.9 CARFIN – DEFINE A CARTESIAN LOCAL GRID REFINEMENT

Description

CARFIN defines a Cartesian local grid refinement ("LGR") in a cell or a group of cells in the main model.

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

6.3.10 CIRCLE – COMPLETION OF RADIAL GRID CIRCLE ACTIVATION

Description

CIRCLE activates the completion of the circle for a radial grid by generating non-neighboring connections between the first and last cells in the radial plane and for all layers in the model. This is only activated if the radial grid extends 360 degrees in the radial plane. 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.

6.3.11 COALNUM – DEFINE THE COAL REGION NUMBERS

Description

The COALNUM keyword defines the coal region numbers for each grid block used with the coal bed methane option. OPM Flow does not have a coal bed methane option and therefore this keyword is ignored by OPM Flow; however, it is documented here for completeness.

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 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 6.10: COALNUM Keyword Description

Example

The example below sets three COALNUM regions for a 4 x 5 x 2 model.

```
COALNUM

2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1

3 3 1 1 # layer 2
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.

6.3.12 COORD – DEFINE A SET OF COORDINATES LINES FOR A RESERVOIR GRID

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 6.11: 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.

6.3.13 COORDSYS – DEFINE COORDINATE GRID OPTIONS

Description

This keyword sets various options for when multiple grid system are being used.

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

6.3.14 COPY – COPY ARRAY DATA TO ANOTHER ARRAY

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 6.12: COPY Keyword Description

The applicable arrays for each section are defined in Table 6.13 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 6.13: 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.

6.3.15 COPYREG – COPY AN ARRAY TO ANOTHER ARRAY BASED ON A REGION NUMBER

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.

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 6.14: COPYREG Keyword Description

The applicable arrays for each section are defined in Table 6.15 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 6.15: 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
     'PERMZ'     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.

6.3.16 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.

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 6.16: DR Keyword Description

See also the DRV, DTHETAV, DZ and TOPS keywords in the GRID section to fully define a radial grid model.

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

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.

6.3.17 DRV - DEFINE THE SIZE OF GRID BLOCKS IN THE R DIRECTION VIA A VECTOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DRV[23] 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.

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 6.17: DRV Keyword Description

See also the DR, DTHETAV, DZ and TOPS keywords in the GRID section to fully define a radial grid model.

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
/--
--        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.

[23] *Radial grids are not currently implemented in OPM Flow version 2018-04 but is expected to be incorporated in a future release.*

6.3.18 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.

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 6.18: DTHETA Keyword Description

See also the DRV, DTHETAV, DZ and TOPS keywords in the GRID section to fully define a radial grid model.

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

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.

6.3.19 DTHETAV - SETS THE SIZE OF GRID BLOCKS IN THETA DIRECTION VIA A VECTOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

DTHETAV[24] 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.

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 6.19: DTHETA Keyword Description

See also the DRV, DZV and TOPS keywords to fully define a radial grid model.

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

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.

[24] *Radial grids are not currently implemented in OPM Flow version 2018-04 but is expected to be incorporated in a future release.*

6.3.20 DUMPFLUX – ACTIVATE WRITING OUT OF A FLUX FILE

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.

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.

6.3.21 DX - DEFINE THE SIZE OF GRID BLOCKS IN THE X DIRECTION FOR ALL CELLS

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 6.20: 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.

6.3.22 DXV - DEFINE THE SIZE OF GRID BLOCKS IN THE X DIRECTION VIA A VECTOR

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 6.21: 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.

6.3.23 DY - DEFINE THE SIZE OF GRID BLOCKS IN THE Y DIRECTION FOR ALL CELLS

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 6.22: 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.

6.3.24 DYV - DEFINE THE SIZE OF GRID BLOCKS IN THE Y DIRECTION VIA A VECTOR

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 6.23: 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.

6.3.25 DZ - DEFINE THE SIZE OF GRID BLOCKS IN THE Z DIRECTION FOR ALL CELLS

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 6.24: 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.

6.3.26 DZV - DEFINE THE SIZE OF GRID BLOCKS IN THE Z DIRECTION VIA A VECTOR

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 6.25: 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.

6.3.27 ENDBOX – DEFINE THE END OF THE BOX DEFINED GRID

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.

6.3.28 ENDFIN – END THE DEFINITION OF A LOCAL GRID REFINEMENT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

ENDFIN defines the end of a Cartesian or radial local grid refinement ("LGR") definition and a LGR property definition data set.

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.

6.3.29 EQUALREG – SETS AN ARRAY TO A CONSTANT BY REGION NUMBER

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.

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 6.26: EQUALREG Keyword Description

The applicable arrays for each section are defined in Table 6.27 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 6.27: EQUALREG Keyword Applicable Arrays by Section

Examples

```
-- 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.

6.3.30 EQUALS – SETS A SPECIFIED ARRAY TO A CONSTANT

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 6.28: EQUALS Keyword Description

The applicable arrays for each section are defined in Table 6.29 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 6.29: EQUALS Keyword Applicable Arrays by Section

Examples

```
--
-- -- 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 above example resets the PERMX, PERMY and PERMZ, arrays to 0.10, 0.10, and 0.01 for all cells in layer five, respectively.

6.3.31 FAULTS – DEFINE FAULTS IN THE GRID GEOMETRY

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 6.30: 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'                    /
……..
/
```

6.3.32 FILEUNIT – ACTIVATE UNIT CONSISTENCY CHECKING

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 6.31: FILEUNIT Keyword Description

OPM Flow's behaviour is controllable through the "UNIT_SYSTEM_MISMATCH" environment variable. The default behaviour 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.

6.3.33 FLUXNUM – DEFINE THE FLUX REGIONS

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

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 6.32: FLUXNUM Keyword Description

Examples

The example below sets three FLUXNUM regions for a 4 x 5 x 2 model.

```
FLUXNUM

2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1

3 3 1 1 # layer 2
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
/
```

6.3.34 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.

6.3.35 GDFILE – LOAD A GRID FILE

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 6.33: 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'  /
```

6.3.36 GDORIENT - DEFINE GRID ORIENTATION PARAMETERS

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.

6.3.37 GRID - DEFINE THE START OF THE GRID SECTION OF KEYWORDS

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.

6.3.38 GRIDFILE – SET THE GRID FILE OUTPUT OPTIONS

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: 1) - for no GRID file to be written out. 2) - for the standard GRID file to be written out. 3) - 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 6.34: 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

6.3.39 GRIDUNIT – DEFINE THE GRID UNITS

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 6.35: GRIDUNIT Keyword Description

Example

```
--
--       SET THE GRID UNITS FOR THE GRID
--
GRIDUNIT
         METRES                                                    /
```

The above example defines that the GRID units to be metric.

6.3.40 HEATCR – DEFINE RESERVOIR ROCK HEAT CAPACITY FOR ALL CELLS

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 6.36: 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)
--
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.

6.3.41 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 6.37: 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)
--
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.

6.3.42 INIT – ACTIVATE THE INIT FILE OPTION

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 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 and when activated the binary form of the file is used

There is no data required 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.

6.3.43 INRAD – DEFINE THE INNER RADIUS OF A RADIAL GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

INRAD[25] 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 6.38: 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.

[25] *Radial grids are not currently implemented in OPM Flow version 2018-04 but is expected to be incorporated in the next release.*

6.3.44 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 6.39: 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.

6.3.45 JFUNC - ACTIVATE THE LEVERETT J-FUNCTION OPTION

Description

JFUNC keyword activates Leverett-J-Function[26] 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.

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

[26] *Leverett, M. C.; "Capillary Behaviour in Porous Solids", Trans. AIME (1941) 142, 152-168.*

No.	Name	Description	Default
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.	XY
Notes: 1) The keyword is terminated by "/".			

Table 6.40: 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[27], 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:

[27] *Leverett, M. C.; "Capillary Behaviour in Porous Solids", Trans. AIME (1941) 142, 152-168.*

$$J\left(S_w\right) = \frac{P_{c,res}\left(S_w\right)\left(\frac{k^{\beta}}{\varphi^{\alpha}}\right)}{\sigma} \quad (6.7)$$

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.

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 a J-Functions, and that the J-Function s 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.

6.3.46 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 6.41: 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.

6.3.47 MAPUNITS – DEFINE THE MAP AXES UNITS

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.

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 6.42: 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.

6.3.48 MAXVALUE – SETS A MAXIMUM VALUE FOR AN ARRAY ELEMENT

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 6.43: MAXVALUE Keyword Description

The applicable arrays for each section are defined in Table 6.44 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 6.44: MAXVALUE Keyword Applicable Arrays by Section

Example

```
--
--        -- ARRAY     CONSTANT --   ---------- BOX ---------
--                                    I1  I2    J1  J2    K1  K2
MAXVALUE
          'PERMX'      1.0E2         1*  1*    1*  1*    5   5   / MAXIMUM PERMX
          'PERMY'      1.0E2         1*  1*    1*  1*    5   5   / MAXIMUM PERMY
          'PERMZ'      1.0E1         1*  1*    1*  1*    5   5   / MAXIMUM 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.

6.3.49 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 mode (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	MPVTHRES	MPVTHRES is a real positive number that defines the minimum pore volume for a cell to be active in the model.			
		rb	rm^3	rcc	
		1.0e-6	1.0e-6	1.0e-6	Defined
Notes: 1) The keyword is terminated by "/".					

Table 6.45: 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.

6.3.50 MINPVV – SET A MINIMUM GRID BLOCK PORE VOLUME THRESHOLD FOR INDIVIDUAL CELLS

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 1.0e-6	rm^3 1.0e-6	rcc 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 6.46: 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.

6.3.51 MINVALUE – SET A MINIMUM VALUE FOR AN ARRAY ELEMENT

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 6.47: MINVALUE Keyword Description

The applicable arrays for each section are defined in Table 6.48 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 6.48: MINVALUE Keyword Applicable Arrays by Section

Example

```
--
--        -- ARRAY     CONSTANT --   ---------- BOX ---------
--                                    I1   I2    J1   J2    K1   K2
MINVALUE
          'PERMX'      1.0E1         1*   1*    1*   1*    5    5   / MAXIMUM PERMX
          'PERMY'      1.0E1         1*   1*    1*   1*    5    5   / MAXIMUM PERMY
          'PERMZ'      1.0E-1        1*   1*    1*   1*    5    5   / MAXIMUM 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.

6.3.52 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 6.49: 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.

6.3.53 MULTIPLY – MULTIPLY A SPECIFIED ARRAY BY A CONSTANT

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 6.50: MULTIPLY Keyword Description

The applicable arrays for each section are defined in Table 6.51 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 6.51: 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.

6.3.54 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 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 6.52: MULTIREG Keyword Description

The applicable arrays for each section are defined in Table 6.53 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		
DZNET				SPOLY		
PORO						
NTG						
FLUXNUM						
MULTNUM						
MPANUM						
DIFFX						
DIFFY						
DIFFZ						
DIFFR						
DIFFTHT						

Table 6.53: 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.

6.3.55 MULTNUM – DEFINE THE MULTIPLE TRANSMISSIBILITY REGIONS

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 6.54: MULTNUM Keyword Description

Examples

The example below sets three MULTNUM regions for a 4 x 5 x 2 model.

```
MULTNUM

2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1
3 3 1 1 # layer 2
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               /
/
```

6.3.56 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 6.55: 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.

6.3.57 MULTREGP– MULTIPLY PORE VOLUMES BASED ON REGION NUMBER

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 NUMBER	REGION NUMBER 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	REGION ARRAY	The REGION ARRAY to use for applying the CONSTANT in (2) based on the REGION NUMBER in (1). 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 6.56: 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.

6.3.58 MULTREGT– MULTIPLY TRANSMISSIBILITIES BETWEEN REGIONS

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.	0
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
	TYPE	A character string that defines the type of connections the transmissibility multiplier should be applied to, should be one of the following: 1) NNC – Only apply the transmissibility multiplier between REGION1 and REGION2 to non-neighbor connections. 2) NONNC – Do not apply the transmissibility multiplier between REGION1 and REGION2 to non-neighbor connections. 3) ALL - Apply the transmissibility multiplier between REGION1 and REGION2 to all connections.	ALL
4	REGION ARRAY	The REGION ARRAY to use for applying the CONSTANT in (2) based on the REGION NUMBER in (1). 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 6.57: MULTREGT Keyword Description

Example

```
--
-- 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
/
```

The above example isolates all regions from one another by setting the transmissibility for the MULTNUM regions to zero for all directions and for connections types.

6.3.59 MULTX - MULTIPLY CELL TRANSMISSIBILITY IN THE +X DIRECTION

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 6.58: MULTX Keyword Description

See also the MULTX-, MULTY, MULTY-, MULTZ and MULTZ- keywords for scaling transmissible between grid cells.

Examples

```
--
--       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.

6.3.60 MULTX- - MULTIPLY CELL TRANSMISSIBILITY IN THE -X DIRECTION

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 6.59: MULTX- Keyword Description

See also the MULTX, MULTY, MULTY-, MULTZ and MULTZ- keywords for scaling transmissible between grid cells.

Examples

```
--
--       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.

6.3.61 MULTY - MULTIPLY CELL TRANSMISSIBILITY IN THE +Y DIRECTION

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 6.60: MULTY Keyword Description

See also the MULTY-, MULTX, MULTX-, MULTZ and MULTZ- keywords for scaling transmissible between grid cells.

Examples

```
--
--       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.

6.3.62 MULTY- - MULTIPLY CELL TRANSMISSIBILITY IN THE -Y DIRECTION

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 6.61: MULTY- Keyword Description

See also the MULTY, MULTX, MULTX-, MULTZ and MULTZ- keywords for scaling transmissible between grid cells.

Examples

```
--
--       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.

6.3.63 MULTZ - MULTIPLY CELL TRANSMISSIBILITY IN THE +Z DIRECTION

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 6.62: MULTZ Keyword Description

See also the MULTZ-, MULTX, MULTX-, MULTY and MULTY- keywords for scaling transmissible between grid cells.

Examples

```
--
--       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.

6.3.64 MULTZ- - MULTIPLY CELL TRANSMISSIBILITY IN THE -Z DIRECTION

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 6.63: MULTZ- Keyword Description

See also the MULTZ, MULTX, MULTX-, MULTY and MULTY- keywords for scaling transmissible between grid cells.

Examples

```
--
--       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.

6.3.65 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.

Example

```
--
--       ACTIVATE IRREGULAR CORNER-POINT GRID TRANSMISSIBILITIES
--
NEWTRAN
```

The above example manually activates Irregular Corner-Point Grid transmissibility calculations.

6.3.66 NNC – DEFINE NON-NEIGHBOR CONNECTIONS BETWEEN CELLS MANUALLY

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 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 iin 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). 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 6.64: 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.

6.3.67 NOGGF – DEACTIVATE OUTPUT OF GRID GEOMETRY FILE

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.

6.3.68 NTG – DEFINE THE NET-TO-GROSS RATIO FOR ALL THE CELLS

Description

NTG defines the Net-to-Gross Ratio ("NTG") for all the cells in the model via an array. The keyword can be used for 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 6.65: NTG Keyword Description

See also the PORO, PERMX, PERMY and PERMX 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.

6.3.69 OLDTRAN – ACTIVATE CARTESIAN REGULAR GRID TRANSMISSIBILITIES

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.

Example

```
--
--       ACTIVATE CARTESIAN REGULAR GRID TRANSMISSIBILITIES
--
OLDTRAN
```

The above example manually activates Cartesian Regular Grid transmissibility calculations.

6.3.70 OPERATE – DEFINE MATHEMATICAL OPERATIONS ON ARRAYS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the 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.

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

6.3.71 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.

6.3.72 OPERNUM – DEFINE REGIONS FOR MATHEMATICAL OPERATIONS ON ARRAYS

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.

6.3.73 OUTRAD - DEFINE THE OUTER RADIUS OF A RADIAL GRID

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

OUTRAD[28] 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 6.66: 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:

$$\frac{R_i}{R_{i-1}} = \left(\frac{OUTRAD}{R_{i_j-1}}\right)^{\frac{1}{(NX - i_j + 1)}} \tag{6.8}$$

or

$$R_i = \left(R_{i_j-1}\right)\left(\frac{OUTRAD}{R_{i_j-1}}\right)^{\frac{(i - i_j + 1)}{(NX - i_j + 1)}} \tag{6.9}$$

and the DR value for the i^{th} cell, that is the value that can also be manually entered on the DR keyword in the GRID section, is given by:

$$DR_i = R_i - R_{i-1} \tag{6.10}$$

Where:

DR_i = DR value for the i^{th} 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 6.67 shows the grid size calculations.

[28] *Radial grids are not currently implemented in OPM Flow version 2018-04 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 6.67: 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.

6.3.74 PERMR – DEFINE THE PERMEABILITY FOR EACH CELL IN THE R DIRECTION

Description

PERMR[29] 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.

[29] *Radial grids are not currently implemented in this version of OPM Flow but are expected to be incorporated in a future release.*

6.3.75 PERMTHT – DEFINE THE PERMEABILITY FOR EACH CELL IN THE THETA DIRECTION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

PERMTHT[30] 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.

[30] *Radial grids are not currently implemented in this version of OPM Flow but are expected to be incorporated in a future release.*

6.3.76 PERMX - DEFINE THE PERMEABILITY IN THE X DIRECTION FOR ALL THE CELLS

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 6.68: 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.

6.3.77 PERMXX – DEFINE THE PERMEABILITY TENSOR IN THE XX DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the permeability tensor off-diagonal values for the XX direction.

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

6.3.78 PERMXY – DEFINE THE PERMEABILITY TENSOR IN THE XY DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the permeability tensor off-diagonal values for the XY direction.

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

6.3.79 PERMY - DEFINE THE PERMEABILITY IN THE Y DIRECTION FOR ALL THE CELLS

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 6.69: 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.

6.3.80 PERMYY – DEFINE THE PERMEABILITY TENSOR IN THE YY DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the permeability tensor off-diagonal values for the YY direction.

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

6.3.81 PERMYZ – DEFINE THE PERMEABILITY TENSOR IN THE YZ DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the permeability tensor off-diagonal values for the YZ direction.

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

6.3.82 PERMZ - DEFINE THE PERMEABILITY IN THE Z DIRECTION FOR ALL THE CELLS

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 6.70: 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.

6.3.83 PERMZX – DEFINE THE PERMEABILITY TENSOR IN THE ZX DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the permeability tensor off-diagonal values for the ZX direction.

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

6.3.84 PERMZZ – DEFINE THE PERMEABILITY TENSOR IN THE ZZ DIRECTION FOR ALL THE CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the permeability tensor off-diagonal values for the ZZ direction.

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

6.3.85 PINCH – DEFINE PINCH-OUT LAYER OPTIONS

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 6.71: 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
   1*          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.

6.3.86 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.

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 6.72: PINCHNUM Keyword Description

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate, but it is documented here for completeness.

Examples

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.

6.3.87 PINCHREG - DEFINE PINCH-OUT REGION OPTIONS

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 6.73: 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.

6.3.88 PORO - DEFINE THE POROSITY VALUES FOR ALL THE CELLS

Description

PORO defines the porosity for all the cells in the model via an array. The keyword can be used for 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 6.74: 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.

6.3.89 RADFIN – DEFINE A RADIAL LOCAL GRID REFINEMENT WITH ONE COLUMN

Description

This keyword defines the a radial local grid refinement using one columns Local grid refinement is currently not supported by OFM Flow.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate, but it is documented here for completeness.

6.3.90 RADFIN4 – DEFINE A RADIAL LOCAL GRID REFINEMENT WITH FOUR COLUMNS

Description

This keyword defines the 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.

6.3.91 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 but is documented here for completeness.

6.3.92 RPTGRID – DEFINE GRID SECTION REPORTING

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 6.75: 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                  /
```

6.3.93 SPECGRID- DEFINE THE DIMENSIONS OF A CORNER-POINT GRID

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 6.76: 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 the a 46 x 112 x 22 grid with one set of irregular corner-point data.

6.3.94 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 for 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 6.77: 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.

6.3.95 THCGAS – DEFINE GAS PHASE THERMAL CONDUCTIVITY FOR ALL CELLS

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 6.78: 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:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - PORO) \times THCROCK \quad \textbf{(6.11)}$$

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.

6.3.96 THCOIL – DEFINE OIL PHASE THERMAL CONDUCTIVITY FOR ALL CELLS

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 6.79: 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:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - \text{PORO}) \times \text{THCROCK} \quad \textbf{(6.12)}$$

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.

6.3.97 THCONR – DEFINE ROCK AND FLUID THERMAL CONDUCTIVITY FOR ALL CELLS

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 6.80: 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.

6.3.98 THCONSF – DEFINE GAS SATURATION DEPENDENT THERMAL CONDUCTIVITY SCALING FACTOR FOR ALL CELLS

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 6.81: 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:

$$\Omega_{i,j,k} = \left(1 - \text{THCONSF x Gas Saturation}\right)_{i,j,k} \quad \textbf{(6.13)}$$

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)
--
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.

6.3.99 THCROCK – DEFINE RESERVOIR ROCK THERMAL CONDUCTIVITY FOR ALL CELLS

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 6.82: 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:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - PORO) \times THCROCK \quad \textbf{(6.14)}$$

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.

6.3.100 THCSOLID – DEFINE SOLID PHASE THERMAL CONDUCTIVITY FOR ALL CELLS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The THCSOLID keyword defines the solid phase thermal conductivity for when the thermal calculation is activated by the THERMAL keyword in the RUNSPEC section in the commercial simulator. THCSOLID should be used in conjunction with THCROCK keyword in the GRID section.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate.

This keyword can only be used if the thermal option has been activated by the THERMAL keyword in the RUNSPEC section in the commercial simulator.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	THCSOLID	THCSOLID is an array of real positive numbers that define the thermal conductivity of the solid 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 6.83: THCSOLID Keyword Description

The THSOLID data is used in conjunction with the other thermal conductivity arrays to calculate the porosity weighted thermal conductivity of a grid block using:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - PORO) \times THCROCK \qquad (6.15)$$

See also the THCGAS, THCOIL, THCWATER and THCROCK keywords in the GRID section.

Example

```
--
--       DEFINE GRID BLOCK RESERVOIR SOLID PHASE THERMAL CONDUCTIVITY
-        FOR ALL CELLS (BASED ON NX x NY x NZ = 300)
--
THSOLID
         300*20.0                                                    /
```

The above example defines the solid 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.

6.3.101 THCWATER – DEFINE WATER PHASE THERMAL CONDUCTIVITY FOR ALL CELLS

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 6.84: 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:

$$\text{Average Thermal Conductivity} = \frac{PORO \times (THCOIL + THCGAS + THCWATER + THCSOLID)}{\text{NUMBER OF PHASES IN THE MODEL}} \times (1 - PORO) \times THCROCK \quad \textbf{(6.16)}$$

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.

6.3.102 THPRESFT - DEFINE FAULT THRESHOLD PRESSURES

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 6.85:THPRESFT Keyword Description

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 included in a future release.

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                                                     /
      /
```

6.3.103 TOPS - DEFINE THE DEPTH AT THE CENTER OF THE TOP FACE FOR EACH CELL

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 6.86: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 ALL LAYERS (BASED ON NX = 5, NY = 5, NZ = 3)
--
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                                                                     /
```

The next 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 (BASED ON 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                                                                     /
```

6.3.104 ZCORN – DEFINE THE DEPTH OF EACH CORNER-POINT OF A GRID BLOCK

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 uses 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 6.87: 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.

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 indicitive 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[31] field is shown in Figure 7.1 and Figure 7.2 illustrates the model's transmissibility in the x-direction (TRANX).

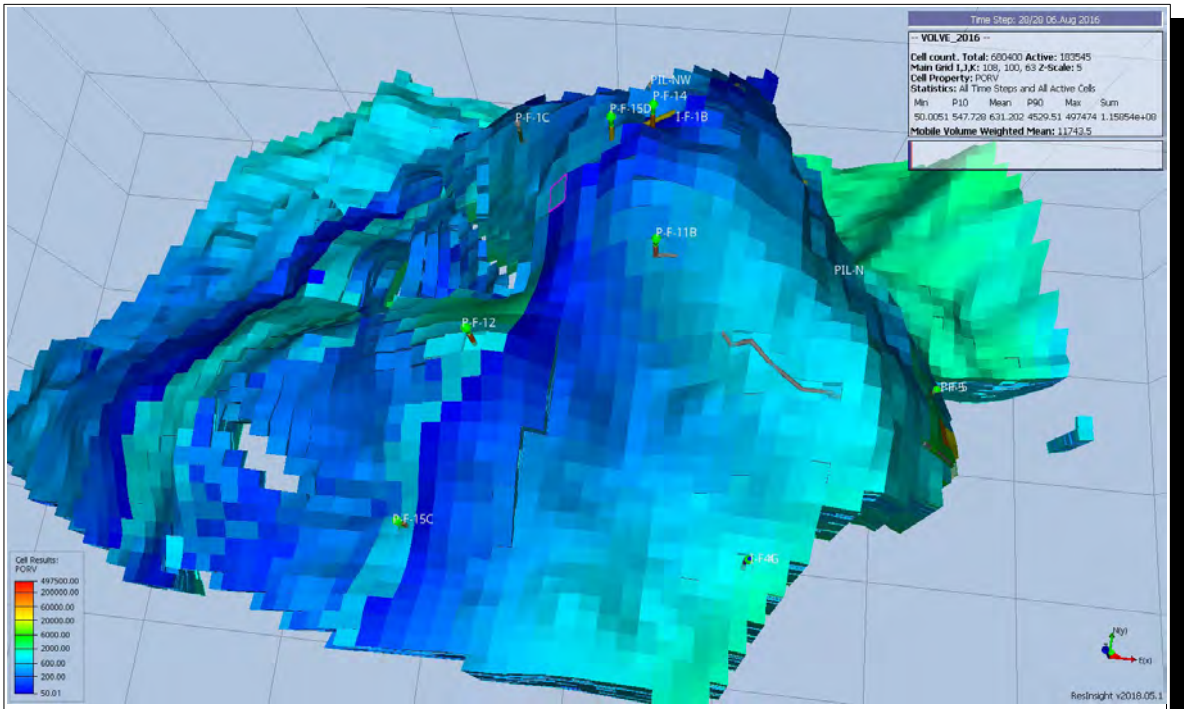

Figure 7.1: Volve Full Field Model PORV Array

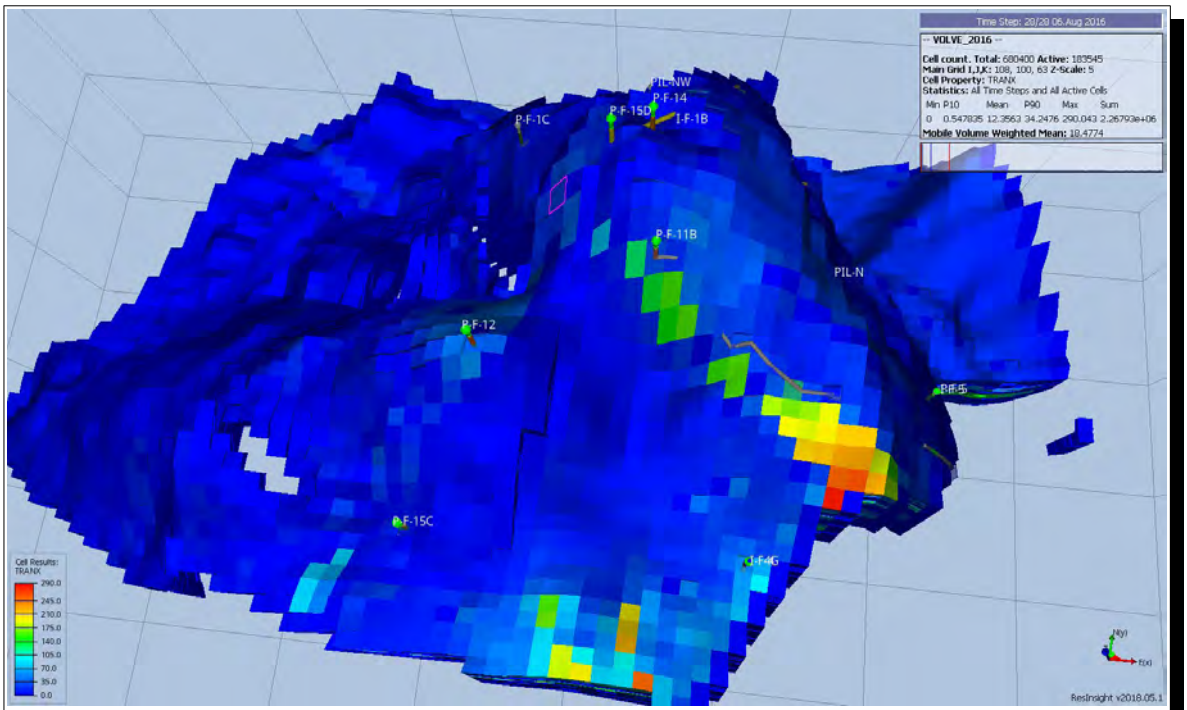

Figure 7.2: Volve Full Field Model TRANX Array

[31] *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 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.

7.3.4 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.

7.3.5 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.

7.3.6 DEPTH - EDITS THE DEPTH AT THE CENTER OF EACH CELL

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.

