



# ECHELON REFERENCE MANUAL

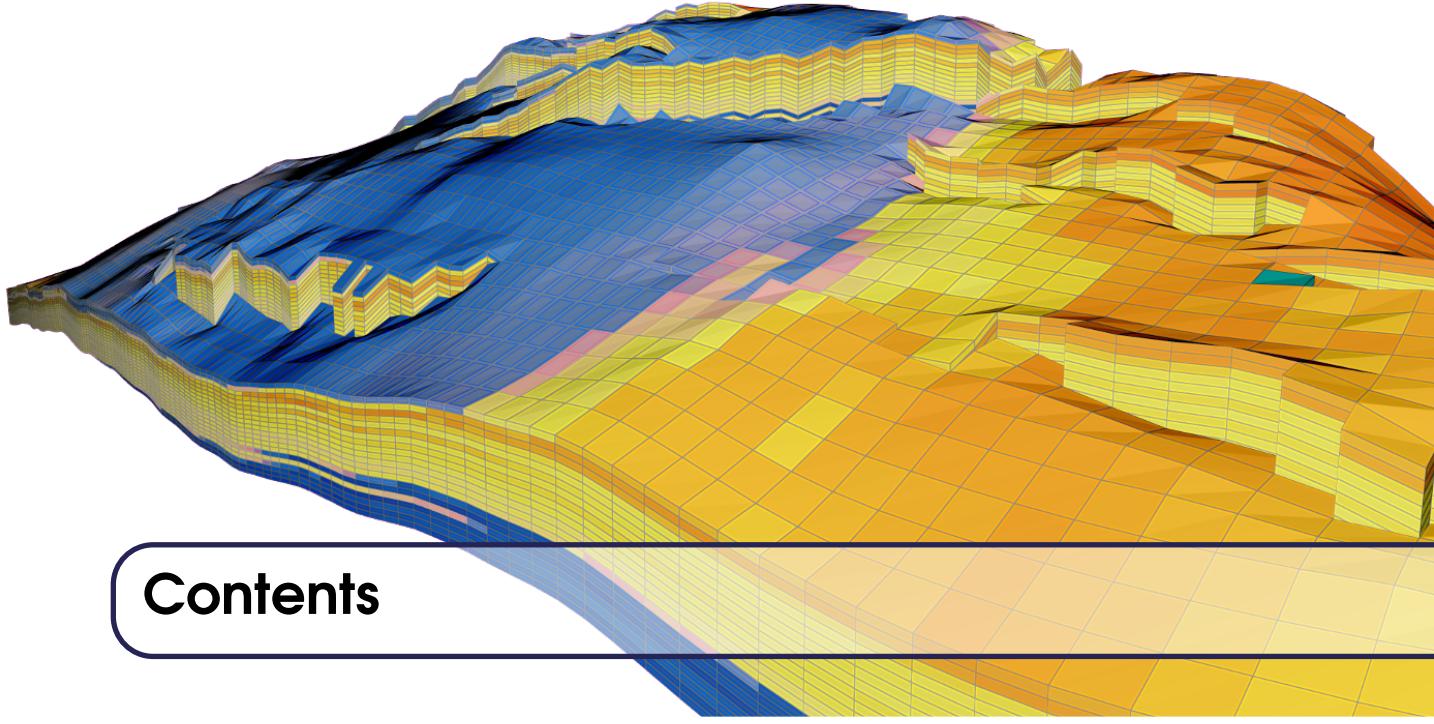
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2015 Emmorton Rd. Suite 204  
Bel Air, Maryland 21015, USA  
<https://www.stoneridgetechnology.com>  
[info@stoneridgetechnology.com](mailto:info@stoneridgetechnology.com)

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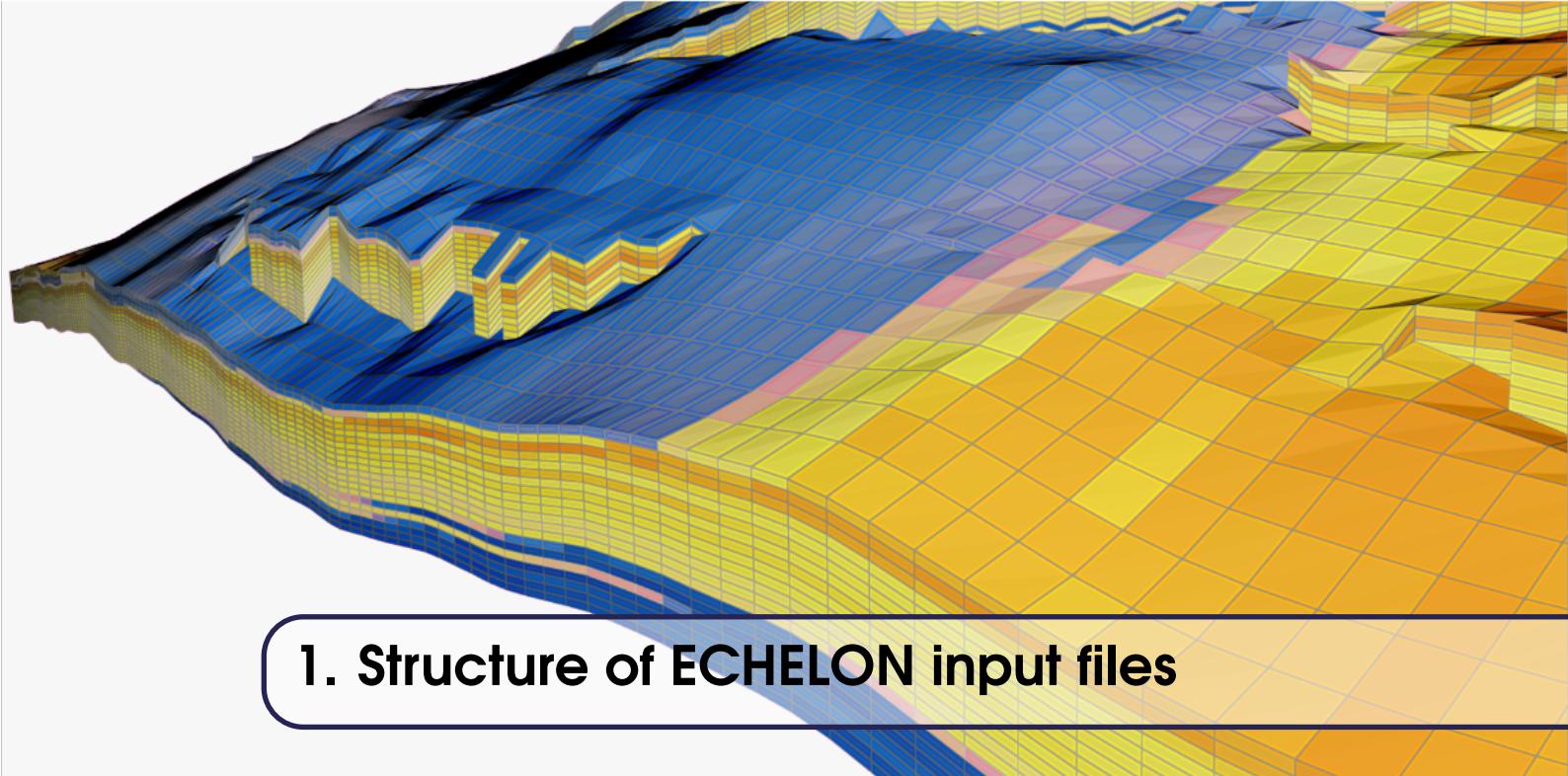
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# 1. Structure of ECHELON input files

## 1.1 Basic structure

ECHELON utilizes a keyword-based input file that is largely compatible with the widely used industry-standard input format. This input can consist of a single file in ASCII format. Alternatively, any number of other files can be included from the main file through the [INCLUDE](#) directive. The use of multiple files can facilitate flexibility in composing variations of models. For example, black-oil and compositional PVT properties can be stored in separate [INCLUDE](#) files, allowing most of the model to be common among these two descriptions.

The primary input file is usually given the extension `.DATA`. This is not required, but is the *de facto* convention utilized by pre- and post-processing software.

## 1.2 Keyword terminology and syntax

An ECHELON keyword consists of a contiguous group of letters, underscores, and numbers, but must begin with a letter. Keywords must appear at the beginning of a line. They are not case-sensitive, but are conventionally represented with all capital letters.

Many keywords have data associated with them. These data are organized into groups known as *records*, which are terminated by the slash (/) character. Each record can contain zero or more *fields*, which are simply data elements separated by one or more whitespace characters.

### 1.2.1 Data field syntax

Field data may consist of integers, floating-point numbers, or strings. Floating point numbers can be specified with the conventional exponent syntax (e.g. `3.9e-3`). Many, but not all, fields have default values. A field can be left at its default value by using the syntax “`1*`” in place of the field value. Multiple successive values can be left defaulted with the syntax “`N*`”, where  $N$  is the number of values to be defaulted. For example “`3*`” implies that the next 3 fields should retain their default values.

For keywords with repetitive data, field values can be repeated with a similar syntax: “`N*value`”. For example, the sequence “`3.1 3.1 3.1 3.1`” can be equivalently represented as “`4*3.1`”.

## 1.3 DATA file sections

The [DATA](#) file is divided into the following sections, which should appear sequentially:

1. [RUNSPEC](#)
2. [GRID](#)
3. [EDIT](#)
4. [PROPS](#)
5. [REGIONS](#)
6. [SOLUTION](#)
7. [SUMMARY](#)
8. [SCHEDULE](#)

### 1.3.1 Specifying and modifying data for each cell

Many keywords are used to specify a value of a particular quantity for each cell in the reservoir. For example, the [PORO](#) keyword is used to specify the porosity of each cell. For a model with dimensions ( $N_x, N_y, N_z$ ) cells, these keywords are followed (unless otherwise specified) by a single record containing  $N_x \times N_y \times N_z$  values, i.e. one for each cell. The values are ordered such that the  $x$  index changes fastest, followed by  $y$ , and, finally,  $z$ .

Largely to assist in the adjustment of model parameters when attempting to match history, several keywords are provided that permit modifying all or part of these 3D arrays of cell values after the initial values are given.

## 1.4 The RUNSPEC section

The [RUNSPEC](#) section contains keywords governing the overall behavior of the simulator. These keywords enable, disable, and control many of the features available in ECHELON. Other keywords in this section set overall dimensions of the grid, the numbers of various interpolation tables, as well as select formulation options.

The keywords available in this section include:

ACTPARAM	AIM	API	BLACKOIL	BOX	BRINE
COMPS	DIMENS	DISGAS	DUALPERM	DUALPORO	END
EQLDIMS	EQLOPTS	FAULTDIM	FIELD	FLUXNUM	FNS
FORMOPTS	FULLIMP	GAS	IMBNUM	IMPES	JFUNC
JFUNCR	LOAD	LOWSALT	LSALTFNC	METRIC	MISCIBLE
NCOMPS	NONNC	OIL	OVERBURD	PETOPTS	PINCHNUM
PMANUM	POLYMER	REFINE	REGDIMS	RESERVOIRS	ROCKCOMP
ROCKTAB	SAVE	START	TABDIMS	THPRES	THPRESFT
TITLE	TRACK	UDQDIMS	UDQPARAM	VAPOIL	WAPI
WATER					

Table 1.1: Keywords allowed in the [RUNSPEC](#) section.

## 1.5 The GRID section

In this section, keywords are provided to describe the geometry of the underlying grid, which cells are active, and the physical properties of each cell including permeability, porosity, and the net-to-gross ratio.

ACTNUM	ADD	ADDREG	ADDZCORN	AQUANCON
AQUCON	AQUCT	BOX	CONNREP	COORD
COPY	COPYBOX	COPYREG	DGRID	DPNUM
DX	DXV	DY	DYV	DZ
DZV	END	ENDBOX	ENDFIN	EQUALREG
EQUALS	FAULTS	FLUXNUM	FRAC_STAGE	GDFILE
HXFIN	HYFIN	HZFIN	INIT	JFUNC
JFUNCR	KRNUMMF	LTOSIGMA	LX	LY
LZ	MAXTRANP	MAXTRANZ	MAXVALUE	MINNNCT
MINPORV	MINPV	MULTFLT	MULTPV	MULTSIGV
MULTX-	MULTX	MULTY-	MULTY	MULTZ-
MULTZ	NEWTRAN	NNC	NNCGEN	NODPPM
NONNC	OLDTRAN	OPERATE	OPERATER	OPERNUM
PINCH	PINCHNUM	PINCHREG	PLANAR_FRACTURE_TEMPLATE	PORO
REFINE	SIGMA	SIGMAV	THPRESFT	TOPS
WELL_FRAC	ZCORN			

**Table 1.2:** Keywords allowed in the `GRID` section.

### 1.5.1 Specifying geometry

There are three primary types of grid geometry supported by ECHELON: block-centered, corner-point, and unstructured. These grid types are described extensively in Chapter 4 of the Technical Description.

#### ***Block-centered geometry***

Block-centered geometry can be used to generate a simple "sugar-cube" type model without geometric faulting, pinchouts, etc. It is specified using the following keywords:

Keyword	Description
TOPS	Specifies the depth of the tops of each cell
DX	Specifies the X dimension (width) of each cell
DY	Specifies the Y dimension (length) of each cell
DZ	Specifies the Z dimension (length) of each cell
DXV	Specifies the X dimension of each YZ plane of cells
DYV	Specifies the Y dimension of each XZ plane of cells
DZV	Specifies the Z dimension of each XY plane of cells

**Table 1.3:** Keywords specifying block-centered grids.

#### ***Corner-point grids***

Corner-point grids are a more generalized form of Cartesian grids. The grid geometry is specified by  $(NX + 1) \times (NY + 1)$  coordinate pillar lines, roughly in the vertical direction, and  $8 \times NX \times NY \times NZ$  values specifying the depths of the 8 corners of each cell along the corresponding coordinate lines. This generalization allows a more natural description of faults with throw, pinch-outs, and other geological features that are difficult or impossible to accurately capture in block-centered grids. The keywords utilized in this description can be found in Table 1.4

Keyword	Description
<a href="#">COORD</a>	Defines the coordinate pillars for the grid
<a href="#">ZCORN</a>	Specifies the depth of the each corners of each cell
<a href="#">PINCH</a>	Sets parameters for automatic pinch-out generation
<a href="#">ADDZCORN</a>	Allows modification of the cell corner depths

**Table 1.4:** Keywords used to define corner-point grids.***Local grid refinement (LGR)***

In some reservoir models, it is desirable to have higher resolution near some features of interest, such as wellbores or faults, in order better represent heterogeneity in these areas or to capture scale-dependent dynamic effects such as coning. Beginning with a global grid, it is possible to replace Cartesian blocks of cells from the original grid with a more refined grid, known as a *local grid refinement*, or *LGR*. This process is detailed in Section 4.7 of the Technical Description. See Table 1.5 for the LGR-related keywords descriptions.

Keyword	Description
<a href="#">CARFIN</a>	Specifies a refinement for a block of cells
<a href="#">ENDFIN</a>	Sets parameters for automatic pinch-out generation
<a href="#">HXFIN</a>	Define cell spacing ration in the X direction
<a href="#">HYFIN</a>	Define cell spacing ration in the Y direction
<a href="#">HZFIN</a>	Define cell spacing ration in the Z direction
<a href="#">REFINE</a>	Specifies the depth of the each corners of each cell

**Table 1.5:** Keywords used in the grid section to describe local grid refinements (LGRs).***Cell properties***

Some properties, including the porosity and permeability, must be defined for every cell in the simulation. Other keywords, including that for the net-to-gross ratio, are optional. These keywords expect data in the format described in Section 1.3.1. See Table 1.6 for keyword descriptions.

Keyword	Description
<a href="#">PORO</a>	Defines the porosity of each cell
<a href="#">PERMX</a>	Specifies the permeability of the cell in the X (or I) direction
<a href="#">PERMY</a>	Specifies the permeability of the cell in the Y (or J) direction
<a href="#">PERMZ</a>	Specifies the permeability of the cell in the Z (or K) direction
<a href="#">NTG</a>	Specifies the net-to-gross ratio for each cell

**Table 1.6:** Keywords specifying physical properties of each cell.***Dual-porosity and dual permeability***

In both naturally and hydraulically-fractured reservoirs, a separation of time scales may exist between the propagation of fluids within the fracture network and within the underlying rock matrix. In this case, a *dual-porosity* description of the reservoir may be used to model matrix and fracture as distinct cells occupying the same physical space. This is described in Chapter 5 of the Technical Description. Keywords related to this description are provided in Table 1.7.

Keyword	Description
DPGRID	Indicates that most cell properties from the matrix should be duplicated in the fracture
LX	Define the average fracture spacing in the X direction
LY	Define the average fracture spacing in the Y direction
LZ	Define the average fracture spacing in the Z direction
LTOSIGMA	Specifies coefficients used in computing transmissibility from LX, LY, and LZ
SIGMA	Give the $\sigma$ coefficient used in the matrix-fracture transmissibility calculation
SIGMAV	Specify a $\sigma$ value for each cell

**Table 1.7:** Keywords specifying dual porosity and dual permeability properties.

See Chapter 5 of the Technical Description for detailed information about constructing dual porosity and dual permeability models.

## 1.6 The EDIT section

In this optional section, data provided in the [GRID](#) section can be modified. A comprehensive list of the supported keywords is given in Tab. (1.8).

Operations can be applied to specific portions of the grid using the [BOX](#) and [ENDBOX](#) keywords in conjunction with the operator keywords [ADD](#), [COPY](#), [EQUALS](#), [MULTIPLY](#), [MAXVALUE](#) or [MINVALUE](#). Alternatively, specific operations can be applied on a per region basis using [ADDREG](#) [COPYREG](#) [EQUALREG](#), [MULTIREG](#), [MULTREGT](#) and [MULTREGP](#).

Grid quantities can be specified by enumeration (in the global grid or in a specific box) using [DEPTH](#), [PORV](#), [TRANX](#), [TRANY](#), [TRANZ](#) or modified through dedicated multipliers keywords such as [MULTPV](#), [MULTX](#) and [MULTFLT](#).

Finally, NNC transmissibilities are also editable in this section using [EDITNNC](#) and [EDITNNCR](#).

ADD	ADDREG	BOX	COPY	COPYREG
DEPTH	EDITNNC	EDITNNCR	END	ENDBOX
ENDFIN	EQUALREG	EQUALS	MAXVALUE	MINVALUE
MULTFLT	MULTIPLY	MULTIREG	MULTPV	MULTREGP
MULTREGT	MULTX	MULTX-	MULTY	MULTY-
MULTZ	MULTZ-	OPERATE	OPERATER	PORV
REFINE	TRANX	TRANY	TRANZ	

**Table 1.8:** Keywords allowed in the [EDIT](#) section.

## 1.7 The PROPS section

The [PROPS](#) section of the input file allows the user to provide the properties of the reservoir fluids, subsurface rock, and their interaction between them. This includes density and viscosity properties of the reservoir fluids, whether through tabulated black-oil properties, or through parameterized equations of state for compositional simulations. It also includes rock compressibility, whether through an analytic expression or tables of rock compaction factors with corresponding transmissibility modifiers. Finally, it includes tabulations of relative permeability and capillary pressure versus phase saturations. Several keywords are used to govern formulation options with respect to these properties (Tab. (1.9)).

ACF	ACFS	ADD	ADDREG	ADSALNOD	APIGROUP
AQUCT	AQUTAB	BDENSITY	BIC	BICS	BOX
CNAMES	COMPVD	COPY	COPYBOX	COPYREG	DENSITY
DNGL	END	ENDBOX	ENDFIN	EOS	EQUALREG
EQUALS	GRAVITY	IKRG	IKRGR	IKRO	IKRORG
IKRORW	IKRW	IKRWR	IPCG	IPCW	ISGCR
ISGL	ISGU	ISOGCR	ISOWCR	ISWCR	ISWL
ISWLP	ISWU	KRG	KRGR	KRO	KRORG
KRORW	KRW	KRWR	LBCCOEFR	LKRO	LKRORG
LKRORW	LKRW	LKWR	LPCW	LSALTFNC	LSOGR
LSOWCR	LSWCR	LSWL	LSWLP	LSWU	MAXVALUE
MISCEXP	MISCSTR	MISCSTRR	MW	NCOMPS	OMEGAA
OPERATE	OPERATER	OVERBURD	PARACHOR	PCG	PCRIT
PCW	PEDERSEN	PEDTUNE	PEDTUNER	PLMIXPAR	PLYADS
PLYADSS	PLYDEGT	PLYMAX	PLYROCK	PLYVISC	PLYVISCS
PPCWMAX	PRCORR	PVCO	PVDG	PVDO	PVTG
PVTO	PVTW	PVTSALT	REFINE	RKTRMDIR	ROCK
ROCKTAB	RSCONST	RSCONSTT	RTEMP	RVCONST	RVCONSTT
SALTNODE	SCALECRS	SGCR	SGFN	SGL	SGOF
SGU	SGWFN	SLGOF	SOF2	SOF3	SOGCR
SOWCR	SSHIFT	SSHIFTS	STCOND	SWATINIT	SWCR
SWL	SWLPC	SWOF	SWU	TCRIT	TOLCRIT
TRACER	VCRIT	ZCRIT	ZCRITS	ZCRITVIS	ZI

Table 1.9: Keywords allowed in the `PROPS` section.