```
--   ---------- BOX ---------
--   I1  I2   J1  J2   K1  K2
BOX
      1  10   11  11   20  20 / SET BOX AREA TO BE MODIFIED
/
--  DEFINE GRID BLOCK X DIRECTION CELL SIZE (BASED ON NX = 5)
--
DEPTH
  10*3500.0                                                                  /
--
--   ---------- BOX ---------
--   I1  I2   J1  J2   K1  K2
BOX
     1*  1*   1*  1*   1*  1* / RESET BOX DEFAULTS
/
```

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
/
```

7.3.7 EDIT - DEFINE THE START OF THE EDIT SECTION OF KEYWORDS

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.

7.3.8 EDITNNC – SCALE NON-NEIGHBOR CONNECTIONS BETWEEN CELLS MANUALLY

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
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.

7.3.9 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.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate.

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

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 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.

7.3.10 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.

7.3.11 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.

7.3.12 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.

7.3.13 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.

7.3.14 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.

7.3.15 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.

7.3.16 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.

7.3.17 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.

7.3.18 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.

7.3.19 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.

7.3.20 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.

7.3.21 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.

7.3.22 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.

7.3.23 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.

7.3.24 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.

7.3.25 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.

7.3.26 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.

7.3.27 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.

7.3.28 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.

7.3.29 OPERATE – DEFINE MATHEMATICAL OPERATIONS ON ARRAYS

This keyword defines the 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.

See *OPERATE – Define Mathematical Operations on Arrays* in the GRID section for a full description.

7.3.30 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.

7.3.31 PORV - DEFINE THE PORE VOLUMES FOR ALL THE CELLS

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 7.5: 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.

7.3.32 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.

7.3.33 TRANX - DEFINE THE TRANSMISSIBILITY IN THE X DIRECTION FOR ALL THE CELLS

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 tranmissibility 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 7.6: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.

7.3.34 TRANY - DEFINE THE TRANSMISSIBILITY IN THE Y DIRECTION FOR ALL THE CELLS

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.			
		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: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.

7.3.35 TRANZ - DEFINE THE TRANSMISSIBILITY IN THE Z DIRECTION FOR ALL THE CELLS

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 7.8: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.

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.

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.

8.2.1 FLUID PROPERTY TABLES

Table 8.1 outlines the various fluid types that can be active in the model, together with the associated RUNSPEC section keywords that activate the phases, versus the PVT keywords that can be used to define the PVT behavior.

Fluid Property Keywords Versus Fluid Type							
Item	**Oil**		**Gas**		**Water**	**Polymer** **Solvent**	
Fluid Type	Dead Oil	Live Oil	Dry Gas	Wet Gas	Water	Polymer	Solvent
RUNSPEC Keywords	OIL	OIL DISGAS	GAS	GAS VAPOIL	WATER	POLYMER	SOLVENT
Pressure Dependent PVT	PVCDO PVDO	PVCO PVTO	PVDG PVZG	PVTG	PVTW		PVDS
Pressure Independent PVT	RSCONST RSCONSTT		RVCONST RVCONSTT				
Surface Density	DENSITY GRAVITY						SDENSITY
Polymer						PLYADS PLYROCK PLYVISC PLMIXPAR PLYMAX PLYSHLOG	

Fluid Property Keywords Versus Fluid Type							
Item	**Oil**		**Gas**		**Water**	**Polymer** **Solvent**	
Fluid Type	Dead Oil	Live Oil	Dry Gas	Wet Gas	Water	Polymer	Solvent

Notes:

1) Currently the GRAVITY, PVZG, RSCONST, RSCONSTT, RVCONST, and RVCONSTT keywords are not supported in OPM Flow.
2) When two keywords are stated for a given fluid type then either one can be used to define the PVT behavior for the given phase.
3) 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.
4) 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.

Table 8.1: Fluid Property Keywords versus Fluid Type

In addition to the above the ROCK keyword should be used to define the rock compressibility.

Typical live oil and dry gas PVT data is from the Volve[32] field is shown in Figure 8.1 and Figure 8.2, respectively.

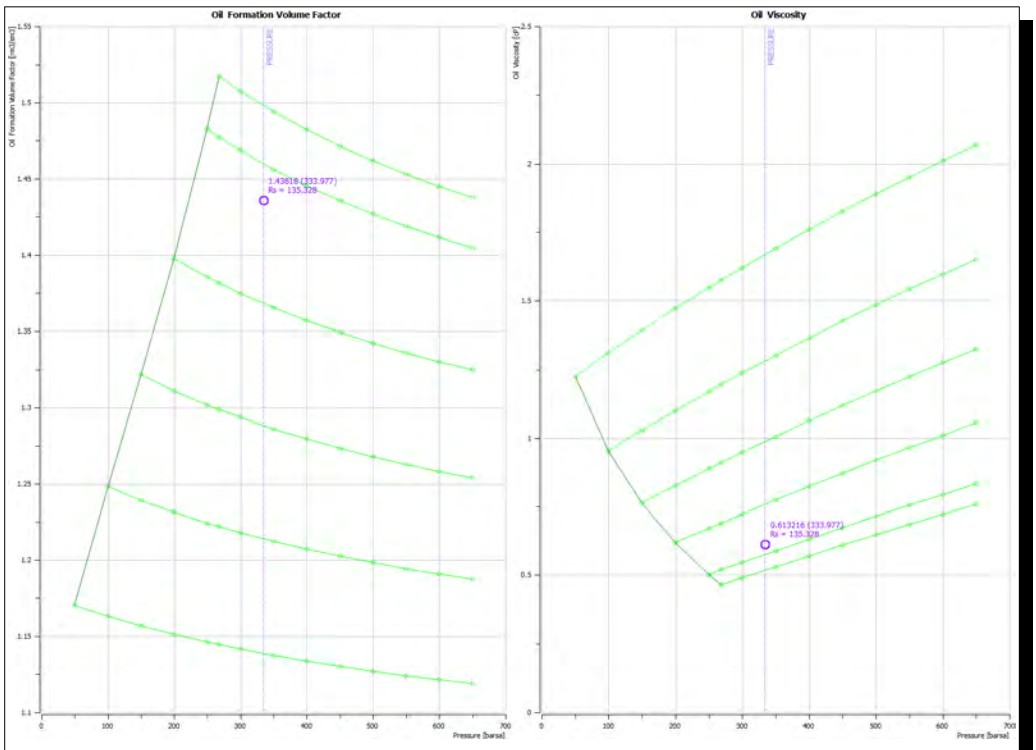

Figure 8.1: Volve Field Live Oil PVT Data

[32] *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.*

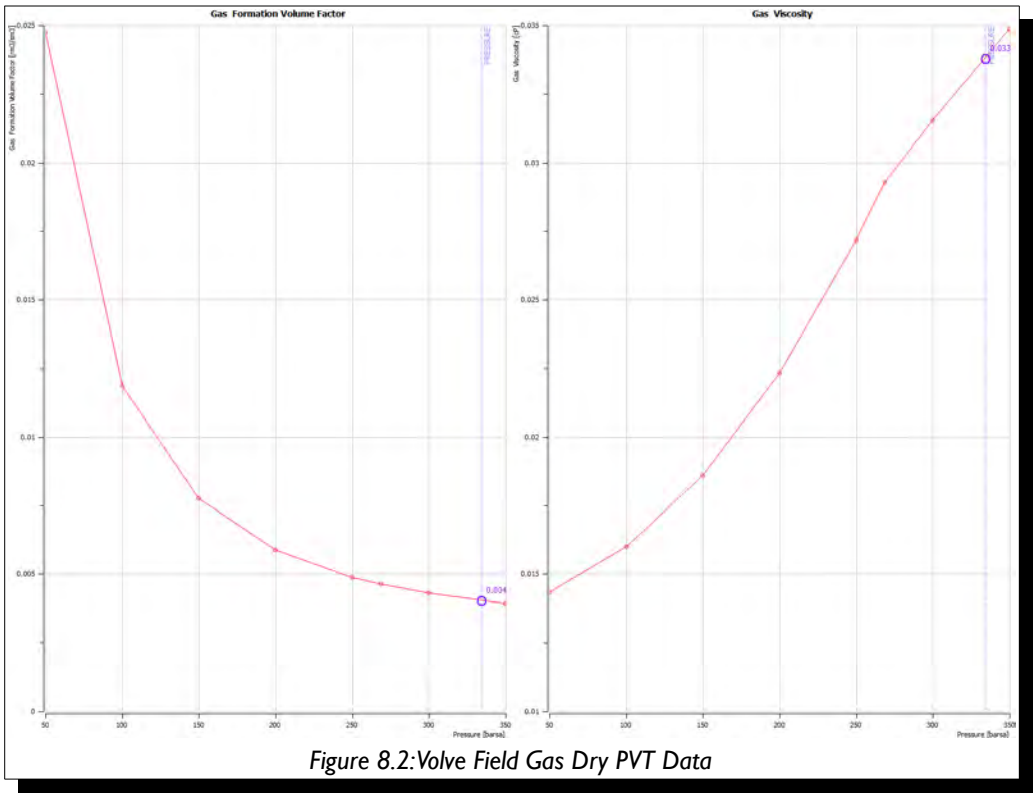

Figure 8.2:Volve Field Gas Dry PVT Data

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).

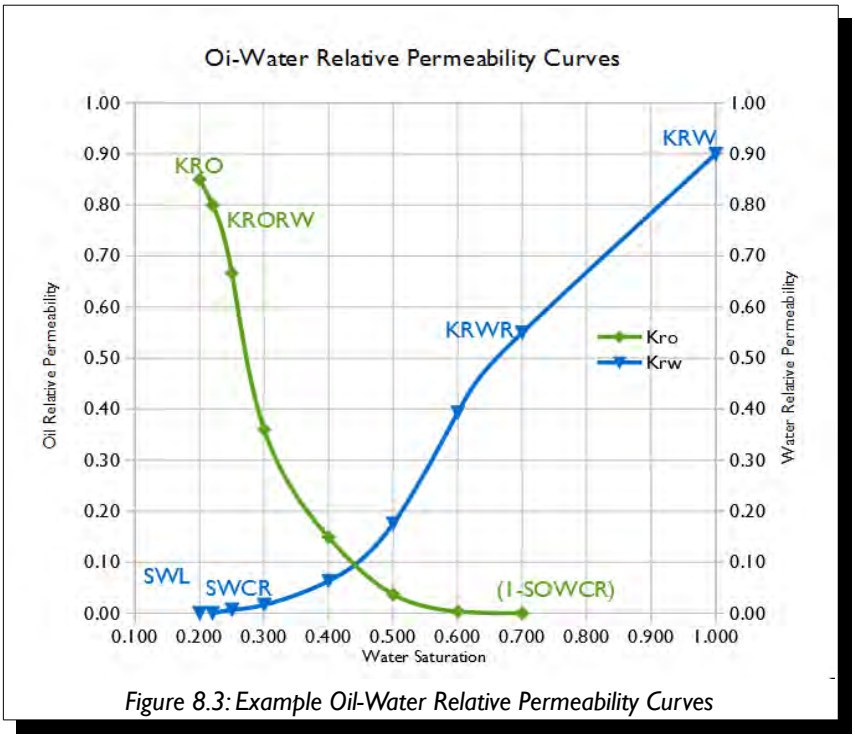

Figure 8.3: Example Oil-Water Relative Permeability Curves

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.

Table 8.2: 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).

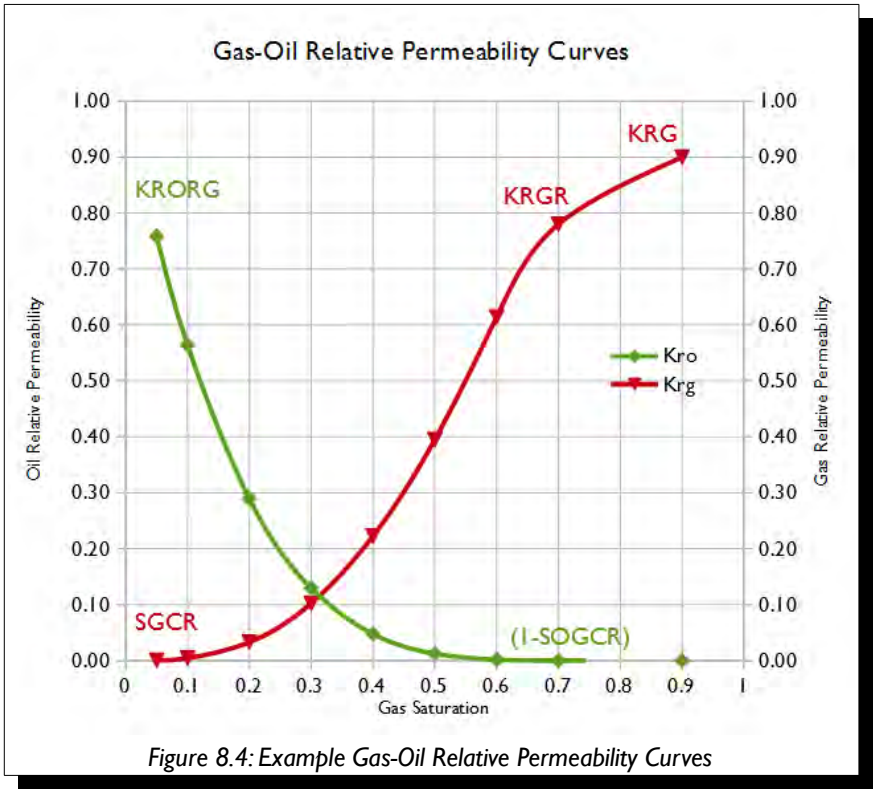

Figure 8.4: Example Gas-Oil Relative Permeability Curves

The gas-oil end-point definitions are outlined in the following table:

Type	End-Point Keyword	Gas-Oil End-Point Definitions
Saturation	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.

Table 8.3: 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 8.2 and Table 8.3 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) 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.
2) 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.
3) Defines oil in relative with respect to water and oil relative permeability with respect gas.

Table 8.4: 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 8.5: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 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

8.3.5 ASPKDAM – DEFINE ASPHALTENE PERMEABILITY DAMAGE

Description

This keyword defines the data required to model permeability damage, that is permeability reduction, due to the deposit of asphaltene coming out solution. This modeling option is not implemented in OPM Flow as this feature is normally incorporated in compositional simulators.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate.

8.3.6 ASPPW2D – DEFINE ASPHALTENE TWO PARAMETERS PRECIPITATION DATA

Description

This keyword defines the data required to model asphaltene precipitation case where the precipitation is a function of pressure and temperature based on the percentage molar weight of one or more specified components. The characterization is specified by the first item of the ASPHALTE keyword, and the component range is specified by the ASPFLOC keyword. This modeling option is not implemented in OPM Flow as this feature is normally incorporated in compositional simulators.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate.

8.3.7 ASPREWG -DEFINE ASPHALTENE AS PERCENTAGE WEIGHT

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

This keyword defines the data required to model asphaltene precipitation case where the precipitation is a function of pressure based on the percentage molar weight of one or more specified components. The characterization is specified by the first item of the ASPHALTE keyword, and the component range is specified by the ASPFLOC keyword. This modeling option is not implemented in OPM Flow as this feature is normally incorporated in compositional simulators.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate.

8.3.8 ASPWETF – DEFINE ASPHALTENE WETTABILITY FACTOR DATA

Description

This keyword defines the wettability factor as a function of asphaltene deposition. This modeling option is not implemented in OPM Flow as this feature is normally incorporated in compositional simulators.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate.

8.3.9 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

8.3.10 AQUTAB – DEFINE CARTER-TRACY AQUIFER INFLUENCE FUNCTIONS

Description

The AQUTAB keyword defines additional Carter-Tracy[33] 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[34], 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 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 8.6: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 8.7 to Table 8.10 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[35] 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: $r_D = \frac{r_e}{r_o}$.

[33] *Carter, R. D., and Tracy, G.W. "An Improved Method for Calculating Water Influx." Transactions of AIME, Vol. 219 (1060), pp 415-417.*

[34] *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.*

[35] *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 8.7: 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 8.8: 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 8.9: 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 8.10: Carter-Tracy Aquifer Influence Functions (R_D =10 and Finite Linear)

For the finite linear Carter-Tracy influence function in Table 8.10 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 8.11 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[36] 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 8.11: Carter-Tracy Infinite Radial Aquifer Influence Function (Default)

For an overview of analytical aquifers see Dake[37].

[36] *Bradley Howard B., et. al,, Petroleum Engineering Handbook, Society of Petroleum Engineers (June 1989), ISBN:9781555630102.*

[37] *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.

8.3.11 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.

8.3.12 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.

8.3.13 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.

8.3.14 DENSITY – DEFINE THE SURFACE OIL, WATER GAS DENSITIES FOR THE FLUIDS

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 8.12: DENSITY Keyword Description

According to the SPE SI standard[38], ***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.

See also the GRAVITY keyword.

[38] *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.

8.3.15 EHYSTR – DEFINE HYSTERESIS MODEL AND PARAMETERS

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[39] and Killough[40] 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.		

[39] *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).*

[40] *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 8.13: 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.

8.3.16 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.

8.3.17 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.

8.3.18 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 versus depth for the three phases. This functionality is not supported in OPM Flow.

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

8.3.19 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. This functionality is not supported in OPM Flow.

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

8.3.20 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.

8.3.21 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.

8.3.22 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.

8.3.23 FILLEPS – ACTIVATE SATURATION END-POINT EXPORT TO THE INIT FILE

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

There is no data required for this keyword.

This keyword is not supported by OPM Flow but is documented here for completeness.

Example

```
--
--       ACTIVATESATURATION 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.

8.3.24 GASDENT – DEFINE GAS DENSITY TEMPERATURE COEFFICIENTS

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 8.14: 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.

8.3.25 GASVISCT – DEFINE GAS VISCOSITY VERSUS TEMPERATURE FUNCTIONS

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 8.15: 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.

8.3.26 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.

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 8.16: GRAVITY Keyword Description

According to the SPE SI standard[41], ***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.

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.

[41] *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.

8.3.27 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. This functionality is not supported in OPM Flow.

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

8.3.28 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. This functionality is not supported in OPM Flow.

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

8.3.29 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 for all grid types.

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{IPCG}{P_{c_{TABLE-MAX}}} \right) \quad (8.1)$$

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 $S_g = 1 - S_{wco}$.

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 8.17: IPCG Keyword Description

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 a IPCG for 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.30 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 for all grid types.

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{IPCW}{P_{c_{TABLE-MAX}}} \right) \quad (8.2)$$

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).

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 8.18: IPCW Keyword Description

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 a IPCW for 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.31 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 for 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) Note this the non-direction dependent 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 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 8.19: 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 ALL 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.

8.3.32 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 for 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) Note this the non-direction dependent 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 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 8.20: 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.

8.3.33 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 for all grid types.

This feature is not available in OPM Flow; however it is documented here for completeness.

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) Note this the non-direction dependent 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 keyword should be used.

2) The keyword is terminated by "/".

Table 8.21: 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.

8.3.34 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 for 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) Note this the non-direction dependent 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 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 8.22: 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.

8.3.35 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 for 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) Note this the non-direction dependent 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 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 8.23: 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.

8.3.36 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 for 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) Note this the non-direction dependent 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 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 8.24: 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 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

8.3.37 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 for 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) Note this the non-direction dependent 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 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 8.25: 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.

8.3.38 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 for 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) Note this the non-direction dependent 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 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 8.26: 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.

8.3.39 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 for all grid types.

This feature is not available in OPM Flow; however it is documented here for completeness

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) Note this the non-direction dependent 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 keyword should be used.

2) The keyword is terminated by "/".

Table 8.27: 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.

8.3.40 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 for 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) Note this the non-direction dependent 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 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 8.28: 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.

8.3.41 KRG – END-POINT SCALING OF GRID CELL KRG(SGU) (DRAINAGE)

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 "/".

Table 8.29: 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:

$$k_{rg} = k_{rg\,TABLE}\left(\frac{KRG}{k_{rg\,TABLE-MAX}}\right) \quad \textbf{(8.3)}$$

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 8.30: 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 hysteresis 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
/
```

8.3.42 KRGR – END-POINT SCALING OF GRID CELL KRGR(1-SOGCR) (DRAINAGE)

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 KGRGT 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 "/".

Table 8.31: 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 8.32: 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 hysteresis 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
/
```

8.3.43 KRO – END-POINT SCALING OF GRID CELL KRO(SWL) (DRAINAGE)

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 "/".

Table 8.33: 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:

$$k_{ro} = k_{ro_{TABLE}} \left(\frac{KRO}{k_{ro_{TABLE-MAX}}} \right) \quad \textbf{(8.4)}$$

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 8.34: 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 hysteresis 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
/
```

8.3.44 KRORG – END-POINT SCALING OF GRID CELL KRO(SGCR) (DRAINAGE)

Description

KRORG defines the scaling parameter 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 "/".

Table 8.35: 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 8.36: 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 hysteresis 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
/
```

8.3.45 KRORW – END-POINT SCALING OF GRID CELL KRO(SWCR) (DRAINAGE)

Description

KRORW defines the scaling parameter 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 "/".

Table 8.37: 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 8.38: 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 hysteresis 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
/
```

8.3.46 KRW – END-POINT SCALING OF GRID CELL KRW(SW =1.0) (DRAINAGE)

Description

KRW defines the scaling parameter at the maximum drainage oil 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 "/".

Table 8.39: 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:

$$k_{rw} = k_{rw\,TABLE}\left(\frac{KRW}{k_{rw\,TABLE-MAX}}\right) \quad \textbf{(8.5)}$$

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 8.40: 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 hysteresis 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
/
```

8.3.47 KRWR – END-POINT SCALING OF GRID CELL KRWR(SW =1.0) (DRAINAGE)

Description

KRWR defines the scaling parameter at the maximum drainage oil 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	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 "/".

Table 8.41: 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 8.42: 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 hysteresis 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
/
```

8.3.48 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.

8.3.49 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.

8.3.50 MISC – DEFINE SOLVENT MISCIBILITY-IMMISCIBILITY TRANSFORM FUNCTIONS

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 8.43: MISC Keyword Description

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

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.

8.3.51 MSFN – MISCIBLE NORMALIZED RELATIVE PERMEABILITY TABLES

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). Why 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 8.44: MSFN Keyword Description

Examples

```
--
--       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.

8.3.52 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.

8.3.53 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.

8.3.54 OILDENT – DEFINE OIL DENSITY TEMPERATURE COEFFICIENTS

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 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 8.45: 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.

8.3.55 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 8.46: 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
```

8.3.56 OPERATE – DEFINE MATHEMATICAL OPERATIONS ON ARRAYS

This keyword defines the 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.

See *OPERATE – Define Mathematical Operations on Arrays* in the GRID section for a full description.

8.3.57 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.

8.3.58 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 8.47: 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
```

The net result of the two examples in this case is identical.

8.3.59 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 for all grid types.

The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{PCG}{P_{c_{TABLE-MAX}}} \right) \quad (8.6)$$

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 $S_g = 1 - S_{wco}$.

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 8.48: PCG 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 IPCG keyword for the equivalent imbibition functionality.

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 a PCW for 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.60 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 for all grid types. The capillary pressure for a grid block is scaled by:

$$P_c = P_{c_{TABLE}} \left(\frac{PCW}{P_{c_{TABLE-MAX}}} \right) \quad \textbf{(8.7)}$$

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).

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 8.49: PCW Keyword Description

See also the IPCW keyword for the equivalent imbibition functionality.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate, but it is documented here for completeness.

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 a PCW for 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.61 PLMIXPAR – DEFINE THE POLYMER TODD-LONGSTAFF MIXING PARAMETERS

Description

The PLMIXPAR keyword defines the Todd-Longstaff[42] 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 8.50: 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.

[42] *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.*

8.3.62 PLYADS - DEFINE POLYMER ROCK ADSORPTION TABLES

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 8.51: 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.

8.3.63 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.

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 8.52: 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

```
--
--       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
--
PLYADS
--       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.

8.3.64 PLYDHFLF - DEFINE POLYMER THERMAL DEGRADATION HALF-LIFE TABLES

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.

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 8.53: PLYDHFLF Keyword Description

This keyword is not supported by OPM Flow but is documented here for completeness, as the thermal option is currently under development.

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.

8.3.65 PLYMAX - DEFINE POLYMER-SALT VISCOSITY MIXING CONCENTRATIONS

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 8.54: 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.

8.3.66 PLYROCK - DEFINE POLYMER-ROCK PROPERTIES

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 desorption option. 1) then polymer desorption may occurs by retracing the polymer adsorption isotherm when the local polymer concentration in the solution decreases. 2) then no polymer desorption may occurs			
		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 NPLMIX tables as declared on the REGDIMS 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 8.55: 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 REGDIMS keyword in the RUNSPEC section being equal to three.

8.3.67 PLYSHEAR – ACTIVATE AND DEFINE POLYMER SHEARING PARAMETERS

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 8.56: 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.

8.3.68 PLYSHLOG - ACTIVATE AND DEFINE THE POLYMER SHEARING LOGARITHMIC PARAMETERS

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 8.57: 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.

8.3.69 PLYVISC – DEFINE POLYMER VISCOSITY SCALING FACTORS

Description

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.

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 8.58: 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.

8.3.70 PMISC – DEFINE MISCIBILITY VERSUS PRESSURE TABLES

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 8.59: 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.

8.3.71 PPCWMAX – DEFINE SWATINIT CALCULATED CAPILLARY PRESSURE CONSTRAINTS

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.

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 8.60: PPCWMAX Keyword Description

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

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.

8.3.72 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.

8.3.73 PVCDO - OIL PVT PROPERTIES FOR DEAD OIL (CONSTANT COMPRESSIBILITY)

Description

PVCDO defines the oil PVT properties for dead oil[43] 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 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 8.61: 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.

[43] *"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.

8.3.74 PVDG - GAS PVT PROPERTIES FOR DRY GAS

Description

PVDG defines the gas PVT properties for dry gas[44]. 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 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 8.62: PVDG Keyword Description

See also the RVCONST and RVCONSTT keywords to define the constant Rv for dry gas.

[44] *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.*

Examples

```
--
--        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.

8.3.75 PVDO – OIL PVT PROPERTIES FOR DEAD OIL

Description

PVDO defines the oil PVT properties for dead oil[45]. 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 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 8.63: 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.

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

Examples

```
--
--      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.

8.3.76 PVDS - SOLVENT PVT PROPERTIES FOR THE SOLVENT MODEL

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 8.64: PVDS Keyword Description

Examples

```
--
--        GAS SOLVENT PVT TABLE
--
PVTS
--        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.

8.3.77 PVTG - GAS PVT PROPERTIES FOR WET GAS

Description

PVTG defines the gas PVT properties for wet gas[46]. 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 wet gas in the model. 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 values that defines the gas phase pressure. that defines 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 Rvs 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

[46] *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 8.65: PVTG Keyword Description

Examples

```
--
--       GAS PVT TABLE FOR WET GAS
--
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.

8.3.78 PVTO - OIL PVT PROPERTIES FOR LIVE OIL

Description

PVTO defines the oil PVT properties for live[47] 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 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

[47] *"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 8.66: PVTO Keyword Description

Examples

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.

8.3.79 PVTW - DEFINE WATER FLUID PROPERTIES FOR VARIOUS REGIONS

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 viiscosibility (μ_{wc}) at the water reference pressure, Uwc(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 8.67: 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.

```
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.

8.3.80 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.

8.3.81 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.

8.3.82 ROCK - DEFINE THE ROCK COMPRESSIBILITY FOR VARIOUS REGIONS

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	barsa	atma	
		1.032	1.032	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	1/barsa	1/atma	
		0.0	0.0	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 8.68: 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
--
-- (1) 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
--
-- (1) 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.

8.3.83 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 8.69: 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.

Examples

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.

8.3.84 ROCK2DTR – TRANSMISSIBILITY COMPACTION VERSUS PRESSURE AND SW TABLES

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 8.70: 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.

Examples

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.

8.3.85 ROCKOPTS – DEFINE ROCK COMPACTION AND COMPRESSIBILITY OPTIONS

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: 3) 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 4) 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 8.71: 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.

8.3.86 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 8.72: 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.

Examples

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.

8.3.87 ROCKTAB – ROCK COMPACTION TABLES

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 should only be used if compaction option has been enabled.

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 8.73: ROCKTAB 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 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 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 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.

8.3.88 RPTPROPS – DEFINE PROPS SECTION REPORTING

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 8.74: 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                                       /
```

8.3.89 RSCONST – DEFINE CONSTANT GOR FOR 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[48] 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 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 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 8.75: 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.

Examples

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                                /
```

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

8.3.90 RSCONSTT – DEFINE CONSTANT GOR FOR DEAD OIL PVT FLUIDS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

RSCONSTT defines a constant Gas-Oil Ratio ("GOR"), for each dead oil[49] 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 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			
		Mscf/stb	sm^3/sm^3	scc/scc	None
2	PRESS	A real positive columnar vector that defines the saturation pressure (bubble point pressure) for each the oil PVT table in the model.			
		psia	barsa	atma	None

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 8.76: 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.

Examples

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
```

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

8.3.91 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 define the reservoir temperature for the model.			
		°F	°C	°C	None
Notes: 1) The keyword is terminated by "/".					

Table 8.77: 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.

8.3.92 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 8.78: 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.

8.3.93 SALNODE – SALT CONCENTRATION BASED PVTNUM ARRAY

Description

SALNODE defines the salt concentration value based on a cells PVTNUM number. The SALNODE 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 SALNODE data sets with four values of salt concentrations need to be entered.

No.	Name	Description			Default
		Field	**Metric**	**Laboratory**	
1	SALTCON	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 8.79: SALNODE 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.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate, but it is documented here for completeness.

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
--
SALNODE
      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.

8.3.94 SCALECRS – SET END-POINT SCALING OPTION

Description

The SCALECRS keyword sets the end-point scaling option to be either two-point or three-point scaling. 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 8.80: 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 8.81: End-Point Arrays Used in the End-Point Scaling Options

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.

8.3.95 SDENSITY – DEFINE THE MISCIBLE OR SOLVENT SURFACE GAS DENSITY

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	SOLDEN	SOLDEN 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 8.82: 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.

8.3.96 SGCR – END-POINT SCALING GRID CELL CRITICAL GAS SATURATIONS

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 for 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 non-direction dependent 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 8.83: 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.

8.3.97 SGCWMIS – MISCIBLE CRITICAL GAS VERSUS WATER SATURATION FUNCTIONS

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 8.84: 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.

8.3.98 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 8.85: 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.

8.3.99 SGL – END-POINT SCALING GRID CELL CONNATE GAS SATURATIONS

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 for 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 non-direction dependent 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 8.86: 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.

8.3.100 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 for all grid types.

This feature is not available in OPM Flow; however it is documented here for completeness.

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 non-direction dependent 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 8.87: 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.

8.3.101 SGOF – GAS-OIL SATURATION TABLES VERSUS GAS (FORMAT TYPE 1)

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 8.88: 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.

8.3.102 SGU – END-POINT SCALING GRID CELL GAS SATURATION

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 for 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 non-direction dependent 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 8.89: 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.

8.3.103 SGWFN – GAS-WATER SATURATION TABLES (FORMAT TYPE 2)

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 8.90: 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.

8.3.104 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.

8.3.105 SLGOF – GAS-OIL SATURATION TABLES VERSUS GAS (FORMAT TYPE 1)

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 8.91: 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.

8.3.106 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 8.92: 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.

8.3.107 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 8.93: 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.

8.3.108 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 for 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 non-direction dependent 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 8.94: 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.

8.3.109 SORWMIS – MISCIBLE RESIDUAL OIL VERSUS WATER SATURATION FUNCTIONS

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 8.95: 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.

8.3.110 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 for 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 non-direction dependent 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 8.96: 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 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 gas saturation of 0.20 to all 300 cells in the model as defined by the DIMENS keyword in the RUNSPEC section.

8.3.111 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 8.97: 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.

8.3.112 SPECROCK – DEFINE THE SPECIFIC HEAT OF THE RESERVOIR ROCK

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 8.98: 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
--
SPECHEAT
--        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.

8.3.113 SSFN – SOLVENT AND GAS RELATIVE PERMEABILITY TABLES

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). Why 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 8.99: SSFN Keyword Description

Example

```
--
--       SOLVENT RELATIVE PERMEABILITY TABLES
--
SSFN
--       SGAS       KRGT         KRST
--       FRAC
--       --------  --------     --------
          0.0000    0.0000       1.0000
          1.0000    1.0000       0.0000                    / 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       0.0000                    / TABLE NO. 02
```

The above example defines two SSFN tables for use with the MISCIBLE and SOLVENT options.

8.3.114 SWCR – END-POINT SCALING GRID CELL CRITICAL WATER SATURATION

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 for 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 non-direction dependent 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 8.100: 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.

8.3.115 SWFN – WATER SATURATION TABLES (FORMAT TYPE 2)

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 8.101: 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.

8.3.116 SWL – END-POINT SCALING GRID CELL CONNATE WATER SATURATION

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 for 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 non-direction dependent 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 8.102: 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.

8.3.117 SWLPC – END-POINT SCALING GRID CELL CAPILLARY PRESSURE CONNATE GAS 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 for all grid types.

This feature is not available in OPM Flow; however it is documented here for completeness.

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 non-direction dependent 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 8.103: 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.

8.3.118 SWOF – WATER-OIL SATURATION TABLES (FORMAT TYPE 1)

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 8.104: 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.

8.3.119 SWU – END-POINT SCALING GRID CELL GAS SATURATION

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 for 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 non-direction dependent 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 8.105: 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.

8.3.120 THERMEXI – DEFINE COMPONENT THERMAL EXPANSION COEFFICIENTS

Description

THERMEXI defines the thermal expansion coefficients for all components in the model for when the EOS and THERMAL options have been invoked by the EOS and THERMAL keywords in the RUNSPEC section.

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

8.3.121 TLMIXPAR – DEFINE THE MISCIBLE TODD-LONGSTAFF MIXING PARAMETERS

Description

The TLMIXPAR keyword defines the Todd-Longstaff[50] 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 8.106: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.

[50] *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.*

8.3.122 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 8.107: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}.

8.3.123 TRACER – DEFINE PASSIVE TRACER VARIABLES

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 a 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 8.108: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.

8.3.124 TREF - DEFINE COMPONENT FLUID DENSITIES REFERENCE TEMPERATURES

Description

TREF defines the fluid component densities in-situ reference temperatures in the compositional commercial simulator or the live oil component in-situ reference temperature in the "black-oil" commercial simulator with the THERMAL option activated via the THERMAL 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.

8.3.125 TREFS – DEFINE COMPONENT FLUID DENSITIES REFERENCE TEMPERATURE AT SURFACE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

TREFS defines the fluid component densities surface reference temperatures in the compositional commercial simulator

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

8.3.126 VISCREF - DEFINE VISCOSITY-TEMPERATURE REFERENCE CONDITIONS

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			
		psia	barsa	atma	None
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			
		Mscf/stb	sm^3/sm^3	scc/scc	None
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.			
		°API	°API	°API	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 8.109: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.

8.3.127 WATDENT – DEFINE WATER DENSITY TEMPERATURE COEFFICIENTS

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 8.110: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.

8.3.128 WATVISCT – DEFINE WATER VISCOSITY VERSUS TEMPERATURE FUNCTIONS

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 increasing 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 8.111: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    0.500
           110.0    0.550
           120.0    0.580
           150.0    0.620
           165.0    0.625                              / TABLE NO. 01
```

There is no terminating "/" for this keyword.

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

Properties Section	Property Allocation	REGIONS Section Keyword

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[51] field are displayed in Figure 9.1 and Figure 9.2, respectively.

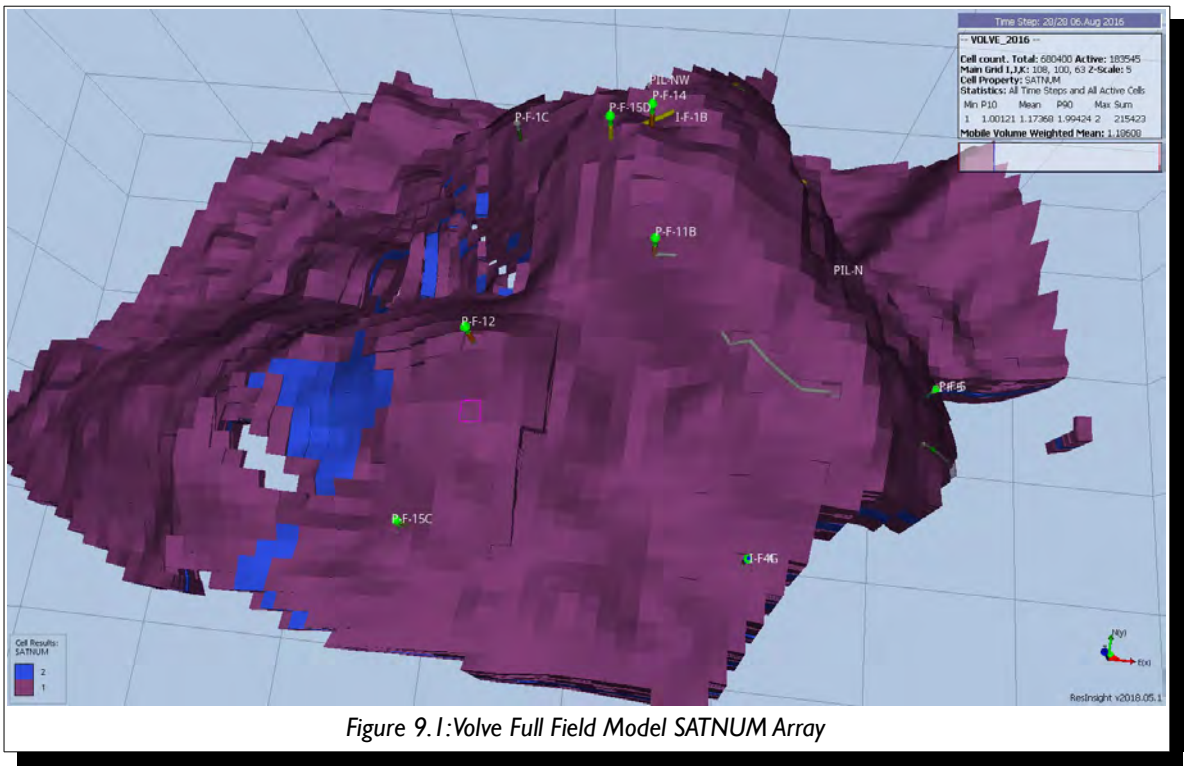

Figure 9.1: Volve Full Field Model SATNUM Array

[51] *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.*

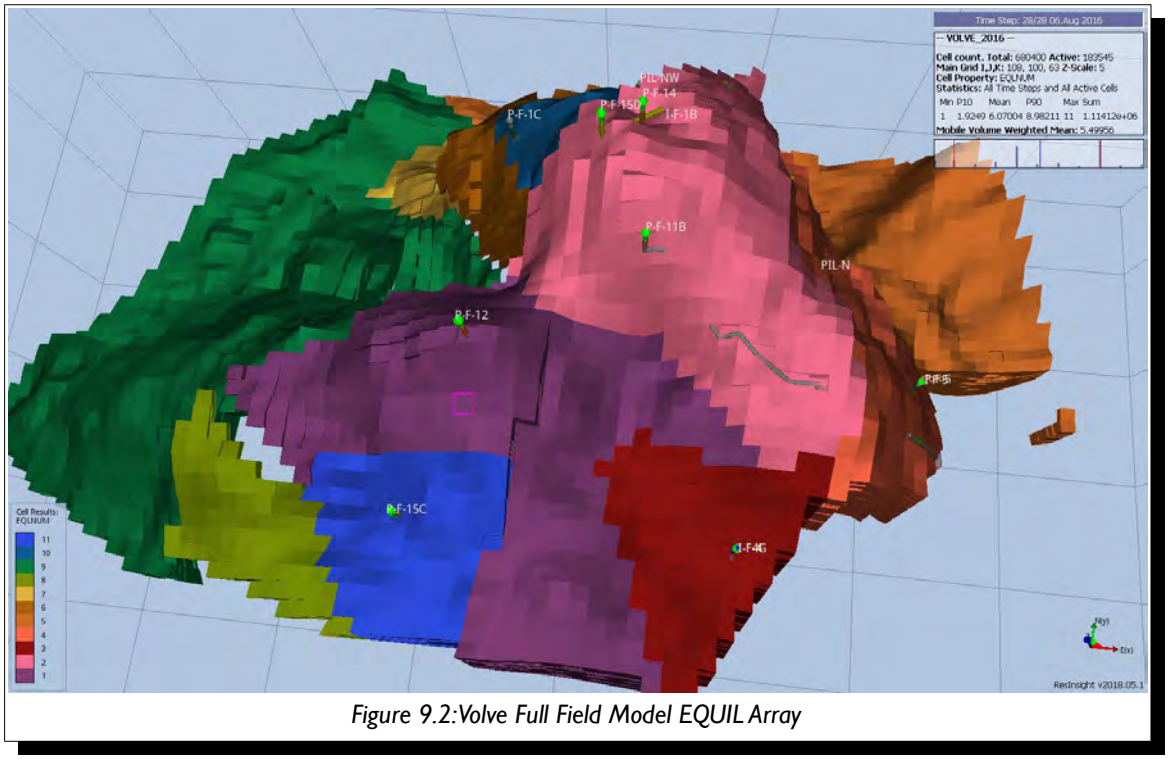

Figure 9.2:Volve Full Field Model EQUIL Array

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 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.

9.3.4 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.

9.3.5 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.

9.3.6 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.

9.3.7 ENDFIN – END THE DEFINITION OF A LOCAL GRID REFINEMENT

Description

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.

9.3.8 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[52] and the ENKRVD[53] 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 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.

```
ENDNUM
2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1

3 3 1 1 # layer 2
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
/
```

[52] *This keyword is ignored by OPM Flow and has no effect on the simulation*

[53] *This keyword is ignored by OPM Flow and has no effect on the simulation*

9.3.9 EQLNUM – DEFINE THE EQUILIBRATION REGION NUMBERS

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 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.

```
EQLNUM

2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1

3 3 1 1 # layer 2
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
/
```

9.3.10 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.

9.3.11 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.

9.3.12 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.

9.3.13 FIPNUM – DEFINE THE FLUID IN-PLACE REGION NUMBERS

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 cell is not assigned a FIPNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.4: FIPNUM Keyword Description

Examples

The example below sets three FIPNUM regions for a 4 x 5 x 2 model.

```
FIPNUM

2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1

3 3 1 1 # layer 2
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
/
```

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.

9.3.14 FIPOWG – ACTIVATE OIL, GAS, AND WATER FIP ZONE REPORTING

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.

9.3.15 IMBNUM – DEFINE THE IMBIBITION SATURATION TABLE REGION NUMBERS

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) If cell is not assigned a IMBNUM region then the default value of one will be used.
3) The keyword is terminated by "/".

Table 9.5: 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.

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
/
```

9.3.16 MISNUM – DEFINE THE MISCIBILITY REGION NUMBERS

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 cell is not assigned a MISNUM region then the default value of one will be used.
3) The keyword is terminated by "/".

Table 9.6: 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
/
```

9.3.17 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.

9.3.18 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.

9.3.19 OPERATE – DEFINE MATHEMATICAL OPERATIONS ON ARRAYS

This keyword defines the 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.

See *OPERATE – Define Mathematical Operations on Arrays* in the GRID section for a full description.

9.3.20 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.

9.3.21 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.

9.3.22 PLMIXNUM – DEFINE THE POLYMER REGION NUMBERS

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 cell is not assigned a PLMIXNUM region then the default value of one will be used.
3) The keyword is terminated by "/".

Table 9.7: 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
/
```

9.3.23 PVTNUM – DEFINE THE PVT REGIONS

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 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 cell is not assigned a PVTNUM region then the default value will be used.
4) The keyword is terminated by "/".

Table 9.8: 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.

```
PVTNUM

2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1

3 3 1 1 # layer 2
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.

9.3.24 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.

9.3.25 REGIONS - DEFINE THE START OF THE REGIONS SECTION OF KEYWORDS

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.

9.3.26 ROCKNUM – DEFINE ROCK COMPACTION TABLE REGION NUMBERS

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 cell is not assigned a ROCKNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.9: ROCKNUM Keyword Description

Examples

The example below sets three ROCKNUM regions for a 4 x 5 x 2 model.

```
ROCKNUM

2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1

3 3 1 1 # layer 2
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
/
```

9.3.27 RPTREGS – DEFINE REGIONS SECTION REPORTING

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 9.10: 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.

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 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
         DX       DY       DZ       DEPTH    PORO     PERMX                /
```

9.3.28 SATNUM – DEFINE THE SATURATION TABLE REGION NUMBERS

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 cell is not assigned a SATNUM region then the default value will be used.
3) The keyword is terminated by "/".

Table 9.11: SATNUM Keyword Description

Examples

The example below sets three SATNUM regions for a 4 x 5 x 2 model.

```
SATNUM

2 2 1 1 # layer 1
2 2 1 1
1 1 1 1
1 1 1 1
1 1 1 1

3 3 1 1 # layer 2
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
/
```

9.3.29 TNUM – DEFINE PASSIVE TRACER CONCENTRATION REGIONS

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. The following table outlines the format of the TNUM keyword name.

No.	Name	Description	Default
1	TNUM	A four letter character equal 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. 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 9.12: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	TNUMDATA	TUNDATA defines an array of positive integers assigning a grid cell to a particular tracer table region. The maximum number of TNUMDATA 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 cell is not assigned a TNUMDATA region then the default value will be used. 3) The keyword is terminated by "/".			

Table 9.13:TNUM Keyword Data Description

See also the TRACER keyword in the PROPS section and the TBLK 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.

Examples

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.

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 AQUANCON – DEFINE ANALYTICAL CONNECTIONS TO THE GRID

AQUANCON keyword defines how analytical aquifers are connected to the simulation grid., this includes Carter-Tracy and Fetkovich analytical aquifers, although the Carter-Tracy aquifer is the only aquifer currently being implemented in OPM Flow.

See *AQUANCON – Define Analytical Connections to the Grid* in the GRID section and AQUCT keyword in the SOLUTION section for a complete example on defining and connecting a Carter-Tracy aquifer to a simulation grid.

10.3.4 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

10.3.5 AQUFETP – DEFINE FETKOVICH ANALYTICAL AQUIFERS

Description

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.

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
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*

No.	Name	Description			Default
		Field	Metric	Laboratory	
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 10.1: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 only hydrocarbon reservoir cells. Try commenting out the aquifer and see if this resolves the instabilities.

Examples

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*              /
```

The Fetkovich Analytical aquifer is defined in the SOLUTION sections as:

```
--
--                      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 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.

10.3.6 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.

10.3.7 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.

10.3.8 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.

10.3.9 DATUM – DEFINE THE DATUM DEPTH FOR THE MODEL

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 10.2: DATUM Keyword Description

See also the DATUMR keyword that defines the datum for each fluid in-place region.

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

10.3.10 DATUMR – DEFINE DATUM DEPTHS FOR THE FIPNUM REGIONS

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 10.3: DATUMR Keyword Description

See also the DATUM keyword that defines the datum depth for the model.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate, but it is documented here for completeness.

Examples

```
--
--        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.

10.3.11 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.

10.3.12 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.

10.3.13 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.

10.3.14 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.

10.3.15 EQUIL – DEFINE THE EQUILIBRATION INITIALIZATION DATA

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 for 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 NTEQL 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 10.4: 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.

Examples

```
--
--        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 NTEQL 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.

10.3.16 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.

10.3.17 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.

10.3.18 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.

10.3.19 OPERATE – DEFINE MATHEMATICAL OPERATIONS ON ARRAYS

This keyword defines the 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.

See *OPERATE – Define Mathematical Operations on Arrays* in the GRID section for a full description.

10.3.20 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.

10.3.21 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 for all grid types.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate, but it 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 10.5: 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.

10.3.22 PBVD – EQUILIBRATION BUBBLE-POINT VERSUS DEPTH TABLES

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	PBVALS	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 NTEQL 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 10.6: 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 NTEQL 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 "/".

10.3.23 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 for all grid types.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate, but it 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 10.7: 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.

10.3.24 PDVD – DEFINE EQUILIBRATION DEW-POINT VERSUS DEPTH TABLES

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 NTEQL 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 10.8: 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 NTEQL 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 "/".

10.3.25 PRESSURE – DEFINE THE INITIAL EQUILIBRATION PRESSURES FOR ALL GRID BLOCKS

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 for all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	PRESS	PRESS 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 10.9: 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.

10.3.26 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.

10.3.27 RESTART – RESTART RUN FROM AN EXISTING RESTART FILE

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 10.10: 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 keywords used to initialize the model (PRESSURE, SGAS, SOIL. SWAT, etc.) in the SOLUTION section.
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.

Examples

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 is advisable to place the SKIPREST keyword at the very beginning of the SCHEDULE section.

10.3.28 RPTRST – DEFINE DATA TO BE WRITTEN TO THE RESTART FILE

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 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 paarameter 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 10.11: 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 10.12: 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                                             /
```

10.3.29 RPTSOL – DEFINE SOLUTION SECTION REPORTING

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 10.13: 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                                     /
```

10.3.30 RS – DEFINE THE INITIAL EQUILIBRATION GOR (RS) FOR ALL GRID BLOCKS

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 for 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 10.14: 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.

10.3.31 RSVD – EQUILIBRATION DISSOLVED GAS-OIL RATIO (RS) VERSUS DEPTH TABLES

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 NTEQL 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 10.15: 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 NTEQL 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.

10.3.32 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.

10.3.33 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.

10.3.34 RTEMPVD - DEFINE THE INITIAL RESERVOIR TEMPERATURE VERSUS DEPTH TABLES

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 10.16: 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.

10.3.35 RV – DEFINE THE INITIAL EQUILIBRATION CGR (RV) FOR ALL GRID BLOCKS

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 for 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 10.17: 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.

10.3.36 RVVD – EQUILIBRATION VAPORIZED OIL-GAS RATIO (RV) VERSUS DEPTH TABLES

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 NTEQL 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: 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 NTEQL 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
--                  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.

10.3.37 SGAS – DEFINE THE INITIAL EQUILIBRATION GAS SATURATION FOR ALL GRID BLOCKS

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 for 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 10.19: 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.

10.3.38 SOIL – DEFINE THE INITIAL EQUILIBRATION OIL SATURATION FOR ALL GRID BLOCKS

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 for 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 10.20: 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.

10.3.39 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 for all grid types.

No.	Name	Description			Default
		Field	Metric	Laboratory	
1	SPOLY	SPOLY is an array of real positive numbers that are greater assigning the initial equilibration polymer concentration values to each cell in the model. Repeat counts may be used, for example 20*0.600.			
		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 10.21: 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 GAS SAT VALUES FOR ALL CELLS IN THE MODEL
--       BASED ON NX = 100, NY = 100 AND NZ = 3
--
SOIL
         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.

10.3.40 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.

10.3.41 SSOL – DEFINE THE INITIAL EQUILIBRATION SOLVENT SATURATION FOR ALL GRID BLOCKS

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 for 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 10.22: 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.

10.3.42 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[54] second three phase oil relative permeability model as modified by Aziz and Settari[55]. 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.

[54] *Stone, H. L. "Estimation of Three-Phase Relative Permeability and Residual Oil Data," Journal of Canadian Petroleum Technology (1973) 12, No. 4, 53-61.*

[55] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

10.3.43 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[56] first three phase oil relative permeability model as modified by Aziz and Settari[57]. 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.

[56] *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.*

[57] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

10.3.44 STONE1EX – DEFINE STONE'S FIRST THREE PHASE OIL RELATIVE PERMEABILITY PARAMETER

Description

This keyword defines the exponent used in Stone's[58] first three phase oil relative permeability model as modified by Aziz and Settari[59]. 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 10.23: 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.

[58] *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.*

[59] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

10.3.45 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[60] second three phase oil relative permeability model as modified by Aziz and Settari[61]. 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.

[60] *Stone, H. L. "Estimation of Three-Phase Relative Permeability and Residual Oil Data," Journal of Canadian Petroleum Technology (1973) 12, No. 4, 53-61.*

[61] *Aziz, K. and Settari, A. Petroleum Reservoir Simulation, London, UK, Applied Science Publishers (1979), page 398.*

10.3.46 SWAT – DEFINE THE INITIAL EQUILIBRATION WATER SATURATION FOR ALL GRID BLOCKS

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 for 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 10.24: 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.

10.3.47 TBLK – DEFINE TRACER INITIAL GRID BLOCK CONCENTRATIONS

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 concatenate 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 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.			
		Liquid: TBLK/stb Gas: TBLK/Mscf	Liquid: TBLK/sm^3 Gas: TBLK/sm^3	Liquid: TBLK/scc Gas: TBLK/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 10.25: 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.

Examples

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.

10.3.48 TEMPI – DEFINE THE INITIAL TEMPERATURE VALUES FOR ALL CELLS

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 for 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 10.26: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.

10.3.49 TEMPVD - DEFINE THE INITIAL RESERVOIR TEMPERATURE VERSUS DEPTH TABLES

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 EQ:DIMS keyword in the RUNSPEC section.
3) Each table is terminated by "/" and there is no "/" terminator for the keyword.

Table 10.27: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.

10.3.50 THPRES - DEFINE EQUILIBRATION REGION THRESHOLD PRESSURES

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 10.28: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 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.

10.3.51 TVDP – DEFINE THE INITIAL EQUILIBRATION TRACER SATURATION VERSUS DEPTH FUNCTIONS

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.

10.3.52 VAPPARS – OIL VAPORIZATION PARAMETERS

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 10.29: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.

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 plot pressure versus time, etc. The properties to be stored on the summary file are entered in the SUMMARY section of the input file. The items requested are written to the summary file at the end of each successful time step. The SUMMARY section is terminated by the SCHEDULE keyword.

To generate a summary vector, the appropriate keyword must be entered in the SUMMARY section of the input data file. The SUMMARY keywords are listed below.

To be written in a future release of the manual.

11.2 DATA REQUIREMENTS

To be written in a future release of the manual.

11.3 KEYWORD DEFINITIONS

11.3.1 ALL – EXPORT STANDARD SUMMARY VARIABLE VECTORS TO FILE

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

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

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.

11.3.2 DATE - ACTIVATE THE DATE OPTION FOR THE SUMMARY FILE

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, activating the DATE option also results in the DATE being written out to the SUMMARY file as well. This option is normally used when RUNSUM keyword in the SUMMARY section has been activated to produce a RSM file.

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

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 the 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
.....
```

Note currently OPM Flow does not write out RSM files.

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.

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

Examples

```
--
--       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

Note currently OPM Flow does not write out RSM files.

11.3.4 FWSET - EXPORT WELL STATUS VECTORS FOR THE FIELD TO FILE

Description

This 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.

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.