### 1.7.1 Fluid properties

Additional details on the fluid models available in ECHELON can be found in Chapter 6 of the Technical Description.

#### *Black-oil fluid properties*

A limited number of keywords are required to define a black-oil fluid model. If the oil is dead, i.e. it does not contain vaporized gas, the oil properties can be specified with `PVDO`. Alternatively, `PVTO` should be used to specify live oil properties. ECHELON also allows a dead-oil formulation to be used if the oil has a time-invariant  $R_s$  and the oil pressure never drops below the bubble point. In this case, the  $R_s$  can be specified with `RSCONST` or `RSCONSTT`. Similarly, the keywords `PVDG` and `PVTG` are available for dry gas and wet gas, respectively, and a dry gas option with constant  $R_v$  can be activated with `RVSCONST` or `RVCONSTT`.

#### *Compositional fluid properties*

In compositional models, the user can select among three different EOSs (keyword `EOS`): Peng-Robinson, Redlich-Kwong and Soave-Redlich-Kwong. Several keywords are required to input all the EOS parameters:

- `TCRIT`, `PCRIT`, `VCRIT` and `ZCRIT` for the critical temperatures, pressures, volumes and compressibilities;
- `BIC` for the binary interaction coefficients;
- `SSHIFT` for the volume shift parameters;
- `MW` for the molecular weights;
- `ACF` for the acentric factor;
- `PARACHOR` for the parachors;
- `OMEGAA` and `OMEGAB` for  $\Omega_A$  and  $\Omega_B$  values of the EOS.

ECHELON allows the definition of a surface EOS by adding the letter "S" at the end of the above keywords. The Lorentz-Bray-Clark method is used in ECHELON to compute the phase viscosities.

LBC coefficients can be modified using the keyword [LBCCOEFF](#). Alternatively, the user can choose the Pedersen model and control its tuning parameters with [PDTUNE](#) and [PDTUNER](#).

### **Water properties**

The properties of water can be defined using the keyword [PVTW](#) for both black-oil and compositional models. If the brine tracking option is active, the keyword [PVTWSALT](#) should be used instead of [PVTW](#) and the keyword [BDENSITY](#) is recommended to account for the impact of salt concentration on the surface density of water.

## **1.7.2 Rock properties**

ECHELON users have two options to account for rock compaction effects in ECHELON simulations:

- a pore compressibility model, where the pressure vs porosity relation is described by a simple quadratic function. The pore compressibility as well as the reference pressure can be specified with the keyword [ROCK](#).
- a rock compaction model, where porosity and permeability multipliers are tabulated versus the effective pressure. The keywords [ROCKTAB](#) (or [ROCKTABH](#) if hysteresis is present) are available to define these tables.

Additional details on the rock compaction models available in ECHELON can be found in Chapter 7 of the Technical Description.

## **1.7.3 Rock-fluid properties**

In ECHELON, saturation functions can be supplied in three ways:

- tabulated with coupled inputs - the [SWOF](#) keyword is used for the water-oil couple, and either [SGOF](#) or [SLGOF](#) for the gas-oil.
- tabulated with split input - the [SWFN](#), [SGFN](#) and [SOF3](#) keywords are used to input the water, gas, and oil relative permeability functions separately. In two-phase black-oil models, these are replaced by [SGWFN](#) in the gas-water case, and [SOF2](#) in the oil-water case.
- Corey functions - the [SGOCOREY](#) and [SWOCOREY](#) can be used to control the Corey model parameters.

## **1.8 The REGIONS section**

The regions allows the grid of the model to be divided into smaller regions to facility property distribution and enhance reporting. Multiple regions sets can be specified for a single model. Each region set is dedicated to a specific functionality of the simulator:

- [PVNUM](#) to specify PVT properties;
- [EQLNUM](#) for equilibration;
- [FIPNUM](#) for fluid-in-place reporting;
- [SATNUM](#) to specify saturation functions. If hysteresis is active, imbibition tables can be added with [IMBNUM](#) and [IMBNUMMF](#). [KRUNMMF](#) can be used to specify saturation tables in dual-porosity and dual permeability models;
- [LSNUM](#), [LWSLTNUM](#) to specify low salinity saturation tables;
- [EOSNUM](#) to specify Equation Of States (EOSs) and [MISCNUM](#) for miscibility;
- [TRACKREG](#) for tracer initialization and [PLMIXNUM](#) for polymer mixing;
- [PMANUM](#) for pressure maintenance.

A comprehensive list of the supported keywords is given in Tab. (1.10).

BOX	END	ENDBOX	ENDFIN	EOSNUM
EQLNUM	FIPNUM	IMBNUM	IMBNUMMF	KRNUMMF
LSENUM	LWSLTNUM	MISCNM	OPERATE	OPERATOR
PLMIXNUM	PMANUM	PVTNUM	REFINE	SATNUM
TRACKREG				

Table 1.10: Keywords allowed in the `REGIONS` section.

## 1.9 The SOLUTION section

This section allows the initial conditions of the model to be specified. A comprehensive list of the supported keywords is given in Tab. (1.11).

ECHELON supports two alternative initialization options:

- Enumeration, where each state variable in each grid block is assigned a value through a dedicated keyword;
- Vertical equilibration, where the initial solution is determined by the balance of gravitational force and phase pressure gradients with only limited data provided by the user.

The following sections provide an overview of the most common keywords required to initialize the model using these two options. This initialization algorithm is described in detail in Chapter 10 of the Technical Description.

Besides initialization, the `SOLUTION` section also allows the definition of analytic aquifers using the keywords `AQUCT` (Carter-Tracy) and `AQUFET` (Fetkovich) as well as their connections with the reservoir grid using `AQUANCON`.

ADD	ADDREG	APIVD	AQUALIST	AQUANCON	AQUCON
AQUCT	AQUFET	AQUFETP	BOX	COPY	COPYREG
DATUM	DATUMR	END	ENDBOX	ENDFIN	EQUALREG
EQUALS	FIELDSEP	FIPSEP	GPTABLE	GPTABLE3	GPTABLEN
OPERATE	OPERATER	PBUB	PBVD	PDEW	PDVD
PRESSURE	REFINE	RS	RSVD	RTEMP	RV
RVVD	SALT	SALTVTD	SGAS	SPOLY	SWAT
TBLK	TEMPI	TEMPVD	THPRES	TVDP	XMF
XMFVP	YMF	YMFVP	ZMF	ZMFVD	

Table 1.11: Keywords allowed in the `SOLUTION` section.

### 1.9.1 Enumerated initial solution

In blackoil models, the initial pressure, saturations, vaporized oil-gas ratio and solution gas-oil ratio can be prescribed with `PRESSURE`, `SGAS`, `SWAT`, `RS` and `RV`, respectively. Instead of the ratios, the user can specify the bubble and dew point using `PBUB` and `PDEW`. In compositional models, users can define the total composition using `ZMF` or specify a composition for each hydrocarbon phase using `XMF` and `YMF`. Furthermore, the initialization of compositional models requires the initial temperature, which can be defined on a per-cell basis using `TEMPI`.

In models using API tracking, brine tracking or polymer flooding, the initial API, salt concentration and polymer concentration are prescribed using `OILAPI`, `SALT` and `SPOLY`. Similarly, the keyword `TBLK` can be used to define the initial concentration of tracers.

### 1.9.2 Vertical hydrostatic equilibrium

If the models is initialized using vertical hydrostatic equilibrium, the user should provide the pressure at the *datum* depth, the depth of the gas-oil contact and water-oil contact and the capillary pressure at the contacts. The keyword `EQUIL` allows the specification of these data for each of the `EQLNUM` regions.

Tables can be used to input the composition along the depth of the reservoir. In black-oil models, [RSVD](#) or [PBVD](#) and [RVVD](#) or [PDVD](#) can be used. In compositional models, the available keywords are [COMPVD](#) and [ZMFVD](#). The temperature gradient is needed in compositional models and can be provided with [TEMPVD](#). In models using API tracking and brine tracking, the initial API and salt concentration are also prescribed using depth gradients through the keywords [APIVD](#) and [SALTVD](#). Similarly, the keyword [TVDP](#) can be used to define the initial concentration of tracers.

## 1.10 The SUMMARY section

This section controls the output of the simulation. The quantities specified here are written in a [SUMMARY](#) file, which is compatible with most post-processing softwares. In general, the output file is updated at each timestep of the simulation. The user can request the update to be performed only at report times using the keyword [RPTONLY](#). A detailed list and description of the keywords supported in this section is given in Chapter 3.

## 1.11 The SCHEDULE section

ACTIONX	AIMFRAC	APILIM	AQUCT	AQUFETP
BOX	CFLLIMIT	COMPDAT	COMPDATL	COMPDATMD
COMPDAT_FRACTURE	COMPLMPL	COMPLUMP	COMPORD	CONNREP
CSKIN	CVCRIT	DATES	DRILPRI	DRSDT
DRVDT	END	ENDACTIO	ENDBOX	ENDFIN
EQUIL	FMLOG	GADVANCE	GCONPRI	GECON
GINJGAS	GPMaint	GPTABLE	GPTABLE3	GPTABLEN
GRUPFUEL	GRUPSALE	GRUPTREE	GUIDERAT	MAXTRANS
MODIFY_FRAC_PROPS	MULTFLT	MULTPV	MULTSIGV	NOSIM
PIDCONTROL	PRIORITY	REFINE	RPTONLY	RPTONLYO
RPTRST	SEPCOND	SOLVER	SWFN	TIME
TSTEP	TSTEPICRIT	TUNING	TUNINGDP	UDQ
VFPINJ	VFPProd	WADVANCE	WAPI	WAVALIM
WCONHIST	WCONINJE	WCONINJH	WCONPROD	WCUTBACK
WDFAC	WDFACCOR	WDRILPRI	WECON	WEFAC
WELDRAW	WELLGROUP	WELLSTRE	WELL_TRAJECTORY	WELPI
WELPRI	WELTARG	WGRUPCON	WHISTCTL	WINJGAS
WINJMIX	WINJORD	WINJSUM	WLIFT	WLIST
WPAVEC	WPAVEDEP	WPICOND	WPIMULT	WPIMULTL
WPOLYMER	WRFTPLT	WSALT	WSEPCOND	WTADD
WTAKEGAS	WTTEST	WTMULT	WTRACER	WVFPDP
WVFPEXP	WWPAVEC			

Table 1.12: Keywords allowed in the [SCHEDULE](#) section.

### 1.11.1 Specifying simulation times

Several commands can be used to advance the simulator to a time in the future. Each time explicitly indicated through these keywords are referred to as *report times*. Internally, the simulator is guaranteed to advance exactly to each of these times. However, the simulator may choose to take a number of intermediate timesteps between the each designated report times. Summary output always includes the report times, but output for the intermediate results can be suppressed with the [RPTONLY](#) keyword. Similarly, the frequency of 3D output can be configured relative to report times with the [RPTRST](#) keyword.

The [DATES](#) keyword can be used to advanced to specific calendar dates. Similarly, the [TIME](#) keyword can be used to advance to specific times (measured in days) relative to the start of the simulation. Finally, the [TSTEP](#) keyword can be used to advance the simulator by specific time increments, also measured in days.

## 1.11.2 Specifying wells

Wells can be added anywhere in the progression of the [SCHEDULE](#) section, but they may not be used until they are defined with the [WELSPECS](#) keyword. In general, [WELSPECS](#) should appear immediately after the date on which the well was completed. The [COMPDAT](#) keyword can be used to specify cells in which the well has been completed along with the completion properties. Note that the well may be recompleted at a later date with subsequent occurrences [COMPDAT](#) anywhere later in the schedule.

When using [COMPDAT](#), intersected cells are usually computed by an external preprocessing software. Alternatively, geometrical well trajectories can be specified in spatial coordinates with the [WELL\\_TRAJECTORY](#) keyword, along with [COMPDATMD](#) to specify the properties of completed segments. In this case, ECHELON will determine which cells are intersected by completed segments of the wellbore and internally compute cell connection transmissibilities from the provided data.

## 1.11.3 Hydraulics tables

Vertical flow performance (VFP) tables can be provided through the [VFPPROD](#) and [VFPINJ](#) keywords. These tables are linearly interpolated to determine the bottom-hole pressure (BHP) as a function of tubing head pressure and flow rates. These tables are typically generated by external steady-state wellbore hydraulics simulators, most of which can export in the format expected by these keywords. See Section 13.8 of the Technical Description for more information.

## 1.11.4 Well controls

Two classes of controls for wells are provided: history-match and forecast. Keywords [WCONHIST](#) (for production wells) and [WCONINJH](#) (for injection wells) can be used to easily add historical data during the history-match period of a simulation. One of historical data can be nominated as the primary control (e.g. oil rate, water rate, gas rate), and the historical data can be output to the Summary time series file for comparison with the simulated production and injection.

For forecasts, keywords [WCONPROD](#) and [WCONINJE](#) provide a flexible means to provide limits on phase rates, molar rates, bottom-hole pressure (BHP), tubing-head pressure (THP), etc. Keyword [WECON](#) allows economic limits on quantities including minimum production rate, maximum water-cut, and maximum gas-oil-ratio can be used to automatically shut-in wells if these economic limits are violated. Several other keywords can be used to modify dynamic well properties, including well efficiency factors ([WEFAC](#)) and productivity indices ([WPIMULT](#)). See Section 13.8 of the Technical Description for more information.

## 1.11.5 Actions and user-defined quantities

In addition to the automated controls based on well and group production and injection targets and economic limits, it is possible for the user to programmatically initiate actions which are triggered by particular conditions within the simulation with the [ACTIONX](#) keyword. This functionality is described in detail in Chapters 21 and 22 of the Technical Description.

## 1.11.6 Linear and nonlinear solver controls

Several keywords are available for governing aspects of the solution methodology. Keyword [TUNING](#) can be used to set nonlinear convergence criteria (primarily for black-oil) and time-stepping constraints. For compositional models, keyword [CVCRIT](#) can be used to set tolerances for nonlinear convergence, and keyword [TSTEPCRIT](#) can be used to specify parameters for limiting timesteps to avoid time truncation error. The [SOLVER](#) keyword can be used to specify parameters for both the linear and nonlinear solvers, including preconditioner types, iteration limits, and convergence tolerances. Most of these parameters can be dynamically changed during the simulation.

## 1.11.7 Summary output controls

The keyword [RPTONLY](#) limits summary file output only to report steps designated by [DATES](#), [TSTEP](#), or [TIME](#), suppressing output at any intermediate timesteps. Keyword [RPTONLYO](#) disables this option,

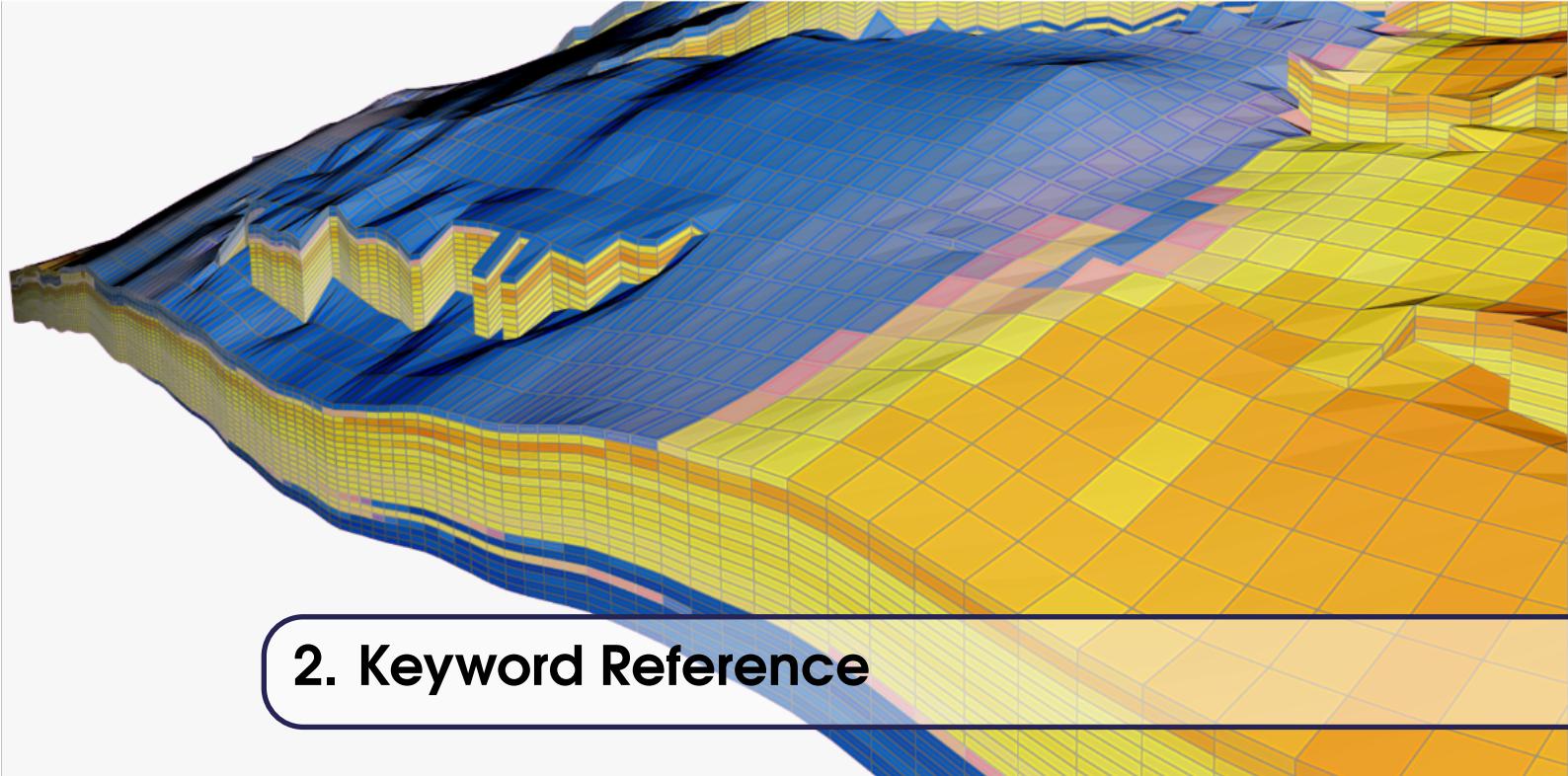
returning summary output to the default of every timestep.

### 1.11.8 Dynamic 3D output controls

ECHELON supports the output of many dynamic quantities to an industry-standard binary format (UNRST). The [RPTRST](#) keyword can be used to specify the quantities to report and the frequency with which they are output. See the keyword reference for further details.

### 1.11.9 Restarting simulation runs

The [SAVE](#) keyword instructs the simulator to periodically output all essential state variables into a binary output file. This file can be used in later runs to restart the simulation from one of these simulation snapshots using the [RESTART](#) keyword. Details on how to setup DATA files for restarted runs can be found in Chapter 11 of the Technical Description.



## 2. Keyword Reference

### 2.1 Introduction

The following pages provide a detailed description of all non-SUMMARY keywords supported in ECHELON, listed in alphabetical order. Keywords for the SUMMARY section are described in a tabular format in the subsequent chapter. Hyperlinks have been provided to allow easy navigation between related keywords.



## 2.2 ABQOPTS

### Description

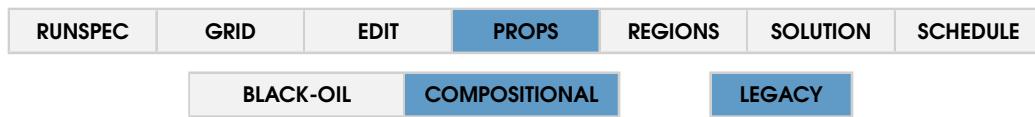
This keyword defines how ECHELON and Abaqus, the Finite Element Analysis package suitable for geomechanical computations, are integrated. Additional information are available in the [COUPLING](#) and [COUPLING\\_TYPE](#) keywords documentation and in the ECHELON Technical Description [Chapter 23](#).

### Record format

1. Maximum strain vector difference for convergence check  
**Type:** Float  
**Default value:** 0.1
2. Maximum pressure vector difference for convergence check  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 0.1
3. Coupling mode: TWO WAY, ONEWAY, EXPLICIT  
**Type:** String  
**Default value:** TWOWAY
4. ECHELON implements the fixed stress coupling (see [Section 23.1](#) in the Technical Documentation).  
**Type:** String  
**Default value:** FIXEDSTRESS

### Example

```
ABQOPTS
 0.1 0.1 TWOWAY FIXEDSTRESS /
```



## 2.3 ACF

### Description

This keyword specifies the acentric factors of the hydrocarbon components in a compositional simulation. [ACF](#) is followed by a record consisting of  $N_c$  non-negative real numbers terminated by a slash character. If multiple equations of state are used, acentric factor values must be specified for each of them through additional records.

There are no default values for acentric factors, hence it is necessary to define specific values.

See [Section 7.4](#) of the Technical Description for further details on the formulation of compositional equations of state.

### Record format

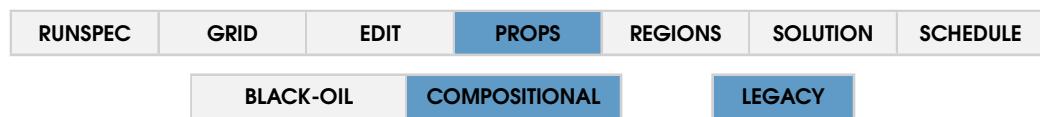
1. **COMP\_ACF:** (repeated NCOMP times)  
Component acentric factors ( $n_c$  real values).