11.3.5 GMWSET - EXPORT WELL STATUS VECTORS BY GROUP TO FILE

Description

This keyword activates the writing out of a set of data vectors that give the production and injections status of all the wells within a group.

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.

11.3.6 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.

11.3.7 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.

11.3.8 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 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.

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.

Examples

```
--
--       ACTIVATE REPORT TIME STEPS ONLY SUMMARY FILE OPTION
--
RPTONLY
```

Note currently OPM Flow does not write out RSM files.

11.3.9 RPTONLYO - DEACTIVATE THE REPORT TIME STEPS ONLY OPTION FOR THE SUMMARY FILE

Description

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.

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.

Examples

```
--
--       DEACTIVATE REPORT TIME STEPS ONLY SUMMARY FILE OPTION
--
RPTONLYO
```

Note currently OPM Flow does not write out RSM files.

11.3.10 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 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 11.1: RPTSMRY Keyword Description

Examples

```
--
--       ACTIVATE OR DEACTIVATE SUMMARY LIST REPORT
--
RPTSMRY
         1                                                    /
```

The example switches on the summary list report.

11.3.11 RUNSUM – ACTIVATE RSM FILE OUTPUT OF THE SUMMARY DATA

Description

This keyword activates the writing out of the SUMMARY file date 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.

See also the EXCEL, RPTONLY and SEPARATE keywords in the SUMMARY section.

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

Examples

```
--
--       ACTIVATE COLUMNAR SUMMARY DATA REPORTING OPTION
--
RUNSUM
```

Note currently OPM Flow does not write out RSM files.

11.3.12 SEPARATE – ACTIVATE THE SEPARATE RSM FILE OUTPUT OPTION

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 been 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.

See also the EXCEL, RPTONLY and RUNSUM keywords in the SUMMARY section.

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

Examples

```
--
--       ACTIVATE SUMMARY DATA RSM FILE OUTPUT OPTION
--
SEPARATE
```

Note currently OPM Flow does not write out RSM files.

11.3.13 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.

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.

11.3.14 SUMTHIN – DEFINE SUMMARY DATA REPORTING TIME STEPS

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 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.

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 RSM file if RSM output has been activated). For example, if SUMSTEP is set to 30 days, and 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 11.2: 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.

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

Examples

```
--
--        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.

12 SCHEDULE SECTION

12.1 INTRODUCTION

To be written in a future release of the manual.

12.2 DATA REQUIREMENTS

To be written in a future release of the manual.

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

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate; 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

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate; 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.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate; 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.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate; use the ACTIONX keyword instead.

12.3.6 ACTIONX – DEFINE ACTION CONDITIONS AND COMMAND PROCESSING

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 are are unlikely to be so, as the ACTIONX keyword implements their functionality with greater flexibility.

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 aborting.

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.

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			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
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 12.2.			Not Applicable

No.	Name	Description	Default

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 12.2 (see also ACTLHS).	Not Applicable

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

No.	Name	Description	Default

		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.
			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 12.1: ACTIONX Keyword Description

The variable types and the associated definitions that are available for use with Boolean conditionals are outlined in Table 12.2.

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.

Variable Type	Description
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`

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).

Variable Type	Description

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`

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.

Variable Type	Description
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 12.2: 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.

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 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.

12.3.8 CECON – DEFINE WELL CONNECTIONS ECONOMIC LIMIT CRITERIA

Description

CECON set 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.

12.3.9 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 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 12.3: 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).

12.3.10 COMPDATL – DEFINE WELL CONNECTIONS TO A LGR GRID

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 COMPORD in the SCHEDULE section for options regarding connection connection ordering).

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

12.3.11 COMPIMB – ASSIGN IMBIBITION SATURATION TABLES TO WELL CONNECTIONS

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.

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 12.4: 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.

12.3.12 COMPLUMP – ASSIGN WELL CONNECTIONS TO COMPLETIONS

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 12.5: 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 defines 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.

12.3.13 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 12.6: 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.

12.3.14 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 12.7: 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 completions for both ordinary wells and multi-segment wells, and the COMPSEGS keyword to define a multi-segment segment completions. 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.

12.3.15 DATES – ADVANCE SIMULATION BY REPORTING DATE

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 12.8: DATES Keyword Description

See also the TSTEP keyword 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.

12.3.16 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 12.9: 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.

12.3.17 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 12.10: 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.

12.3.18 DRVDT – SOLUTION OIL (RV) MAXIMUM RATE OF INCREASE PARAMETERS

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 12.11: 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.

Examples

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.

12.3.19 DRVDTR – SOLUTION OIL (RV) MAXIMUM RATE OF INCREASE PARAMETERS BY REGION

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

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 12.12: 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.

12.3.20 ENDACTIO – END THE DEFINITION OF ACTION COMMANDS

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
```

12.3.21 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.

12.3.22 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.

12.3.23 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.

12.3.24 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		Not used should be defaulted with 1*.			
12		Not used should be defaulted with 1*.			
13		Not used should be defaulted with 1*.			

Notes:

1) The keyword is followed by any numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.13: 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*    /
GRP02     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.

12.3.25 GCONPROD – GROUP PRODUCTION TARGETS AND CONSTRAINTS

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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.14: 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.

12.3.26 GECON – GROUP ECONOMIC CRITERIA FOR PRODUCTION GROUPS

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.

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/d	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/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 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.			
		Mscf/stb	sm^3/sm^3	scc/scc	0.0

No.	Name	Description			Default
		Field	Metric	Laboratory	
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 wort 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. 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.t			NO
9		Not used			

Notes:

1) The keyword is followed by any numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.15: 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.

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 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.

12.3.27 GEFAC – DEFINE GROUP EFFICIENCY

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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.16: GEFAC Keyword Description

See also the WELFAC 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.

12.3.28 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.

12.3.29 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 when the network option has been activated.

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

12.3.30 GRUPNET – DEFINE GROUP STANDARD NETWORK PARAMETERS

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 modelling 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.17: 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.

Example

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 12.1)

12.3.31 GRUPRIG – GROUP DRILLING AND WORKOVER RIG SPECIFICATIONS

Description

Defines a groups drilling and workover specifications.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate.

12.3.32 GRUPTREE – DEFINE GROUP TREE HIERARCHY

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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".			

Table 12.18: 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.

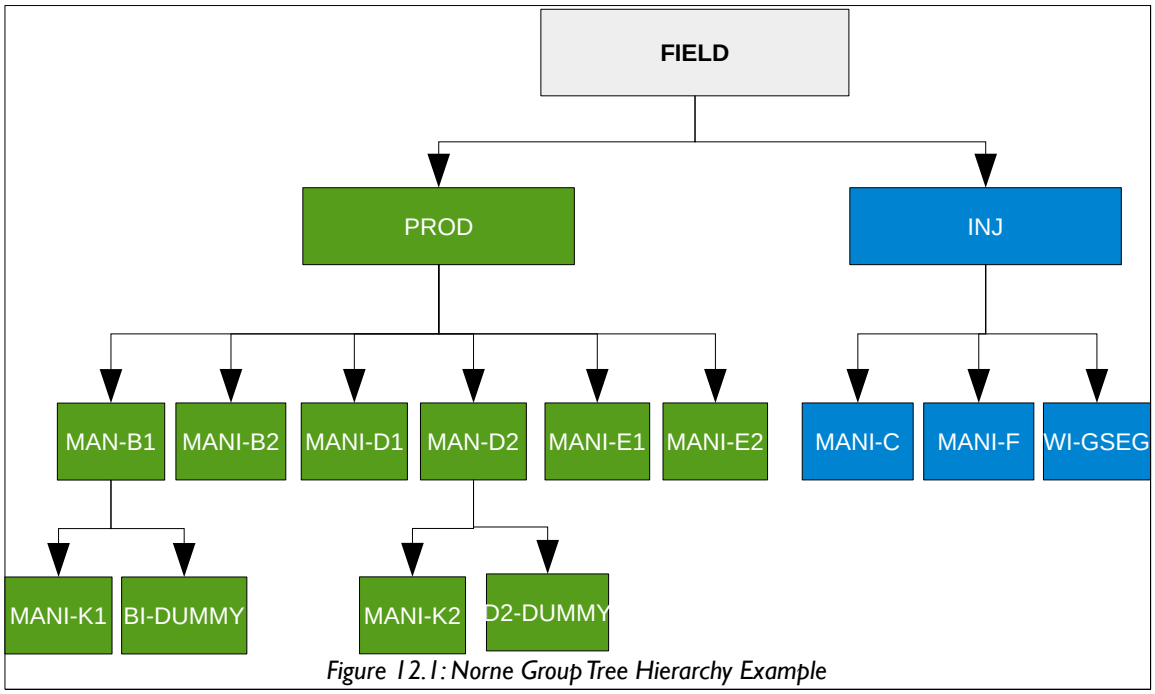

Figure 12.1: Norne Group Tree Hierarchy Example

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.

12.3.33 GSATPROD – DEFINE GROUP SATELLITE PRODUCTION RATES

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

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 production to the model without modeling the "add-in" reservoir model.

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

12.3.34 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.

12.3.35 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.

12.3.36 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.

12.3.37 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.

12.3.38 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.

12.3.39 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.

12.3.40 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.

12.3.41 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.

12.3.42 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.

12.3.43 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.

12.3.44 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 ito 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 be chopped back again to perhaps to less then one day. Using the 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 12.19: NEXTSTEP Keyword Description

See also the DATES and TSTEP keyword 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 2019-04 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.

12.3.45 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.

See section *2.2 Running OPM Flow 2019-04 From The Command Line* on how to set the numerical control parameters for OPM Flow.

12.3.46 PIMULTAB – DEFINE WELL PRODUCTIVITY INDEX VERSUS WATER CUT TABLES

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 12.20: 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 /
```

12.3.47 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.

12.3.48 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.

12.3.49 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 X in the PROPS section for a full description.

12.3.50 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 X in the PROPS section for a full description.

12.3.51 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 *PLYSHEAR – Activate and Define Polymer Shearing Parameters* in the PROPS section for a full description.

12.3.52 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.

12.3.53 PRORDER – DEFINE A GROUP PRODUCTION RULES SEQUENCE

Description

Defines the order of group production rules to be implemented when a group's target is not satisfied.

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

12.3.54 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.

12.3.55 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.

12.3.56 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.

12.3.57 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.

12.3.58 RPTSCHED – DEFINE SCHEDULE SECTION REPORTING

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 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 define the data in the OPM Flow input deck, for example WELSPECS to defined the basic well definitions. 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.

For the purpose of controlling PRT output, this keyword is ignored by OPM Flow and has no effect on the simulation. However, the keyword can also be used to control the writing of restart files and those parts of this keyword are honored.

No.	Name	Description	Default
1	FIP	Print the fluid in-place report.	N/A
2	FIPRESV	Print the reservoir volumes in-place report.	N/A
3	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.	
4			
….		….	
Notes: 1) The keyword is terminated by "/".			

Table 12.21: 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 in 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.

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 SCHEDULE SECTION REPORT OPTION (ORIGINAL FORMAT)
--
RPTSCHED
         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.

```
-- ======================================================================
--
-- 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.

12.3.59 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.

12.3.60 SCHEDULE - DEFINE THE START OF THE SCHEDULE SECTION OF KEYWORDS

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.

12.3.61 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.

12.3.62 SKIPREST – ACTIVATE SKIPPING OF RESTART SCHEDULE DATA

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 RUNSPEC 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.

Note that SKIPREST is not necessary for OPM Flow to restart, the simulator will restart gracefully at the chosen step even without it, and the keyword itself is ignored. It is however advisable to include it if compatibility with other simulators is important.

Examples

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
```

12.3.63 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.

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

12.3.64 TSTEP – ADVANCE SIMULATION BY REPORTING TIME

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 data sets or keywords may be entered to advance the simulator to the next report time.

No.	Name	Description			Default
		Field	Metric	Laboratory	
	TSTEP	A vector of real positive numbers that define the length of the time intervals to subsequent report steps..			
1		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 12.22: TSTEP Keyword Description

See also the DATES keyword in the SCHEDULE section. Note that since OPM Flow uses the standard Gregorian calendar, then 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 honoured.

12.3.65 TUNING - NUMERICAL TUNING CONTROL

Description

Defines the parameters used for controlling the commercial simulator's numerical convergence parameters. 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 2019-04 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 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	0.001

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 LIMMIN 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 LIMMAX 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 12.23: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 2019-04 From The Command Line*) to instruct the simulator to read the first record of the TUNING keyword. Alternatively one could just use:

```
TUNING
/
/
/
```

12.3.66 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.

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

12.3.67 UDQ - DECLARE USER DEFINE QUANTITIES ("UDQ")

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, 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 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 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 12.24: 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[62] ("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 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.

[62] *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  /
/
```

12.3.68 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.

12.3.69 VFPINJ – DEFINE INJECTION VERTICAL FLOW PERFORMANCE TABLES

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 *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 12.25. 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 12.25: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.

12.3.70 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 12.26. 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

No.	Name	Description			Default
		Field	Metric	Laboratory	
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 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 12.26: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 *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.

12.3.71 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 model 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.27: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 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. This option is currently not implemented in OPM Flow but is expected to be incorporated in a future release.

12.3.72 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.

12.3.73 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	

No.	Name	Description			Default
		Field	Metric	Laboratory	
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
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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.28: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.

12.3.74 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

No.	Name	Description			Default
		Field	Metric	Laboratory	
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
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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.29: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.

12.3.75 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.30: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.

12.3.76 WDFACCOR – GAS FLOW DEPENDENT SKIN FACTOR

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

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[63][64][65] and [66].

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

[63] *Dake, L.P. Fundamentals of Reservoir Engineering, Amsterdam, The Netherlands, Elsevier Science BV (1978) Chapter 8.6, pages 252-257.*

[64] *Geertsma, J., 1974. Estimating the Coefficient of Inertial Resistance in Fluid Flow Through Porous Media. Soc.Pet.Eng.J., October: 445-450.*

[65] *Gewers, C.W.W. and Nichol, L.R., 1969. Gas Turbulence Factor in a Microvugular Carbonate. J.Can.Pet.Tech., April.*

[66] *Wong, S.W., 1970. Effects of Liquid Saturation on Turbulence Factors for Gas Liquid Systems. J.Can.Pet.Tech., October*

12.3.77 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 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.

12.3.78 WECON – WELL ECONOMIC CRITERIA FOR PRODUCTION WELLS

Description

The WECON keyword defines 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. Note that this feature is currently not supported in OPM Flow			
		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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.31: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.

12.3.79 WEFAC – DEFINE WELL EFFICIENCY

Description

Defines a well's efficiency or up-time.

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

See the GEFAC keyword in the SCHEDULE section that is implemented in OPM Flow and can be used to set a group's efficiency.

12.3.80 WELCNTL – MODIFY WELL CONTROL AND TARGETS

Description

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. 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.

OPM Flow does not recognize this keyword and the keyword may cause the program to terminate, but it 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

No.	Name	Description			Default
		Field	Metric	Laboratory	
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 is the well will be targeting anliquid 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
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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.32: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.

12.3.81 WELOPEN – DEFINE WELL AND WELL CONNECTIONS FLOWING STATUS

Description

The WELOPEN keyword defines the status of wells and well connection 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.33: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.

12.3.82 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 values enter on this keyword for a given well will override any previously calculated values and values previously entered using this keyword.

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

12.3.83 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	
I-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
I-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 *Drifr Flux Model.* OPM Flow only supports the default value of HO.			HO
I-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
I-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
I-10	XAREA	XAREA 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
I-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	EIPSILON	A real positive value that defines the tubing absolute roughness of the segment for the well.			None

No.	Name	Description			Default
		Field	Metric	Laboratory	
		feet	m	cm	
2-9	XAREASEG	XAREA 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
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 12.34: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 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 12.2 depicts the resulting well configuration for both well segments.

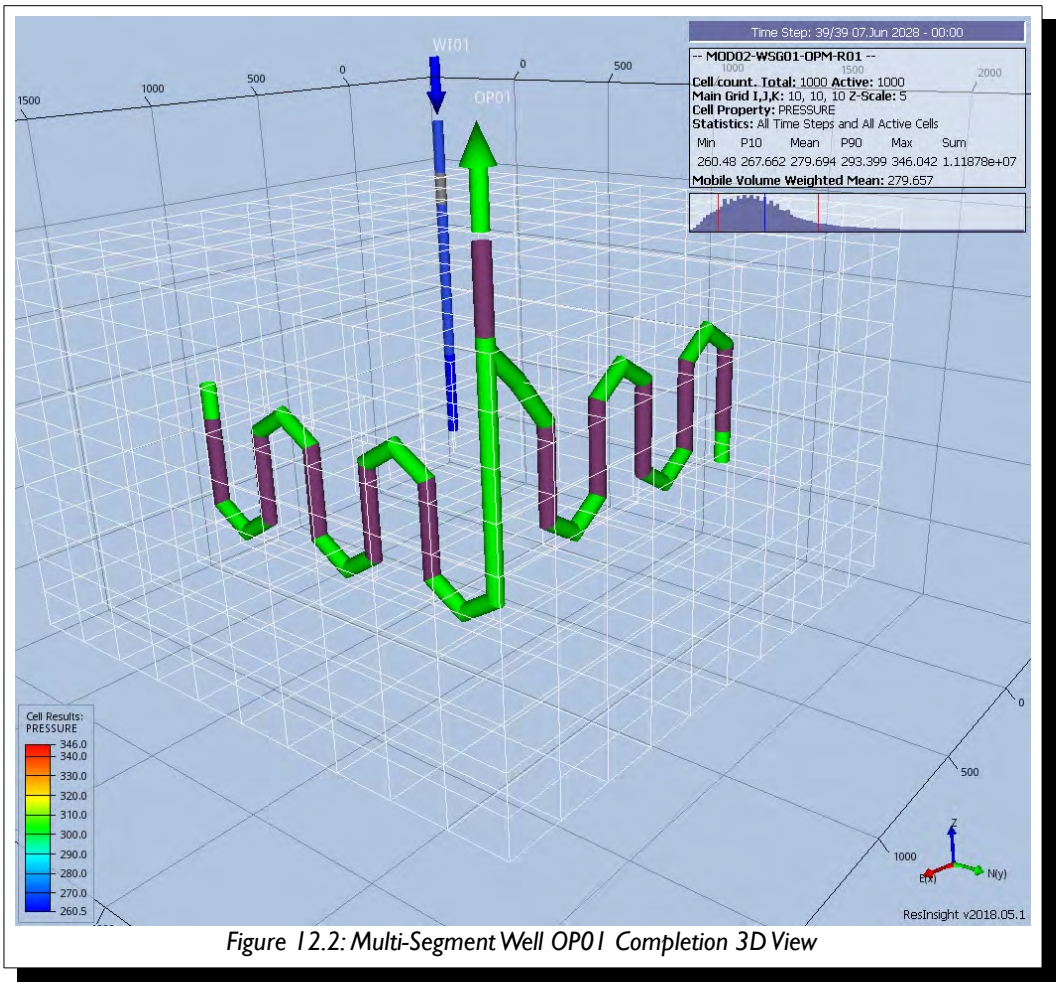

Figure 12.2: Multi-Segment Well OP01 Completion 3D View

12.3.84 WELSPECL – DEFINE WELL SPECIFICATIONS FOR LOCAL GRID REFINEMENTS

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[67] 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.[68] 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

[67] *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.*

[68] *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 numbers 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 12.35: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.

12.3.85 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 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.			
		feet	m	cm	0.0
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[69] 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.[70] 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

[69] *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.*

[70] *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 numbers 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 12.36: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.

12.3.86 WELTARG – MODIFY WELL TARGETS AND CONSTRAINTS 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 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 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.37: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.

12.3.87 WGASPROD – DEFINE SALE GAS WELL PRODUCTION TARGETS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

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 but is documented here for completeness.

12.3.88 WGRUPCON – DEFINE WELL GUIDES 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.38: 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.

12.3.89 WHISTCTL - DEFINE WELL HISTORICAL TARGET PHASE

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 12.39: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.

12.3.90 WINJMULT – DEFINE WELL PRESSURE DEPENDENT INJECTIVITY MULTIPLIERS

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.

12.3.91 WINJTEMP – DEFINE INJECTION FLUID THERMAL PROPERTIES

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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.40: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.

12.3.92 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.

12.3.93 WLIMTOL – DEFINE 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.

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

12.3.94 WLIST – DEFINE WELL LISTS

Description

WLIST declares a group of wells to belong to a named 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.41: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.

Examples

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.

12.3.95 WORKLIM – DEFINE WELL WORKOVER TIME

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.

12.3.96 WORKTHP – DEFINE WELL WORKOVER OPTIONS FOR THP KILLED WELLS

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.

12.3.97 WPAVE – DEFINE WELL BLOCK AVERAGE PRESSURE CALCULATION PARAMETERS

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.

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 12.42: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.

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 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.

12.3.98 WPAVEDEP – DEFINE WELL REFERENCE DEPTH FOR PRESSURE CALCULATIONS

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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.43: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.

12.3.99 WPIMULT – DEFINE WELL CONNECTION MULTIPLIERS

Description

The WPIMULT keyword defines a well connection multiplier factor that scales the existing well connection values. The resulting effect is scale the well' 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.44: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.