**Type:** Float

### Example

This example specifies the acentric factors for a compositional simulation with five components

```
ACF  
0.012 0.138 0.1 0.163 0.271 /
```



## 2.4 ACFS

### Description

This keyword specifies the acentric factors of the hydrocarbon components for the surface equation of state in a compositional simulation. The number of acentric factors should be equal to the number of components in the simulation. If multiple surface equations of state are used, values must be specified for each of them.

If the keyword is not provided the values specified in [ACF](#) are used.

See [Section 7.4](#) of the Technical Description for further details on the formulation of compositional equations of state.

### Record format

1. **COMP\_ACFS:** (repeated NCOMP times)  
Component acentric factors  
**Type:** Float

#### Example

This example specifies the acentric factors for the surface equation of state in a compositional simulation with five components

```
ACFS
0.012 0.138 0.1 0.163 0.271 /
```

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SCHEDULE
BLACK-OIL	COMPOSITIONAL					LEGACY
BLACK-OIL	COMPOSITIONAL					LEGACY

## 2.5 ACTIONX

### Description

The ACTIONX keyword makes it possible to designate a set of commands to be executed when given conditions are met. Keywords specifying these commands are given between ACTIONX keyword and enclosing ENDACTIO keyword. The number of keywords in the action body, that means between an ACTIONX keyword and corresponding ENDACTIO keyword, is not limited. The keywords supported in the action body are as follows:

```
ACTIONX, COMPDAT, COMPDATL, COMPDATM, ENDACTIO, GCONINJE, GCONPRI, GCONPROD, GEFAC,
GRUPFUEL, GRUPSALE, GRUPTARG, MESSAGE, NEXT, NEXTSTEP, NUPCOL, RPTONLY, RPTONLYO,
SEPCOND, UDJQ, WAVAILIM, WCONINJE, WCONPROD, WCUTBACK, WCYCLE, WECON, WEFAC, WELDRAW,
WEOPEN, WEOPENL, WELPTI, WELTARG, WGRUPCON, WLIST, WPIMULT, WPIMULTL, WSALT, WSEPCOND,
WTADD, WTAKEGAS, WTEST, WTMULT, WVFPDP, WVPEXP.
```

In particular, note that actions could be arbitrarily nested, i.e. an ACTIONX keyword, together with the corresponding ENDACTIO keyword, could appear in the body of “outer” ACTIONX keyword.

The ACTIONX keyword itself consists of one header record, and then one or more records with action conditions. The keyword is terminated by an empty record, containing the slash (/) character only.

The action is evaluated, which means logical expression represented by action conditions is recalculated, by default at the end of each timestep of the simulation (or, alternatively, at reporting times). The action is triggered, which means commands that make up the action body are run, in case the result of the evaluation is true.

### Action header record

The header record contains following items:

1. The action name. This is a string that should provide a unique name for given action. If an action with the same name is already previously defined, it gets replaced by newly defined action.
2. An optional integer (default is 1), specifying a maximum number of times that given action could be triggered during the simulation. Once the number of times the action was triggered is greater than this number, the action won’t be triggered even if action conditions are satisfied. If this item set to a non-positive number, the action will never be triggered.
3. An optional real number (default is 0) specifies the minimum interval in days of simulation time between any two successive action trigger events. Namely, once the action is triggered, it won’t be triggered again until this time passes, even if all action conditions are satisfied at the end of some in-between simulation timesteps. If this item set to a negative value, it will have the same effect as if it’s set to 0.
4. An optional string, that could be either “Timestep” (that is default) or “ReportStep”, that specifies the frequency of evaluating given action. If set to “Timestep”, then the action is evaluated at the end of each timestep of simulation, and if set to “ReportStep” then it’s evaluated only at reporting times.

Details on the record fields can be found in the **Record 1 format table** below.

### Action condition records

The records with action conditions contain following items:

1. LHS of the condition. This is a string that represents left-hand side of the condition. Allowed

values are discussed below.

2. The comparison operator. This is a string that represents the right-hand side of the condition. Allowed values of comparison operators, and their meanings, are provided below.
3. RHS of the condition. Same as LHS, but represents the right-hand side of the condition.
4. Logical operator. This item is required for all the conditions except for the last one, and for the last one it is forbidden. Allowed values are “AND” and “OR”, representing corresponding logical operators.

The comparison operators for action conditions are as follows:

Value	Alternative value	Meaning
=	.EQ.	equals
!=	.NE.	not equals
<	.LT.	less than
<=	.LE.	less or equals
>	.GT.	greater than
>=	.GE.	greater or equals

**Table 2.1**

If there are multiple action conditions, logical operators are applied in order, i.e. both AND and OR operators are considered to be of the same priority. The evaluation of multiple action conditions is not short-circuited, i.e. all conditions are always evaluated.

Besides items mentioned, action condition records could contain parentheses, useful to impose arbitrary order of applying logical operators. Left parenthesis could appear before LHS item for given condition, and matching right parenthesis then must appear after the RHS item of this record or one of the consecutive records (and before eventual logical operator at the end of this item). Only one left and one right parentheses may appear in any condition record. The number of parentheses in all action conditions as a whole must match.

As a special case, instead of LHS, comparison operator and RHS, the action condition may contain string “ALWAYS”. If any action condition is of this type, then the whole logical expression represented by action conditions evaluates to true.

Whenever an action is triggered, all action conditions that are evaluated to be true will be printed into the log file.

### The action quantities

Allowed values for LHS/RHS in the action conditions are as follows:

- Real constant. This value could be optionally followed by an increment value, that is another real constant, intended to be added to the first value each time when given action is triggered. If supplied, the increment value is parsed, but at the moment is unused. If omitted, the default for increment value is 0, thus practically at the moment it's like that default increment value is always applied, even if non-default is supplied on input.
- Time designator. This is a string that could have one of the following values:
  - “DAY”, stands for the current day of simulation time at the moment when condition evaluated
  - “MNTH”, stands for the current month of simulation time at the moment when condition evaluated
  - “YEAR”, stands for the current year of simulation time at the moment when condition evaluated
- Month name constant. This is a string, representing month name, typically used when “MNTH” provided on the other side of the comparison. Allowed values are “JAN”, “FEB”, “MAR”, “APR”, “MAY”, “JUN”, “JUL”, “AUG”, “SEP”, “OCT”, “NOV” and “DEC”. These strings are automatically converted to integers in [1, 12] range upon parsing, and used as integer constants afterward.
- String value that is either summary quantity keyword or UDQ name. This string stands for

the value of the corresponding quantity at the moment when condition evaluated. Only field, group and well summary quantity keywords or UDs are allowed at the moment. In the case of group and well quantities, summary quantity keyword or UDQ are followed by another string, designating groups or wells that the given quantity is calculated for, as described in more detail below. For summary quantity keywords that allow for specifying a component index, if an underscore and then the index are appended to the keyword, then given summary quantity is calculated as value for corresponding component.

For group quantities in action condition LHS/RHS, summary quantity keyword (for example GOPR) or UDQ name is followed by group(s) designator. This is a string that could be either a well list name, or individual group name, or a pattern that is matched against group names. In the pattern, “?” is considered matching any single character and “\*” is considered matching any zero or more characters; any number of these two wildcard characters could appear in the pattern. If well list name matched, then corresponding quantity is calculated as for a group that would contain the same wells as the given list. If the pattern is specified as a group designator, then the quantity is calculated for each group matching the pattern, and the condition as a whole is evaluated as true if any of these values satisfies it. Note that there could be multiple values calculated in the same way on the other side of the condition, in which case all combinations are compared.

For well quantities in action condition LHS/RHS, summary quantity keyword (for example WOPR) or UDQ name is followed by well(s) designator string, which could be either a well list name, or individual well name, or a pattern that is matched against well names. The pattern is interpreted the same way as described for group quantities. Well list name is treated like a pattern here, in the sense that at the evaluation time, it gets replaced by names of all wells that belong to the given well list. Finally, as for group quantities, if a given designator string resolves to multiple wells, the condition is repeatedly evaluated for quantity values of each of these wells, and it evaluates to true as a whole only if it holds true when evaluated for any of wells used.

When action conditions evaluated, names of wells that triggered for all conditions having a well quantity on either side are remembered. Then, whenever there is a well keyword, in the action body, that requires specifying well name, then wildcard “?” could be used instead, in which case it will be replaced by these remembered well names. Note that different wells could satisfy different action conditions, thus it could happen that an action having conditions on well quantities triggered, but that set of wells to be used as a replacement for “?” wildcard in commands from the action body is still an empty set.

The structure of an element within a conditional record is reported in **-Record 2 format** table, just above the first example.

### Record 1 format

Name	Type	Units	Description
NAME	String		The action name
MAXTRIG	Integer		Maximum number of times the action can be triggered
MINDELTA	Float	[Day], [Day]	Minimum time interval between two successive action triggering events
FREQ	Integer		Frequency of evaluating action

### Record 2 format

Name	Supported	Description
(	True	Optional left parenthesis
LHS	True	Left hand quantity for the action condition
TEST	True	The comparison operator for the action condition
RHS	True	Right-hand quantity for the action condition
)	True	Optional right parenthesis
ANDOR	True	Optional logical operator to connect this record with other records
/	True	Record terminator

**Example 1**

This action will be eventually triggered once when the gas production rate for group GR1 gets over 5000 units, and it will then shut the P2 well.

```

ACTIONX
SHUTONGGRP 1 /
GGPR GR1 > 5000.0 /
/

WEOPEN
P2 SHUT /
/

ENDACTIO

```

**Example 2**

This action will be eventually triggered once when the simulation is past year 2025, and either field oil production rate greater than 10000 units or oil production rate of the well PROD1 greater than 2000 units. When action is triggered, all wells in the list “\*LIST1” will be shut.

```

ACTIONX
SHUTAFTER2025 1 /
YEAR > 2025 AND /
( FOPR > 10000.0 OR /
  WOPR PROD1 > 2000.0 ) /
/

WEOPEN
'*LIST1' SHUT /
/

ENDACTIO

```

**Example 3**

This action will be triggered no more than 20 times during the simulation, but at least 30 days of simulation time will have to pass before the action can be triggered again. If there are any wells from the list “\*LIST1” that have oil production rate smaller than the given value, these wells will have their oil rate target decreased by 20%. Note how “?” wildcard is used to stand for wells from the given list that fulfill the action condition.

```
ACTIONX
ADJUSTRATE 20 30 /
WOPR '*LIST1' < 2000 /
/

WTMULT
? ORAT 0.8 /
/

ENDACTIO
```

**Example 4**

This action sets the maximum number of times it could be executed to a very large number, making it practically unlimited. Assuming that the that there is well UDJQ with the name WUFOO previously defined in the input file, this action will at each report time check WUFOO value for all wells from the list “\*LIST1”, and will remove wells that have this value greater than 1 from the list.

```
ACTIONX
CLEAN 100000 0 REPORTSTEP /
WUFOO '*LIST1' > 1.0 /
/

WLST
'*LIST1' DEL ? /
/

ENDACTIO
```



## 2.6 ACTNUM

### Description

This keyword is used to indicate whether a grid block is active or inactive. It is followed by one value for each grid cell in the input box, which by default is the entire grid, following natural ordering with index along I running faster, then along J and last along K. Repeat counts may be used for repeated values. A slash (/) should be terminating the record.

#### Example 1

```
ACTNUM  
30*0 50*1 45*0 /
```

#### Example 2

```
ACTNUM  
0 1 1 1 1 1 0 1  
0 0 1 1 0 1 1 1  
0 1 1 1 1 1 0 0  
0 0 1 1 0 1 1 1  
0 0 1 0 0 1 1 0  
0 1 0 1 1 1 0 0  
0 0 0 1 1 1 0 0  
1 1 0 0 1 0 0 0  
0 0 1 0 0 1 1 1 /
```



## 2.7 ACTPARAM

### Description

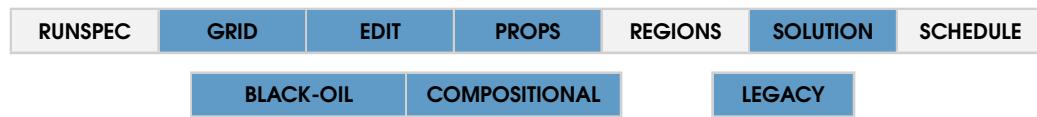
The `ACTPARAM` keyword is used to provide tolerance on the evaluation of equality in the `ACTIONX` keyword when using an equality operator. It is followed by a single record containing two fields, the first of which is reserved for future use.

### Record format

Field	Name	Type	Default	Description
1				<i>Reserved</i>
2	EQUALITY_TOL	Float	$10^{-4}$	Tolerance that is used in evaluating whether two quantities are equal in the ACTIONX keyword

### Example

```
-- Tighten equality comparison for ACTIONX
ACTPARAM
1* 1e-5 /
```



## 2.8 ADD

### Description

This keyword can be used to add a constant to a given 3D array inside a set of grid cells or for the entire grid the 3D array refers to. The keyword can be followed by an arbitrary number of records defined as in the table, with an empty record having only the slash character to terminate input.

The [ADD](#) operation is repeated for every record, setting values of the selected 3D array in a box of cells defined by six integers (fields 3 to 8) subject to the following constraints:

$$1 \leq I\text{MIN} \leq I\text{MAX} \leq NX$$

$$1 \leq J\text{MIN} \leq J\text{MAX} \leq NY$$

$$1 \leq K\text{MIN} \leq K\text{MAX} \leq NZ.$$

If [ADD](#) is used for global grid arrays, then  $NX=NXRES$ ,  $NY=NYRES$  and  $NZ=NZRES$ . If [ADD](#) is used within a local grid refinement definition ([CARFIN/ENDFIN](#) block), or within a local grid refinement editing ([REFINE/ENDFIN](#) block), then the cell box is constrained by the local grid dimensions (i.e.,  $NXREF$ ,  $NYREF$  and  $NZREF$ ). If [ADD](#) is used inside a [BOX/ENDBOX](#) block then  $NX$ ,  $NY$  and  $NZ$  are set in [BOX](#) record.

Notably, if you define a cell box in one [ADD](#) keyword record, record, then the next record inherits that cell box limits as its default values for fields 3 to 8.

### Supported 3D arrays

The [ADD](#) keyword supports the following 3D arrays, reported on a per-section basis:

#### GRID

[DX](#), [DY](#), [DZ](#), [PERMX](#), [PERMY](#), [PERMZ](#), [MULTX](#), [MULTY](#), [MULTZ](#), [PORO](#), [NTG](#), [FLUXNUM](#), [MULTNUM](#), [OPERNUM](#)

#### EDIT

[PORV](#), [DEPTH](#), [TRANX](#), [TRANY](#), [TRANZ](#)

#### PROPS

- [SWL](#), [SWCR](#), [SWU](#), [SGL](#), [SGCR](#), [SGU](#),
- [KRW](#), [KRO](#), [KRG](#), [KRWR](#), [KRGR](#), [KRORW](#), [KRORG](#),
- [ISWL](#), [ISWCR](#), [ISWU](#), [ISGL](#), [ISGCR](#), [ISGU](#),
- [IKRW](#), [IKRO](#), [IKRG](#), [IKRWR](#), [IKRGR](#), [IKRORW](#), [IKRORG](#),
- [PCW](#), [PCG](#), [IPCW](#), [IPCG](#)

#### REGIONS

[SATNUM](#), [PVTNUM](#), [FIPNUM](#), [ROCKNUM](#), [MISCTNUM](#), [EOSNUM](#), [EQLNUM](#)

#### SOLUTION

[PRESSURE](#), [SWAT](#), [SGAS](#), [RV](#), [RS](#), [TBLK](#), [SOIL](#), [PBUB](#), [PDEW](#), [SALT](#), [OILAPI](#)

#### Record format

Field	Name	Type	Default	Minin	Maxin	Description
1	3D array	String				Target 3D array to be updated
2	Constant	Float				Constant used in the operation
3	IMIN	Integer	1	1	NX	First cell to be updated along the I-direction
4	IMAX	Integer	NX	1	NX	Last cell to be updated along the I-direction
5	JMIN	Integer	1	1	NY	First cell to be updated along the J-direction
6	IMAX	Integer	NY	1	NY	Last cell to be updated along the J-direction
7	KMIN	Integer	1	1	NZ	First cell to be updated along the K-direction
8	KMAX	Integer	NZ	1	NZ	Last cell to be updated along the K-direction

### Example 1

In the first example, in the [GRID](#) section, we add 100 to [PERMX](#) in the entire grid (the first record), then add 0.1 to [PORO](#) in the entire grid (the second record), and finally, add 0.2 to [PORO](#) in a column of cells only.

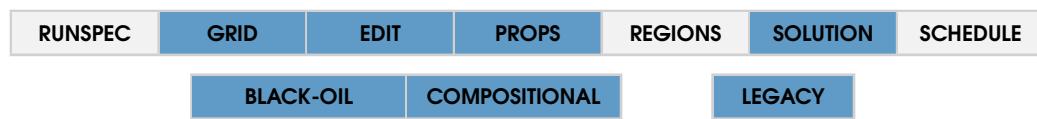
```
ADD
PERMX 100 /
PORO 0.1 /
PERMX 0.2 12 25 25 1 30 /
/
```

### Example 2

In the second example we use [ADD](#) to modify [SATNUM](#) and [EQLNUM](#) in the [REGIONS](#) section:

```
ADD
SATNUM 1 /
EQLNUM 1 /
SATNUM 1 1 20 1 20 1 15 /
/
```

It is worth noticing that values for the 3D array in the [REGIONS](#) section are integer, hence we [ADD](#) integer values.



## 2.9 ADDREG

### Description

This keyword can be used to add a constant to a target 3D array, or a subset of, using a region 3D array as filter. The keyword can be followed by an arbitrary number of records defined as in the table, with an empty record having only the / character to terminate input.

The `ADDERG` operation is repeated for every record, copying values from the source 3D array into the destination 3D array, using by default `MULTNUM` to filter cells. Alternatively it is possible to choose `FLUXNUM` or `MULTNUM` as region 3D array used to filter cells.

### Available 3D arrays

The `ADDERG` keyword supports the following 3D arrays, reported on a per-section basis:

#### GRID

`DX, DY, DZ, PERMX, PERMY, PERMZ, MULTX, MULTY, MULTZ, PORO, NTG, FLUXNUM, MULTNUM, OPERNUM, WORK, IWORK`

#### EDIT

`PORV, DEPTH, TRANX, TRANY, TRANZ, WORK, IWORK`

#### PROPS

`SWL, SWCR, SWU, SGL, SGCR, SGU, KRW, KRO, KRG, KRWR, KRGR, KRORG, ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, IKRW, IKRO, IKRG, IKRWR, IKRGR, IKRORG, PCW, PCG, IPCW, IPCG, WORK, IWORK`

#### REGIONS

`SATNUM, PVTNUM, FIPNUM, ROCKNUM, MISCTNUM, EOSNUM, EQLNUM, IWORK`

#### SOLUTION

`PRESSURE, SWAT, SGAS, RV, RS, TBLK, SOIL, PBUB, PDEW, SALT, WORK, IWORK`

### Record format

Field	Name	Type	Default	Description
1	TARGET	String		Target 3D Array
2	CONSTANT	Float		Constant to add
3	FILTER	Integer		Region number to filter grid cells
4	REGION	Integer	M	3D region array used as filter; it can be M for <code>MULTNUM</code> , F for <code>FLUXNUM</code> , or O for <code>OPERNUM</code>

#### Example 1

`ADDERG` is used in the `GRID` section to add 200 to `PERMX` for cells in region `MULTNUM` equal to 4.

```
ADDERG
PERMX 200 4 /
/
```

**Example 2**

`ADDREG` is used in the `PROPS` section to add 0.1 to `SWL` for cells in region `FLUXNUM` equal to 4, and to add -0.1 to `SOWCR` for cells in region `OPERNUM` equal to 5.

```
ADDREG
  SWL 0.1 5 F /
  SOWCR -0.1 5 O /
/
```



## 2.10 ADDZCORN

### Description

This keyword can be used to add a constant value to corner points ([ZCORN](#)) array. **ADDZCORN** is followed by an arbitrary number of records, each of them defining a modification on a specific set of cell corners, with an empty, slash terminated record to close keyword input.

The modification can be continuous with respect to the adjacent cells or discontinuous, depending on the settings in item 8 to 11 of each record.

The corner points of the cells selected in a box of cells defined by six integers (fields 2 to 7 in the table) subject to the following constraints:

$$\begin{aligned} 0 &\leq \text{IMIN} \leq \text{IMAX} \leq \text{NX}, \\ 0 &\leq \text{JMIN} \leq \text{JMAX} \leq \text{NY}, \\ 0 &\leq \text{KMIN} \leq \text{KMAX} \leq \text{NY}. \end{aligned}$$

If in any record these indexes are defaulted, they are set to the values which were used for the previous operation within the current keyword.