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    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' /
/
--
--        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*   1*   1*    10                /
OP03     1.100    1*  1*   1*   35    50                /
/
```

In this example the WPIMULT scales the well productivity of well OP01 by 1.25, scales the well connection factor in layer 10 only by 0.75 for well OP02, and for OP03, scales the top most 15 well connections by 1.100.

12.3.100 WPITAB - ASSIGN WELL PRODUCTIVITY INDEX VERSUS WATER CUT TABLES

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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.45: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 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.

12.3.101 WPOLYMER - DEFINE WATER INJECTION WELL POLYMER AND SALT CONCENTRATIONS

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

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.

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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.46: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.

12.3.102 WRFT – ACTIVATE WELL RFT REPORTING TO THE RFT FILE

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 Schulmberger 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 12.47: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.

12.3.103 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 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 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.			

No.	Name	Description			Default
		Field	Metric	Laboratory	
Notes: 1) The keyword is followed by any number of records terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.48: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.

12.3.104 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 2019-04 From The Command Line* on how to set the numerical control parameters for OPM Flow.

12.3.105 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 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	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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.49: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.

12.3.106 WSOLVENT - DEFINE GAS INJECTION WELL SOLVENT FRACTION

Description

WSOLVENT defines a gas injection well's solvent faction in the injection stream that is to be used when the solvent option 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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".					

Table 12.50: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.

12.3.107 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.			
		°F	°C	°C	None

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 numbers records with each record terminated by a "/" and the keyword should be terminated by a "/".

Table 12.51: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.

12.3.108 WTEST – WELL TESTING CRITERIA FOR RE-OPENING CLOSED WELLS

Description

The WTEST keyword outlined the testing procedures to be 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 12.52: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                                    /
OPO3     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***

12.3.109 WTRACER – DEFINE AN INJECTION WELL'S TRACER CONCENTRATION

Description

The WELTRACER 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 TRACER keyword in the RUNSPEC section.

OPM Flow has not implemented tracer modeling and therefore this keyword is ignored by OPM Flow and has no effect on the simulation.

12.3.110 ZIPPY2 – ACTIVATE AUTOMATIC TIME STEP CONTROL

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Description

The ZIPPY2 keyword actives 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 2019-04 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	
ADD – Add a Constant to a Specified Array	
ADDREG – Add a Constant to an Array based on a Region Number	
ADSALNOD – Salt Concentration Based on SATNUM Array	
AITS - Intelligent Time Stepping Activation	
ALL – Export Standard Summary Variable Vectors to File	
API – Activate API Tracking	
APIGROUP – Define API Tracking Number of Grouped Oil PVT Tables	
AQUANCON – Define Analytical Connections to the Grid	
AQUCON – Define Numerical Aquifer Connections to the Grid	
AQUCT – Define Carter-Tracy Analytical Aquifers	
AQUDIMS – Aquifer Dimensions	
AQUFETP – Define Fetkovich Analytical Aquifers	
AQUNUM – Numerical Aquifer Assignment	
AQUTAB – Define Carter-Tracy Aquifer Influence Functions	
ASPKDAM – Define Asphaltene Permeability Damage	
ASPPW2D – Define Asphaltene Two Parameters Precipitation Data	
ASPREWG -Define Asphaltene as Percentage Weight	
ASPWETF – Define Asphaltene Wettability Factor Data	

B

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter B	Status
BLACKOIL – Activate Black Oil Phases	
BOX - Define a Range of Grid Blocks to Enter Property Data	

C

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter C	Status
CARFIN – Define a Cartesian Local Grid Refinement	
CECON – Define Well Connections Economic Limit Criteria	
CIRCLE – Completion of Radial Grid Circle Activation	
COALNUM – Define the Coal Region Numbers	
COMPDAT – Define Well Connections to the Grid	
COMPDATL – Define Well Connections to a LGR Grid	
COMPIMB – Assign Imbibition Saturation Tables to Well Connections	
COMPLUMP – Assign Well Connections to Completions	
COMPORD - Define Well Connection Ordering	
COMPSEGS – Define Well Connections for Multi-Segment Wells	
COORD – Define a Set of Coordinates Lines for a Reservoir Grid	
COORDSYS – Define Coordinate Grid Options	
COPY – Copy Array Data to Another Array	
COPYREG – Copy an Array to Another Array based on a Region Number	
CPR – Activate Constrained Pressure Residual ("CPR") Linear Solver	

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	
DEBUG – Define the Debug Data to be Printed to File	
DEADOIL – Activate the Dead Oil Phase (No Free or Dissolved Gas)	
DENSITY – Define the Surface Oil, Water Gas Densities for the Fluids	
DEPTH - Edits the Depth at the Center of Each Cell	
DIMENS – Define the Dimension of the Model	
DISGAS – Activate the Dissolved Gas Phase in the Model	
DR - Define the Size of Grid Blocks in the R Direction for All Cells	
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	
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	
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	
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	
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	
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	
END – Define the End of the Input File	
ENDACTIO – End the Definition of ACTION Commands	
ENDBOX – Define the End of the BOX Defined Grid	
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 *ENKRVD – Define Relative Permeability End-Points versus Depth Functions*	
ENKRVDX- *ENKRVD – Define Relative Permeability End-Points versus Depth Functions*	
ENKRVDY *ENKRVD – Define Relative Permeability End-Points versus Depth Functions*	
ENKRVDY- *ENKRVD – Define Relative Permeability End-Points versus Depth Functions*	
ENKRVDZ *ENKRVD – Define Relative Permeability End-Points versus Depth Functions*	
ENKRVDZ- *ENKRVD – Define Relative Permeability End-Points versus Depth Functions*	
ENPTVD – Define Relative Permeability Saturation End-Points versus Depth	
ENPTVDX *ENPTVD – Define Relative Permeability Saturation End-Points versus Depth*	
ENPTVDX- *ENPTVD – Define Relative Permeability Saturation End-Points versus Depth*	
ENPTVDY *ENPTVD – Define Relative Permeability Saturation End-Points versus Depth*	
ENPTVDY- *ENPTVD – Define Relative Permeability Saturation End-Points versus Depth*	
ENPTVDZ *ENPTVD – Define Relative Permeability Saturation End-Points versus Depth*	
ENPTVDZ- *ENPTVD – Define Relative Permeability Saturation End-Points versus Depth*	
EQLDIMS – Define the Equilibration Data Dimensions	

E

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter E	Status
EQLNUM – Define the Equilibration Region Numbers	
EQLOPTS – Activate the Equilibration Options	
EQUALREG – Sets an Array to a Constant by Region Number	
EQUALS – Sets a Specified Array to a Constant	
EQUIL – Define the Equilibration Initialization Data	
EXCEL - Activate the EXCEL Option for the SUMMARY File	
EXTRAPMS – Activate Extrapolation Warning Messages	

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	
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	
FIPNUM – Define the Fluid In-Place Region Numbers	
FIPOWG – Activate Oil, Gas, and Water FIP Zone Reporting	
FLUXNUM – Define the Flux Regions	
FLUXTYPE – Defines the Flux Boundary Type	
FMTIN – Activate The Format Input File Option	
FMTOUT – Activate The Format Output File Option	
FWSET - Export Well Status Vectors for the Field to File	
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	
GASDENT – Define Gas Density Temperature Coefficients	
GASVISCT – Define Gas Viscosity versus Temperature Functions	
GCONINJE – Group Injection Targets and Constraints	
GCONPROD – Group Production Targets and Constraints	
GDFILE – Load a Grid File	
GDORIENT - Define Grid Orientation Parameters	
GECON – Group Economic Criteria for Production Groups	
GEFAC – Define Group Efficiency	
GLIFTOPT – Define Group Gas Optimization Limits	
GMWSET - Export Well Status Vectors by Group to File	
GNETINJE – Define Group Injection Network Configuration	
GRAVITY– Define the Surface Oil, Water Gas Gravities for the Fluids	
GRID - Define the Start of the GRID Section of Keywords	
GRIDFILE – Set the Grid File Output Options	
GRIDOPTS - Grid Processing Options	
GRIDUNIT – Define the Grid Units	
GRUPNET – Define Group Standard Network Parameters	
GRUPRIG – Group Drilling and Workover Rig Specifications	
GRUPTREE – Define Group Tree Hierarchy	
GSATPROD – Define Group Satellite Production Rates	

H

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter H	Status
HEATCR – Define Reservoir Rock Heat Capacity for All Cells	
HEATCRT – Define Reservoir Rock Heat Capacity Temperature Dependence for All Cells	

I

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter I	Status
IMBNUM – Define the Imbibition Saturation Table Region Numbers	
IMBNUMX *IMBNUM – Define the Imbibition Saturation Table Region Numbers*	
IMBNUMY *IMBNUM – Define the Imbibition Saturation Table Region Numbers*	
IMBNUMZ *IMBNUM – Define the Imbibition Saturation Table Region Numbers*	
IMBNUMX- *IMBNUM – Define the Imbibition Saturation Table Region Numbers*	
IMBNUMY- *IMBNUM – Define the Imbibition Saturation Table Region Numbers*	
IMBNUMZ- *IMBNUM – Define the Imbibition Saturation Table Region Numbers*	
IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions	
IMKRVDX *IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions*	
IMKRVDX- *IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions*	
IMKRVDY *IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions*	
IMKRVDY- *IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions*	
IMKRVDX *IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions*	
IMKRVDZ- *IMKRVD – Imbibition Relative Permeability End-Points versus Depth Functions*	
IMPES – Activate Implicit Pressure Explicit Saturation Solution Option	
IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth	
IMPTVDX *IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth*	
IMPTVDX- *IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth*	
IMPTVDY *IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth*	
IMPTVDY- *IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth*	
IMPTVDZ *IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth*	
IMPTVDZ- *IMPTVD – Imbibition Relative Permeability Saturation End-Points versus Depth*	
INCLUDE – Load Another Data File at the Current Position	
INIT – Activate the INIT File Option	
IPCG – End-Point Scaling of Grid Cell Gas Capillary Pressure (Imbibition)	
IPCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Imbibition)	
INRAD – Define the Inner Radius of a Radial Grid	
ISGCR – End-Point Scaling of Grid Cell Critical Gas Saturation (Imbibition)	

I

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter I	Status
ISGL – End-Point Scaling of Grid Cell Connate Gas Saturation (Imbibition)	
ISGLPC – End-Point Scaling of Grid Cell Capillary Pressure Connate Gas Saturation (Imbibition)	
ISGU – End-Point Scaling of Grid Cell Maximum Gas Saturation (Imbibition)	
ISOGCR – End-Point Scaling of Grid Cell Critical Oil Saturation to Gas (Imbibition)	
ISOLNUM – Define the Independent Reservoir Regions	
ISOWCR – End-Point Scaling of Grid Cell Critical Oil Saturation to Water (Imbib.)	
ISWCR – End-Point Scaling of Grid Cell Critical Water Saturation (Imbibition)	
ISWL – End-Point Scaling of Grid Cell Connate Water Saturation (Imbibition)	
ISWLPC – End-Point Scaling Grid Cell Capillary Pressure Connate Water Saturations (Imbibition)	
ISWU – End-Point Scaling of Grid Cell Maximum Water Saturation (Imbibition)	

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	

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 *KRG – End-Point Scaling of Grid Cell Krg(Sgu) (Drainage)*	
KRGX- *KRG – End-Point Scaling of Grid Cell Krg(Sgu) (Drainage)*	
KRGY *KRG – End-Point Scaling of Grid Cell Krg(Sgu) (Drainage)*	
KRGY- *KRG – End-Point Scaling of Grid Cell Krg(Sgu) (Drainage)*	
KRGZ *KRG – End-Point Scaling of Grid Cell Krg(Sgu) (Drainage)*	
KRGZ- *KRG – End-Point Scaling of Grid Cell Krg(Sgu) (Drainage)*	
KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)	
KRGRX *KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)*	
KRGRX- *KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)*	
KRGRY *KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)*	
KRGRY- *KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)*	
KRGRZ *KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)*	
KRGRZ- *KRGR – End-Point Scaling of Grid Cell Krgr(1-Sogcr) (Drainage)*	
KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)	
KROX *KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)*	
KROX- *KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)*	
KROY *KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)*	
KROY- *KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)*	
KROZ *KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)*	
KROZ- *KRO – End-Point Scaling of Grid Cell Kro(Swl) (Drainage)*	
KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)	
KRORGX *KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)*	
KRORGX- *KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)*	
KRORGY *KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)*	
KRORGY- *KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)*	
KRORGZ *KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)*	
KRORGZ- *KRORG – End-Point Scaling of Grid Cell Kro(Sgcr) (Drainage)*	

K

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter K	Status
KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)	
KRORWX *KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)*	
KRORWX- *KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)*	
KRORWY *KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)*	
KRORWY- *KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)*	
KRORWZ *KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)*	
KRORWZ- *KRORW – End-Point Scaling of Grid Cell Kro(Swcr) (Drainage)*	
KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)	
KRWX *KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)*	
KRWX- *KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)*	
KRWY *KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)*	
KRWY- *KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)*	
KRWZ *KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)*	
KRWZ- *KRW – End-Point Scaling of Grid Cell Krw(Sw =1.0) (Drainage)*	
KRWR – End-Point Scaling of Grid Cell KRWR(Sw =1.0) (Drainage)	
KRWRX *KRWR – End-Point Scaling of Grid Cell KRWR(Sw =1.0) (Drainage)*	
KRWRX- *KRWR – End-Point Scaling of Grid Cell KRWR(Sw =1.0) (Drainage)*	
KRWRY *KRWR – End-Point Scaling of Grid Cell KRWR(Sw =1.0) (Drainage)*	
KRWRY- *KRWR – End-Point Scaling of Grid Cell KRWR(Sw =1.0) (Drainage)*	
KRWRZ *KRWR – End-Point Scaling of Grid Cell KRWR(Sw =1.0) (Drainage)*	
KRWRZ- *KRWR – End-Point Scaling of Grid Cell KRWR(Sw =1.0) (Drainage)*	

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	
LGR – Define Local Grid Refinement Parameters	
LICENSES – Define Required Licenses for Run	
LIFTOPT – Activate Gas Lift Optimization	
LIVEOIL – Activate the Live Oil Phase (Oil with Free and Dissolved Gas)	

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	
MAXVALUE – Sets a Maximum Value for an Array Element	
MEMORY – Define Allocated Memory	
MESSAGES – Define Message Print Limits and Stop Limits	
METRIC – Activate the Metric System of Units for the Model	
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	
MONITOR – Activate Output of the Monitoring Data and File	
MSFN – Miscible Normalized Relative Permeability Tables	
MSGFILE – Active or Deactivate Message File Output	
MULTFLT – Multiply the Transmissibility of a Defined Fault by a Constant	
MULTIN – Activate The Unified Input File Option	
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 Multiple Output File Option	
MULTPV – Multiply Cell Pore Volumes by a Constant	
MULTREGP– Multiply Pore Volumes Based On Region Number	
MULTREGT– Multiply Transmissibilities Between Regions	
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	

M

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter M	Status
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
NETBALAN – Network Balancing Parameters	
NEWTRAN – Activate Irregular Corner-Point Grid Transmissibilities	
NEXTSTEP – Maximum Next Time Step Size	
NNC – Define Non-Neighbor Connections Between Cells Manually	
NOCASC – Activate Linear Solver Tracer Algorithm	
NOECHO – Deactivate Echoing of User Input Files to the Print File	
NOGGF – Deactivate Output of Grid Geometry File	
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	
NOSIM – Activate the No Simulation Mode for Data File Checking	
NOWARN – Deactivate Warning Messages	
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	

O

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter O	Status
OIL – Activate the Oil Phase in the Model	
OILDENT – Define Oil Density Temperature Coefficients	
OILVISCT – Define Oil Viscosity versus Temperature Functions	
OLDTRAN – Activate Cartesian 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	
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 Run Configuration	
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)	
PCW – End-Point Scaling of Grid Cell Water Capillary Pressure (Drainage)	
PDEW – Define the Initial Equilibration Dew-Point Pressure for All Grid Blocks	
PDVD – Define Equilibration Dew-Point versus Depth Tables	
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	
PERMXX – Define the Permeability Tensor in the XX Direction for All the Cells	
PERMXY – Define the Permeability Tensor in the XY Direction for All the Cells	
PERMY - Define the Permeability in the Y Direction for All the Cells	
PERMYY – Define the Permeability Tensor in the YY Direction for All the Cells	
PERMYZ – Define the Permeability Tensor in the YZ Direction for All the Cells	
PERMZ - Define the Permeability in the Z Direction for All the Cells	
PERMZX – Define the Permeability Tensor in the ZX Direction for All the Cells	
PERMZZ – Define the Permeability Tensor in the ZZ Direction for All the Cells	
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	
PINCHREG - Define Pinch-Out Region Options	
PLMIXPAR – Define the Polymer Todd-Longstaff Mixing Parameters	
PLYADS - Define Polymer Rock Adsorption Tables	
PLYADSS - Define Polymer Rock Adsorption with Salt Dependence Tables	
PLYDHFLF - Define Polymer Thermal Degradation Half-Life Tables	

P

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter P	Status
PLYMAX - Define Polymer-Salt Viscosity Mixing Concentrations	
PLMIXNUM – Define the Polymer Region Numbers	
PLYROCK - Define Polymer-Rock Properties	
PLYSHEAR – Activate and Define Polymer Shearing Parameters	
PLYSHLOG - Activate and Define the Polymer Shearing Logarithmic Parameters	
PLYVISC – Define Polymer Viscosity Scaling Factors	
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	
PRESSURE – Define the Initial Equilibration Pressures for All Grid Blocks	
PROPS - Define the Start of the PROPS Section of Keywords	
PRORDER – Define a Group Production Rules Sequence	
PVCDO - Oil PVT Properties for Dead Oil (Constant Compressibility)	
PVDG - Gas PVT Properties for Dry Gas	
PVDO – Oil PVT Properties for Dead Oil	
PVDS - Solvent PVT Properties for the Solvent Model	
PVTG - Gas PVT Properties for Wet Gas	
PVTNUM – Define the PVT Regions	
PVTO - Oil PVT Properties for Live Oil	
PVTW - Define Water Fluid Properties for Various Regions	

Q

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter Q	Status
There Are No Keywords Beginning with the Letter Q	

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	
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	
RESTART – Restart Run From an Existing Restart File	
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	
ROCKNUM – Define Rock Compaction Table Region Numbers	
ROCKOPTS – Define Rock Compaction and Compressibility Options	
ROCKTAB – Rock Compaction Tables	
ROCKWNODE – Water Saturation Values for Compaction Pressure-Sw Tables	
RPTGRID – Define GRID Section 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 for Dead Oil PVT Fluids	

R

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter R	Status
RSCONSTT – Define Constant GOR for Dead Oil PVT Fluids	
RSVD – Equilibration Dissolved Gas-Oil Ratio (Rs) versus Depth Tables	
RTEMP - Define the Initial Reservoir Temperature for the Model	
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	
RVVD – Equilibration Vaporized Oil-Gas Ratio (Rv) versus Depth Tables	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SALNODE – Salt Concentration Based PVTNUM Array	
SATNUM – Define the Saturation Table Region Numbers	
SATOPTS – Activate Relative Permeability Assignment Options	
SAVE – Activate Output of a SAVE File for Fast Restarts	
SCALECRS – Set End-Point Scaling Option	
SCHEDULE - Define the Start of the SCHEDULE Section of Keywords	
SDENSITY – Define the Miscible or Solvent Surface Gas Density	
SEPARATE – Activate the Separate RSM File Output Option	
SGAS – Define the Initial Equilibration Gas Saturation for All Grid Blocks	
SGCR – End-Point Scaling Grid Cell Critical Gas Saturations	
SGCRX *SGCR – End-Point Scaling Grid Cell Critical Gas Saturations*	
SGCRX- *SGCR – End-Point Scaling Grid Cell Critical Gas Saturations*	
SGCRY *SGCR – End-Point Scaling Grid Cell Critical Gas Saturations*	
SGCRY- *SGCR – End-Point Scaling Grid Cell Critical Gas Saturations*	
SGCRZ *SGCR – End-Point Scaling Grid Cell Critical Gas Saturations*	
SGCRZ- *SGCR – End-Point Scaling Grid Cell Critical Gas Saturations*	
SGCWMIS – Miscible Critical Gas versus Water Saturation Functions	
SGFN – Gas Saturation Tables (Format Type 2)	
SGL – End-Point Scaling Grid Cell Connate Gas Saturations	
SGLX *SGL – End-Point Scaling Grid Cell Connate Gas Saturations*	
SGLX- *SGL – End-Point Scaling Grid Cell Connate Gas Saturations*	
SGLY *SGL – End-Point Scaling Grid Cell Connate Gas Saturations*	
SGLY- *SGL – End-Point Scaling Grid Cell Connate Gas Saturations*	
SGLZ *SGL – End-Point Scaling Grid Cell Connate Gas Saturations*	
SGLZ- *SGL – End-Point Scaling Grid Cell Connate Gas Saturations*	
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	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SGUX *SGU – End-Point Scaling Grid Cell Gas Saturation*	
SGUX- *SGU – End-Point Scaling Grid Cell Gas Saturation*	
SGUY *SGU – End-Point Scaling Grid Cell Gas Saturation*	
SGUY- *SGU – End-Point Scaling Grid Cell Gas Saturation*	
SGUZ *SGU – End-Point Scaling Grid Cell Gas Saturation*	
SGUZ- *SGU – End-Point Scaling Grid Cell Gas Saturation*	
SGWFN – Gas-Water Saturation Tables (Format Type 2)	
SHRATE - Activate and Define the Polymer Shearing Logarithmic Parameters	
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	
SLGOF – Gas-Oil Saturation Tables versus Gas (Format Type 1)	
SMRYDIMS – Define Maximum Number of Summary Vectors to be Written	
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)	
SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas	
SOGCRX *SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas*	
SOGCRX- *SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas*	
SOGCRY *SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas*	
SOGCRY- *SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas*	
SOGCRZ *SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas*	
SOGCRZ- *SOGCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Gas*	
SOIL – Define the Initial Equilibration Oil Saturation for All Grid Blocks	
SOLUTION - Define the Start of the SOLUTION Section of Keywords	
SOLVENT – Activate the SOLVENT Phase in the Model	
SORWMIS – Miscible Residual Oil versus Water Saturation Functions	
SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SOWCRX *SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water*	
SOWCRX- *SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water*	
SOWCRY *SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water*	
SOWCRY- *SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water*	
SOWCRZ *SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water*	
SOWCRZ- *SOWCR – End-Point Scaling Grid Cell Critical Oil Saturation with Respect to Water*	
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	
SSOL – Define the Initial Equilibration Solvent Saturation for All Grid Blocks	
START – Simulation Start Date	
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	
SUMMARY - Define the Start of the SUMMARY Section of Keywords	
SUMTHIN – Define SUMMARY DATA Reporting Time Steps	
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 *SWCR – End-Point Scaling Grid Cell Critical Water Saturation*	
SWCRX- *SWCR – End-Point Scaling Grid Cell Critical Water Saturation*	
SWCRY *SWCR – End-Point Scaling Grid Cell Critical Water Saturation*	
SWCRY- *SWCR – End-Point Scaling Grid Cell Critical Water Saturation*	
SWCRZ *SWCR – End-Point Scaling Grid Cell Critical Water Saturation*	
SWCRZ- *SWCR – End-Point Scaling Grid Cell Critical Water Saturation*	

S

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter S	Status
SWFN – Water Saturation Tables (Format Type 2)	
SWL – End-Point Scaling Grid Cell Connate Water Saturation	
SWLX *SWL – End-Point Scaling Grid Cell Connate Water Saturation*	
SWLX- *SWL – End-Point Scaling Grid Cell Connate Water Saturation*	
SWLY *SWL – End-Point Scaling Grid Cell Connate Water Saturation*	
SWLY- *SWL – End-Point Scaling Grid Cell Connate Water Saturation*	
SWLZ *SWL – End-Point Scaling Grid Cell Connate Water Saturation*	
SWLZ- *SWL – End-Point Scaling Grid Cell Connate Water Saturation*	
SWLPC – End-Point Scaling Grid Cell Capillary Pressure Connate Gas Saturations	
SWOF – Water-Oil Saturation Tables (Format Type 1)	
SWU – End-Point Scaling Grid Cell Gas Saturation	
SWUX *SWU – End-Point Scaling Grid Cell Gas Saturation*	
SWUX- *SWU – End-Point Scaling Grid Cell Gas Saturation*	
SWUY *SWU – End-Point Scaling Grid Cell Gas Saturation*	
SWUY- *SWU – End-Point Scaling Grid Cell Gas Saturation*	
SWUZ *SWU – End-Point Scaling Grid Cell Gas Saturation*	
SWUZ- *SWU – End-Point Scaling Grid Cell Gas Saturation*	

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	
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	
THCSOLID – Define Solid Phase Thermal Conductivity for All Cells	
THCWATER – Define Water Phase Thermal Conductivity for All Cells	
THERMAL– Activate the Thermal Modeling Option	
THERMEXI – Define Component Thermal Expansion Coefficients	
THPRES - Define Equilibration Region Threshold Pressures	
THPRESFT - Define Fault Threshold Pressures	
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	
TRACER – Define Passive Tracer Variables	
TRACERS – Activate Tracer Options and Set Tracer Array Dimensions	
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	
TREF - Define Component Fluid Densities Reference Temperatures	
TREFS – Define Component Fluid Densities Reference Temperature at Surface	

T

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter T	Status
TSTEP – Advance Simulation by Reporting Time	
TUNING - Numerical Tuning Control	
TUNINGDP – Numerical Tuning Control for High Throughput Cases	
TVDP – Define the Initial Equilibration Tracer Saturation versus Depth Functions	

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	
UNIFIN – Activate The Unified Input File Option	
UNIFOUT – Activate The Unified Output File Option	

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	
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	
VISCREF - Define Viscosity-Temperature Reference Conditions	

W

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter W	Status
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	
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	
WCONPROD – Define Well Production Targets and Constraints	
WDFACCOR – Gas Flow Dependent Skin Factor	
WDRILTIM – Define Drilling Parameters for Automatic Drilling of New Wells	
WECON – Well Economic Criteria for Production Wells	
WEFAC – Define Well Efficiency	
WELCNTL – Modify Well Control and Targets	
WELLDIMS – Define the Wells and Group Dimensions	
WELOPEN – Define Well and Well Connections Flowing Status	
WELPI – Define Well Productivity and Injectivity Indices	
WELSEGS – Define Multi-Segment Wells and Their Segment Structure	
WELSPECL – Define Well Specifications for Local Grid Refinements	
WELSPECS – Define Well Specifications	
WELTARG – Modify Well Targets and Constraints Values	
WGASPROD – Define Sale Gas Well Production Targets	
WGRUPCON – Define Well Guides for Group Control	
WHISTCTL - Define Well Historical Target Phase	
WINJMULT – Define Well Pressure Dependent Injectivity Multipliers	
WINJTEMP – Define Injection Fluid Thermal Properties	
WLIFT – Define Well Re-Tubing, THP and Lift Switching Workover Operations	
WLIMTOL – Define Constraint Tolerance	

W

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SUMMARY	SCHEDULE

Alphabetic Listing Of Keywords Starting With The Letter W	Status
WLIST – Define Well Lists	
WORKLIM – Define Well Workover Time	
WORKTHP – Define Well Workover Options for THP Killed Wells	
WPAVE – Define Well Block Average Pressure Calculation Parameters	
WPAVEDEP – Define Well Reference Depth for Pressure Calculations	
WPIMULT – Define Well Connection Multipliers	
WPITAB - Assign Well Productivity Index versus Water Cut Tables	
WPOLYMER - Define Water Injection Well Polymer and Salt Concentrations	
WRFT – Activate Well RFT Reporting to the RFT File	
WRFTPLT – Activate Well RFT and PLT Reporting to the RFT File	
WSEGDIMS – Define Multi-Segment Well Dimensions	
WSEGITER – Define Multi-Segment Wells Iteration Parameters	
WSEGSICD – Define Multi-Segment Well Spiral ICD Connections	
WSOLVENT - Define Gas Injection Well Solvent Fraction	
Error: Reference source not found	
WTEST – Well Testing Criteria for Re-Opening Closed Wells	
WTRACER – Define An Injection Well's Tracer Concentration	

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	
ZIPPY2 – Activate Automatic Time Step Control	

APPENDIX B: OPM FLOW RELEASE HISTORY

B.1 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 2019-04 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.1.

No.	Keyword	Comment
1	AQUFETP	The AQUFETP keyword defines Fetkovich Analytical aquifers and the aquifer properties. Fully functional.
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. Fully functional.
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. Fully functional.
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. Fully functional.
	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. Not supported by OPM Flow.
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.

No.	Keyword	Comment
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. Fully functional.
8	MULTOUT	This keyword switches on the Multiple Output Files option for all output files. Fully functional.
9	OVERBURD	Recognized by the input deck parser and simulator support available in the experimental "ebos" simulator. Not supported by OPM Flow.
10	ROCK2D	Recognized by the input deck parser and simulator support available in the experimental "ebos" simulator. Not supported by OPM Flow.
11	ROCK2DTR	Recognized by the input deck parser and simulator support available in the experimental "ebos" simulator. Not supported by OPM Flow.
12	ROCKWNOD	Recognized by the input deck parser and simulator support available in the experimental "ebos" simulator. Not supported by OPM Flow.
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 available in the experimental "ebos" simulator. Not supported by OPM Flow.

No.	Keyword	Comment
18	THPRESFT	Recognized by the input deck parser and simulator support available in the experimental "ebos" simulator. Not supported by OPM Flow.
19	WLIST	WLIST declares a group of wells to belong to a named well list. Fully functional.

Table B.1: New Keywords for the 2019-04 Release

Bård Skaflestad, Tor Harald Sandve, and David Baxendale

B.2 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 *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 *5.2.59 THERMAL– Activate the Thermal Modeling Option* keyword in the RUNSPEC section outlining the available keywords.

Apart form the new thermal keywords summarized in section *5.2.59 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. Fully functional.
3	TOLCRIT	This keyword defines the Critical Saturation Tolerance. Fully functional.
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. Full functional.

Table B.2: New Keywords for the 2018-10 Release

Joakim Hove

B.3 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 *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.

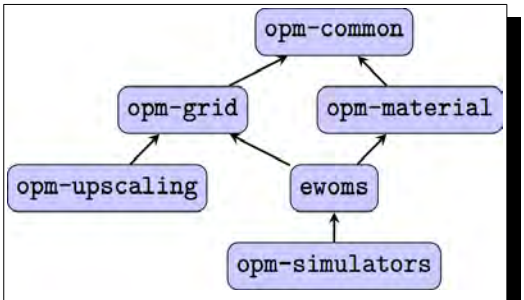

Figure B.1: OPM Flow Module Configuration

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. Fully functional.
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. Fully functional.
3	AQUDIMS	The AQUDIMS keyword defines the dimensions of the various aquifer property data. Fully functional.
4	AQUTAB	AQUTAB keyword defines additional Carter-Tracy aquifer functions to be used in the model. Fully functional.
5	COMSEGS	The COMSEGS keyword defines how a multi-segment well is connected to the reservoir by defining or modifying existing well connections.. Fully functional.
6	DRSDT	DRSDT defines the maximum rate at which the solution gas-oil ratio (Rs) can be increased in a grid cell. Fully functional.
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. Fully functional.

No.	Keyword	Comment
8	WELSEGS	The WELSEGS keyword defines a well to be a multi-segment well and defines the well's segment structure. Fully functional.
9	WSEGSDIMS	The WSEGSDIMS keyword defines the multi-segment well dimensions for the multi-segment well model. Fully functional.

Table B.3: New Keywords for the 2018-04 Release

Tor Harald Sandve

B.4 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.5 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.6 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 2018-10

OPM Flow release 2018-10 and beyond have switched to the eWoms/ebos[71] 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.1.

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

[71] *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**
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
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 *5.2.37 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

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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}

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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[72]. 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 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

[72] *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**
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
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[73]		

[73] *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**
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
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

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2018-10 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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.1: OPM Flow 2018-10 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.

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
#
ecl-output-dir=OPM
#
# ------------------------------------------------------------------------
# NEWTON SOLVER PARAMETER
# ------------------------------------------------------------------------
#
# Define Numerical Tolerances
#
flow-tolerance-mb=1e-5
flow-tolerance-cnv=1e-2
flow-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 C.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
```

C.2 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[74] 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. 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 deck_filename=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 *output_dir* command line parameter, for instance:

```
flow 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 deck_filename=path_to_data/CASENAME.param
```

A list of command line options for this release is given in Table C.2.

If OPM Flow is installed with parallel capabilities.

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

will start OPM Flow on four nodes etc. Additional tutorials for running OPM Flow is available on OPM website in the *Tutorials* section.

[74] *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 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.

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: 4) none: No output to the files. 5) log or false: Output logging information only. 6) 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
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

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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
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[75]. 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

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

OPM Flow 2018-04 Command Line Options			
No.	**Variable Name**	**Description**	**Default**
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.2: OPM Flow 2018-04 Command Line Options

As mentioned previously, it is also possible to put multiple options together in a parameter file, by using a filename ending with the extension ".param" and then passing that filename as a command line parameter to OPM Flow.

Note

As the run parameters will effect the results and run times of a simulation it may be worth considering having a parameter file for each run of the form CASENAME.param. This can be then be used to audit any runs when evaluating the results and run times.

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.

Example

```
// -----------------------------------------------------------------------------
// INPUT AND OUTPUT OPTIONS
// -----------------------------------------------------------------------------
//
// Input File
//
deck_filename=NORNE_ATW2013.DATA
//
// Output and Output Directory
//
output=true
output_dir=OPM
// -----------------------------------------------------------------------------
// NEWTON SOLVER PARAMETER
// -----------------------------------------------------------------------------
//
//Define Numerical Tolerances
//
tolerance_mb=1e-5
tolerance_cnv=1e-2
tolerance_wells=1e-2
//
// Set Min Newtonian Solver iterations to 1 and Max to 15
//
min_iter=1
max_iter=15
//
// Set Residual Threshold for Time Step Chop (Restart Solver)
//
max_residual_allowed=1e5
//
// USE BiCG Solver
//
newton_use_gmres=false
//
// Set Linear Solver Parameters
//
linear_solver_reduction=0.01
linear_solver_maxiter=50
linear_solver_restart=40
// -----------------------------------------------------------------------------
// TIME STEPPING PARAMETERS
// -----------------------------------------------------------------------------
//
// Set Time Stepping Scheme Option to Adaptive and Control Scheme
//
timestep.adaptive=true
timestep.control=pid+iteration
//
// PID Control Tolerance (default = 1e-3)
//
timestep.control.tol=4e-5
//
// Set Target iteration that is the Sum of all Linear Iterations Over All
// Newton Iterations per Time Step
//
timestep.control.targetiteration=8
//
// Set the Minimum Allowed Value a Time Step Can be Decreased
// After the Solver Failes to Converge
//
```

```
solver.restartfactor=0.3
//
// Set the Maximum Allowed Value a Time Step Can be Increased by,
// Subject to the Maximum Allowable Time Step Size
//
timestep.control.maxgrowth=1.6
//
// Max Number of Restarts (Time Step Chops) Before the Simulation is Terminated
//
solver.restart=10
//
// Verbosity of Solver and Adaptive Time Stepping
//
solver.verbose=true
timestep.verbose=true
// ------------------------------------------------------------------------
```

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.