### Record format

1. **Constant:** Constant to be added to the corner point  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
2. **IMIN:** First cell to be updated along the I-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** 1
3. **IMAX:** Last cell to be updated along the I-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** NX
4. **JMIN:** First cell to be updated along the J-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** 1
5. **IMAX:** Last cell to be updated along the J-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** NY
6. **KMIN:** First cell to be updated along the K-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** 1

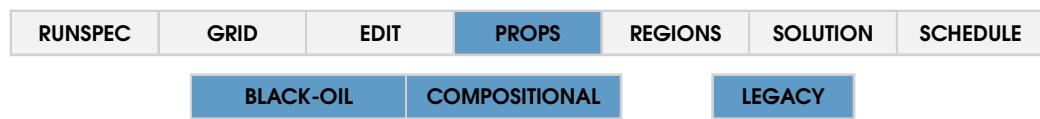
7. **KMAX:** Last cell to be updated along the K-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** NZ
8. **IMIN\_A:** IMIN-1 or IMIN  
**Type:** Integer  
**Default value:** IMIN-1 if IMIN > 1
9. **IMAX\_A:** IMAX+1 or IMAX  
**Type:** Integer  
**Default value:** IMAX+1 if IMAX < NX
10. **JMIN\_A:** JMIN-1 or JMIN  
**Type:** Integer  
**Default value:** JMIN-1 if JMIN > 1
11. **JMAX\_A:** JMAX+1 or JMAX  
**Type:** Integer  
**Default value:** JMAX+1 if JMAX < NY
12. **KMIN\_A:** KMIN-1 or KMIN  
**Type:** Integer  
**Default value:** KMIN-1 if KMIN > 1
13. **KMAX\_A:** KMAX+1 or KMAX  
**Type:** Integer  
**Default value:** KMAX+1 if KMAX < NZ
14. **OPERATION:** Action: ALL, TOP, or BOTTOM  
**Type:** String  
**Default value:** ALL  
**Allowed values:**

Name	Description
ALL	modify both top and bottom corners z-coordinates of all cells
TOP	modify both top and bottom corners z-coordinates of all cells except for cells in the bottom layer where only the top corners are modified
BOTTOM	modify both top and bottom corners z-coordinates of all cells except for cells in the top layer where only the bottom corners are modified

### Example

In this example, **ADDZCORN** is used to modify corner points of a 10x10x5 model

```
ADDZCORN
 50.0 1 10 1 10 1 5 / Add 50 ft to all the layers
 -10.0 4 6 7 8 1 5 4 6 7 8 / Raise a fault block 10 ft
 /
```



## 2.11 ADSALNOD

### Description

This keyword specifies the brine concentrations to compute the concentration of polymer adsorbed by the rock. The data should be entered as a one-column table for [NTSFUN](#) regions with at least two rows. [ADSALNOD](#) should be used in conjunction with the keywords [POLYMER](#), [BRINE](#), and [PLYADSS](#). The keyword may contain up to [NSSFUN](#) number of records in a table, each table must be terminated with a slash (/).

### Record format

#### 1. CONCENTRATION: The brine concentration

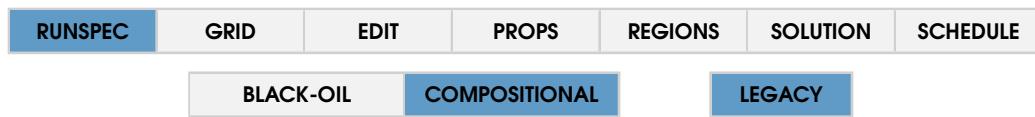
Values in the table must strictly increase down the column and correspond to the number of entries in [PLYADSS](#)

**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

### Example

The keyword specifies [NTSFUN](#) = 2 tables and is compatible with the [PLYADSS](#) example.

```
ADSALNOD
-- first region has 3 ADSALNOD entries
0.0
0.5
1.0
/
-- second region has 2 ADSALNOD entries
0.0
1.0
/
```



## 2.12 AIM

### Description

The [AIM](#) keyword specifies that the Adaptive Implicit Method of time discretization should be used. This method is a hybrid between the Fully Implicit Method (see [FULLIMP](#)) and the Implicit Pressure/Explicit Saturation method (see [IMPES](#)). It is available only in compositional simulations. These methods are discussed in [Chapter 3](#) of the ECHELON Technical Description. No data records are associated with this keyword.

See [Section 3.7](#) of the Technical Description for more information on the Adaptive Implicit Method.

### Example

```
RUNSPEC  
AIM
```



## 2.13 AIMFRAC

### Description

In simulations using the adaptive implicit method ([AIM](#)), a fraction of cells is discretized in time with implicit mobilities, while the remaining cells utilize mobilities explicitly in time. Explicit cells require only a single variable per cell (pressure) in the linear system solved at each Newton iteration, while implicit cells each require  $N_c + 4$  variables. On the other hand, the length of each timestep is limited by the explicit cell with the highest CFL number. The [AIMFRAC](#) keyword sets the target for the fraction of cells marked implicit. A higher fraction may result in a higher cost per linear iteration but may allow larger timesteps to be taken. The default fraction of 0.1 is often near the optimal value, but the fraction can be adjusted. For example, if the CFL criterion causes very small timesteps to be selected, increasing [AIMFRAC](#) may improve performance.

Note that this target fraction is generally an upper bound. If the timestep size is limited by something other than CFL (e.g. time-truncation error), the fraction of explicit cells may be significantly lower than this specified target. Conversely, cells connected to wells are automatically marked implicit, which is not accounted for in the target fraction, so the actual fraction of implicit cells may occasionally exceed the target value by a small amount.

See [Section 3.7](#) of the Technical Description for more information on the Adaptive Implicit Method.

### Record format

Field	Name	Default	Minimum	Maximum	Description
1	IMPLICIT_FRACTION	0.1	0	1	Target implicit fraction

### Example

The following increases the target implicit fraction to 0.15 from the default of 0.1.

```
AIMFRAC
0.15 /
```



## 2.14 AMF

### Description

The [AMF](#) keyword is used to provide the initial composition of the aqueous phase in each cell when using enumerated initial conditions and the gas solubility in the aqueous phase is activated using the [GASWAT](#) option. For equilibrated initial conditions, see [AMFVD](#).

The keyword is followed by a record consisting of  $N_x \times N_y \times N_z \times N_c$  values, where  $N_x$ ,  $N_y$ , and  $N_z$  are the number of cells in the  $X$ ,  $Y$ , and  $Z$  directions (specified in the [DIMENS](#) keyword), respectively and  $N_c$  is the number of components (specified in the [COMPS](#) keyword). The data is ordered such that the  $X$  index progresses fastest, while the component index increases slowest. Since the data represent the component mole fraction for a phase, the component data for each cell should sum to 1.0.

### Example

For a reservoir of dimensions  $5 \times 5 \times 3$  with six components:

```
SOLUTION  
  
AMF  
-- Component 1  
75*0.001  
-- Component 2  
75*0.0  
-- Component 3  
75*0.002  
-- Component 4  
75*0.001  
-- Component 5  
75*0.001  
-- Component 6 Water  
75*0.995  
/
```



## 2.15 AMFVD

### Description

The keyword is used in models where gas solubility in the aqueous phase is activated using [GASWAT](#) option and equilibrium initial conditions are specified with [EQUIL](#) keyword. It is used to provide a table of aqueous phase composition vs. depth. The aqueous composition of each cell will be interpolated from this table using the cell depth.

The table consists of one record for each equilibration region. The number of equilibration regions is specified in the [EQLDIMS](#) keyword. Each record consists of NCOMP+1 columns of numbers, where NCOMP is the number of components in the equation-of-state (specified by the [COMPS](#) keyword). The first column is the depth, and the remaining NCOMP columns define the aqueous phase composition. The composition at each depth should sum to 1.

### Table columns

#### Example

This example specifies the aqueous phase composition for a model with four components:

```
AMFVD
900  0.0001  0.0001  0.0002  0.9996
1900 0.0001  0.0001  0.0002  0.9996 /
```



## 2.16 API

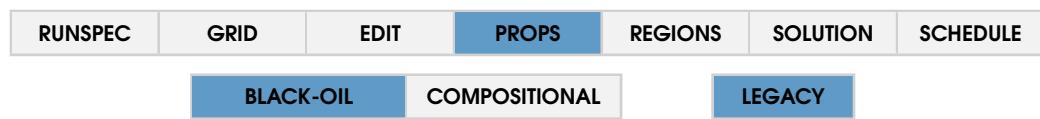
### Description

This keyword means that the API Tracking option is enabled. See Section 7.3 of the Technical Description for further information on the API Tracking.

### Example

In the RUNSPEC section:

```
RUNSPEC  
    API
```



## 2.17 APIGROUP

### Description

This keyword specifies the maximum number of groups of oil PVT tables to be used with the API tracking option. This value is one by default.

The PVT tables are arranged following records in the [DENSITY](#) or [GRAVITY](#) keywords, ordered following increasing oil densities (decreasing API gravity), but if [APIGROUP](#) is used, discontinuities in the table mark changes of [APIGROUP](#). Then, which group of PVT tables used in a given cell depends on the [PVTNUM](#) value for the cell at hand: in a cell with [PVTNUM](#) equal to 4, tables from the 4<sup>th</sup> [APIGROUP](#) are used.

### Example

```
APIGROUP  
3 /
```



## 2.18 APILIM

### Description

This keyword controls how cells where API values are not inside prescribed bounds are reported in a simulation where API tracking is used. It is also possible to constrain the values of cell API within prescribed bounds

### Record format

1. **TYPE:** Type of limiting to be applied

**Type:** String

**Allowed values:**

Name	Description
NONE	Disable any API value, used for monitoring or limiting, set before
WARN	Provides a summary of cells with API values outside prescribed bounds on a timestep basis (with additional details for every report step)
LIMIT	Cell API values are constrained to lay within the upper and lower bounds provided in the second record of the keyword.
BOTH	Both 2 and 3 are set

2. **SCOPE:** Selection of bounds to be used when the first field is LIMIT or BOTH

**Type:** String

**Allowed values:**

Name	Description
LOWER	Limit on the lower bound
UPPER	Limit only on the upper bound
BOTH	Limit on both lower and upper bounds

3. **LOWER\_LIM:** Lower API limit

**Type:** Float

**Allowed values:**

4. **UPPER\_LIM:** Upper API limit

**Type:** Float

5. **NUM\_ROWS:** Number of rows that a tabular output has in the more detailed tabulated summary

**Type:** Integer

**Example**

The following example shows setting APILIM to report in BOTH types and disable the reporting after a timestep of 30.

```
SCHEDULE  
  
APILIM  
BOTH BOTH 10.0 30.0 25 /  
  
TSTEP  
30 /  
  
APILIM  
NONE /
```



## 2.19 APIVD

### Description

This keyword specifies NTEQUL tables of oil API gravity versus depth. These tables are associated with the NTEQUL equilibration regions set in [EQLDIMS](#) each equilibration region. Notably, each table consists of two columns and the number of lines can not be greater than MAXVNOD, a bound set in [EQLDIMS](#) keyword. To interpolate, it is also necessary that at least two lines are provided.

### Table columns

#### Example

In this example, we define API versus depth using one equilibration region and MAXNODVD>= 3

```
APIVD
    7113 40.5
    7982 33
    8578 28.8
    /
```



## 2.20 AQUALIST

### Description

This keyword provides an option to create named (list of) analytic aquifers. The name can be assigned set of aquifers defined [AQUCT](#) or [AQUFET](#) keywords. Then summary output can be requested for the sum of the aquifers in a defined list using [ALQR](#) and [ALQT](#). Lists are identified by a specific name, a string with up to 8 characters. Notably, repeated records may be used to add (append) subsets of aquifers to the same list. Each record is terminated by a slash and an empty record (with a single slash) closes keyword input.

### Record format

#### 1. Aquifer List Name:

Type: String

#### 2. Aquifer Number(s):

Type: Integer

### Example

Here analytical aquifer 1 is assigned the name AQU1 and aquifers 1 and 2 are combined using the name AQU1-2.

```
AQUALIST
'AQU1' 1/
'AQU1-2' 1 2/
/
```



## 2.21 AQUANCON

### Description

**AQUANCON** is used to specify the connection between analytical aquifers and the reservoir. The keyword is followed by an arbitrary number of slash terminated records, with an empty record to close the whole input.

The aquifer is connected to the face (item 8) of the active cells on the outer side of a box defined using items 2-7 in each record.

### Record format

1. **ID:** Aquifer identification number  
**Type:** Integer
2. **I\_MIN:** Lower index of the connecting grid blocks in the x-direction  
**Type:** Integer
3. **I\_MAX:** Upper index of the connecting grid blocks in the x-direction  
**Type:** Integer
4. **J\_MIN:** Lower index of the connecting grid blocks in the y-direction  
**Type:** Integer
5. **J\_MAX:** Upper index of the connecting grid blocks in the y-direction  
**Type:** Integer
6. **K\_MIN:** Lower index of the connecting grid blocks in the z-direction  
**Type:** Integer
7. **K\_MAX:** Upper index of the connecting grid blocks in the z-direction  
**Type:** Integer
8. **FACE:** Index defining the face of the reservoir cell connected to the aquifer  
**Type:** Integer

#### Allowed values:

Name	Description
-I	I=1 face
+I	I=NX face
-J	J=1 face
+J	J=NY face
-K	K=1 face (top)
+K	K=NZ face (bottom)

9. **FLUX\_COEFF:** Aquifer influx coefficient. This coefficient defines the communication area between the reservoir and the aquifer for the given connection, and it can not be negative. The default value is the cell face area, while if the coefficient is defined many times for the same cell face ECHELON accumulates all the provided values. This coefficient is ignored for constant flux aquifers.  
**Type:** Float  
**Units:** ft<sup>2</sup> (FIELD), m<sup>2</sup> (METRIC)
10. **FLUX\_COEFF\_MULT:** Aquifer influx coefficient multiplier.  
**Type:** Float

11. **ADJOINING:** Allows aquifer connections to cell faces adjoining active cells

**Type:** String

**Allowed values:**

Name	Description
YES	Allow connection to active adjoint cells, which means the aquifer can be connected to the middle of the reservoir
NO	Do not allow connection to an active adjoining cell

### Example

The following example defines a Fetkovich aquifer that is connected to the outer size of I=NXRES and J=NYRES of the reservoir, assuming it is a 10x10x10 model.

```
AQUFETP
 1 5000.0 4000.0 1E8 1E-6 300.0 1 /
AQUANCON
 1 1 12 12 12 1 2 'J+' /
 1 12 12 1 12 1 2 'I+' /
/
```



## 2.22 AQUCHGAS

### Description

The keyword is followed by an arbitrary number of slash (/) terminated records, with an empty one to close the whole input.

Each record in this keyword specifies the properties of a constant head/pressure gas aquifer. Connections with the reservoir are set using [AQUANCON](#) or [AQUANCONL](#) keywords.

### Record format

1. Aquifer index number

**Type:** Integer

2. Datum depth

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

3. Gas pressure at the datum depth

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

4. Aquifer productivity index (rate per pressure drop)

**Type:** Float

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

5. Gas table (e.g. PVDG) index

**Type:** Integer

### Example

```
AQUCHGAS
1 1000.0 2000.0 400.0 1 /
/
```



## 2.23 AQUCON

### Description

This keyword is used to specify the connection between numerical aquifers and the reservoir. The aquifer is connected to the face (item 8) of the active cells on the outer side of an I-J-K box defined in items 2-7. The keyword is followed by an arbitrary number of slash (/) terminated records, with an empty one to close the whole input.

### Record format

1. **ID:** Aquifer identification number  
**Type:** Integer
2. **I\_MIN:** Lower index of the connecting grid blocks in the x-direction  
**Type:** Integer
3. **I\_MAX:** Upper index of the connecting grid blocks in the x-direction  
**Type:** Integer
4. **J\_MIN:** Lower index of the connecting grid blocks in the y-direction  
**Type:** Integer
5. **J\_MAX:** Upper index of the connecting grid blocks in the y-direction  
**Type:** Integer
6. **K\_MIN:** Lower index of the connecting grid blocks in the z-direction  
**Type:** Integer
7. **K\_MAX:** Upper index of the connecting grid blocks in the z-direction  
**Type:** Integer
8. **FACE:** Index defining the face of the reservoir connected to the aquifer  
**Type:** Integer

#### Allowed values:

Name	Description
-I	I=1 face
+I	I=NX face
-J	J=1 face
+J	J=NY face
-K	K=1 face (top)
+K	K=NZ face (bottom)

9. **TRANS\_MULT:** Transmissibility multiplier  
**Type:** Float  
**Allowed values:**
10. **TRANS\_CALC:** Allows connection transmissibility to be calculated by setting this option to 1.  
**Type:** Integer  
**Allowed values:**
11. **ADJOINING:** Allows aquifer connections to cell faces adjoining active cells

**Type:** String

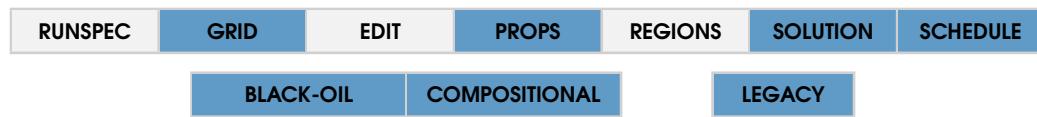
**Allowed values:**

Name	Description
YES	Allow connection to an active adjoining cell, which means the aquifer can be connected to the middle of the reservoir
NO	

### Example

The following example defines numerical aquifer 1 connection to the I- (I=1) outer side of the reservoir assuming the it is a 10x10x5 model.

```
AQUCON  
1 1 5 1 10 1 5 'I-' 1.0 /  
/
```



## 2.24 AQUCT

### Description

This keyword is used to specify the parameter for Carter-Tracy aquifers. It is followed by an arbitrary number of records, each of them defining a new Carter-Tracy aquifer, with an empty record terminated by a slash character to close the keyword input. Connections between Carter-Tracy aquifers and reservoir cells can be established using [AQUANCON](#) or [AQANCONL](#) keyword.

Carter-Tracy aquifers are described in [Chapter 11](#) of ECHELON Technical Description.

### Record format

1. **ID:** Aquifer identification number  
**Type:** Integer
2. **DATUM\_DEPTH:** Datum depth  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
3. **DATUM\_PRESS:** Initial aquifer pressure at the datum depth. If this field is defaulted (1\*) then the simulator uses an algorithm to find a pressure value that sets the aquifer as close as possible to an equilibrium condition with the reservoir.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)
4. **PERM:** Permeability of the aquifer  
**Type:** Float  
**Units:** mDarcy (FIELD), mDarcy (METRIC)
5. **PORO:** Porosity of the aquifer  
**Type:** Float  
**Default value:** 1.0
6. **CT:** Total compressibility of the rock and fluid  
**Type:** Float  
**Units:** 1/psi (FIELD), 1/bar (METRIC)
7. **AQUIFER\_RADIUS:** Inner radius of the aquifer  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
8. **THICKNESS:** Thickness  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
9. **ANGLE:** Angle of influence  
**Type:** Integer  
**Default value:** 360
10. **WATER\_TAB:** Table number for water pressure  
**Type:** Integer
11. **AQUA\_TAB:** Table number for influence function, see [AQUTAB](#)  
**Type:** Integer
12. **SALT\_CONC:** Initial salt concentration in the aquifer  
**Type:** Float

**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

### Example

The following example defines a Carter Tracy aquifer. Note that this aquifer can be connected to reservoir through [AQUANCON](#).

```
AQUCT
1 5000.0 4000.0 100.0 0.2 1E-6 300.0 50.0 10.0 /
/
```



## 2.25 AQUCWFAC

### Description

**AQUCWFAC** allows the user to modify the datum depth and pressures for all the constant head aquifers previously defined with the **AQUCHWAT** keyword. The data items are terminated with a slash (/).

### Record format

1. **ADD\_DEPTH:** Value to add to all constant head aquifer datum depths.  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** 0 (FIELD), 0 (METRIC)
2. **MULT\_PRES:** Multiply all constant head aquifer datum pressures by a value.  
**Default value:** 1

#### Example

Increase the datum depth by 100ft and multiply the datum pressure by 1.05

```
AQUCWFAC  
100.0 1.05 /
```



## 2.26 AQUDIMS

### Description

The [AQUDIMS](#) keyword is used to specify the number of analytic aquifers in the model.

### Record format

Field	Name	Type	Default	Description
1 - 4				<i>Reserved</i>
5	NAQUIFER	Integer	1	The number of analytic aquifers in the model

### Example

For a model with three analytic aquifers:

```
NAQUIFER  
4* 3 /
```



## 2.27 AQUFET

### Description

This keyword is used to specify the Fetkovich aquifer parameters. Note that this keyword has limited options: [AQUFET](#) together with [AQUANCON](#) provide a more general definition of Fetkovich aquifer.