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 2019-04 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.	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. 2) The extended GRID file format. 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.	Fully Supported

File Type	Data Type	Description	OPM Flow Status
INIT	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 file being written out.	Fully Supported
LOG	Output File	The LOG file for the commercial simulator contains an ASCII copy of the output from the terminal. 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` Will copy the terminal output to the CASENAME.LOG file.	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.	Fully Supported
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. The data is used to visualize the simulation results of the model in two and three dimensional space using post-processing software. The data is also used to "restart" from a previous simulation case.	Fully Supported

File Type	Data Type	Description	OPM Flow Status
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. 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 to compare the actual wire line logging data with the simulation derived results in post processing software.	Fully Supported
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.	Not 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
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.	Fully Supported

Notes:

1) All files can be written out in either ASCII or binary formats, except for DBG , LOG and PRT 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) is set via a set of 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
Output	FMTOUT	The keyword 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
	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

Process	RUNSPEC Keyword	Description	Files

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.

File Type	Unformatted Extension	Description	Formatted Extension
DATA	*.DATA	Input data file.	*.DATA
DBG	*.DBG	Output debug file.	*.DBG
EGRID	*.EGRID	EGRID files contain the same information as the GRID files but employs the extensible GRID format, which is more compact than the GRID formatted files 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	*.LOG	Output log file.	*.LOG

File Type	Unformatted Extension	Description	Formatted Extension
PRT	*.PRT	Output print file.	*.PRT
RESTART Index	*.RSSPEC	The RESTART index file for both unified and non-unified formats.	*.FRSSPEC

RESTART Data Non-Unified	*.Xnnnn	The RESTART data files containing the solution arrays requested to be written to the RESTART files. For example, typing the following command from the terminal:
		`flow CASENAME`
		Will generate the following RESTART data non-unified binary files:
		`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, typing the following command from the terminal:
		`flow CASENAME`
		Will generate the following SUMMARY data unified binary files:
		`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, typing the following command from the terminal:
		`flow CASENAME`
		Will generate the following RFT data binary file:
		`CASENAME.RFT`
			*.FRFT

RSM	*.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, typing the following command from the terminal:
		`flow CASENAME`
		Will generate the following SUMMARY non-unified binary files:
		`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, typing the following command from the terminal:
		`flow CASENAME`
		Will generate the following 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.

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.

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

Developers using the Intel FORTRAN or GNU FORTRAN compilers need to use CONVERT='BIG_ENDIAN' option in the FORTRAN OPEN statement when opening unformatted files. For "LOGICAL" data "false" has all bits set to zero and "true" has at least one non-zero bit.

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. For

example, OPM Flow's grid file writing support is implemented via the ecl_grid_fwrite_EGRID2() library function from LibECL. In turn, the fwrite_EGRID2() function unconditionally writes unformatted files:

```
void ecl_grid_fwrite_EGRID2(ecl_grid_type * grid, const char * filename,
                            ert_ecl_unit_enum output_unit) {
  bool fmt_file        = false;
  fortio_type * fortio = fortio_open_writer(filename, fmt_file, ECL_ENDIAN_FLIP);
```

Where fmt_file is a flag that indicates whether or not to create a formatted output file (fmt_file = true) or an unformatted output file (fmt_file = false).

The following sections outline the format of the various individual files supported by OPM Flow, except for the DBG, LOG and PRT 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 records that define the header record data type, the number of data entries, and then the associated header record data. There are a total of four major record header types for this file type (1) File Header, (2) Global Grid Header, (3) Local Grid Refinement Header (repeated for each local grid refinement in the model), and (4) Non-Neighbor Connection Header. Each major header is subdivided into a series of sub-headers that define a particular data set record. The general format for header record is the record name (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).

For a formatted EGRID file (*.FGRID) file structure for a global grid is of the form:

```
 '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
 '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  ' '         '
 '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'
 '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
.....:.....
```

Whereas the unformatted file looks something like this if viewed in a text editor:

```
    FILEHEAD   dINTE                Ô



                                  GRIDHEAD   dINTE



                                                                                  COORD       Ö
REAL        X                          Dz   Dz          Dz       Dz   Dú            Dú
Dz   E;€          E;€      Dz   Ez              Ez       Dz   Ece@          Ece@      Dz   E»€
          E»€      Dz   EÚÀ          EÚÀ      Dz   Eú           Eú       Dz   F
F         Dz   F @          F @      Dz       Dz                Dz   Dz   Dz   Dz        Dz   Dz
Dz   Dú   Dz        Dú   Dz   Dz   E;€ Dz        E;€ Dz   Dz   Ez   Dz        Ez   Dz   Dz   Ece@
Dz        Ece@ Dz   Dz   E»€ Dz        E»€ Dz   Dz   EÚÀ Dz        EÚÀ Dz   Dz   Eú   Dz
Eú   Dz   Dz   F    Dz        F    Dz   Dz   F @ Dz        F @ Dz   Dz        Dú             Dú
Dz   Dz   Dú        Dz   Dú   Dz   Dú   Dú        Dú   Dú   Dz   E;€ Dú        E;€ Dú   Dz   Ez
Dú        Ez   Dú   Dz   Ece@ Dú        Ece@ Dú   Dz   E»€ Dú        E»€ Dú   Dz   EÚÀ Dú
EÚÀ Dú    Dz   Eú   Dú        Eú   Dú   Dz   F    Dú        F    Dú   Dz   F @ Dú        F @ Dú
Dz        E;€           E;€ Dz   Dz   E;€      Dz   E;€ Dz   Dú   E;€      Dú   E;€ Dz   E;€
E;€       E;€ E;€ Dz   Ez   E;€      Ez   E;€ Dz   Ece@ E;€      Ece@ E;€ Dz   E»€ E;€
E»€ E;€   Dz   EÚÀ E;€      EÚÀ E;€ Dz   Eú   E;€      Eú   E;€ Dz   F    E;€      F    E;€
Dz   F @  E;€      F @  E;€ Dz        Ez             Ez   Dz   Dz   Ez        Dz   Ez   Dz   Dú
Ez        Dú   Ez   Dz   E;€ Ez        E;€ Ez   Dz   Ez   Ez        Ez   Ez   Dz   Ece@ Ez
Ece@ Ez   Dz   E»€ Ez        E»€ Ez   Dz   EÚÀ Ez        EÚÀ Ez   Dz   Eú   Ez        Eú   Ez
Dz   F    Ez        F    Ez   Dz   F @  Ez        F @  Ez   Dz        Ece@           Ece@ Dz   Dz
Ece@      Dz   Ece@ Dz   Dú   Ece@      Dú   Ece@ Dz   E;€ Ece@      E;€ Ece@ Dz   Ez   Ece@
Ez   Ece@ Dz   Ece@ Ece@      Ece@ Ece@ Dz   E»€ Ece@      E»€ Ece@ Dz   EÚÀ Ece@      EÚÀ Ece@
Dz   Eú   Ece@      Eú   Ece@ Dz   F    Ece@      F    Ece@ Dz   F @  Ece@      F @  Ece@ Dz
```

Figure D.1: EGRID Unformatted File Format Viewed in a Text Editor

The following sections describe the format of the various record header data and the associated data set.

D.2.1 EGRID HEADER RECORD

The FILEHEAD record defines the key attributes of the file via a series of integer constants, this is then followed by the MAPUNITS, MAPAXES, GRIDUNIT and GDORIENT records and their associated data sets. Note that some records 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.5 outlines the structure of the File Header Record and the associated sub-records for this data set.

No.	Record Name	EGRID Header Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	FILEHEAD	File header record for the EGRID file defines the start of this record type.			Required
1-1	Format	FILEHEAD	100	INTE	
2-1	Data	Version number for this file type, for example 3.			
2-2	Data	The year this version of the file format was released, for example 2004.			
2-3	Data	Not used.			
2-4	Data	Version number of earliest this file format is supported, normally set to 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).			
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.			
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	Map units header record that defines the start the MAPUNITS record Normally set to FEET or METRES.			Optional
1-1	Format	MAPUNITS	1	CHAR	
2-1	Data	The units of the map data, normally set to FEET or METRES.			
	MAPAXES	Start of the MAPAXES header record data that 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.			

No.	Record Name	EGRID Header Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	GRIDUNIT	The GRIDUNIT header record defines units of the COORD and ZCORN arrays and the grid coordinate space			Required
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 header record, that 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 sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and thos colred red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the FILEHEAD header Record Name should be written out as 'FILEHEAD'.
4) GDORIENT keyword in the GRID section is not supported by OPM Flow.

Table D.5: EGRID Header Record

Example: EGRID Header Record

The following example shows a typical formatted file header record 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
 '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 record is not written out.

D.2.2 EGRID GLOBAL IRREGULAR CORNER POINT GRID RECORD

Following the File Header data set, the Global Grid Header data set 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.6.

No.	Record Name	Global Irregular Corner Point Grid Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	GRIDHEAD	Global grid header record for the EGRID file defines the start of this record 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.			
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 0 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 refence 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.			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.	Record Name	Global Irregular Corner Point Grid Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	BOXORIG	Not supported.			Optional
1-1	Format	BOXORIG	3	INTE	
2-1 to 2-3	Data	Ignored by OPM Flow.			
	COORD	Property header record 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 header record 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 data in the same format as the COORD keyword described in the GRID section			
	COORDSYS	Coordinate definitions for each NUMRES reservoir. The number of data values for this header record 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 header record 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 header record 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			
	ACTNUM	Property header record 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 is status is set to Optional, it is normally always written out by pre-processing software. The number of data values for this header record 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			

No.	Record Name	Global Irregular Corner Point Grid Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	CORSNUM	Property header record that defines the start of the CORSNUM data set., for when the grid has be coarsened Grid coarsening is currently not supported in OPM Flow. The number of data values for this header record be NX x NY x NZ integer values.			Optional
1-1	Format	CORSNUM	NX x NY x NZ	INTE	
2-1	Data	CORSNUM data set.			
1-1	ENDGRID	The ENDGRID header record marks the end of the Global Grid Header section. Always set to 0 to indicate that there is no Data section for this record type.			Required
1-2	Format	ENDGRID	0	INTE	

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the FILEHEAD header Record Name should be written out as 'FILEHEAD'.

Table D.6: Global Irregular Corner Point Grid Record

Example: Global Irregular Corner Point Grid Record

The following example shows a typical formatted global grid header record 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 RECORD

The file structure for Local Gride Refinement ("LGR") record for Irregular Corner Point Grids is similar to the global grid record 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 record is repeated for each LGR in the model. The record description is outlined in Table D.7.

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Header Record Name	EGRID LGR Irregular Corner Point Grid Record (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. of Entries	Data Type	
	LGR	LGR grid header record for the EGRID file defines the start of this record type 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 record data set that defines the parent LGR for when nested LGR have been used.			Required
1-1	Format	LGRPARNT	1	CHAR	
2-1	Data	Name of parent LGR			
	LGRSGRID	Start of the LGRSGRID record for LGRs parented from a sub-grid.			Optional
1-1	Format	LGRSGRID	1	CHAR	
2-1	Data	Name of parent LGR			
	GRIDHEAD	Global grid header record for the EGRID file defines the start of this record type. The format is the same as the Global grid see Table D.6.			Required
	BOXORIG	Not supported. The format is the same as the Global grid see Table D.6.			Optional
	COORD	Property header record that defines the start of the LGR COORD data set. The COORD data defines a set of coordinate lines or pillars for athe LGR grid via an array. The format is the same as the Global grid see Table D.6.			Required
	COORDSYS	Coordinate definitions for the LGR. The format is the same as the Global grid see Table D.6.			Optional
	ZCORN	Property header record 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 format is the same as the Global grid see Table D.6.			Required

No.	Header Record Name	EGRID LGR Irregular Corner Point Grid Record (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. of Entries	Data Type	
	ACTNUM	Property header record 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 is status is set to Optional, it is normally always written out by pre-processing software. The format is the same as the Global grid see Table D.6.			Optional
	HOSTNUM	Property header record that defines the start of the HOSTNUM data set. which is only applicable to LGR grids. Number of data values for this header record 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.			
	ENDGRID	The ENDGRID header record marks the end of the Global Grid Header section. Always set to 0 to indicate that there is no Data section for this record type.			Required
1-1	Format	ENDGRID	0	INTE	
	ENDLGR	ENDLGRecord marks the end of the LGR Header section. Always set to 0 to indicate that there is no Data section for this record type.			Optional
1-1	Format	ENDLGR	0	INTE	

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.
4) COORDSYS keyword in the GRID section is not supported by OPM Flow.

Table D.7: EGRID LGR Irregular Corner Point Grid Records

Note that this record type is repeated for each LGR in the model as demonstrated in the following example.

Example: EGRID LGR Irregular Corner Point Grid Record

The following example shows a typical formatted global grid header record 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 Grid Header Record for LGR Irregular Corner Point Grids is 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
           2            2            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
 '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
   0.00000000E+00   0.10000000E+04   0.15000000E+04   0.10000000E+04
   0.15000000E+04   0.15000000E+04   0.00000000E+00   0.15000000E+04
   0.15000000E+04   0.10000000E+04   0.20000000E+04   0.15000000E+04
   0.00000000E+00   0.20000000E+04   0.15000000E+04   0.10000000E+04
   0.10000000E+04   0.20000000E+04   0.00000000E+00   0.10000000E+04
   0.20000000E+04   0.10000000E+04   0.15000000E+04   0.20000000E+04
   0.00000000E+00   0.15000000E+04   0.20000000E+04   0.10000000E+04
   0.20000000E+04   0.20000000E+04   0.00000000E+00   0.20000000E+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
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+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
   0.83450000E+04   0.83450000E+04   0.83450000E+04   0.83450000E+04
   0.83450000E+04   0.83450000E+04   0.83450000E+04   0.83450000E+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           0           0
           0           0           0           0           0           0
           0           0           0           0           0           0
           1           1           0           9           9           1
           9           9           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
 '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
   0.00000000E+00   0.85000000E+04   0.80000000E+04   0.10000000E+04
   0.90000000E+04   0.80000000E+04   0.00000000E+00   0.90000000E+04
   0.80000000E+04   0.10000000E+04   0.80000000E+04   0.85000000E+04
   0.00000000E+00   0.80000000E+04   0.85000000E+04   0.10000000E+04
   0.85000000E+04   0.85000000E+04   0.00000000E+00   0.85000000E+04
   0.85000000E+04   0.10000000E+04   0.90000000E+04   0.85000000E+04
   0.00000000E+00   0.90000000E+04   0.85000000E+04   0.10000000E+04
   0.80000000E+04   0.90000000E+04   0.00000000E+00   0.80000000E+04
   0.90000000E+04   0.10000000E+04   0.85000000E+04   0.90000000E+04
   0.00000000E+00   0.85000000E+04   0.90000000E+04   0.10000000E+04
   0.90000000E+04   0.90000000E+04   0.00000000E+00   0.90000000E+04
   0.90000000E+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
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
   0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+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
   0.83450000E+04   0.83450000E+04   0.83450000E+04   0.83450000E+04
   0.83450000E+04   0.83450000E+04   0.83450000E+04   0.83450000E+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 RECORD

No.	Header Record Name	EGRID Non-Neighbor Connections For Irregular Corner Point Grid Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	NNCREAD	This record marks the start of the non-neighbor records and defines the number of non-neighbor connections.			
1-1	Format	NNCREAD	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 the LGR number.			
2-3 to 2-10	Data	Not used.			
	NNC1	NNC1 starts the record for the cell numbers for UPSTREAM non-neighbor connections, where NUMNNC is the number of non-neighbor connections.			
1-1	Format	NNC1	NUMNNC	INTE	
2-1	Data	NUMNNC integer values defining the cell numbers for UPSTREAM non-neighbor connections.			
	NNC2	NNC2 starts the record for the cell numbers for DOWNSTREAM non-neighbor connections, where NUMNNC is the number of non-neighbor connections			
1-1	Format	NNC2	NUMNNC	INTE	
2-1	Data	NUMNNC integer values defining the cell numbers for DOWNSTREAM non-neighbor connections.			
	NNCL	This record defines the local cells connected to the global grid, where NCONGL is the number of entries.			
1-1	Format	NNCL	NCONCL	INTE	
2-1	Data	NCONCL integer values defining the local cells connected to the global grid.			
	NNCG	This record defines the global cells connected to the current local grid being defined on this record, where NCONGL is the number of entries.			
1-1	Format	NNCG	NCONGL	INTE	
2-1	Data	NCONGL integer values defining the global cells connected to the current local grid.			
	NNCHEADA	This record defines the start of records that specify the connection between two LGRs that have been amalgamated.			
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).			

No.	Header Record Name	EGRID Non-Neighbor Connections For Irregular Corner Point Grid Record			Status Or Value
		Keyword	No. of Entries	Data Type	
2-3 to 2-10		Not used			
	NNA1	This record defines the ILOC1 cells connected in the amalgamation, where NUMNCA is the number of entries.			
1-1	Format	NNA1	NUMNCA	INTE	
2-1	Data	NUMNCA integer values defining the ILOC1 cells connected in the amalgamation.			
	NNA2	This record 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) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the FILEHEAD header Record Name should be written out as 'NNCHEAD '.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Local Grid Refinements are currently not supported by OPM Flow and neither therefore is LGR amalgamation of LGRs.

Table D.8: EGRID Non-Neighbor Connections for Irregular Corner Point Grid Record

Example: EGRID Grid Record for Non-Neighbor Connections for Irregular Corner Point Grids

```
'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

To be written in a future release of the manual.

D.6.1 INIT INDEX FILE

To be written in a future release of the manual.

D.6.2 INIT DATA FILE SPECIFICATION

This file type contains the global and LGR grid property data, 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. The individual data records are structured in as shown in Table D.9.

Reference Table	Global Records	Global Data Records	LGR Records	LGR Data Records	Notes
D.10	GRID DATA				Global grid data record for the INIT Data file that defines the start of global grid data
D.12	PROPERTY	Property 1			Global grid property records that defines the global grid property data defined in the GRID and Edit sections.
		Property 2			
		etc.			
D.18			LGR-1	Property 1	LGR property record that defines the start of the PORV global grid data set. for the first LGR This must be the first data set for this record type. Subsequent PROPERTY records can be in any order, and the record is repeated until all the PROPERTY data has been defined for an LGR. The LGR records are repeated for each each LGR in the model
				Property 2	
				etc.	
			LGR-2	Property 1	
				Property 2	
				etc.	
			etc.		
			LGRSGONE		End of LGR section record.
	TABDIMS				Tabulated data, PVT tables, relative permeability tables etc. records
	TAB				
	CON				
D.13	REGION	Region 1			Region property data for the global grid as defined in the REGION section (PVTNUM, SATNUM etc.). The record is repeated to account for all region property data.
		Region 2			
		etc.			
D.19			LGR-1	Region 1	LGR Region property data for the LGR grid as defined in the REGION section (PVTNUM, SATNUM etc.). The record is repeated to account for all region property data. The LGR records are repeated for each each LGR in the model
				Region 2	
				etc.	
			LGR-2	Region 1	
				Region 2	
				etc.	
			etc.		
			LGRSGONE		End of LGR section record.
D.11	NNC	Nnc 1			Non-neighbor connection property data (NNC) for the global grid. The record is repeated to account for various NNC arrays.

Reference Table	Global Records	Global Data Records	LGR Records	LGR Data Records	Notes
		Nnc 2			
		etc.			
D.17			LGR-1	Nnc 1	LGR Region property data for the LGR grid as defined in the REGION section (PVTNUM, SATNUM etc.). The record is repeated to account for all region property data. The LGR records are repeated for each each LGR in the model
				Nnc 2	
				etc.	
			LGR-2	Nnc 1	
				Nnc 2	
				etc.	
			etc.		
			LGRSGONE		End of LGR section record.
D.14	SATFUNS	SatFuns 1			Global Grid Saturation and End-Point Data Records. The record users the same keywords outlined in the GRID and PROPS section, for example, the SWL, SWATINIT, KRG, PCW, etc. arrays
		SatFuns 2			
		etc.			
D.20			LGR-1	Region 1	LGR Grid Saturation and End-Point Data Records. The record is repeated to account for all region property data. The LGR records are repeated for each each LGR in the model
				Region 2	
				etc.	
			LGR-2	Region 1	
				Region 2	
				etc.	
			etc.		
			LGRSGONE		End of LGR section record.

Table D.9: INIT Data File Structure

D.6.3 INIT DATA - GLOBAL GRID DATA RECORD

The INIT Data - Global Grid Data Record is the first data set that should be read or written to the INIT file. This data set includes INITHEAD, LOGIHEAD and DOUBHEAD records that define versus parameters used in subsequent records in the INIT file. This is then followed by a series of global grid PROPERTY data records that defined the various global grid property arrays for each grid cell in the model.

The structure for this type of record is defined in Table D.10.

No.	Record Name	INIT Data - Global Grid Data Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	SEQNUM	Report time step number, only used for unified restart files. Should be set to 0.			Optional
1-1	Format	SEQNUM	1	INTE	
2-1	Data	Report time step number.			0
	INITHEAD	Global grid header record for the INIT Data file that defines the start of INIT Global Grid Record and contains the integer variables for this header record.			Required
1-1	Format	INITHEAD	249	INTE	
2-1	Data	Undefined			0
2-2	Data	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	Data	Undefined.			0
2-9	Data	The number of grid blocks in the x-direction (NX).			
2-10	Data	The number of grid blocks in the y-direction (NY).			
2-11	Data	The number of grid blocks in the z-direction (NZ).			
2-12	Data	Number of global active cells in the model			
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.			
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.			
2-16 to 2-64	Data	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

No.	Record Name	INIT Data - Global Grid Data Record			Status Or Value
		Keyword	No. of Entries	Data Type	
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
2-68 to 2-94	Data	Undefined.			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.			
2-96 to 206	Data	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.			
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.			
2-209 to 410	Data	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.			SS
2-412 to 249	Data	Undefined.			0
	LOGIHEAD	Global grid record for the INIT Data file that defines the logical variables (T for true and F for false) for this record.			Required
1-1	Format	LOGIHEAD	79	LOGI	
2-1	Data	Dissolved gas is present in the model indicator, set to T if present in the model else set to F.			
2-2	Data	Vaporized oil is present in the model indicator, set to T if present in the model else set to F.			
2-3	Data	Model utilizes directional relative permeabilities in the model, set to T or F.			
2-4	Data	Model utilizes reversible directional relative permeabilities in the model indicator, set to T or F.			
2.5	Data	Radial grid geometry has been used for the model indicator, set to T or F.			
2.6	Data	Undefined.			0

No.	Record Name	INIT Data - Global Grid Data Record			Status Or Value
		Keyword	No. of Entries	Data Type	
2-7	Data	The hysteresis option has been activated in the model indicator, set to T or F.			
2-8 to 2-14	Data	Undefined.			0
2-15		The dual porosity option has been activated in the model indicator, set to T or F.			
2-16	Data	Undefined.			0
2-17	Data	The end-point scaling option has been activated in the model indicator, set to T or F.			
2-18	Data	The directional end-point scaling option has been activated in the model indicator, set to T or F.			
2.19	Data	The reversible end-point scaling option has been activated in the model indicator, set to T or F.			
2-20	Data	The alternative end-point scaling option has been activated in the model indicator, set to T or F. See the *SCALECRS – Set End-Point Scaling Option* keyword in the PROPS section for further information.			
2-21 to 2-35	Data	Undefined.			0
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	Data	Undefined.			0
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 2-79	Data	Undefined.			0
	DOUBHEAD	Global grid record for the INIT Data file that defines the double precision REAL variables for this record.			Required
1-1	Format	DOUBHEAD	185	DOUB	
2-1 to 2-185	Data	Undefined.			0.0

No.	Record Name	INIT Data - Global Grid Data Record			Status Or Value
		Keyword	No. of Entries	Data Type	

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the PORV and PROPERTY fields should be written out as 'PORV ' and 'DEPTH ', etc.

Table D.10: INIT Data - Global Grid Data Record

Example: INIT Data - Global Grid Data Record

The following example shows a typical formatted global grid property data record.

```
'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'
  0.000000000000000D+00   0.100000000000000D+01   0.365000000000000D+03
  0.100000000149012D+00   0.150000000596046D+00   0.300000000000000D+01
  0.300000001192093D+00   0.100000000149012D+00   0.100000000149012D+00
 ..............................................
 -0.100000000200409D+21   0.100000000000000D+01   0.100000000000000D+01
  0.100000000000000D+01   0.000000000000000D+00   0.000000000000000D+00
  0.100000000000000D+01   0.100000000000000D-03
```

End of Example

D.6.4 INIT DATA – GLOBAL GRID NON-NEIGHBOR CONNECTION DATA RECORD

The INIT Data – Global Grid Non-Neighbor Connection Data Record defines the Global Grid Non-Neighbor Connection arrays as generated by OPM Flow. This includes the TRANCC, DIFFNNC, HEATNNC, TRANGL arrays.

Item No.	Record Name	INIT Data – Global Grid Non-Neighbor Connection Data Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	NNC	The NNC record defines the start of a gobal grid non-neighbor connection array. NNC is the keyword name of the non-neighbor connection array being written out, and should be set to: 1) DIFFNNC: the non-neighbor connection diffusivities within the LGR. Only required if the DIFFUSE 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 LGR. Only required if OPM Flow's THERMAL option has been activated by the THERMAL keyword in the RUNSPEC section. The following two addition NNC records 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 record data set should set to the number of non-neighbor connection to be read or written out (NUMNNC) for the TRANCC, DIFFNNC, and HEATNCC arrays The NNC record (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.			

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.

Table D.11: INIT Data – Global Grid Non-Neighbor Connection Data Record

This record type is repeated for each non-neighbor connection data set in the model; see the following example.

Example: INIT Data - Global Non-Neighbor Connection Data Record

The following example shows a typical formatted INIT Data - Global Non-Neighbor Connection Data Record.

```
 'TRANNNC '       11363 'REAL'
   0.52157912E-03   0.60928073E-05   0.73730538E-03   0.51154610E-03
   0.36839943E-03   0.44034168E-03   0.14111123E-02   0.27143997E-02
   0.14248013E-02   0.18686920E-02   0.27998611E-02   0.76166220E-03
   0.72630920E-03   0.34133402E-04   0.24275912E-04   0.19163921E-03
/......./.....//
```

End of Example

D.6.5 INIT DATA - GLOBAL GRID PROPERTY DATA RECORD

The INIT Data - Global Grid Property Data Record records defined various global grid property arrays for each grid cell in the model. The PROPERTY record users 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 PROPERTY records also include the calculated pore volumes (PORV) and transmissibility arrays (TRANX, TRANY and TRANZ) after processing the GRID and EDIT sections.

Note for the PROPERTY record the first property should always be the PORV array.

The structure for this type of record is defined in Table D.12.

No.	Record Name	INIT Data - Global Grid Property Data Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	PROPERTY	The PROPERTY record defines the start of a global 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 record (items 1-1 and 2-1) is repeated for each global property. The PORV property must be the first data set for this record type and is written out in full for each cell in the model (that is NXYZ = NX x NY x NZ values). Note the array values for inactive cells etc. are set to a constant value of zero. Subsequent global 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.			

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the PORV and PROPERTY fields should be written out as 'PORV ' and 'DEPTH ', etc.

Table D.12: INIT Data - Global Grid Property Data Record

Example: INIT Data - Global Grid Property Data Record

The following example shows a typical formatted global grid property data record.