### Record format

1. **ID:** Aquifer identification number  
**Type:** Integer
2. **DATUM\_DEPTH:** Datum depth  
**Type:** Float
3. **DATUM\_PRESS:** Initial aquifer pressure at the datum depth  
**Type:** Float
4. **WATER\_VOL:** Initial volume of water in the aquifer  
**Type:** Float
5. **COMPRES:** Total compressibility of the rock and fluid  
**Type:** Float
6. **PROD\_INDEX:** Productivity index  
**Type:** Float
7. **I\_MIN:** Lower index of the connecting grid blocks in the x-direction  
**Type:** Integer
8. **I\_MAX:** Upper index of the connecting grid blocks in the x-direction  
**Type:** Integer
9. **J\_MIN:** Lower index of the connecting grid blocks in the y-direction  
**Type:** Integer
10. **J\_MAX:** Upper index of the connecting grid blocks in the y-direction  
**Type:** Integer
11. **K\_MIN:** Lower index of the connecting grid blocks in the z-direction  
**Type:** Integer
12. **K\_MAX:** Upper index of the connecting grid blocks in the z-direction  
**Type:** Integer
13. **FACE:** Index defining the face of the reservoir connected to the aquifer  
**Type:** Integer

#### Allowed values:

Name	Description
-I	I=1 face
+I	I=NX face
-J	J=1 face
+J	J=NY face
-K	K=1 face (top)
+K	K=NZ face (bottom)

**14. Reserved****Example**

The following example defines a Fetkovich aquifer that is connected to the bottom of the 10x10x10 reservoir

```
AQUFET  
1 5000.0 4000.0 1E8 1E-6 300.0 1 1 10 1 10 10 10 'K+'/  
/
```



## 2.28 AQUFETP

### Description

This keyword is used to specify parameters for Fetkovitch aquifers. The keyword is followed by an arbitrary number of records, each of them defining a separate aquifer, with an empty record with only a trailing slash used to close keyword input. The connection with reservoir cells can be defined using the keyword [AQUANCON](#) but today it is not possible to connect the aquifer with a cell inside a local grid refinement.

Fetkovitch aquifers are described in [Chapter 11](#) of ECHELON Technical Description.

### Record format

1. **ID:** Aquifer identification number  
**Type:** Integer
2. **DATUM\_DEPTH:** Datum depth  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
3. **DATUM\_PRESS:** Initial aquifer pressure at the datum depth. If it is defaulted (1\*) then the initial pressure is calculated by the simulator to set an equilibrium condition between the aquifer and the reservoir.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)
4. **Water\_VOL:** Initial volume of water in the aquifer  
**Type:** Float  
**Units:** stb (FIELD), sm<sup>3</sup> (METRIC)
5. **COMPRES:** Total compressibility of the rock and fluid  
**Type:** Float  
**Units:** 1/psi (FIELD), 1/bar (METRIC)
6. **PROD\_INDEX:** Productivity index  
**Type:** Float  
**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)
7. **WATER\_TAB:** Table number for water pressure properties  
**Type:** Integer
8. **SALT\_CONCENT:** Initial salt concentration in the aquifer  
**Type:** Float  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)
9. *Reserved*

### Example

The following example defines a Fetkovitch aquifer. Note that this aquifer can be connected to reservoir through [AQUANCON](#).

```
AQUFETP
1 5000.0 4000.0 1E8 1E-6 300.0 /
/
```



## 2.29 AQUFLUX

### Description

This keyword allows defining constant flux aquifers. [AQUFLUX](#) is followed by up to NANAQU of slash terminated records, each of them referring to an aquifer where the flux is fixed by the second field of the record (see record format below). NANAQU is the maximum number of analytic aquifers allowed in the simulation and is set using the fifth field of [AQUDIMS](#) keyword.

The set of cells the aquifer is connected to is defined by means of [AQUANCON](#) or [AQANCONL](#) keywords. When we use the constant flux aquifer, the influx of water,  $Q_w^{STC}$ , into a connected cell is defined as:

$$Q_w^{STC} = FLUX \cdot A \cdot m,$$

where  $FLUX$  is defined in the second field of the record,  $A$  is the area of the cell face connected with the aquifer and  $m$  is a multiplier defined by means of [AQUANCON](#) or [AQANCONL](#).

### Record format

1. **ID:** Aquifer index number  
**Type:** Integer
2. **FLUX:** Aquifer Flux Rate (UNITS: sm<sup>3</sup>/day/m<sup>2</sup> (METRIC), stb/day/ft<sup>2</sup> (FIELD))  
**Type:** Float
3. **SALT\_CONC:** Aquifer salt concentration (only if using [BRINE](#) option. ignored otherwise)  
**Type:** Float

### Example

Two constant flux aquifers are defined with rates per unit area of 0.010 and 0.015 stb/d/ft<sup>2</sup>

```
AQUFLUX
1 0.010 /
2 0.015 /
/
```



## 2.30 AQUNNC

### Description

This keyword enables user-defined transmissibility to be explicitly defined to connect specified grid cells with numerical aquifer cells. The numerical aquifer cells are defined using the [AQUNUM](#) keyword. The [AQUCON](#) keyword is most commonly used to define the numerical aquifer connections; however, the AQUNNC keyword provides more flexibility in definitions. The keyword allows the user to explicitly specify the cells to be linked and their required transmissibility value. Each line of data must be terminated by a slash (/) and an additional slash ends the keyword.

### Record format

1. **ID:** Aquifer identification number  
**Type:** Integer
2. **I1:** i-index of the first connecting grid blocks  
**Type:** Integer
3. **J1:** j-index of the first connecting grid blocks  
**Type:** Integer
4. **K1:** k-index of the first connecting grid blocks  
**Type:** Integer
5. **I2:** i-index of the second connecting grid blocks  
**Type:** Integer
6. **J2:** j-index of the second connecting grid blocks  
**Type:** Integer
7. **K2:** k-index of the second connecting grid blocks  
**Type:** Integer
8. **TRANSMISSIBILITY:** Transmissibility for cell-to-cell connection  
**Type:** Float
9. **SATNUM1:** Saturation table for flow from cell 1 to 2  
**Type:** Integer
10. **SATNUM2:** Saturation table for flow from cell 2 to 1  
**Type:** Integer
11. **PVTNUM1:** Pressure table for flow from cell 1 to 2  
**Type:** Integer
12. **PVTNUM2:** Pressure table for flow from cell 2 to 1  
**Type:** Integer

**Example**

Here a numerical aquifer cell is connected to 3 different reservoir cells

```
AQUNNC
--AQ    I1   J1   K1      I2   J2   K2  Trans
 1  500 200 1      100  249 10     500.0 /
 1  500 200 1      100  250 10     600.0 /
 1  500 200 1      100  251 10     750.0 /
/
```



## 2.31 AQUTAB

### Description

An [AQUTAB](#) keyword in the PROPS section can be used to supply tables of dimensionless time versus dimensionless pressure to define the influence function for the Carter-Tracy aquifer influx model. The default table provided in Echelon is for an infinite aquifer; however, alternative tables for various aquifer-to-reservoir radii ratios can be supplied using the [AQUCT](#) keyword. The Carter-Tracy aquifer model (see [AQUCT](#)) is based on the solution of a pressure diffusion problem for a radial aquifer characterized by an inner radius  $r_0$  (the reservoir radius), an outer aquifer radius ( $r_1$ ), along with various other constant aquifer properties such as thickness and porosity (see the [AQUCT](#) and the ECHELON technical manual for details and references).

Considering uniform porosity,  $\phi$ , and uniform and isotropic permeability,  $k$ , the water pressure,  $p$ , follows a diffusion equation which can be written in radial coordinates as defined in the ECHELON technical manual. The Carter-Tracy aquifer model is a simplified approximation to a fully transient model, which avoids the need for superposition. The method uses a dimensionless table that supplies a constant terminal rate influence function. Although the theory has been developed for a radially symmetric reservoir surrounded by an annular aquifer, the method applies to arbitrarily shaped reservoirs.

The aquifer properties (compressibility, porosity, initial pressure, depth, radius and influence angle, *etc.*) are defined using the keyword [AQUCT](#), and the aquifer connections to external grid faces of the reservoir can be made with [AQUANCON](#). Summary file quantities for the aquifer may be obtained using [AAQR](#) (influx rate) and [AAQT](#) (cumulative influx) in the [SUMMARY](#) section. For tracer tracking runs, the initial concentrations of water phase tracers in the aquifer may be supplied using the keyword [AQANTRC](#) in the [SOLUTION](#) section. For the brine tracking option, the initial salt concentration may be supplied using the [AQUCT](#) keyword in the [SOLUTION](#) section.

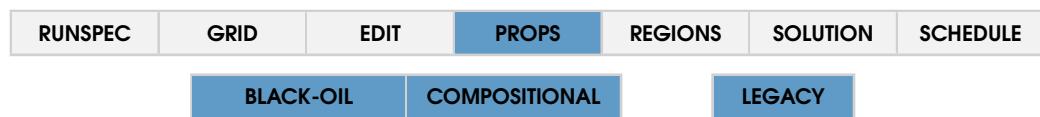
### Table columns

1. **TD:** Dimensionless time
2. **PD:** Dimensionless pressure

**Example**

Here an aquifer influence function table is defined for a radius ratio (aquifer-to-reservoir) of 5.0. Note that this is table number 2 to be assigned on item #11 of the **AQUCT** keyword. Table #1 (for an infinite aquifer) is stored internally in Echelon.

```
AQUTAB
1.00E-02      0.10810
1.50E-02      0.13118
2.00E-02      0.15031
2.50E-02      0.16692
3.00E-02      0.18176
4.00E-02      0.20767
5.00E-02      0.23007
6.00E-02      0.24997
7.00E-02      0.26800
8.00E-02      0.28455
9.00E-02      0.29989
1.00E-01      0.31423
1.50E-01      0.37514
2.00E-01      0.42425
2.50E-01      0.46593
3.00E-01      0.50242
4.00E-01      0.56461
5.00E-01      0.61685
6.00E-01      0.66219
7.00E-01      0.70241
8.00E-01      0.73865
9.00E-01      0.77170
1.00E+00      0.80213
1.50E+00      0.92679
2.00E+00      1.02235
2.50E+00      1.10050
3.00E+00      1.16730
4.00E+00      1.28031
5.00E+00      1.37821
6.00E+00      1.46878
7.00E+00      1.55571
8.00E+00      1.64082
9.00E+00      1.72501
1.00E+01      1.80875
1.50E+01      2.22559
2.00E+01      2.64218
2.50E+01      3.05885
3.00E+01      3.47555
4.00E+01      4.30895
5.00E+01      5.14232
6.00E+01      5.97569
7.00E+01      6.80906
8.00E+01      7.64242
9.00E+01      8.47578
1.00E+02      9.30915
1.50E+02      13.47596
2.00E+02      17.64277
2.50E+02      21.80958
/
```



## 2.32 BDENSITY

### Description

This keyword optionally defines brine surface density as a function of the salt concentration. If the keyword is not present, the density properties are taken from [DENSITY](#) or [GRAVITY](#). The data should be entered as a multi-row table for [NTPVT](#) regions, with [NTPVT](#) defined with [TABDIMS](#) keyword..

**BDENSITY** should be used in conjunction with the keywords [BRINE](#) and [PVTWSALT](#). The values in each row correspond to the salt concentrations for each table in the [PVTWSALT](#) table.

The keyword may contain an arbitrary number of rows in a table and each row must be terminated with a slash (/).

### Record format

1. **BRINE\_DENSITY:** Brine density at surface conditions (one value for each row of the corresponding PVTWSALT keyword table).

**Units:** lb/ft<sup>3</sup> (FIELD), kg/m<sup>3</sup> (METRIC)

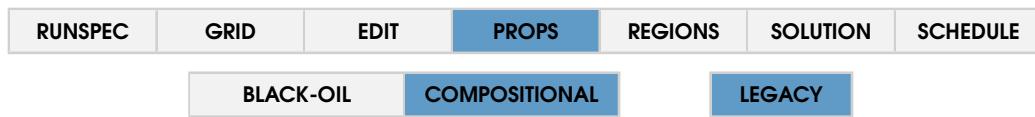
### Example

This example specifies two tables for [NTPVT](#) = 2,

```
BDENSITY
-- first region
60.0  61.0  62.0 /
-- second region
61.0  62.0 /
```

and compatible with the following [PVTWSALT](#) table.

```
PVTWSALT
-- first region table
4400      10 /
0          1.04    3.0E-6  0.76   0
5          1.02    2.9E-6  0.86   0
10         1.01    2.8E-6  0.96   0   /
-- second region table
4400      /
0          1.04    3.0E-6  0.8    0
10         1.02    2.8E-6  1.0    0   /
```



## 2.33 BIC

### Description

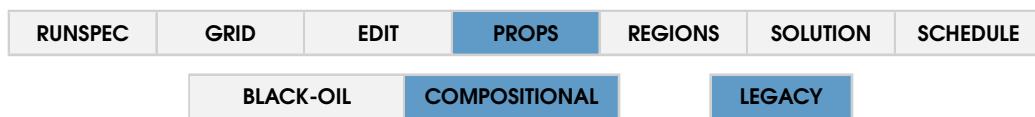
Specifies the binary interaction coefficients for reservoir equations of state. For an equation of state with  $N_c$  components, the binary interaction coefficients are an  $N_c \times N_c$  matrix representing the interaction between component species. Since this matrix is symmetric and the diagonal coefficients are zero (i.e. no self-interaction), the lower diagonal part of the matrix is sufficient to fully specify the BICs. Hence, this keyword expects  $N_c(N_c - 1)/2$  parameters (representing the lower diagonal) for each record. The number of records should be equal to the number of EOS regions, specified in the keyword [TABDIMS](#).

See [BICS](#) for the corresponding keyword for the surface equations of state. See [Section 7.4](#) of the Technical Description for further details on the formulation of compositional equations of state.

### Example

For an EOS with 5 components

```
BIC
0.0
0.0 0.05
0.0 0.05 0.03
0.0 0.05 0.02 0.0
0.0 0.05 0.03 0.0 0.0 /
```



## 2.34 BICS

### Description

Specifies the binary interaction coefficients for surface equations of state. For an equation of state with  $N_c$  components, the binary interaction coefficients are an  $N_c \times N_c$  matrix representing the interaction between component species. Since this matrix is symmetric and the diagonal coefficients are zero (i.e. no self-interaction), the lower diagonal part of the matrix is sufficient to fully specify the BICs. Hence, this keyword expects  $N_c(N_c - 1)/2$  parameters (representing the lower diagonal) for each record. The number of records should be equal to the number of EOS regions, specified in the keyword [TABDIMS](#).

See [BIC](#) for the corresponding keyword for the reservoir equations of state. See [Section 7.4](#) of the Technical Description for further details on the formulation of compositional equations of state.

### Example

For an EOS with 5 components

```
BICS
0.0
0.0 0.05
0.0 0.05 0.03
0.0 0.05 0.02 0.0
0.0 0.05 0.03 0.0 0.0 /
```



## 2.35 BLACKOIL

### Description

Enables a black-oil run as opposed to a compositional run. **BLACKOIL** is equivalent to the specification of **OIL**, **WATER**, **GAS**, **DISGAS** (if PVTO or PVCO is present) and **VAPOIL** (if PVTG is present).

### Example

```
RUNSPEC  
BLACKOIL
```



## 2.36 BOX

### Description

This keyword is used to redefine the input box in GRID, EDIT, PROPS, REGION and SOLUTION sections. It can also be used in the SCHEDULE section to update locally multipliers like [MULTX](#), [MULTY](#), [MULTZ](#) and [MULTPV](#).

[BOX](#) is followed by a single record with six integer fields (see record format below), which define the geometry of the box, terminated by a slash character.

Notably, the following constraints also holds:

$$\text{IMIN} \leq \text{IMAX},$$

$$\text{JMIN} \leq \text{JMAX}, \text{ and}$$

$$\text{KMIN} \leq \text{KMAX},$$

while the boundary of the new input box is bounded by the reservoir grid dimensions, NXRES, NYRES and NZRES, as defined in [DIMENS](#).

[BOX](#) remains in effect until another it is reset with another keyword or ended with [ENDBOX](#). When it is in effect, values for grid property keywords are given only for the number of cells in the present box, i.e.

$$\text{Number of values} = (\text{IMAX} - \text{IMIN} + 1) \times (\text{JMAX} - \text{JMIN} + 1) \times (\text{KMAX} - \text{KMIN} + 1).$$

### Record format

1. **IMIN:**  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NXRES
2. **IMAX:**  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NXRES
3. **JMIN:**  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NYRES
4. **JMAX:**  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NYRES
5. **KMIN:**  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZRES
6. **KMAX:**  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZRES

**Example**

In this example **BOX** is used to define a subgrid of 4 x 4 x 3 cells, where various properties can be set/modified:

```
BOX  
16 19 23 26 10 12 /
```



## 2.37 BRINE

### Description

The keyword BRINE specifies that the Brine Tracking model should be used.

No data records are associated with this keyword.

The keyword in conjunction with the keyword [POLYMER](#) activates the Salt-Sensitive Polymer Flood Model.

### Example

```
RUNSPEC  
BRINE
```



## 2.38 CARFIN

### Description

This keyword is used to define a cartesian local grid refinement (LGR) inside a host grid. It is followed by a single record terminated by a slash character. [CARFIN](#) record begins with the name of the LGR, then 6 integers defining the boundary of the box of cells along I-direction, J and the K-directions, 3 integers defining the number of cells along I-direction, J and K in the LGR, the maximum number of wells in the LGR and the name of the parent grid. The last field can be used to define nested LGR, where the host grid is another local grid.

[CARFIN](#) can be followed by a set of keywords that allows to specifically define cell properties, e.g. [PORO](#), inside the local grid. This flexibility includes the possibility to define refinement spacing inside LGR using the following keywords:

- [NXFIN](#), [NYFIN](#), [NZFIN](#): define the number of local cells in each host cell;
- [HXFIN](#), [HZFIN](#), [HZFIN](#): define ratios for splitting the host cell into local blocks.

[CARFIN](#) block of keywords is closed by [ENDFIN](#) keyword.

In dual porosity or dual-permeability models, where the first NZRES/2 layers are for matrix cells and the remaining NZRES/2 (with NZRES set by [DIMENS](#)) are for fracture cells, NZR is an even integer number with the first NZR/2 local layers for matrix cells and the remaining NZR/2 layers for fracture cells.

### Record format

Field	Name	Type	Description
1	LGRNAME	String	up to 8 characters
2	IMIN	Integer	lower cell index along the I-direction in the parent grid
3	IMAX	Integer	upper cell index along the I-direction in the parent grid
4	JMIN	Integer	lower cell index along the J-direction in the parent grid
5	JMAX	Integer	upper cell index along the J-direction in the parent grid
6	KMIN	Integer	lower cell index along the K-direction in the parent grid
7	KMAX	Integer	upper cell index along the K-direction in the parent grid
8	NXR	Integer	number of refined cells along the I-direction
9	NYR	Integer	number of refined cells along the J-directions
10	NZR	Integer	number of refined cells along the K-direction
11	NWMAX	Integer	maximum number of wells inside LGR
12	PARENT	String	parent grid, which can be the reservoir grid or another LGR

### Example 1

[CARFIN](#) is used to define an LGR and [PERMZ](#) is locally updated:

```
CARFIN
  LGR1 21 23 15 17 1 10 9 9 10 1 /
EQUALS
  PERMZ 1000 1 9 1 9 1 10 /
  PERMZ 10000 4 6 4 6 1 10 /
/
ENDFIN
```

**Example 2**

[CARFIN](#) is used twice to define a nested local grid refinement:

```
CARFIN
  LGR1 21 23 15 17 1 10 9 9 10 1 /
ENDFIN
CARFIN
  LGR2 4 6 4 6 1 10 9 9 10 LGR1 /
ENDFIN
```



## 2.39 CECON

### Description

This keyword defines economic limits for production well connections. The violation of an individual connection of one of its economic limits will automatically close the connection. Before utilizing this keyword, the well connections must have already been established.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.  
**Type:** String  
**Default value:** '\*'
2. **I:** I-index location of the connection  
**Type:** Integer  
**Default value:** 0 (select any i value in this well connections)
3. **J:** J-index location of the connection  
**Type:** Integer  
**Default value:** 0 (select any j value in this well connections)
4. **K-UP:** K-index location of the upper connection  
**Type:** Integer  
**Default value:** 0 (select the top connection in this well connections)
5. **K-LOW:** K-index location of the lower connection  
**Type:** Integer  
**Default value:** 0 (select the bottom connection in this well connections)
6. **WCT:** The upper economic limit for the water-cut ratio. A value of 0.0 switches off this limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)
7. **GOR:** The upper economic limit for the gas-oil ratio. A value of 0.0 switches off this limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)
8. **WGR:** The upper economic limit for the water-gas ratio. A value of 0.0 switches off this limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/Mscf (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)
9. **WORKOVER:** Workover action if water cut, gas-oil ratio, water-gas ration or gas-liquid ratio is violated  
**Type:** Float  
**Default value:** CON  
**Allowed values:**

Name	Description
CON	Shutin the worst offending completion
+CON	Shutin the worst offending completion and all below
WELL	Shutin or stop the well depending on item 9 of keyword <a href="#">WELSPECS</a>

10. *Reserved*

11. **MIN\_OPR:** The lower economic limit for the oil production rate.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

12. **MIN\_GPR:** The lower economic limit for the gas production rate.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

13. *Reserved*

### Example

This example sets limits for 2 wells. Well P1 has a maximum possible gas oil ratio limit of 5.0 on the first 4 connections. In case, the gas oil ratio exceed the limit in any of these connections, it will be closed.

Well P2 has a maximum possible water cut of 0.95 on all of its connections. If the water cut exceed this limit in any connection, the corresponding connection and all below it will be closed.

```
CECON
P1  2*   1   4  1*  5.0   /
P2  4*   0.95 2* +CON   /
/
```



## 2.40 CFLLIMIT

### Description

The **CFLLIMIT** keyword sets parameters for the target value of the Courant-Friedrichs-Lowy condition governing timestep selection and implicit/explicit cell partition in **IMPES** and **AIM** simulation runs.

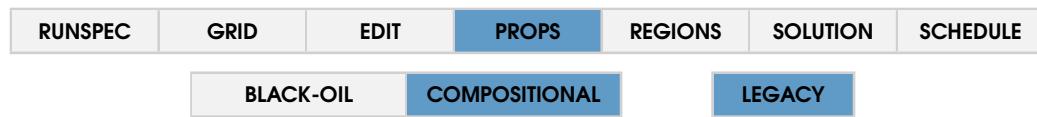
### Record format

Field	Type	Default	Description
1			<i>Reserved</i>
2	Float	1.0	Maximum CFL number for explicit cells (used to set the maximum stable timestep)
3	Float	1.0	Maximum CFL number for implicit cells in AIM simulations (cells with a higher CFL number are set implicit)
4			<i>Reserved</i>
5	Float	0.10	Target fraction of implicit cells for AIM simulation. Also set by <b>AIMFRAC</b> keyword.

### Example

For IMPES simulations, adjust the maximum CFL number for cells down to 0.8.

```
CFLLIMIT
1* 0.8 /
```



## 2.41 CNAMES

### Description

This keyword specifies the name of each hydrocarbon component in a compositional simulation. The number of names should be equal to the number of components in the simulation.

### Record format

1. **COMP\_NAME:** (repeated NUM\_COMP times)  
Hydrocarbon component names  
**Type:** String

#### Example

This example specifies the six component names for a compositional simulation with six components

```
CNAMES
N2CO2  CH4  C2  C3  C4-8  C8+  /
```



## 2.42 COLORING

### Description

The keyword defines the algorithm used in the multicolor reordering of the cell (see [Section 3.8](#) in the Technical Description). Multicolor reordering, which is necessary to exploit GPU coarse-grained parallelism, means associating an integer value - a color - to each reservoir cell with the purpose to color strongly connected cells differently. Then, within each color cells are ordered using specific criteria.

The choice of the multi-coloring methods is associated with the specific second-stage preconditioner used in the simulation (see CPR\_STAGE2 filed in [SOLVER](#) keyword) , and ultimately to the type of grid and thermodynamic formulation used. We recommend the user to carefully read Technical Description, more specifically [Chapter 3](#), before modifying Simulator default choices.

It is possible to view model colors using the property COLOR in the INIT file (see keyword [INIT](#)).

The keyword is followed by a single, slash terminated record, with only one field which defines the algorithm used.

### Record format

#### 1. METHOD:

**Type:** String

**Default value:** The value is established by the simulator based on model-specific features.

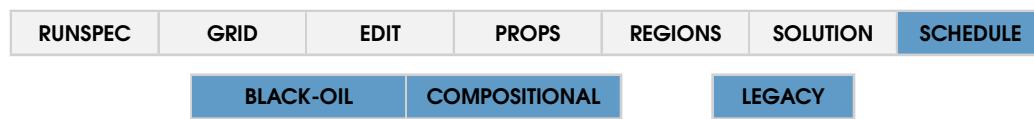
**Allowed values:**

Name	Description
GRAPH	Jones-Plassman algorithm (Jones and Plassmann, 1991) is used to color the connectivity graph of the reservoir such that no neighbors have the same color. This is the default coloring strategy for use with ILU(0) and DILU preconditioners.
GRAPH2	GRAPH2: uses the same algorithm as above in two passes to provide a distance-2 coloring, such that every cell has a different color than both their neighbors and their neighbors' neighbors. This can improve convergence in some cases at the cost of increasing the number of colors, which reduces available parallelism. Note that with GRAPH or GRAPH2, the number of colors is case-dependent
GEOMETRIC	it colors the grid with a regular pattern based on the IJK coordinates of the cell. It can provide faster convergence than GRAPH or GRAPH2 for reservoirs with simple Cartesian connectivity, i.e. with no non-neighbor connections due to faulting, pinchouts, or explicit NNCs
NF	It colors the reservoir model with each vertical pillar having the same color, and adjacent pillars colored geometrically for use with the ANISO second-stage preconditioner. This preconditioner can be effective for models with vertically-dominated transmissibility. It is the default coloring for the ANISO preconditioner and is not appropriate for other second-stage preconditioners.
TRANSORDER	It is not a real coloring method. Rather, cells are sorted using the transmissibility between them as a criterion.

### Example

Cells are sorted using the transmissibility values as guidelines:

```
COLORING
TRANSORDER /
```



## 2.43 COMPDAT

### Description

This keyword defines completion properties of a well or a list of wells that has been previously declared in the [SCHEDULE](#) with the keyword [WELSPECs](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the [SCHEDULE](#) section.  
**Type:** String  
**Default value:** '\*'
2. **I:** I-location of the perforated grid block. If set to zero or defaulted, the I-location of the wellhead defined in the keyword [WELSPECs](#) will be used.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** as in [WELSPECs](#)
3. **J:** J-location of the perforated grid block. If set to zero or defaulted, the J-location of the wellhead defined in the keyword [WELSPECs](#) will be used.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** as in [WELSPECs](#)
4. **K1:** K-location of the upper perforated grid block  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** None
5. **K2:** K-location of the lower perforated grid block  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** None
6. **STATUS:** Connection status. During input interpretation, only the first letter is taken into account. Any value starting with "S" will be accepted as "SHUT", and similarly, any value starting with "O" - as "OPEN".  
**Type:** String  
**Default value:** OPEN  
**Allowed values:**

Name	Description
OPEN	The connection is open to flow
SHUT	The connection is shutin

7. **SATNUM:** Saturation table number for connections relative permeabilities.

- If a default, negative or zero value is entered, connection relative permeabilities are computed using the connected cell saturation table, specified with the keyword **SATNUM**
- If the Hysteresis option is active, the number entered here applies to both drainage and imbibition. If defaulted, the respective connected cell table (**SATNUM** for drainage and **IMBNUM** for imbibition) will be used.

**Type:** Integer

**Default value:** 0

8. **T\_FAC:** Transmissibility factor for each connection in this interval. This value will also be used to compute either the effective connection  $Kh$  or the geometric factor,  $\ln(r_o/r_w) + S$ , according to the following rules:

- If  $Kh$  is also given in item 10, the geometric factor is computed from the connection transmissibility factor and the given  $Kh$
- If  $Kh$  is defaulted or set to a negative value in item 10, the effective  $Kh$  is computed from the connection transmissibility factor and the geometric factor evaluated from grid block dimensions
- If  $Kh = 0.0$  in item 10, it is replaced by the effective  $Kh$  of the grid block, i.e.  $\sqrt{K_x K_y} \times \Delta z$  for vertical wells, and then used together with the connection transmissibility factor to compute the geometric factor

If this item is defaulted, the connection transmissibility is computed internally using the remaining data in this record.

**Type:** Float

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

9. **DIAMETER:** The wellbore diameter.

**BO** If the connection transmissibility is defaulted in this record, the wellbore diameter must be supplied.

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** BO: None (FIELD), None (METRIC)

COMP: 1 (FIELD), 0.3048 (METRIC)

10. **KH:** Effective  $Kh$  (permeability times thickness) for each connection in this interval. If defaulted or a zero value is entered, the effective  $Kh$  is computed internally from grid block properties (see item 8)

**Type:** Float

**Units:** mD·ft (FIELD), mD·m (METRIC)

**Default value:** None (FIELD), None (METRIC)

11. **SKIN:** Skin factor for each connection in this interval.

**Type:** Float

**Default value:** 0.0

12. *Reserved*

13. **DIR:** The direction in which this set of connections penetrates the grid blocks.

**Type:** String

**Default value:** Z

**Allowed values:**

Name	Description
X	This connection interval penetrates the grid block in the x-direction
Y	This connection interval penetrates the grid block in the y-direction
Z	This connection interval penetrates the grid block in the z-direction

14. **R0:** Pressure equivalent radius

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** From Peaceman's formula (FIELD), From Peaceman's formula (METRIC)

### Example

This example defines perforation intervals for 3 wells. All connections are OPEN. Well P1 has X- and Y-coordinates defined in the [WELSPECS](#) and it is perforated in two layers, namely Z=1 and Z=2. Well diameter, skin factor and orientation is taken by default, while transmissibility factor and effective Kh is calculated internally. Well I1 has coordinates I=16 and J=13 and it is perforated in five layers from Z=1 to z=5. The diameter is set to 0.16 and the perforations are oriented in the X-direction. Well PR1 is perforated in two layers: in the first layer it is oriented in the X-direction with a zero (defaulted) skin, while in the second layer, it is oriented in the Y-direction with a skin of 3.5.

```
COMPDAT
--name I   J   K1  K2  stat   sat   Tf    d     Kh   S   -   dir   r0
P1   1*  1*  1   2   OPEN          / 
I1   16   13  1   5   OPEN   2*      0.16  20   1   1*   Z   1*  /
PR1  5    5   1   1   OPEN   2*      0.16  3*          X   1*  /
PR1  5    5   2   2   OPEN   2*      0.16  1*   3.5  1*   Y   1*  /
/
```



## 2.44 COMPDATL

### Description

This keyword defines completion properties in local grids. The well or the list of wells should have been previously declared in the [SCHEDULE](#) section using the keyword [WELSPECL](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the [SCHEDULE](#) section.

**Type:** String

**Default value:** ‘\*’

2. **LGR\_NAME:** Name of the local grid

**Type:** String

3. **I:** I-location of the perforated grid block in the local grid coordinates system. If set to zero or defaulted, the I-location of the wellhead defined in keyword [WELSPECL](#) will be used.

**Type:** Integer

**Default value:** 0

4. **J:** J-location of the perforated grid block in the local grid coordinates system. If set to zero or defaulted, the J-location of the wellhead defined in the keyword [WELSPECL](#) will be used.

**Type:** Integer

**Default value:** 0

5. **K1:** K-location of the upper perforated grid block in the local grid coordinates system.

**Type:** Integer

**Default value:** None

6. **K2:** K-location of the lower perforated grid block in the local grid coordinates system.

**Type:** Integer

**Default value:** None

7. **STATUS:** Connection status. During input interpretation, only the first letter is taken into account. Any value starting with “S” will be accepted as “SHUT”, and similarly, any value starting with “O” - as “OPEN”.

**Type:** String

**Default value:** OPEN

**Allowed values:**

Name	Description
OPEN	The connection is open to flow
SHUT	The connection is shutin

8. **SATNUM:** Saturation table number for connections relative permeabilities.

- If a default, negative or zero value is entered, connection relative permeabilities are computed using the connected cell saturation table, specified with the keyword [SATNUM](#)
- If the Hysteresis option is active, the number entered here applies to both drainage and imbibition. If defaulted, the respective connected cell table ([SATNUM](#) for drainage and

[IMBNUM](#) for imbibition) will be used.

**Type:** Integer  
**Default value:** 0

9. **T\_FAC:** Transmissibility factor for each connection in this interval. This value will also be used to compute either the effective connection  $Kh$  or the geometric factor,  $\ln(r_o/r_w) + S$ , according to the following rules:

- If  $Kh$  is also given in item 10, the geometric factor is computed from the connection transmissibility factor and the given  $Kh$
- If  $Kh$  is defaulted or set to a negative value in item 10, the effective  $Kh$  is computed from the connection transmissibility factor and the geometric factor evaluated from grid block dimensions
- If  $Kh = 0.0$  in item 10, it is replaced by the effective  $Kh$  of the grid block, i.e.  $\sqrt{K_x K_y} \times \Delta z$  for vertical wells, and then used together with the connection transmissibility factor to compute the geometric factor

If this item is defaulted, the connection transmissibility is computed internally using the remaining data in this record.

**Type:** Float  
**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)

10. **DIAMETER:** The wellbore diameter.

**BO** If the connection transmissibility is defaulted in this record, the wellbore diameter must be supplied.

**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** BO: None (FIELD), None (METRIC)  
COMP: 1 (FIELD), 0.3048 (METRIC)

11. **KH:** Effective  $Kh$  (permeability times thickness) for each connection in this interval. If defaulted or a zero value is entered, the effective  $Kh$  is computed internally from grid block properties (see item 8)

**Type:** Float  
**Units:** mD·ft (FIELD), mD·m (METRIC)  
**Default value:** None (FIELD), None (METRIC)

12. **SKIN:** Skin factor for each connection in this interval.

**Type:** Float  
**Default value:** 0.0

13. *Reserved*

14. **DIR:** The direction in which this set of connections penetrates the grid blocks.

**Type:** String  
**Default value:** Z  
**Allowed values:**

Name	Description
X	This connection interval penetrates the grid block in the x-direction
Y	This connection interval penetrates the grid block in the y-direction
Z	This connection interval penetrates the grid block in the z-direction

15. **R0:** Pressure equivalent radius

**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** From Peaceman's formula (FIELD), From Peaceman's formula (METRIC)

**Example**

This example defines perforation intervals for 2 wells. All connections are OPEN. Well P1 is located in the grid LGR1 and has X- and Y-coordinates defined in the [WELSPEC1](#). It is perforated in two layers, namely Z=1 and Z=2. Well diameter, skin factor and orientation are taken by default, while transmissibility factor and effective Kh are calculated internally. Well PR1 is located in the grid LGR2 and is perforated in two layers: in the first layer it is oriented in the X-direction with a zero (defaulted) skin, while in the second layer it is oriented in the Y-direction with a skin of 3.5.

```
COMPDATA1
--name LGR I J K1 K2 stat sat Tf d      Kh S   - dir r0
P1   LGR1 1* 1* 1  2   OPEN          / 
PR1  LGR2 5   5  1  1   OPEN  2*       0.16 3*      X  1* /
PR1  LGR2 5   5  2  2   OPEN  2*       0.16 1*  3.5 1*  Y  1* /
/
```



## 2.45 COMPDATM

### Description

This keyword is an alias for the keyword [COMPDATL](#).



## 2.46 COMPDATMD

### Description

This keyword is used to define the perforation intervals between an upper measured depth (MD) and lower MD.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** \*

2. *Reserved*

3. **MDU:** Upper measured depth of the perforation.

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

4. **MDL:** Lower measured depth of the perforation

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** None (FIELD), None (METRIC)

5. **TYPE:** Measured Depth (MD) is the only measurement type currently supported, but it can be extended to true vertical depth (TVD) and stage (STAGE).

**Type:** String

**Default value:** MD

6. **STATUS:** Connection status. During input interpretation, only the first letter is taken into account. Any value starting with "S" will be accepted as "SHUT", and similarly, any value starting with "O" - as "OPEN".

**Type:** Float

**Default value:** OPEN

**Allowed values:**

Name	Description
OPEN	The connection is open to flow
SHUT	The connection is shutin

7. **SATNUM:** Saturation table number for connections relative permeabilities.

- If a default, negative or zero value is entered, connection relative permeabilities are computed using the connected cell saturation table, specified with the keyword [SATNUM](#)
- If the Histeresys option is active, the number entered here applies to both drainage and imbibition. If defaulted, the respective connected cell table ([SATNUM](#) for drainage and [IMBNUM](#) for imbibition) will be used.

**Type:** Integer

**Default value:** None

8. **T\_FAC:** Transmissibility factor for each connection in this interval. If not defaulted, this

value will also be used to compute either the effective connection  $Kh$  or the geometric factor,  $\ln(r_o/r_w) + S$ , according to the following rules:

- If  $Kh$  is also given in item 10, the geometric factor is computed from the connection transmissibility factor and the given  $Kh$
- If  $Kh$  is defaulted or set to a negative value in item 10, the effective  $Kh$  is computed from the connection transmissibility factor and the geometric factor evaluated from grid block dimensions
- If  $Kh = 0.0$  in item 10, it is replaced by the effective  $Kh$  of the grid block, i.e.  $\sqrt{K_x K_y} \times \Delta z$  for vertical wells, and then used together with the connection transmissibility factor to compute the geometric factor

If this item is defaulted, the connection transmissibility is computed internally using the remaining data in this record.

**Type:** Float

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

#### 9. DIAMETER: The wellbore diameter.

**BO** If the connection transmissibility is defaulted in this record, the wellbore diameter must be supplied.

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** BO: None (FIELD), None (METRIC)

COMP: 1 (FIELD), 0.3048 (METRIC)

#### 10. KH: Effective Kh (permeability times thickness) for each connection in this interval. If defaulted or a zero value is entered, the effective Kh is computed internally from grid block properties (see item 8)

**Type:** Float

**Units:** mD·ft (FIELD), mD·m (METRIC)

**Default value:** None (FIELD), None (METRIC)

#### 11. SKIN: Skin factor for each connection in this interval.

**Type:** Float

**Default value:** 0.0

#### 12. Reserved

#### 13. CON\_MULTI: Connection Factor multiplier

**Type:** Float

**Default value:** None (FIELD), None (METRIC)

#### 14. TYPE: Completion type which can be 'FRAC' (fracture), 'MAT' (matrix) or BOTH as values for this item.

**Type:** String

**Default value:** FRAC (FIELD), FRAC (METRIC)

### Example

This example defines the perforation interval for WELL1 which is between 1700.0 and 2900.0 measured depth.

```
COMPDATMD
-- WELLNAME BRANCH MDU      MDL  TYPE STATUS FILT_TBL TFAC D KH SKIN
  'WELL1'    1*  1700.0 2900.0 1* 'OPEN'   1*    1*  0.2 1* 5.0 /
/
```



## 2.47 COMPDAT\_FRACTURE

### Description

This keyword is used in the context of defining planar fracture template. It defines the completion properties of a well or a list of wells with their trajectory previously defined in [GRID](#) section by using [WELL\\_TRAJECTORY](#) keyword. Note that the well heads are still defined by the [WELSPCS](#) keyword.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template. If this item is defaulted, this keyword applies to all wells already defined in the [SCHEDULE](#) section

**Type:** String

**Default value:** '\*'

2. **FRAC\_INDEX:** The index of the fracture to be modified. If set to zero or is defaulted, all the fractures in this well are modified.

**Type:** Integer

**Default value:** 0

3. **STATUS:** Connection status. During input interpretation, only the first letter is taken into account. Any value starting with "S" will be accepted as "SHUT", and similarly, any value starting with "O" - as "OPEN".

**Type:** String

**Default value:** OPEN

#### Allowed values:

Name	Description
OPEN	The connection is open to flow
SHUT	The connection is shutin

4. **SATNUM:** Saturation table number for connections relative permeabilities.

- If a default, negative or zero value is entered, connection relative permeabilities are computed using the connected cell saturation table, specified with the keyword [SATNUM](#)
- If the Hysteresis option is active, the number entered here applies to both drainage and imbibition. If defaulted, the respective connected cell table ([SATNUM](#) for drainage and [IMBNUM](#) for imbibition) will be used.

**Type:** Integer

**Default value:** 0

5. **T\_FAC:** Transmissibility factor for each connection in this interval. If not defaulted, this value will also be used to compute either the effective connection  $K_h$  or the geometric factor,  $\ln(r_o/r_w) + S$ , according to the following rules:

- If  $K_h$  is also given in item 10, the geometric factor is computed from the connection transmissibility factor and the given  $K_h$
- If  $K_h$  is defaulted or set to a negative value in item 10, the effective  $K_h$  is computed from the connection transmissibility factor and the geometric factor evaluated from grid block dimensions
- If  $K_h = 0.0$  in item 10, it is replaced by the effective  $K_h$  of the grid block, i.e.  $\sqrt{K_x K_y} \times \Delta z$  for vertical wells, and then used together with the connection transmissibility factor to compute the geometric factor

If this item is defaulted, the connection transmissibility is computed internally using the

remaining data in this record.

**Type:** Float

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

6. **DIAMETER:** The wellbore diameter.

**BO** If the connection transmissibility is defaulted in this record, the wellbore diameter must be supplied.

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** BO: None (FIELD), None (METRIC)

COMP: 1 (FIELD), 0.3048 (METRIC)

7. **KH:** Effective Kh (permeability times thickness) for each connection in this interval. If defaulted or a zero value is entered, the effective Kh is computed internally from grid block properties (see item 8)

**Type:** Float

**Units:** mD·ft (FIELD), mD·m (METRIC)

**Default value:** None (FIELD), None (METRIC)

8. **SKIN:** Skin factor for each connection in this interval.

**Type:** Float

**Default value:** 0.0

### Example

In this example, all fractures of well P1 are opened initially and then the 3rd and 5th fractures are shut.

```
COMPDAT_FRAC
--name frac_index stat sat Tf diam Kh S
P1      1*      OPEN  1*   1*  0.65  1*  1* /
P1      3       SHUT   1*   1*  0.65  1*  1* /
P1      5       SHUT   1*   1*  0.65  1*  1* /
/
```



## 2.48 COMPLMPL

### Description

This keyword lumps connections in local grids, as defined by the [COMPDATL](#) keyword in the [SCHEDULE](#) section, into completion. This procedure allows automatic workovers and economic criteria to be applied to the completions (i.e., a set of connections) instead of the connections. In this case, the worst-offending completion is identified by summing the production rates of all its connections and, if a limit is violated, all these connections will be shut. Completion number can also be used to perform actions on a range of connections in keywords [WEOPEN](#) and [WPIMULT](#).