```
 '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
   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
   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
   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
   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
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
   0.50000000E+03   0.50000000E+03   0.50000000E+03   0.50000000E+03
..............................
etc.
```

End of Example

D.6.6 INIT DATA - GLOBAL GRID REGION DATA RECORD

The INIT Data - Global Grid Region Data Record defines the global grid REGION arrays. The REGION record name users the same keywords outlined in the REGION section of the manual in naming the subsequent data arrays. For example, the EQLNUM, FIPNUM, PVTNUM, ROCKNUM, SATNUM arrays etc.

Note that this record type does not include the INITHEAD, LOGIHEAD and DOUBHEAD records and there is no specific terminating record for this record type

No.	Record Name	INIT Data - Global Grid Region Data Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	REGION	The REGION record defines the start of the global grid region array. 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. Region global REGION arrays can be in any order and only the active cells are written out (NACTIV). The REGION record (items 1-1 and 2-1) is repeated for each global region array..			Required
1-1	Format	REGION	NACTIV	INTE	
2-1	Data	REGION data set.			

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the EQLNUM should be written out as 'EQLNUM '.

Table D.13: INIT Data - Global Grid Region Data Record

Example: INIT Data - Global Grid Region Data Record

The following example shows a typical formatted INIT Data - Global Grid Region Data Record data set.

```
 '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
 ……….……..
           1           1           1           1
 'FIPNUM  '          100 'INTE'
           1           1           1           1           1           1
           1           1           1           1           1           1
 ……….……..
           1           1           1           1
```

End of Example

D.6.7 INIT DATA - GLOBAL GRID SATURATION AND END-POINT DATA RECORD

The INIT Data - Global Grid Saturation and End-Point Data Record defines the global grid saturation and end-point arrays. The SATFUNS record users the same keywords outlined in the GRID and PROPS section of the manual in naming the subsequent data arrays. For example, the SWL, SWATINIT, KRG, PCW, etc. arrays

Note that this record type does not include the INITHEAD, LOGIHEAD and DOUBHEAD records and there is no specific terminating record for this record type.

No.	Record Name	INIT Data - Global Grid Saturation And End-Point Data Record Data			Status Or Value
		Keyword	No. of Entries	Data Type	
	SATFUNCS	The SATFUNS record defines the start of the global grid saturation and end-point data REAL arrays. SATFUNS 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. Type of data in the Data fields should be set to REAL for arrays with real values (SWL, SWATINIT, etc) or INTE for integer arrays (ENDNUM etc.) Region global SATFUNS arrays can be in any order and only the active cells are written out (NACTIV). This record (items 1-1 and 2-1) is repeated for each global REAL saturation and end-point array being written out., as the arrays 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	SATFUNS	NACTIV	INTE or REAL	
2-1	Data	SATFUNS data set.			

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the EQLNUM should be written out as 'EQLNUM '.

Table D.14: INIT Data - Global Grid Saturation and End-Point Data Record

Example: INIT Data - Global Grid Saturation and End-Point Data Record

The following example shows a typical formatted INIT Data - Global Grid Saturation and End-Point Data Record.

```
  'SWCR    '         100 'REAL'
   0.24444000E+00   0.23999999E+00   0.23999999E+00   0.23999999E+00
   0.23999999E+00   0.79999998E-01   0.79999998E-01   0.79999998E-01
   0.79999998E-01   0.79999998E-01   0.23999999E+00   0.23999999E+00
……..……..
   0.79999998E-01   0.79999998E-01   0.79999998E-01   0.79999998E-01
   0.79999998E-01   0.79999998E-01   0.79999998E-01   0.79999998E-01
   0.79999998E-01   0.79999998E-01   0.79999998E-01   0.79999998E-01
 'SGCR    '         100 'REAL'
   0.10000000E+00   0.10000000E+00   0.10000000E+00   0.10000000E+00
   0.10000000E+00   0.30000001E+00   0.30000001E+00   0.30000001E+00
   0.30000001E+00   0.30000001E+00   0.10000000E+00   0.10000000E+00
……..……..
   0.30000001E+00   0.30000001E+00   0.30000001E+00   0.30000001E+00
   0.30000001E+00   0.30000001E+00   0.30000001E+00   0.30000001E+00
   0.30000001E+00   0.30000001E+00   0.30000001E+00   0.30000001E+00
 'SOWCR   '         100 'REAL'
   0.15000001E+00   0.15000001E+00   0.15000001E+00   0.15000001E+00
   0.15000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
   0.18000001E+00   0.18000001E+00   0.15000001E+00   0.15000001E+00
……..……..
   0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
   0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
   0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
 'SOGCR   '         100 'REAL'
   0.15000001E+00   0.15000001E+00   0.15000001E+00   0.15000001E+00
   0.15000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
   0.18000001E+00   0.18000001E+00   0.15000001E+00   0.15000001E+00
……..……..
   0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
   0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
   0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
 'SWL     '         100 'REAL'
   0.24444000E+00   0.23999999E+00   0.23999999E+00   0.23999999E+00
   0.23999999E+00   0.79999998E-01   0.79999998E-01   0.79999998E-01
   0.79999998E-01   0.79999998E-01   0.23999999E+00   0.23999999E+00
……..……..
   0.79999998E-01   0.79999998E-01   0.79999998E-01   0.79999998E-01
   0.79999998E-01   0.79999998E-01   0.79999998E-01   0.79999998E-01
   0.79999998E-01   0.79999998E-01   0.79999998E-01   0.79999998E-01
 'SWU     '         100 'REAL'
   0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
   0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
   0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
……..……..
   0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
   0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
   0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
 'SGL     '         100 '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
 'SGU     '         100 'REAL'
   0.69999999E+00   0.69999999E+00   0.69999999E+00   0.69999999E+00
```

```
   0.69999999E+00   0.85000002E+00   0.85000002E+00   0.85000002E+00
   0.85000002E+00   0.85000002E+00   0.69999999E+00   0.69999999E+00
..............................................
   0.85000002E+00   0.85000002E+00   0.85000002E+00   0.85000002E+00
   0.85000002E+00   0.85000002E+00   0.85000002E+00   0.85000002E+00
   0.85000002E+00   0.85000002E+00   0.85000002E+00   0.85000002E+00
 'KRW     '         100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
..............................................
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'KRG     '         100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
..............................................
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'KRO     '         100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
..............................................
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'SWATINIT'       100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
..............................................
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'KRWR    '         100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
..............................................
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'KRGR    '         100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
..............................................
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'KRORG   '         100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
..............................................
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'KRORW   '         100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
```

```
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
……..……..
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'SWLPC    '          100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
……..……..
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'SGLPC    '          100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
……..……..
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'PCW      '          100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
……..……..
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'PCG      '          100 'REAL'
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
……..……..
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 'ENDNUM   '          100 'INTE'
           1           1           1           1           1           1
           1           1           1           1           1           1
           1           1           1           1           1           1
……..……..
           1           1           1           1           1           1
           1           1           1           1           1           1
           1           1           1           1
```

End of Example

D.6.8 INIT DATA - LGR GRID DATA RECORD

The file structure for INIT Data - LGR Grid Data Record record is similar to the global grid INIT Data - Global Grid Data Record described previously. This data is immediately written after the first INIT Data - LGR Grid Header Record for each LGR. The record description is outlined in Table D.15.

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Record Name	INIT Data - LGR Grid Data Record (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. of Entries	Data Type	
	INITHEAD	LGR grid record for the INIT Data file that defines the start of INIT LGR Grid record and contains the integer variables for this record. This record is the same as the Global INITHEAD record but the data pertains to the current LGR. See Table D.10 for a detailed description of this record type.			Required Only Once
	LOGIHEAD	Global grid record for the INIT Data file that defines the logical variables (T for true and F for false) for this record. This record is the same as the Global LOGIHEAD record but the data pertains to the current LGR. See Table D.10 for a detailed description of this record type.			Required Only Once
	DOUBHEAD	Global grid record for the INIT Data file that defines the double precision REAL variables for this record. This record is the same as the Global DOUBHEAD record but the data pertains to the current LGR. See Table D.10 for a detailed description of this record type.			Required Only Once

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.

Table D.15: INIT Data - LGR Grid Data Record

Example: INIT Data - LGR Grid Data Record

The following example shows a typical formattedINIT Data - LGR Grid Data Record data set for a single LGR grid named LGR-1.

```
'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
```

End of Example

D.6.9 INIT DATA - LGR GRID HEADER RECORD

The INIT Data - LGR Grid Header Record defines an LGR's properties, LGR Name for example, and always proceeds an LGR data set for a given LGR; that is the record is repeated for each LGR data set in the model. Note that an LGR data set is terminated by the LGRSGONE record which switches input back to the global grid properties. The record description is outlined in Table D.16.

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Record Name	INIT Data - LGR Grid Header Record (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. of Entries	Data Type	
	LGR	LGR grid header record 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 record.			Always Required
1-1	Format	LGRHEADI	45	INTE	
2-1 to 2-45	Data	Undefined.			
	LGRHEADQ	LGR grid record for the INIT Data file that defines the logical variables (T for true and F for false) for this record.			Always Required
1-1	Format	LGRHEADQ	5	LOGI	
2-1 to 2-5	Data	Undefined			
	LGRHEADD	LGR grid record for the INIT Data file that defines the double precision REAL variables for this record.			Always Required
1-1	Format	LGRHEADD	5	DOUB	5
2-1 to 2-5	Data	Undefined.			
	LGRSGONE	The LGRSGONE record 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.	Record Name	INIT Data - LGR Grid Header Record (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. of Entries	Data Type	

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.

Table D.16: INIT Data - LGR Grid Header Record

This record type is repeated for each LGR in the model with the last LGR data set terminated by the LGSGONE record to mark the end of the LGR input; see the following example.

Note

The LGR, LGRHEADI, LGRHEADQ and LGRHEADD always proceed LGR data sets and the LGRSGONE record terminates the end of a data section of LGR data.

Example: INIT Data - LGR Grid Header Record

The following example shows a typical formatted INIT Data Record for LGR Grid Header data set dor 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.6.10 INIT DATA - LGR NON-NEIGHBOR CONNECTION DATA RECORD

The INIT Data - LGR Non-Neighbor Connection Data Record defines the LGR Non-Neighbor Connection arrays as generated by OPM Flow. This includes the TRANCC, DIFFNNC, HEATNNC, TRANGL arrays.

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Record Name	INIT Data - LGR Non-Neighbor Connection Data Record (Repeated For Each LGR In The Model)	Status Or Value
1-1	LGR	LGR grid header record (see Table D.16)	Required
	LGRHEADI		
	LGRHEADQ		
	LGRHEADD		
1-2	NNC	LGR NNC data for the current LGR – same format as the Global NCC record (see Table D.11).	Required
1-3	LGRSGONE	The LGRSGONE record marks the end of the LGR section.	Required

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.

Table D.17: INIT Data - LGR Non-Neighbor Connection Data Record

This record type is repeated for each LGR in the model with the last LGR data set terminated by the LGSGONE record to mark the end of the LGR input; see the following example.

Example: INIT Data - LGR Non-Neighbor Connection Data Record

The following example shows a typical formatted INIT Data - LGR Non-Neighbor Connection Data Record 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
'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
'TRANNNC '           0 'REAL'
'TRANGL  '          16 'REAL'
  0.37566667E+01   0.37566667E+01   0.37566667E+01   0.37566667E+01
  0.37566667E+01   0.37566667E+01   0.37566667E+01   0.37566667E+01
```

```
  0.37566667E+01   0.37566667E+01   0.37566667E+01   0.37566667E+01
  0.37566667E+01   0.37566667E+01   0.37566667E+01   0.37566667E+01
'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
'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
'TRANNNC '           0 'REAL'
'TRANGL  '          16 'REAL'
  0.37566667E+01   0.37566667E+01   0.37566667E+01   0.37566667E+01
  0.37566667E+01   0.37566667E+01   0.37566667E+01   0.37566667E+01
  0.37566667E+01   0.37566667E+01   0.37566667E+01   0.37566667E+01
  0.37566667E+01   0.37566667E+01   0.37566667E+01   0.37566667E+01
'LGRSGONE'           0 'MESS'
```

End of Example

D.6.11 INIT DATA - LGR GRID PROPERTY DATA RECORD

The file structure for INIT Data - LGR Grid Property Data Record is similar to the global grid INIT Data Grids record described in the previous section. However, additional data that the defines the LGR properties (LGR Name for example) are included in this record definition and the LGR record is repeated for each LGR in the model. The record description is outlined in Table D.18.

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Record Name	INIT Data - LGR Grid Property Data Record (Repeated For Each LGR In The Model)	Status Or Value
1-1	LGR	LGR Grid Header Record (see Table D.16)	Required
	LGRHEADI		
	LGRHEADQ		
	LGRHEADD		
1-2	INITHEAD	LGR Grid Data Record (see Table D.15)	
	LOGIHEAD		
	DOUBHEAD		
1-3	PROPERTY	LGR PROPERTY data for the current LGR – same format as the Global PROPERTY record (see TableD.26).	Required
1-4	LGRSGONE	LGR grid header section termination record (see Table D.16)	Required

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.

Table D.18: INIT Data - LGR Grid Property Data Record

This record type is repeated for each LGR in the model with the last LGR data set terminated by the LGSGONE record to mark the end of the LGR input; see the following example.

Example: INIT Data - LGR Grid Property Data Record

The following example shows a typical formatted INIT Data - LGR Grid Property Data Record 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
'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
'PERMY   '           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
'PERMZ   '           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
'MULTX   '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'MULTY   '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'MULTZ   '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.63999999E+00   0.63999999E+00   0.63999999E+00   0.63999999E+00
'PORO    '           8 'REAL'
  0.30000001E+00   0.30000001E+00   0.30000001E+00   0.30000001E+00
  0.30000001E+00   0.30000001E+00   0.30000001E+00   0.30000001E+00
'NTG     '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'TOPS    '           8 'REAL'
  0.83250000E+04   0.83250000E+04   0.83250000E+04   0.83250000E+04
  0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
'DEPTH   '           8 'REAL'
  0.83300000E+04   0.83300000E+04   0.83300000E+04   0.83300000E+04
  0.83400000E+04   0.83400000E+04   0.83400000E+04   0.83400000E+04
'TRANX   '           8 'REAL'
```

```
  0.56349998E+01   0.00000000E+00   0.56349998E+01   0.00000000E+00
  0.56349998E+01   0.00000000E+00   0.56349998E+01   0.00000000E+00
'TRANY   '           8 'REAL'
  0.56349998E+01   0.56349998E+01   0.00000000E+00   0.00000000E+00
  0.56349998E+01   0.56349998E+01   0.00000000E+00   0.00000000E+00
'TRANZ   '           8 'REAL'
  0.14087500E+05   0.14087500E+05   0.14087500E+05   0.14087500E+05
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
'MINPVV  '           8 'REAL'
  0.10000000E-05   0.10000000E-05   0.10000000E-05   0.10000000E-05
  0.10000000E-05   0.10000000E-05   0.10000000E-05   0.10000000E-05
'MULTPV  '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'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
'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           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
'PERMY   '           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
```

```
'PERMZ   '           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
'MULTX   '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'MULTY   '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'MULTZ   '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.63999999E+00   0.63999999E+00   0.63999999E+00   0.63999999E+00
'PORO    '           8 'REAL'
  0.30000001E+00   0.30000001E+00   0.30000001E+00   0.30000001E+00
  0.30000001E+00   0.30000001E+00   0.30000001E+00   0.30000001E+00
'NTG     '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'TOPS    '           8 'REAL'
  0.83250000E+04   0.83250000E+04   0.83250000E+04   0.83250000E+04
  0.83350000E+04   0.83350000E+04   0.83350000E+04   0.83350000E+04
'DEPTH   '           8 'REAL'
  0.83300000E+04   0.83300000E+04   0.83300000E+04   0.83300000E+04
  0.83400000E+04   0.83400000E+04   0.83400000E+04   0.83400000E+04
'TRANX   '           8 'REAL'
  0.56349998E+01   0.00000000E+00   0.56349998E+01   0.00000000E+00
  0.56349998E+01   0.00000000E+00   0.56349998E+01   0.00000000E+00
'TRANY   '           8 'REAL'
  0.56349998E+01   0.56349998E+01   0.00000000E+00   0.00000000E+00
  0.56349998E+01   0.56349998E+01   0.00000000E+00   0.00000000E+00
'TRANZ   '           8 'REAL'
  0.14087500E+05   0.14087500E+05   0.14087500E+05   0.14087500E+05
  0.00000000E+00   0.00000000E+00   0.00000000E+00   0.00000000E+00
'MINPVV  '           8 'REAL'
  0.10000000E-05   0.10000000E-05   0.10000000E-05   0.10000000E-05
  0.10000000E-05   0.10000000E-05   0.10000000E-05   0.10000000E-05
'MULTPV  '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'LGRSGONE'           0 'MESS'
```

End of Example

D.6.12 INIT DATA - LGR REGION DATA RECORD

The INIT Data - LGR Region Data Record defines the LGR REGION arrays, The REGION record users the same keywords outlined in the REGION section of the manual in naming the subsequent data arrays. For example, the EQLNUM, FIPNUM, PVTNUM, ROCKNUM, SATNUM arrays etc.

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Record Name	INIT Data - LGR Region Data Record (Repeated For Each LGR In The Model)	Status Or Value
1-1	LGR	LGR grid header record (see Table D.16)	Required
	LGRHEADI		
	LGRHEADQ		
	LGRHEADD		
1-2	REGION	LGR REGION data for the current LGR – same format as the Global REGION record (see Table D.19).	Required
1-3	LGRSGONE	LGR grid header section termination record (see Table D.16)	Required

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.

Table D.19: INIT Data - LGR Region Data Record

This record type is repeated for each LGR in the model with the last LGR data set terminated by the LGSGONE record to mark the end of the LGR input; see the following example.

Example: INIT Data - LGR Region Data Record

The following example shows a typical formatted INIT Data - LGR Region Data Record 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
'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.6.13 INIT DATA - LGR SATURATION AND END-POINT DATA RECORD

The INIT Data - LGR Saturation and End-Point Data Record defines the global grid saturation and end-point arrays. The SATNUM record users the same keywords outlined in the GRID and PROPS section of the manual in naming the subsequent data arrays. For example, the SWL, SWATINIT, KRG, PCW, etc. arrays

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Record Name	INIT Data - LGR Saturation And End-Point Data Record	Status Or Value
1-1	LGR	LGR grid header record (see Table D.16)	Required
	LGRHEADI		
	LGRHEADQ		
	LGRHEADD		
1-2	SATFUNS	LGR SATFUNS data for the current LGR – same format as the Global SATFUNS record (see Table D.20).	Required
1-3	LGRSGONE	LGR grid header section termination record (see Table D.16)	Required

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the EQLNUM should be written out as 'EQLNUM '.

Table D.20: INIT Data - LGR Saturation and End-Point Data Record

This record type is repeated for each LGR in the model with the last LGR data set terminated by the LGSGONE record to mark the end of the LGR input; see the following example.

Example: INIT Data - LGR Saturation and End-Point Data Record

The following example shows a typical formatted INIT Data - LGR Saturation and End-Point Data Record.

```
'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
'SWCR    '           8 'REAL'
  0.13300000E+00   0.22200000E+00   0.22200000E+00   0.22200000E+00
  0.11100000E+00   0.11100000E+00   0.50000000E+00   0.11100000E+00
'SGCR    '           8 'REAL'
  0.22200000E+00   0.22200000E+00   0.22200000E+00   0.22200000E+00
  0.22200000E+00   0.22200000E+00   0.22200000E+00   0.22200000E+00
'SOWCR   '           8 'REAL'
  0.15000001E+00   0.15000001E+00   0.15000001E+00   0.15000001E+00
  0.15000001E+00   0.15000001E+00   0.15000001E+00   0.15000001E+00
'SOGCR   '           8 'REAL'
  0.15000001E+00   0.15000001E+00   0.15000001E+00   0.15000001E+00
  0.15000001E+00   0.15000001E+00   0.15000001E+00   0.15000001E+00
'SWL     '           8 'REAL'
  0.13300000E+00   0.22200000E+00   0.22200000E+00   0.22200000E+00
  0.11100000E+00   0.11100000E+00   0.50000000E+00   0.10101000E+00
'SWU     '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'SGL     '           8 '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
'SGU     '           8 'REAL'
  0.69999999E+00   0.69999999E+00   0.69999999E+00   0.69999999E+00
  0.69999999E+00   0.69999999E+00   0.69999999E+00   0.69999999E+00
'KRW     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRG     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRO     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'SWATINIT'           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRWR    '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRGR    '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRORG   '           8 'REAL'
```

```
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRORW   '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'SWLPC   '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'SGLPC   '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'PCW     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'PCG     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'ENDNUM  '           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
'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
'SWCR    '           8 'REAL'
  0.13300000E+00   0.22300000E+00   0.22300000E+00   0.22300000E+00
  0.11300000E+00   0.11300000E+00   0.93000001E+00   0.11300000E+00
'SGCR    '           8 'REAL'
  0.22300000E+00   0.22300000E+00   0.22300000E+00   0.22300000E+00
  0.22300000E+00   0.22300000E+00   0.22300000E+00   0.22300000E+00
'SOWCR   '           8 'REAL'
  0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
  0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
'SOGCR   '           8 'REAL'
  0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
  0.18000001E+00   0.18000001E+00   0.18000001E+00   0.18000001E+00
'SWL     '           8 'REAL'
  0.13300000E+00   0.22300000E+00   0.22300000E+00   0.22300000E+00
  0.11300000E+00   0.11300000E+00   0.93000001E+00   0.10103000E+00
'SWU     '           8 'REAL'
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
  0.10000000E+01   0.10000000E+01   0.10000000E+01   0.10000000E+01
'SGL     '           8 '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
'SGU     '           8 'REAL'
  0.85000002E+00   0.85000002E+00   0.85000002E+00   0.85000002E+00
  0.85000002E+00   0.85000002E+00   0.85000002E+00   0.85000002E+00
'KRW     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
```

```
'KRG     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRO     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'SWATINIT'           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRWR    '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRGR    '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRORG   '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'KRORW   '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'SWLPC   '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'SGLPC   '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'PCW     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'PCG     '           8 'REAL'
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
 -0.10000000E+21  -0.10000000E+21  -0.10000000E+21  -0.10000000E+21
'ENDNUM  '           8 'INTE'
          1           1           1           1           1           1
          1           1
'LGRSGONE'           0 'MESS'
```

D.6.14 INIT DATA - TABULAR DATA RECORD

To be written in a future release of the manual.

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[76]. 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 *2.2Running OPM Flow 2019-04 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 following sections outline the format for these two file types.

[76] *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.7.1 RESTART INDEX FILES

To be written in a future release of the manual.

D.7.2 RESTART DATA FILE SPECIFICATION

This file type contains the global and LGR grid solution data property data[77], for example porosity (PRESSURE, SGAS, SOIL and SWAT) and group, well and connection data[78]. The overall structure of this file is similar to the INIT file. and the individual data records are structured in the following manner:

Reference Section	Global Records	Global Data Records	LGR	LGR Records	LGR Data Records	Notes
D.7.3	SEQNUM					Global grid header record for that defines the start of a RESTART Global Grid Record time step data set.
D.7.3	INTEHEAD LOGIHEAD DOUBHEAD					Global grid header record and defines the integer, logical and double precision variables for this header record.
D.7.4	IGRP SGRP etc.					Group, well, and connection data status records for this reporting time step.
D.7.5	IAAQ SAAQ et.					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 record marks the start of the solution variable section for the global grid.
D.7.7	SOLUTION	Solution 1 Solution 2 etc.				SOLUTION array section (PRESSURE, SGAS, SOILS, WAT, 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.6.8			LGR-1	LGR LGRHEADI LGRHEADQ LGRHEADD		LGR grid header record for that defines the start of a RESTART Global Grid Record time step data set.

[77] *Several record types are used for both global and LGR grids, for example the INTEHEAD, LOGIHEAD, DOUBHEAD and SOLUTION arrays.*

[78] *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 Records	Global Data Records	LGR	LGR Records	LGR Data Records	Notes
D.7.3				INTEHEAD LOGIHEAD DOUBHEAD		LGR header record and defines the integer, logical and double precision variables for this header record.
D.7.4				IGRP SGRP etc.		Group, well, and connection data status records for this reporting time step.
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		Start of SOLUTION array section.
D.7.7				SOLUTION		Solution arrays.
					Solution 1 Solution 2 etc.	SOLUTION array section (PRESSURE, SGAS, SOILS, WAT, etc.) for the current LGR.
D.7.7				ENDSOL		End of the solution variable section for the current LGR grid.
D.6.8				ENDLGR		End of current LGR section.
D.6.8			LGR-2	LGR LGRHEADI LGRHEADQ LGRHEADD		LGR grid header record for that defines the start of a RESTART Global Grid Record time step data set.
D.7.4				IGRP SGRP etc.		Group, well, and connection data status records for this reporting time step.
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		Start of SOLUTION array section.
D.7.7				SOLUTION		Solution arrays.
					Solution 1 Solution 2 etc.	SOLUTION array section (PRESSURE, SGAS, SOILS, WAT, etc.) for the current LGR.
D.7.7				ENDSOL		End of the solution variable section for the current LGR grid.
D.6.8				ENDLGR		End of current LGR section.

Reference Section	Global Records	Global Data Records	LGR	LGR Records	LGR Data Records	Notes
D.7.3	SEQNUM					Global grid header record for that defines the start of a RESTART Global Grid Record time step data set.

Figure D.2: RESTART Data File Structure

The individual records section are described in the following sections.

D.7.3 RESTART DATA - HEADER RECORD

The Restart Data - Header Record[79] is the first data set that should be read or written to the RESTART file. This data set includes INITHEAD, LOGIHEAD and DOUBHEAD records that define versus parameters used in subsequent records in the RESTART file for the global and LGR grids. This is then followed by a series of global:

1) Well, group and connection records for the grid.
2) Grid SOLUTION data records that defined the various grid solution arrays for each grid cell in the model.
3) Grid NNC solution arrays.
4) List of LGRs
5) LGR Data for each LGR.

The structure for this type of record is defined in Table D.22.

No.	Record Name	RESTART Data - Header Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	SEQNUM	Global grid header record for the RESTART Data file that defines the start of a RESTART Global Grid Record time step report data set for unified restart files only. Defines the report time step number.			Optional
1-1	Format	SEQNUM	1	INTE	
2-1	Data	Report time step number.			0
	INITHEAD	Global grid header record for the RESTART Data file that defines the start of a RESTART Global Grid Record for non-unified multiple files, and defines the integer variables for this header record.			Required
1-1	Format	INITHEAD	249	INTE	
2-1	Data	Undefined			0
2-2	Data	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	Data	Undefined.			0
2-9	Data	The number of grid blocks in the x-direction (NX).			
2-10	Data	The number of grid blocks in the y-direction (NY).			
2-11	Data	The number of grid blocks in the z-direction (NZ).			
2-12	Data	Number of global active cells in the model			
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.			

[79] *The RESTART Data – Header Record format is 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 head records and terminated by an LGR termination record.*

No.	Record Name	RESTART Data - Header Record			Status Or Value
		Keyword	No. of Entries	Data Type	
2-16	Data	Undefined.			0
2-17	Data	Number of wells in the model maximum number of grid block connections per well for this model.			NWELLS
2-18	Data	Maximum number of grid block connections per well.			MXCONS
2-19	Data	Not used.			
2-20	Data	Maximum number of wells belonging to a group in the model.			MXGRPW
2-21	Data	Maximum number of groups for this mode.			MXGRPS
2-22 to 2-24	Data	Not used.			
2-25	Data	Number of values per well in the IWEL array.			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 values per well in the ZWEL array.			NZWELZ
2-29 to 2-32	Data	Not used.			
2-33	Data	Number of values per well in the ICON array.			NICONZ
2-34	Data	Number of values per well in the SCON array.			NSCONZ
2-35	Data	Number of values per well in the XCON array.			NXCONZ
2-36	Data	Not used.			0
2-37	Data	Number of values per well in the IGRP array.			NIGRPZ
2-38	Data	Number of values per well in the SGRP array.			NISGRPZ
2-39	Data	Number of values per well in the XGRP array.			NIXGRPZ
2-40	Data	Number of values per well in the ZGRP array.			NIZGRPZ
2-41	Data	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

No.	Record Name	RESTART Data - Header Record			Status Or Value
		Keyword	No. of Entries	Data Type	
2-49 to 2-65	Data	Not used.			
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 2019.			YEAR
2-68 to 2-94	Data	Undefined.			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.			
2-96 to 2-131	Data	Undefined.			0
2-132	Data	Maximum number of nodes in an extended network model or zero if the extended network option has not been activated.			NODMAX
2-133	Data	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

No.	Record Name	RESTART Data - Header Record			Status Or Value
		Keyword	No. of Entries	Data Type	
2-140 to 2-162	Data	Undefined.			0
2-163	Data	Maximum number of used aquifer connections.			NGCAUS
2-164 to 2-175	Data	Undefined.			0
2-176	Data	Maximum number of multi-segmented wells in the model, for when multi-segment wells have been activated, or zero otherwise.			NSWLMX
2-177	Data	Maximum number of segments per multi-segment well, for when multi-segment wells have been activated, or zero otherwise.			NSEGMX
2-178	Data	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.			NLBRMZ
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	Data	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.			HH
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.			MM
2-209 to 2-223	Data	Undefined.			0
2-224	Data	Number of integer lines in the ACTNUM data set.			NILAQN
2-225	Data	Number of integer lines in the ACTNUM data set.			NIRAQN
2-226	Data	Undefined.			0
2-227	Data	Number of entries in the ACTNUM data set.			NUMAQN
2-228 to 2-234	Data	Undefined.			0
2-235	Data	Number of items in the ICOT array.			NICOTZ

No.	Record Name	RESTART Data - Header Record			Status Or Value
		Keyword	No. of Entries	Data Type	
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 items in the model plus 2.			NSTRA2
2-242 to 2-252	Data	Undefined.			0
2-253	Data	Maximum umber of analytical aquifers in the model.			MAAQID
2.254 to 2-270	Data	Undefined.			0
2.271	Data	Maximum number of segment links per multi-segment well for when multi-segment wells have been activated, or zero otherwise.			
2-272 to 2-410	Data	Undefined.			0
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.			SS
2-412 to 249	Data	Undefined.			0
	LOGIHEAD	Global grid record for the RESTART Data file that defines the logical variables (T for true and F for false) for this record.			Required
1-1	Format	LOGIHEAD	79	LOGI	
2-1 to 2-3	Data	Not used.			F
2-4	Data	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.			F
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.			F

No.	Record Name	RESTART Data - Header Record			Status Or Value
		Keyword	No. of Entries	Data Type	
2.6 to 2-14	Data	Undefined.			0
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.			F
2-16 to 2-30	Data	Undefined.			0
2-31	Data	Coal Bed Methane option has been activated in the composition model indicator, set to T or F. Note that currently OPM Flow does not support the Coal Be Methane option and therefore this item should be set to F.			F
2-32 to 2-79	Data	Undefined.			0
	DOUBHEAD	Global grid record for the RESTART Data file that defines the double precision REAL variables for this record.			Required
1-1	Format	DOUBHEAD	185	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 to 2-160	Data	Undefined.			0
2-160	Data	The simulation START time, expressed in days for all units, except for the LAB system of units which should expressed in hours.			
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 data elements (2-1) and (2-161).			
2-163 to 2-185	Data	Undefined.			0

Table D.21: RESTART Data - Header Record

Example: RESTART Data - Header Record

The following example shows a typical formatted RESTART Data - Header Record data set.