Note that, if this keyword is not used, completions and connections are the same.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the [SCHEDULE](#) section.  
**Type:** String  
**Default value:** '\*'
2. **LGR\_NAME:** Name of the local grid containing the connections  
**Type:** String  
**Default value:** LGR name defined in [WELSPECL](#)
3. **I:** I-location of the connections in this completion in the local grid coordinate system.  
**Type:** Integer  
**Default value:** Allows any I-value
4. **J:** J-location of the connections in this completion in the local grid coordinate system.  
**Type:** Integer  
**Default value:** Allows any I-value
5. **K1:** K-location of the upper connection in this completion in the local grid coordinate system.  
**Type:** Integer  
**Default value:** 0
6. **K2:** K-location of the lower connection in this completion in the local grid coordinate system.  
**Type:** Integer  
**Default value:** 0
7. **N\_COMP:** Completion number. The set of connections that are within the indices defined in items 2-5 will be lumped together and given the completion number specified with this item. If items from 2 to 5 are all defaulted, all well connections will be lumped into this completion.  
**Type:** Integer  
**Default value:** None

**Example**

This example defines 2 completions for the well P1. All connections defined in layers from Z=1 to Z=3 in the grid LGR1 are lumped into completion 1, while all connections defined in layers from Z=4 and Z=7 in the LGR2 are lumped into completion 2.

```
COMPLMPL
--name LGR  I   J   K1   K2   N
P1    LGR1  1*  1*  1     3     1   /
P1    LGR2  1*  1*  4     7     2   /
/
```



## 2.49 COMPLUMP

### Description

This keyword lumps connections, as defined by the [COMPDAT](#) keyword in the [SCHEDULE](#) section, into completion. This procedure allows automatic workovers and economic criteria to be applied to the completions (i.e., a set of connections) instead of the connections. In this case, the worst-offending completion is identified by summing the production rates of all its connections. If a limit is violated, the workover is accomplished by shutting all connections associated with that completion together. Completion number can also be used to perform actions on a range of connections in keywords [WEOPEN](#) and [WPIMULT](#).

Note that, if this keyword is not used, completions and connections are the same.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the [SCHEDULE](#) section.  
**Type:** String  
**Default value:** '\*'
2. **I:** I-location of the connections in this completion  
**Type:** Integer  
**Default value:** Allows any I-value
3. **J:** J-location of the connections in this completion  
**Type:** Integer  
**Default value:** Allows any J-value
4. **K1:** K-location of the upper connection in this completion  
**Type:** Integer  
**Default value:** 0
5. **K2:** K-location of the lower connection in this completion  
**Type:** Integer  
**Default value:** 0
6. **N\_COMP:** Completion number. The set of connections that are within the indices defined in items 2-5 will be lumped together and given the completion number specified with this item. If items from 2 to 5 are all defaulted, all well connections will be lumped into this completion.  
**Type:** Integer

**Example**

This example defines 2 completions for the well P1. All connections defined in layers from Z=1 to Z=3 are lumped together into completion 1, while all connections defined in layers from Z=4 and Z=7 are lumped together into completion 2.

```
COMPLUMP
--name I J K1 K2 N
P1   1* 1* 1   3   1 /
P1   1* 1* 4   7   2 /
/
```



## 2.50 COMPORD

### Description

This keyword specifies the order of well connections. The connection ordering is used to determine reference depth (in case it was not specified in [WELSPECS](#), the depth of the first connection is taken as a reference depth for the well), and when calculating the hydrostatic head with the segmented density option.

If [COMPORD](#) is defined several times for the same well, only the last specification is taken into account.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template. If this item is defaulted, this keyword applies to all wells already defined in the [SCHEDULE](#) section  
**Type:** String  
**Default value:** '\*'
2. **METHOD:** Method for ordering the connections  
**Type:** String  
**Default value:** INPUT  
**Allowed values:**

Name	Description
INPUT	Connections are ordered according to their declaration in <a href="#">COMPDAT</a> keyword
DEPTH	Connections are ordered according to their depth (from top downward)

### Example

Connections of well P1 are sorted according to their input, while connections of well P2 are sorted according to their depth, from the shallowest to the deepest.

```
COMPORD
  P1    INPUT  /
  P2    DEPTH /
/
```



## 2.51 COMPS

### Description

This keyword selects the compositional formulation and specifies the number of components used in the simulation. ECHELON currently supports up to 30 components.

### Record format

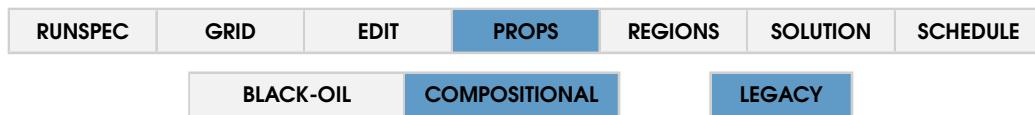
1. **NUM\_COMP:** Number of hydrocarbon components

Type: Integer

#### Example

This example specifies that the simulation is compositional and includes nine components.

```
COMPS  
9 /
```



## 2.52 COMPVD

### Description

The `COMPVD` keyword is used to provide tables specifying the variation of the composition of the reservoir fluids with depth in the reservoir. These tables are used during the initialization of the reservoir in vertical hydrostatic equilibrium with the `EQUIL` keyword. One table should be provided for each equilibration region and should be consistent with the number of regions specified in the `EQLDIMS` keyword.

Each table consists of  $N_c + 3$  columns. The first column gives the depth. The next  $N_c$  columns give the composition of the hydrocarbon fluid corresponding to each depth value. In the case of a reservoir with an initial gas-oil contact, the composition should correspond to the gas (vapor) phase above the contact and the oil (liquid) phase below the contact depth. The next column consists of integers that indicate whether the composition corresponds to vapor (0) or liquid (1) phase. The final column gives the saturation pressure ( $P_b$  or  $P_{\text{dew}}$ ) at each depth.

Column(s)	Type	Description	Units
1	Float	Depth	ft (FIELD), m (METRIC)
2... $N_c + 1$	Float	Composition of vapor or liquid phase	
$N_c + 2$	Integer	0 (vapor) or 1 (liquid)	
$N_c + 3$	Float	Saturation pressure	psi (FIELD), bar (METRIC)

Table 2.2

### Example

For a reservoir without an initial gas-oil contact, no variation of composition with depth, and an equation of state with six components:

```
COMPVD
-- Depth    Y1      Y2      Y3      Y4      Y5      Y6      Vap/Liq  Psat
  4000    0.0025  0.0080  0.8257  0.0863  0.0497  0.0278    0     3075
 12000    0.0025  0.0080  0.8257  0.0863  0.0497  0.0278    0     3075
/
```



## 2.53 CONNREP

### Description

This keyword requests printing of the transmissibility between cells, including for natural and non-neighboring connections (NNCs), into a specific file with the .NNC extension. It is followed by a single record with two fields (see Record Format below).

`CONNREP` is allowed in the `GRID` section (note: transmissibility modifications performed in the `EDIT` section are also taken into account in the report), as well as in the `SCHEDULE` section.

Connections in the .NNC file are labeled as described in [Section 4.8](#) inside Technical Description.

### Record format

1. **NATURAL\_CONN:** Selector for natural connection output

**Type:** Integer

**Default value:** 1

**Allowed values:**

Name	Description
1	write natural connection in .NNC file
0	do not write natural connection in .NNC file

2. **NNC:** Selector for NNC output

**Type:** Integer

**Default value:** 1

**Allowed values:**

Name	Description
1	write NNCs in .NNC file
0	do not write NNCs in .NNC file

### Example

`CONNREP` can be used to double-check non-neighboring connections only:

```
CONNREP
 0 1* /
```

If the simulation data file is MODEL.DATA, then NNC information is reported in MODEL.NNC.



## 2.54 COORD

### Description

This keyword is necessary for conjunction with [ZCORN](#) to define a corner point geometry (CPG) grid. [COORD](#) sets the CPG coordinate lines, segments where the corners of the cells lie. A generic coordinate line  $l$  is defined using two points in the 3D space, namely two triplets of real numbers:  $x_l^{top}, y_l^{top}, z_l^{top}$  (top point) and  $x_l^{bot}, y_l^{bot}, z_l^{bot}$  (bottom point).

Then, for a grid of  $NX \times NY \times NZ$  cells  $(NX+1) \times (NY+1)$  coordinate lines are needed.

The keyword is followed by a single, slash terminated, record with  $6 \times (NX+1) \times (NY+1)$  real numbers, ordered as follows:

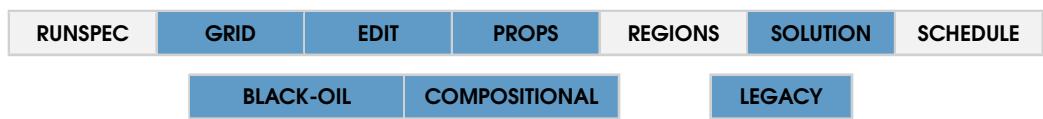
$$x_1^{top}, y_1^{top}, z_1^{top}, \dots, x_{NX+1}^{top}, y_{NX+1}^{top}, z_{NX+1}^{top}, \dots, x_{(NX+1)(NY+1)}^{top}, y_{(NX+1)(NY+1)}^{top}, z_{(NX+1)(NY+1)}^{top}, \\ x_1^{bot}, y_1^{bot}, z_1^{bot}, \dots, x_{NX+1}^{bot}, y_{NX+1}^{bot}, z_{NX+1}^{bot}, \dots, x_{(NX+1)(NY+1)}^{bot}, y_{(NX+1)(NY+1)}^{bot}, z_{(NX+1)(NY+1)}^{bot} /$$

**Units:** ft (FIELD), m (METRIC)

### Example

This example shows coordinate lines for a simple grid consisting of a single column ( $NX=1$  and  $NY=1$ ):

```
COORD
 0   0   0
 0   0 1000
20   0   0
20   0 1000
 0  20   0
 0  20 1000
20  20   0
20  20 1000
/
```



## 2.55 COPY

### Description

This keyword can be used to copy a source 3D array, or a subset of, to a destination 3D array. The keyword can be followed by an arbitrary number of records defined as in the table, with an empty record having only the / character to terminate input.

The [COPY](#) operation is repeated for every record, copying a subset of the source 3D array onto the corresponding part of the destination 3D array. The subset is a 3D box of cells defined by six integers (fields 3 to 8 in the table) subject to the following constraints:

$$1 \leq \text{IMIN} \leq \text{IMAX} \leq \text{NX}; \quad 1 \leq \text{JMIN} \leq \text{JMAX} \leq \text{NY}; \quad 1 \leq \text{KMIN} \leq \text{KMAX} \leq \text{NZ}.$$

If [COPY](#) is used for global grid arrays, then NX=NXRES, NY=NYRES and NZ=NZRES. If [ADD](#) is used within a local grid refinement definition ([CARFIN/ENDFIN](#) block), or within a local grid refinement editing ([REFINE/ENDFIN](#) block), then the cell box is constrained by the local grid dimensions (i.e., NXREF, NYREF and NZREF). If [COPY](#) is used inside a [BOX/ENDBOX](#) block then NY, NX and NZ are set in [BOX](#) record.

Notably, if you define a cell box in one record, then the next record inherits that cell box limits as its default values for fields 3 to 8.

### Available 3D arrays

Available 3D arrays for [COPY](#) keyword on a section basis are:

#### GRID

[DX](#), [DY](#), [DZ](#), [PERMX](#), [PERMY](#), [PERMZ](#), [MULTX](#), [MULTY](#), [MULTZ](#), [PORO](#), [NTG](#), [FLUXNUM](#), [MULTNUM](#), [OPERNUM](#)

#### EDIT

[PORV](#), [DEPTH](#), [TRANX](#), [TRANY](#), [TRANZ](#)

#### PROPS

[SWL](#), [SWCR](#), [SWU](#), [SGL](#), [SGCR](#), [SGU](#), [KRW](#), [KRO](#), [KRG](#), [KWR](#), [KRGR](#), [KRORW](#), [KRORG](#), [ISWL](#), [ISWCR](#), [ISWU](#), [ISGL](#), [ISGCR](#), [ISGU](#), [IKRW](#), [IKRO](#), [IKRG](#), [IKWR](#), [IKRGR](#), [IKRORW](#), [IKRORG](#), [PCW](#), [PCG](#), [IPCW](#), [IPCG](#)

#### REGIONS

[SATNUM](#), [PVTNUM](#), [FIPNUM](#), [ROCKNUM](#), [MISCTNUM](#), [EOSNUM](#), [EQLNUM](#)

#### SOLUTION

[PRESSURE](#), [SWAT](#), [SGAS](#), [RV](#), [RS](#), [TBLK](#), [SOIL](#), [PBUB](#), [PDEW](#), [SALT](#)

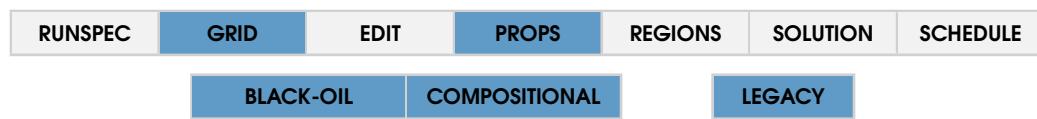
### Record format

Field	Name	Type	Default	Minin	Maxin	Description
1	SRC	String				Existing 3D array to be copied
2	DEST	String				Array created or overwritten in the operation
3	IMIN	Integer	1	1	NX	First cell to be updated along the I-direction
4	IMAX	Integer	NX	1	NX	Last cell to be updated along the I-direction
5	JMIN	Integer	1	1	NY	First cell to be updated along the J-direction
6	IMAX	Integer	NY	1	NY	Last cell to be updated along the J-direction
7	KMIN	Integer	1	1	NZ	First cell to be updated along the K-direction
8	KMAX	Integer	NZ	1	NZ	Last cell to be updated along the K-direction

**Example**

In the first example, section [GRID](#), we copy [PERMX](#) into [PERMY](#) for the whole grid (first record), [PERMX](#) into [PERMZ](#) for a box of cells only (second record) and [NTG](#) into [PORO](#) (third record). Please note that the [COPY](#) operation in the third record inherits the definition of the cell box in the previous record.

```
COPY
PERMX PERMY /
PERMX PERMZ 3 10 3 10 2 20 /
NTG     PORO /
/
```



## 2.56 COPYBOX

### Description

This keyword copies values of a source 3D array from one box of cells (the source box) to another box of cells (the destination box) for a given 3D array in `GRID`, `PROPS` and `REGIONS` sections. The keyword is followed by an arbitrary number of records formatted as described below and terminated by a single slash character.

Notably, fields 2 to 7 define the source box, and fields 8 to 13 define the destination box. Source and destination boxes must have the same sizes along I, J and K, and may not overlap. Assuming the grid where `COPYBOX` operates has NX, NY and NZ as sizes, for the I-direction the following constraints hold:

$$\begin{aligned} 1 &\leq \text{ISRC\_MIN} \leq \text{ISRC\_MAX} \leq \text{NX}, \\ 1 &\leq \text{IDEST\_MIN} \leq \text{IDEST\_MAX} \leq \text{NY}, \\ \text{ISRC\_MAX} - \text{ISRC\_MIN} &= \text{IDEST\_MAX} - \text{IDEST\_MIN}. \end{aligned}$$

and similarly for the J and the K-directions.

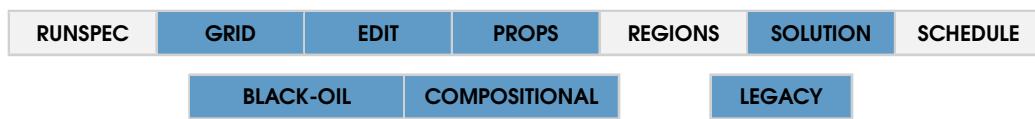
### Record format

Field	Name	Type	Description
1	3D Array	String	3D array for the copy operation
2	ISRC_MIN	Integer	First cell along the I-direction in the source box
3	ISRC_MAX	Integer	Last cell along the I-direction in the source box
4	JSRC_MIN	Integer	First cell along the J-direction in the source box
5	JSRC_MAX	Integer	Last cell along the J-direction in the source box
6	KSRC_MIN	Integer	First cell along the K-direction in the source box
7	KSRC_MAX	Integer	Last cell along the K-direction in the source box
8	IDEST_MIN	Integer	First cell along the I-direction in the destination box
9	IDEST_MAX	Integer	Last cell along the I-direction in the destination box
10	JDEST_MIN	Integer	First cell along the J-direction in the destination box
11	JDEST_MAX	Integer	Last cell along the J-direction in the destination box
12	KDEST_MIN	Integer	First cell along the K-direction in the destination box
13	KDEST_MAX	Integer	Last cell along the K-direction in the destination box

### Example

In the section `GRID`, `COPYBOX` can be used to copy properties from one box to another:

```
COPYBOX
NTG 3 7 4 9 1 2    15 19 12 17 8 9 /
/
```



## 2.57 COPYREG

### Description

This keyword can be used to copy a source 3D array, or a subset of, to a destination 3D array using a region 3D array as filter. The keyword can be followed by an arbitrary number of records defined as in the table, with an empty record having only the slash character, to terminate input.

The `COPYREG` operation is repeated for every record, copying values from the source 3D array into the destination 3D array, filtering using by default `MULTNUM`. Alternatively, it is possible to choose `FLUXNUM` or `MULTNUM` as region 3D array used to filter cells.

### Available 3D arrays

Available 3D arrays for `COPYREG` keyword on a section basis are:

#### GRID

`DX, DY, DZ, PERMX, PERMY, PERMZ, MULTX, MULTY, MULTZ, PORO, NTG, FLUXNUM, MULTNUM, OPERNUM`

#### EDIT

`PORV, DEPTH, TRANX, TRANY, TRANZ`

#### PROPS

`SWL, SWCR, SWU, SGL, SGCR, SGU, KRW, KRO, KRG, KRWR, KRGR, KRORW, KRORG, ISWL, ISWCR, ISWU, ISGL, ISGCR, ISGU, IKRW, IKRO, IKRG, IKRWR, IKRGR, IKRORW, IKRORG, PCW, PCG, IPCW, IPCG`

#### REGIONS

`SATNUM, PVTNUM, FIPNUM, ROCKNUM, MISCTNUM, EOSNUM, EQLNUM`

#### SOLUTION

`PRESSURE, SWAT, SGAS, RV, RS, TBLK, SOIL, PBUB, PDEW, SALT`

### Record format

1. Source 3D array  
**Type:** String
2. Destination 3D array  
**Type:** String
3. Filter value for the 3D array set in the next item  
**Type:** Integer
4. This field defines the 3D array used to filter cells.  
**Type:** String  
**Default value:** M

#### Allowed values:

Name	Description
M	MULTNUM
F	FLUXNUM
O	OPERNUM

**Example 1**

COPYREG is used in GRID section to copy PERMX into PERMZ for MULTNUM cells with value equal to 4:

```
COPYREG  
PERMX PERMY 4 /  
/
```

**Example 2**

COPYREG is used in PROPS section to copy SWL into SWCR for cells where FLUXNUM equals 4, and SOWCR into SOGCR for cells where OPERNUM equals 5:

```
COPYREG  
SWL SWCR 5 F /  
SOWCR SOGCR 5 O /  
/
```



## 2.58 COUPLING

### Description

This keyword specifies the transport settings for coupling with the third-party simulators (see [ABQOPTS](#) and [COUPLING\\_TYPE](#) keyword). ECHELON can act as a client or as a server.

### Record format

1. **Type:** 3rd party simulator used in the coupling. Currently only ABAQUS is supported.  
**Type:** String
2. **Setting:** SERVER or CLIENT  
**Type:** String  
**Default value:** SERVER
3. **Transport:** Communication library. Currently only ZMQ is supported.  
**Type:** String  
**Default value:** ZMQ
4. **Port:** Port number  
**Type:** String  
**Default value:** 27184

### Example

```
COUPLING
ABAQUS CLIENT ZMQ 27184 /
```



## 2.59 COUPLING\_TYPE

### Description

This keyword specifies the coupling logic between ECHELON reservoir models and FNS network models (see [Chapter 20](#) and [Chapter 22](#) in the ECHELON Technical Documentation for more details on the coupling algorithm). ECHELON may simulate a single reservoir model or multiple reservoir models using the ERC option.

### Record format

1. Coupling type.

#### Allowed values:

Name	Description
PERIODIC	The runs are coupled after a fixed user-defined period of time defined in record 2.
TIMESTEP	The runs are coupled at every timestep.
ITERATIVELY_LAGGED	The runs are coupled at every Newton.

2. Size of the time period in days. This field is needed only if the coupling type is set to PERIODIC.

### Example 1

The coupled models are synced every 5 days.

```
COUPLING_TYPE
'PERIODIC' 5 /
```

### Example 2

The coupled models are synced at every timestep.

```
COUPLING_TYPE
'TIMESTEP' /
```

### Example 3

The coupled model is synced at every Newton iterations.

```
COUPLING_TYPE
'ITERATIVELY_LAGGED' /
```



## 2.60 CPIFACT

### Description

This keyword provides the possibility to scale the connection transmissibility factors for well connection/completions, with completions numbers possibly defined by [COMPLUMP](#) keyword. using a multiplier defined in the second field of the keyword records. The keyword is followed by an arbitrary number of slash terminated records, each of them using a specific multiplier to scale connection factors. The keyword input is terminated by an empty record.