```
'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 RECORDS

The Restart Data – Well and Group Completion Record[80] defines various parameters associated with groups, wells and connection records in the RESTART file 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:

1) Well, group and connection records for the grid.
2) Grid SOLUTION data records that defined the various grid solution arrays for each grid cell in the model.
3) GridlNNC solution arrays.

The structure for this type of record is defined in Table D.22.

No.	Record Name	RESTART Data – Group, Well And Connection Records			Status Or Value
		Keyword	No. of Entries	Data Type	
	IGRP	RESTART Data file record that defines the integer Group, well, and connection data for this record.			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 record. 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	RESTART Data file record that defines the real GROUP data for this record this record.			Required
1-1	Format	SGRP	NSGRPZ x NGMAXZ	REAL	
2-1	Data	Real group data array SGRP(NIGRPZ,NGMAXZ) where NIGRPZ and NGMAXZ are defined on the INTEHEAD record.			
	XGRP	RESTART Data file record that defines the double precision GROUP data for this record.			Required
1-1	Format	XGRP	NSGRPZ x NGMAXZ	DOUB	
2-1	Data	Double precision group data array XGRP(NIGRPZ,NGMAXZ) where NIGRPZ and NGMAXZ are defined 0n the INTEHEAD record.			
	ZGRP	RESTART Data file record that defines the character GROUP data for this record.			Required

[80] *The RESTART Data – Group, Well and Connection Record format is 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 head records and terminated by an LGR termination record.*

No.	Record Name	RESTART Data – Group, Well And Connection Records			Status Or Value
		Keyword	No. of Entries	Data Type	
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 record.			
	ISEG	Integer multi-segment well data array ISEG (NISEGZ, NSEGMX, NSWLMX) where NISEGZ, NSEGMX, and NSWLMX are defined on the INTEHEAD record.			Optional
1-1	Format	ISEG	NISEGZ x NSEGMX x NSWLMX	INTE	
2-1	Data	Undefined.			
2-2	Data	Defines the multi-segment outlet segment number starting with 0 for the segment nearest wellhead (NISEGZ = 2).			
2-3	Data	Undefined.			
2-4	Data	Defines the multi-segment branch for this segment number 1 for main stem and 0 if not active (NISEGZ = 4).			
	RSEG	Double precision multi-segment well data array RSEG (NISEGZ, NSEGMX, NSWLMX) where NISEGZ, NSEGMX, and NSWLMX are defined on the INTEHEAD record.			Optional
1-1	Format	RSEG	NISEGZ x NSEGMX x NSWLMX	DOUB	
2-1	Data	RSEG (NISEGZ, NSEGMX, NSWLMX) array			
	ILBS	Integer multi-segment well data array for lateral branches ILBR (NLBRMX,NSWLMX) where NLBRMX and NSWLMX are defined on the INTEHEAD record.			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 record.			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 record.			Optional
1-1	Format	ILBR	2 x NCRDMX x NSWLMX	INTE	
2-1	Data	ICRD (2, NCRDMX, NSWLMX) array.			
	IWEL	Well integer data array IWEL(NIWELZ, NWELLS) where NIWELX and NWELS are defined on the INTEHEAD record.			
1-1	Format	IWEL	NIWELZ*NWELLS	INTE	Required

No.	Record Name	RESTART Data – Group, Well And Connection Records			Status Or Value
		Keyword	No. of Entries	Data Type	
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	Defines the location of the wellhead in the grid for the 4 dimension. (NIWELZ = 3)			
2-4	Data	Undefined.			
2-5	Data	Defines the number of well connections in the grid (NIWELZ = 5).			
2-6	Data	Defines the group index that the well belongs to (NIWELZ = 6).			
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 to 2-10	Data	Undefined			
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 to 42	Data	Undefined.			
2-43	Data	Defines the LGR index for a well with local completions in a LGR (NIWELZ = 43).			
2-44 to 2-48	Data	Undefined.			
2-49	Data	Defines the well friction indicator, set to non-zero for horizontal wells (NIWELZ = 49).			
2-50 to 2-70	Data	Undefined.			
2-71	Data	Defines the segmented well number, set to zero for ordinary wells (NIWELZ = 71).			
	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	SWEL(NSWELZ, NWELLS) array.			
	XWEL	Well double precision data array XWEL(NXWELZ, NWELLS) where NXWELX and NWELS defined on the INTEHEAD record.			
1-1	Format	XWEL	NSWELZ*NWELLS	DOUB	Required

No.	Record Name	RESTART Data – Group, Well And Connection Records			Status Or Value
		Keyword	No. of Entries	Data Type	
2-1	Data	XWEL(NXWELZ, NWELLS) array.			
	ZWEL	Well character data array ZWEL(NXWELZ, NWELLS) where NXWELX and NWELS are defined on the INTEHEAD record.			
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).			
2-3	Data	Defines the end of time step action for the well (NXWELZ = 3).			
	ICON	Connection integer data array ICON(NICONZ, NCWMAX, NWELLS) where NICONZ, NCWMAX, and NWELLS are defined on the INTEHEAD record. Data records are required for each completion in the well and the number of data items, N, should be NICONZ x NCWMAX x NWELLS.			
1-1	Format	ICON	N	INTE	
2-1	Data	Defines the well connect index (NICONZ = 1).			
2-2	Data	Defines the location of connection in the grid for the I dimension (NICONZ = 2).			
2-3	Data	Defines the location of connection in the grid for the J dimension (NICONZ = 3).			
2-4	Data	Defines the location of connection in the grid for the K dimension (NICONZ = 4).			
2-5	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).			
2-6 2-13	Data	Undefined.			
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).			
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 record. Data records 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 factor NSCONZ = 1 in the SCON array.			
2-2 to 2-3	Data	Undefined.			

No.	Record Name	RESTART Data – Group, Well And Connection Records			Status Or Value
		Keyword	No. of Entries	Data Type	
2-4	Data	Connection KH, that is the net thickness times the permeability, NSCONZ = 4 in the SCON array.			
	XCON	Connection double precision data array XCON(NXCONZ, NCWMAX, NWELLS) where NXCONZ, NCWMAX, and NWELLS are defined on the INTEHEAD record. The number of data items, N, should be NXCONZ x NCWMAX x NWELLS			Required
1-1	Format	ICON	N	DOUB	
2-1	Data	XCON(NXCONZ, NCWMAX, NWELLS) array.			
	ICOT	Tracer connection integer data array ICOT(NICOTZ, NSTRA2, NCWMAX, NWELLS) where NICOTZ, NSTRA2, NCWMAX, and NWELLS are defined on the INTEHEAD record. 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 record. 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 record. The number of records, 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 record. The number of records, 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 record. The number of records, 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 record. The number of records, N, should be NXGRTNZ x NSTRA2 x NWMAXZ.			Optional

No.	Record Name	RESTART Data – Group, Well And Connection Records			Status Or Value
		Keyword	No. of Entries	Data Type	
1-1	Format	XGRT	N	DOUB	
2-1	Data	XWET(NXWETZ, NSTRA2, NWMAXZ) array.			
	INODE	Network node integer data array INODE(NINODE, NODMAX) where NINODE and NODMAX are defined in the INTEHEAD record.			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 record.			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 record.			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 record.			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 record.			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 record.			Optional
1-1	Format	ZNODE	NZNODE x NODMAX	CHAR	
2-1	Data	ZNODE(NZNODE, NODMAX) array.			

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Record Name should be enclosed in single quotations, for example the ZNODE record should be written out as 'ZNODE '.

Table D.22: RESTART Data – Group, Well and Connection Records

Example: RESTART Data – Group, Well and Connection Records

The following example shows a typical formatted RESTART Data – Group, Well and Connection Record data set, showing the IGRP, SGRP, XGRP and ZGRP records.

```
 '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'
  0.000000000000000D+00   0.000000000000000D+00   0.000000000000000D+00
  0.000000000000000D+00   0.000000000000000D+00   0.000000000000000D+00
  0.000000000000000D+00   0.000000000000000D+00   0.000000000000000D+00
 ……….……..
  0.000000000000000D+00   0.000000000000000D+00   0.000000000000000D+00
  0.000000000000000D+00   0.000000000000000D+00   0.000000000000000D+00
  0.000000000000000D+00   0.000000000000000D+00   0.000000000000000D+00
  0.000000000000000D+00
'ZGRP    '           80 'CHAR'
'MANI-C  ' '        ' '        ' '        ' 'B1-DUMMY' '        '
'        ' '        ' '        ' 'MANI-D1 ' '        ' '        '
'        ' 'INJE    ' '        ' '        ' '        ' 'PROD    '
'        ' '        ' '        ' '        ' 'MANI-B2 ' '        ' '        '
'        ' '        ' 'MANI-B1 ' '        ' '        ' '        ' '        '
'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 RECORDS

The RESTART Data – Aquifer Data Records defines the various aquifer arrays written out by OPM Flow. If there are no aquifers in the model then this set of records are skipped. If an analytical or numerical model aquifer is present in the model, the a complete set of records, 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 records should be written to the file.

The structure for this type of record is dependent on the aquifer type, for analytical aquifers the format is outlined in Table D.23 and for numerical aquifers in characterized in TableD.24.

No.	Record Name	RESTART Data – Aquifer Data Records Analytical Aquifer Records			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 record.			Optional
1-1	Format	IAAQ	NIAAQZ x MAAQID	INTE	
2-1	Data	IAAQ(NIAAQZ, MAAQID) array.			
	SAAQ	Analytical aquifers real data array SAAQ(NSAAQZ, MAAQID) where NSAAQZ and MAAQIDR are defined in the INTEHEAD record.			Optional
1-1	Format	SAAQ	NSAAQZ x MAAQID	REAL	
2-1	Data	SAAQ(SIAAQZ, MAAQID) array.			
	XAAQ	Analytical aquifers double precision data array XAAQ(NXAAQZ, MAAQID) where NXAAQZ and MAAQIDR are defined in the INTEHEAD record.			Optional
1-1	Format	XAAQ	NXAAQZ x MAAQID	DOUB	
2-1	Data	XAAQ(NXAAQZ, MAAQID) array.			
	IAQL	Analytical aquifers integer aquifer list data array IAQL(NIAQLX, MXNALI, MXAAQL) where NIAQLX, MXNALI, and MXAAQL are defined in the INTEHEAD record.			Optional
1-1	Format	IAQL	NIAQLX x MXNALI x MXAAQL	INTE	
2-1	Data	IAQL(NIAQLX, MXNALI, MXAAQL) array.			
	ZAQL	Analytical aquifers integer aquifer list data array ZAQL(NZAQLX, MXNALI) where NZAQLX, and MXNALI are defined in the INTEHEAD record.			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 record.			Optional
1-1	Format	ICAQ	NICAQZ x NGCAUS x MAAQID	INTE	
2-1	Data	ICAQ(NICAQZ, NGCAUS, MAAQID) array.			

No.	Record Name	RESTART Data – Aquifer Data Records Analytical Aquifer Records			Status Or Value
		Keyword	**No. of Entries**	**Data Type**	
	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 record.			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 record.			Optional
1-1	Format	ACAQ	NACAQZ x NGCAUS x MAAQID	DOUB	
2-1	Data	ACAQ(NSCAQZ, NGCAUS, MAAQID) array.			

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the ACAQ record should be written out as 'ACAQ '.

Table D.23: RESTART Data – Analytical Aquifer Data Records

And for numerical aquifers the format is outlined in TableD.24.

No.	Record Name	RESTART Data – Aquifer Data Records Numerical Aquifer Records			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 record.			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 record.			Optional
1-1	Format	RAAQ	NIRAQN x NUMAQN	REAL	
2-1	Data	RAQN (NIIAQN, NUMAQN) array.			

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the RAQN record should be written out as 'RAQN '.

TableD.24: RESTART Data – Numerical Aquifer Data Records

Example: RESTART Data – Aquifer Data Records

The following example shows a typical formatted RESTART Data – Aquifer Data Record data set for an analtytical 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 RECORD

The Restart Data – Hidden Record [81] defines SOLUTION arrays that have not been exported by OPM Flow,

The structure for this type of record is defined in Table D.25.

No.	Record Name	RESTART Data – Hidden Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	HIDDEN	RESTART Data – Hidden Record 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 charaters 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:

3) Note all character variables, including the Record Name should be enclosed in single quotations, for example the SOMAX record should be written out as 'SOMAX '.

Table D.25: RESTART Data – Hidden Record

Example: RESTART Data – Group, Well and Connection Records

The following example shows a typical formatted RESTART Data – Hidden Record 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

[81] *The RESTART Data – Hidden Record format is used both for global and LGR grids.*

D.7.7 RESTART DATA - SOLUTION DATA RECORD

The Restart Data – Solution Data Record[82] defines 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 record is defined in TableD.26 and a list of SOLUTION names is tabulated in

No.	Record Name	RESTART Data - Solution Data Record			Status Or Value
		Keyword	No. of Entries	Data Type	
	STARTSOL	This record marks the start of the solution variable section for both global and local grids. Note that there is no data associated with this record.			Required
1-1	Format	STARTSOL	0	MESG	
	LGRNAMES	This record 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 quotations and each having a length of eight characters.			
	SOLUTION	The SOLUTION record 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.28. For example, PRESSURE, SWAT, SGAS, RS, RV etc. The SOLUTION record (items 1-1, 1-2, 1-3, 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 record marks the end of the solution variable section for both global and local grids. Note that there is no data associated with this record.			Required
1-1	Format	ENDSOL	0	MESG	

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Note all character variables, including the Record Name should be enclosed in single quotations, for example the SOLUTION array for PRESSURE should be written out as 'PRESSURE '.

TableD.26: RESTART Data - Solution Data Record

For SOLUTION tracer concentration arrays the ZTRACER keyword must precede the SOLUTION tracer data array – see Table D.27 for a description of ZTRACER record.

[82] *The RESTART Data - Solution Data Record format is used both for global and LGR grids SOLUTION arrrays. The LGR data is preceded by a series of LGR head records and terminated by an LGR termination record.*

No.	Record Name	RESTART Data – Solution Data Record For Tracer Concentration Name			Status Or Value
		Keyword	No. of Entries	Data Type	
	ZTRACER	This record marks the start of the solution variable section for both global and local grids.			Optional
1-1	Format	ZTRACER	2	CHAR	
2-1	Data Format	Tracer name (TRACER)			
		TRACER	' '		
	TRACER	TRACER is the name of the tracer concentration that is contained on the next record. 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) Note all character variables, including the Record Name should be enclosed in single quotations, including the tracer name.

Table D.27: RESTART Data – Solution Data Record for Tracer Concentration Name

The SOLUTION record keywords are listed in Table D.28.

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	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
				order to satisfy the solution change convergence criteria at the last time step.	
		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.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		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.	
		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.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		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.	
		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.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		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.	
		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.	

Model Type		Model Option	Solution Data Keywords	Solution Variable Description	OPM Output Status
Black-Oil	Compositional				
		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.	
		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.28: RESTART Data - Solution Data Keywords

Example: RESTART Data – Solution Data Record

The following example shows a typical formatted global grid RESTART Data – Solution Data Record.

```
 '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 'DOUBHEAD'
.............................. . ............... . .
 '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
.............................. . ............... . .
etc.
```

End of Example

D.7.8 RESTART DATA - LGR GRID HEADER RECORD

The RESTART Data - LGR Grid Header Record defines an LGR's properties, LGR Name for example, and always proceeds an LGR data set for a given LGR; that is the record is repeated for each LGR data set in the model. Note that a given LGR data set is terminated by the ENDLGR record and the SEQNUM records terminate the input for a time step which switches the input back to the global grid properties. The record description is outlined in Table D.29.

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Record Name	RESTART Data - LGR Grid Header Record (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. Of Entries	Data Type	
	LGR	LGR grid header record for the RESTART 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 record.			Always Required
1-1	Format	LGRHEADI	45	INTE	
2-1 to 2-45	Data	Undefined.			
	LGRHEADQ	LGR grid record for the RESTART Data file that defines the logical variables (T for true and F for false) for this record.			Always Required
1-1	Format	LGRHEADQ	5	LOGI	
2-1 to 2-5	Data	Undefined			
	LGRHEADD	LGR grid record for the RESTART Data file that defines the double precision REAL variables for this record.			Always Required
1-1	Format	LGRHEADD	5	DOUB	5
2-1 to 2-5	Data	Undefined.			
	LGRSGONE	The ENDLGR record 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	ENDLGR	0	MESG	

No.	Record Name	RESTART Data - LGR Grid Header Record (Repeated For Each LGR In The Model)			Status Or Value
		Keyword	No. Of Entries	Data Type	

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.

Table D.29: RESTART Data - LGR Grid Header Record

This record type is repeated for each LGR in the model with the last LGR data set terminated by the LGSGONE record to mark the end of the LGR input; see the following example.

Note

The LGR, LGRHEADI, LGRHEADQ and LGRHEADD always proceed LGR data sets and the ENDLGR record terminates the end of a data section of LGR data.

Example: RESTART Data - LGR Grid Header Record

The following example shows a typical formatted RESTART Data Record for 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
'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 RECORD

The file structure for RESTART Data - LGR Solution Data Record is similar to the global grid RESTART Data Grids record described previously. However, additional data that the defines the LGR properties (LGR Name for example) are included in this record definition and the LGR record is repeated for each LGR in the model. The record description is outlined in Table D.30.

Note that currently OPM Flow does not support LGR grids and therefore this record format cannot be used by OPM Flow.

No.	Record Name	RESTART Data - LGR Grid Property Data Record (Repeated For Each LGR In The Model)	Status Or Value
	LGR LGRHEADI LGRHEADQ LGRHEADD	LGR Grid Header Record See section D.7.8 RESTART Data - LGR Grid Header Record	Required
	INITHEAD LOGIHEAD DOUBHEAD	Header Record See section D.7.3 RESTART Data - Header Record	
	IGRP SGRP etc.	Group, well, and connection data status records for this reporting time step. See section D.7.4 RESTART Data – Group, Well and Connection Data Records	Required
	HIDDEN	HIDDEN solution data, that is a list of solution arrays NOT to be read by post processing software.	
	SOLUTION	SOLUTION array section (PRESSURE, SGAS, SOILS, WAT, etc.) for the Global grid. See section D.7.7 RESTART Data - Solution Data Record	Required
	ENDSOL ENDLGR	LGR grid header section termination records See section D.7.8 RESTART Data - LGR Grid Header Record	Required

Notes:

1) Rows shaded in gray indicate sub-records in this header record type.
2) Item No. cells colored orange indicate that this item is not supported by OPM Flow and those colored red are either "Not Used" or "Undefined".
3) Note all character variables, including the Header Record Name should be enclosed in single quotations, for example the LGR header Record Name should be written out as 'LGR '.

Table D.30: RESTART Data – LGR Solution Data Record

This record type is repeated for each LGR in the model with the last LGR data set terminated by the ENDSOL and ENDLGR records to mark the end of the LGR input; see the following example.

Example: RESTART Data - LGR Solution Data Record

The following example shows a typical formatted RESTART Data - LGR Solution Data Record 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
 'INTEHEAD'         249 'INTE'
  -954922105      200400           1       -2345       -2345       -2345
       -2345       -2345           3           3           1           9
           3       -2345           7       -2345           0          36
           1          84           2           0           0           0
……..……..
           1           6           1          10           1          10
           9           1           7           0          30           3
          18          10           9
 'LOGIHEAD'          79 'LOGI'
  T   T   F   T   F   F   T   F   T   F   F   F   F   F   F   F   T   F   T   T   F   F   F   F   F
  F   F   F   F   F   F   T   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F   F
  F   F   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
 'DOUBHEAD'         185 'DOUB'
   0.00000000000000D+00   0.10000000000000D+01   0.10000000000000D+02
……..……..
  -0.10000000200409D+21   0.10000000000000D+01   0.10000000000000D+01
   0.10000000000000D+01   0.00000000000000D+00   0.00000000000000D+00
   0.10000000000000D+01   0.10000000000000D-03
 'IGRP    '         358 'INTE'
           0           0           0           0           0           0
           0           0           0           0           0           0
……..……..
           0           0           0           2           2           0
           0           0           0           0
 'SGRP    '         186 '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   0.10000000E+01
 'XGRP    '         348 '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
 'ZGRP    '          10 'CHAR'
 '        ' '        ' '        ' '        ' 'FIELD   ' '        '
 '        ' '        ' '        '
 'ICOT    '           0 'INTE'
```

```
 'XCOT    '           0 'DOUB'
 'IWET    '           0 'INTE'
 'XWET    '           0 'DOUB'
 'IGRT    '          18 'INTE'
          0           0           0           0           0           0
          0           0           0           0           0           0
          0           0           0           0           0           0
 'XGRT    '         180 'DOUB'
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.10000000200409D+21   0.10000000200409D+21   0.10000000200409D+21
   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
……..……..
   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   '
 '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    '
 'STARTSOL'           0 'MESS'
 'PRESSURE'           9 'REAL'
   0.26823886E+03   0.26824997E+03   0.26826108E+03   0.26822879E+03
   0.26824088E+03   0.26825293E+03   0.26821875E+03   0.26823175E+03
   0.26824478E+03
 'SWAT    '           9 'REAL'
   0.10500000E+00   0.10500000E+00   0.10500000E+00   0.10500000E+00
   0.10500000E+00   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
   0.89499998E+00   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
   0.12021925E+03   0.12022604E+03   0.12020680E+03   0.12021413E+03
   0.12022144E+03
 'RV      '           9 'REAL'
   0.57467099E-04   0.57473411E-04   0.57479720E-04   0.57461380E-04
   0.57468234E-04   0.57475085E-04   0.57455662E-04   0.57463058E-04
   0.57470450E-04
……..……..
 'ENDSOL  '           0 'MESS'
 'ENDLGR  '           1 'INTE'
          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
 'INTEHEAD'         249 'INTE'
  -954922105      200400           1       -2345       -2345       -2345
       -2345       -2345           3           3           1           9
           3       -2345           7       -2345           0          36
           9           1           7           0          30           3
          18          10           9
 'LOGIHEAD'          79 'LOGI'
  T  T  F  T  F  F  T  F  T  F  F  F  F  F  F  F  T  F  T  T  F  F  F  F  F
  F  F  F  F  F  F  T  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F  F
  F  F  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
 'DOUBHEAD'         185 'DOUB'
   0.00000000000000D+00   0.10000000000000D+01   0.10000000000000D+02
   0.10000000000000D-05   0.15000000000000D+00   0.30000000000000D+01
……..……..
   0.10000000000000D+01   0.00000000000000D+00   0.00000000000000D+00
   0.10000000000000D+01   0.10000000000000D-03
 'IGRP    '         358 'INTE'
           0           0           0           0           0           0
           0           0           0           0           0           0
……..……..
           0           0           0           2           2           0
           0           0           0           0
 'SGRP    '         186 '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   0.10000000E+01
 'XGRP    '         348 '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
 'ZGRP    '          10 'CHAR'
 '        ' '        ' '        ' '        ' '        ' 'FIELD   ' '        '
 '        ' '        ' '        '
 'ICOT    '           0 'INTE'
 'XCOT    '           0 'DOUB'
 'IWET    '           0 'INTE'
 'XWET    '           0 'DOUB'
 'IGRT    '          18 'INTE'
           0           0           0           0           0           0
           0           0           0           0           0           0
           0           0           0           0           0           0
 'XGRT    '         180 'DOUB'
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
   0.00000000000000D+00   0.00000000000000D+00   0.00000000000000D+00
……..……..
   0.10000000200409D+21   0.10000000200409D+21   0.10000000200409D+21
   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
……..……..
   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   '
 '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    '
 'STARTSOL'           0 'MESS'
 'PRESSURE'           9 'REAL'
  0.26813840E+03   0.26813367E+03   0.26812894E+03   0.26812656E+03
  0.26813242E+03   0.26813831E+03   0.26811469E+03   0.26813120E+03
  0.26814767E+03
 'SWAT    '           9 'REAL'
  0.10500000E+00   0.10500000E+00   0.10500000E+00   0.10500000E+00
  0.10500000E+00   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
  0.89499998E+00   0.89499998E+00   0.89499998E+00   0.89499998E+00
  0.89499998E+00
 'RS      '           9 'REAL'
  0.12016161E+03   0.12015896E+03   0.12015630E+03   0.12015495E+03
  0.12015826E+03   0.12016157E+03   0.12014828E+03   0.12015756E+03
  0.12016683E+03
 'RV      '           9 'REAL'
  0.57410016E-04   0.57407331E-04   0.57404646E-04   0.57403286E-04
  0.57406625E-04   0.57409969E-04   0.57396555E-04   0.57405923E-04
  0.57415291E-04
..........:.........:.........:.........:.........:.........:.........:.........:..
 'ENDSOL  '           0 'MESS'
 'ENDLGR  '           1 'INTE'
           2
 'SEQNUM  '           1 'INTE'
           4
```

End of Example

D.8 RFT FILES – PRESSURE, SATURATION AND PRODUCTION LOG DATA

To be written in a future release of the manual.

D.9 SUMMARY FILES – PRODUCTION DATA

To be written in a future release of the manual.

D.10 SAVE FILES - INITIALIZATION AND SOLUTION DATA

This file format is currently not supported by OPM Flow.

End of Document