The record defines the well the keyword applies to, the multiplier and then gives the possibility to select which connections/completions connection factors are modified. If all items from 3 to 7 are defaulted, the multiplier applies to all the connections in the well and it actually sets a multiplier for the well productivity/injectivity.

Differently from [WPIMULT](#), CPIFACT multipliers are not cumulative meaning that each time the factor applies to the original transmissibility factor of the connection as set by [COMPDAT](#). If connections between grid and well are reset using [COMPDAT](#) again, the multiplier is set to 1 and it is the neccessary to enter a new CPIFACT again in case it is necessary to define the multiplier again.

### Record format

1. **WELL\_NAME:** This field can be a specific Well name, a list of wells (as defined by [WLIST](#)) or a template (=a quote delimited string with '\*' as wild card). The keyword applies to wells already defined in the SCHEDULE section and, if defaulted, it applies to all wells.  
**Type:** String  
**Default value:** None
2. **CONN\_MULTI:** Multiplier to be applied to the well connections. This quantity can be defined using a user defined quantity as argument ([UDA](#)).  
**Type:** Float  
**Default value:** 1.0
3. **I:** I-location of the perforated grid block. If set to zero or defaulted, the I-location can be any location.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** 0
4. **J:** J-location of the perforated grid block. If set to zero or defaulted, the J-location can be any location.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** 0
5. **K:** K-location of the upper updated perforated grid block; If set to zero or defaulted any K-location can be selected  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** 0
6. **1ST\_COMPL:** First completion in a range that should be modified. If defaulted, all the completions till the second completion in item 7 will be modified.

**Type:** Integer

**Default value:** 0

7. **2ND\_COMPL:** Second completion in a range that should be modified. If defaulted, all the completions from the first completion in item 6 will be modified.

**Type:** Integer

**Default value:** 0

### Example

In this example connection transmisibility factor is modified.

In well 'P1', all the connection factors are multiplied by a factor of 2. In well 'P2', the connections between completions 2 and 3 are multiplied by a factor of 2.5. In well 'P3', the transmisibility factor of the connection at the specified indexes is multiplied by 3.0

```
CPIFACT
--name CT_FACT I J K hi_compl low_compl
'P1'    2.0 /
'P2'    2.5    1* 1* 1*      2       3 /
'P3'    3.0    5   5   2  /
/
```



## 2.61 CPIFACTL

### Description

This keyword provides the possibility to scale the connection transmissibility factors for well connection/completions, with completions numbers possibly defined by [COMPLMPL](#) keyword. using a multiplier defined in the second field of the keyword records. The keyword is followed by an arbitrary number of slash terminated records, each of them using a specific multiplier to scale connection factors. The keyword input is terminated by an empty record.

The record defines the well the keyword applies to, the multiplier and then gives the possibility to select which connections/completions connection factors are modified. If all items from 4 to 8 are defaulted, the multiplier applies to all the connections in the well and it actually sets a multiplier for the well productivity/injectivity.

Differently from [WPIMULT](#), CPIFACT multipliers are not cumulative meaning that each time the factor applies to the original transmissibility factor of the connection as set by [COMPDATL](#). If connections between grid and well are reset using [COMPDATL](#) again, the multiplier is set to 1 and it is the neccessary to eneter a new CPIFACTL again in case it is necessary to define the multiplier again.

### Record format

1. **WELL\_NAME:** his field can be a specific Well name, a list of wells (as defined by [WLIST](#)) or a template (=a quote delimited string with '\*' as wild card). The keyword applies to wells already defined in the SCHEDULE section and, if defaulted, it applies to all wells.  
**Type:** String  
**Default value:** None
2. **CONN\_MULTI:** Multiplier to be applied to the well connections. This quantity can be defined using uder defined arguement ([UDA](#)).  
**Type:** Float  
**Default value:** 1.0
3. **LGR\_NAME:** LGR name that contains the connections in the well to be modified multiple wells.  
**Type:** String  
**Default value:** None
4. **I:** I-location of the perforated grid block. If set to zero or defaulted, the I-location can be any location.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** 0
5. **J:** J-location of the perforated grid block. If set to zero or defaulted, the J-location can be any location.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** 0
6. **K:** K-location of the upper updated perforated grid block; If set to zero or defaulted any K-location can be selected  
**Type:** Integer  
**Minimum:** 1

**Maximum:** NZ

**Default value:** 0

7. **1ST\_COMPL:** First completion in a range that should be modified. If defaulted, all the completions till the second completion in item 8 will be modified.

**Type:** Integer

**Default value:** 0

8. **2ND\_COMPL:** Second completion in a range that should be modified. If defaulted, all the completions from the first completion in item 7 will be modified.

**Type:** Integer

**Default value:** 0

### Example

In this example connection transmisibility factor is modified.

In well 'P1', all the connection factors are multiplied by a factor of 2. In well 'P2', the connections between completions 2 and 3 in all LGRs are multiplied by a factor of 2.5. In well 'P3', the connections between completions 2 and 3 in 'LGR1' are multiplied by a factor of 3.0, while the connection with the specified indexes in LGR3 in the same well is multiplied by a factor of 3.5.

```
CPIFACTL
--name CT_FACT    LGR   I   J   K   hi_compl  low_compl
'P1'    2.0  /
'P2'    2.5    1*   1*  1*   1*      2       3  /
'P3'    3.0  'LGR1' 1*   1*  1*   1*      2       3  /
'P3'    3.5  'LGR3' 5     5   2   /
```



## 2.62 CSKIN

### Description

This keyword allows updating the skin factor for well connections and consequently changes the well connection transmissibility factor.

Note that large positive or negative skin factors can cause convergence problems.

The keyword is followed by an arbitrary number of slash (/) terminated records, with a final empty record to close its input stream.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template  
**Type:** String  
**Default value:** None
2. **I:** I-location of the perforated grid block. If set to zero or defaulted, the I-location of the wellhead defined in the keyword [WELSPECS](#) will be used.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** 0
3. **J:** J-location of the perforated grid block. If set to zero or defaulted, the J-location of the wellhead defined in the keyword [WELSPECS](#) will be used.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** 0
4. **K1:** K-location of the upper updated perforated grid block; the default is the topo-most connection in the well  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** 1\*
5. **K2:** K-location of the lower updated perforated grid block; the default is the deepest perforated cell of the well.  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** 1\*
6. **CONN\_SKIN\_FACTOR:** The factor can be a positive or a negative value  
**Type:** Float  
**Default value:** 0.0

**Example**

This example defines skin factors. The skin value in only one connection is multiplied by a positive factor, whereas in the second well all the skin of connections in the first and second layers are multiplied by a factor. The last record defines the skin factor for all the connections in the well.

```
CSKIN
--name I J K1 K2 SKIN
P1    2  3   1   1   1.5 /
P2    1* 1*  1   2  -2.0 /
P3    4*          2.5 /
/
```



## 2.63 CVCRIT

### Description

The **CVCRIT** keyword is used to set convergence criteria as well as linear and nonlinear solver parameters for compositional simulations. It consists of a single record with fields listed in the table below. Some of these parameters can also be set with the **TUNING** and **SOLVER** keywords. Several fields specify nonlinear convergence tolerances. Note that all of these criteria need to be satisfied for the timestep to be considered converged. Note that any items defaulted in this keyword will leave the current value for the corresponding parameter unchanged.

See [Section 3.3](#) in the Technical Description for additional information.

### Record format

1. **DELTA\_P\_CONV:** Maximum pressure change allowed during the last Newton iteration for the timestep to be considered converged; the default values are 0.1 atm in both unit systems  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 1.4696 (FIELD), 0.1013 (METRIC)
2. **MAX\_NEWTONS:** Maximum number of Newton iterations allowed during a timestep  
**Type:** Integer  
**Default value:** 20
3. **REL\_TOL2:** Square of the tolerance of the linear residual relative to the initial linear residual  
**Type:** Float  
**Default value:** 1e-6
4. **MAX\_LINEARS:** Maximum number of iterations allowed for the linear solver for each Newton iteration  
**Type:** Integer  
**Default value:** 20
5. *Reserved*
6. **MIN\_LINEARS:** Minimum number of linear iterations employed to solve the linear system of equations  
**Type:** Integer  
**Default value:** 1
7. **MAX\_SPEC\_VOL\_CHANGE:** Maximum allowed change in the specific volume of each component during the last Newton iteration for the timestep to be considered converged  
**Type:** Float  
**Default value:** 0.01
8. *Reserved*
9. **MIN\_NEWTONS:** Minimum number of Newton iterations  
**Type:** Integer  
**Default value:** 1
10. **ABS\_TOL:** Absolute L2 norm for linear solver  
**Type:** Float  
**Default value:** N/A
11. *Reserved*
12. *Reserved*

13. *Reserved*

14. **DELTA\_P\_CHOP:** The maximum allowed absolute change in cell pressure during a Newton iteration. If the linear solver returns a larger change than this, it will be truncated to this maximum.

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Example**

The following loosens the tolerance of the maximum allowed cell pressure change for convergence to 15 psi in FIELD units and the maximum specific volume change to 0.1. All of the other parameters are left at their defaults.

```
CVCRIT  
15.0 5* 0.1 /
```



## 2.64 DATES

### Description

The [DATES](#) keyword is used to specify report steps to which the simulated time is progressed. While the simulator may take intermediate timesteps, it is required to step to each of the simulation dates specified in this keyword. Each date is given as a slash-terminated record in the format given below. The keyword is terminated by an extra slash (/). Each date must occur later than the current simulation date to ensure time progresses only forward. Alternatively, the simulation date can be progressed to an absolute number of days from the simulation [START](#) with the [TIME](#) keyword or by time increments with the [TSTEP](#) keyword.

### Record format

Field	Name	Type	Description
1	DAY	Integer	Integer from 1 to the number of days in the month.
2	MONTH	String	Allowed values are JAN, FEB, MAR, APR, MAY, JUN, JLY, AUG, SEP, OCT, NOV or DEC. JUL is also an alias for JLY.
3	YEAR	Integer	Four-digit year
4	TIME	String	Time of day in the format HH:MM:SS.SSSS

### Example

```
DATES
1 JAN 2013 /
1 FEB 2013 /
2 FEB 2013 12:36 /
2 FEB 2013 12:42:03 /
/
```



## 2.65 DATUM

### Description

This keyword sets the datum depth to be used for phase potential reporting. If a **DATUM** keyword is not present, the datum depth used in the phase potential calculation is set to 0.0 or to the datum depth of the first equilibration region if defined.

### Record format

1. **DATUMDEPTH:** datum depth default value is 0.0

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** 0 (FIELD), 0 (METRIC)

### Example

This example sets the datum depth for phase potential calculation to 4500 (using the model unit system):

```
DATUM  
4500 /
```

notice that by defaulting the DATUM field, as in the following example, a 0.0 datum depth will be used regardless of the presence of an equilibration region with a specified datum depth

```
DATUM  
1* /
```



## 2.66 DATUMR

### Description

This keyword allows the definition of an array of datum depths to be used in the region phase potential calculation and reporting. The number of datum depth values should be equal to NTFOP, the maximum number of equilibration regions defined with `EQLDIMS` keyword. However, a default value of 0.0 will be used if the number of values provided by the user is less than the number of regions. On the other hand, the values of the set that exceed the number of regions will be silently ignored by Echelon.

### Record format

1. **DATUMDEPTHES:** set of datum depth values, one for each equilibration region. The default value is 0.0.

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

### Example

Assuming NTFIP=3, this example sets the datum depths for phase potential calculation to 4500 for the first region, 4300 for the second and 4200 for the third one.

```
DATUMR
 4500 4300 4200 /
```

Assuming NTFIP=4, in this example the first two regions will have a datum depth of 4500 and 4300, respectively, while the last two regions will have the datum depth default of 0.0

```
DATUMR
 4500 4300 /
```

Assuming NTFIP=3, the last two datum depth values will be silently ignored by Echelon

```
DATUMR
 4500 4300 4200 5000 5500 /
```



## 2.67 DECOMP

### Description

This keyword can be used to select the algorithm used in the decomposition of the grid when more than one GPU is used, see [Section 3.8](#) in the Technical Description. The keyword is followed by a unique, slash-terminated, record with only one field, which defines the specific domain decomposition method used by the simulator.

It is possible to view model domains using the property DOMAINS in the INIT output file (see keyword [INIT](#)).

### Record format

1. **DDMETHOD:** Domain Decomposition method

**Type:** String

**Default value:** METIS

**Allowed values:**

Name	Description
METIS	It uses the Metis software library. It uses multilevel algorithms to maintain good load balance while minimizing the area of the interfaces between domains. It is the default decomposition method and should be used in almost all cases
AREAL_METIS	It uses the same library as above but performs a 2D areal decomposition after grouping all cells in the same pillars. This can be helpful for some models with very strongly vertically dominated transmissibility. It should not be used in models with local grid refinement or unstructured grid
SLICEI	it divides the grid into uniformly-spaced slices in the I-direction. This should only be used for box-shaped models (e.g. unconventional drill spacing units) under limited circumstances.
SLICEJ	It divides the grid into uniformly-spaced slices in the K-direction. This should only be used for box-shaped models (e.g. unconventional drill spacing units) under limited circumstances.
SLICEK	It divides the grid into uniformly-spaced slices in the K-direction. This should only be used for box-shaped models (e.g. unconventional drill spacing units) under limited circumstances.
SLICEMAX	It divides on the I, J, or K dimension with the largest number of cells.

### Example

In a strongly vertically connected problem it can be convenient to prevent the possibility that cells in the same column are split among different domains:

```
DECOMP
  AREAL_METIS /
```



## 2.68 DEFAULTS

### Description

The [DEFAULTS](#) keyword gives the user the possibility to override default models or assumptions. Some of these can later be overridden by specific keywords.

Most of the keys expect values YES or NO values, although abbreviation Y or N are also accepted. Other keys expect float values.

### Record format

1. **ALTERNATE\_REFERENCE\_PRESSURE\_SPLIT:** In compositional models, when the NOPCSPT option of the FORMOPTS keyword is active,  $P_o$  (liquid phase pressure) is used as reference pressure, else a pressure split is applied whereby the reference pressure is averaged between the liquid and vapor phase pressures.  
When the pressure split is active and the record at hand is set to YES, the water-oil capillary pressure ( $P_{cwo}$ ) is interpreted as the pressure difference between the reference pressure and the water pressure. Note: this is incorrect in the presence of gas-oil capillary pressure and setting the key to NO is physically more sound.  
**Type:** String  
**Default value:** BO: N/A, COMP: YES
2. **ADD\_LOWER\_PVT\_TABLE\_POINT:** If set to YES, introduces an additional point at zero pressure in the black-oil PVT tables with  $R_s = R_v = 0$ . This ensures that extrapolation of user-input tables to low pressures cannot lead to negative values of  $R_s$  or  $R_v$ .  
**Type:** String  
**Default value:** BO: NO, COMP: N/A
3. **REQUIRE\_SEPARATE\_FRACTURE\_REGNUMS:** If set to YES, all of MULTNUM, FLUXNUM, PINCHNUM, and OPERNUM arrays must be separately specified for matrix and fracture cells in dual media runs. If set to NO, only the MULTNUM array must be specified for both media and the others are copied from matrix to fracture. Can be overridden with the [OPTIONS](#) keyword.  
**Type:** String  
**Default value:** BO: NO, COMP: YES
4. **PREVENT\_KR\_SCANNING\_CROSSING\_DRAINAGE:** If set to YES, ignore the non-wetting phase relative permeability hysteresis when the scanning curve would cross the drainage curve.  
**Type:** String  
**Default value:** NO
5. **ENFORCE\_KILLOUGH\_FOR\_PC\_HYSTERESIS:** If set to NO, ECHELON will compute  $S_{ncrt}$  for capillary pressure hysteresis using the same model as for the relative permeability (i.g., either Carlson or Killough), else Sncrt will be computed with the Killough model.  
In either case, the Killough model is used to generate the capillary pressure scanning curves.  
**Type:** String  
**Default value:** BO: NO, COMP: YES
6. **DAMP\_WELLHEAD\_FOR\_STOP\_ONLY:** If set to YES, ECHELON will by default only damp the gravity head of STOP wells.  
If the [WHHDFACT](#) keyword is used in the SCHEDULE section, the user-input value will apply to both OPEN and STOP wells, regardless of the value of the key at hand.  
**Type:** String  
**Default value:** BO: YES, COMP: NO

7. **NO\_HYSTERESIS ABOVE\_SNMAX:** If set to YES, ECHELON prevents non-wetting scanning curves to start at  $S_{hy} > S_{nmaxd}$ .  
**Type:** String  
**Default value:** BO: YES, COMP: NO
8. **PRESERVE\_SW\_FROM\_INITIALIZATION\_SPLINES:** When set to yes, it determines whether we want to preserve  $S_w$  (water saturation) from the equilibration splines during model initialization.  
**Type:** String  
**Default value:** BO: N/A, COMP: NO
9. **REQUIRE\_WATER\_PVT:** If set to YES, ECHELON requires water PVT properties to be input in the [PROPS](#) section, else default properties will be used if absent.  
**Type:** String  
**Default value:** BO: YES, COMP: NO
10. **DATUM\_PRESSURE\_RESET\_WITH\_TOLERANCE:** In compositional models initialized with dew-point or bubble-point equilibration (field 10 of [EQUIL](#) keyword set to 2 or 3), only reset the datum pressure to the saturation pressure if they are further apart than 1 atm.  
**Type:** String  
**Default value:** BO: N/A, COMP: YES
11. **FINESCALE\_EQUILIBRATION\_ACCURACY:** Sets the default parameter for equilibration accuracy. This can be overridden by field 9 of the [EQUIL](#) keyword.  
**Type:** Integer  
**Default value:** BO: -5, COMP: 0
12. **MATRIX\_FRACTURE\_TRANS\_THRESHOLD:** Transmissibility threshold between matrix and fracture in dual media runs below which it is considered to be zero.  
**Type:** Float  
**Default value:** BO: 1e-20, COMP: 1e-6
13. **COMPUTE\_WELL\_PI\_FROM\_MOLAR\_PI:** When set to YES, in compositional models, well productivity indexes (WPI summary) are computed by ECHELON by summing molar connection-level productivity indexes (PI) and then converting these to volumetric PIs. Setting this key to NO is physically more sound.  
**Type:** String  
**Default value:** BO: N/A, COMP: YES
14. **REPORT\_WPI\_FOR\_STOP\_WELLS:** If set to YES, ECHELON reports WPI for open and stop wells, else ECHELON reports WPI for open wells only.  
**Type:** String  
**Default value:** BO: NO, COMP: YES
15. **TREAT\_PHASES\_AS\_RATE\_FOR\_WGRUPCON:** If set to YES, injectors can only store a single guiderate set by [WGRUPCON](#), which will be used even in case of change in injected phase or if a well switches from injection to production and vice-versa.  
**Type:** String  
**Default value:** BO: YES, COMP: NO
16. **ALTERNATE\_DATUM\_CONVERSION\_FOR\_STOP\_WELLS:** Alternate method for shifting the well BHP to datum depth for stop wells when located above the shallowest perforation.  
**Type:** String  
**Default value:** NO
17. **CORNER\_DEPTHS\_FOR\_EQUILIBRATION:** If set to YES, ECHELON builds equilibration splines spanning from the minimum and maximum of cells corner-point depths. If set to NO, equilibration splines would span from the minimum and maximum of cell faces depths.  
**Type:** String  
**Default value:** NO
18. **USE\_DEFAULT\_BHP\_LIMIT\_IF\_ZERO:** If set to YES, when a BHP limit is set to 0 in a

- well control, ECHELON replaces it with default values.
- Type:** String  
**Default value:** BO: NO, COMP: YES
19. **USE\_KILLOUGH\_ACTIVATION\_THRESHOLD:** If set to YES, ECHELON requires a measurable threshold between Shy and Sncrd to activate hysteresis.
- Type:** String  
**Default value:** BO: YES, COMP: NO
20. **CAP\_SNCRI\_AT\_SNMAXHY\_FOR\_PCW\_HYSTER:** If set to YES ECHELON, replaces  $S_{ncri}$  by  $\min(S_{ncri}, S_{hy})$  to compute  $S_{ncrt}$  used in water-oil capillary pressure hysteresis calculations.
- Type:** String  
**Default value:** BO: NO, COMP: YES
21. **RESCALE\_IMBIBITION\_PCG\_WITH\_SGCRT:** If set to YES, ECHELON rescales the gas capillary pressure imbibition curves horizontally between  $S_{grct}$  and  $S_{gmax}$ .
- Type:** String  
**Default value:** BO: YES, COMP: NO
22. **RESCALE\_NW\_IMBIBITION\_KR\_TO\_DRAINAGE\_MAX:** If set to YES, ECHELON vertically rescales the imbibition relative permeability curve of the non-wetting phase to ensure that  $k_{ri}(S_{nmax}) = k_{rd}(S_{nmax})$ .
- Type:** String  
**Default value:** BO: YES, COMP: NO
23. **ORIGINAL\_API\_INTERPOLATION\_RULE:** If set to NO, ECHELON will linearly interpolate fluid properties between PVT tables with API tracking.
- Type:** String  
**Default value:** BO: YES, COMP: N/A
24. **STATIC\_PORV\_REGION\_AVERAGES:** If set to YES, ECHELON will perform region property averages (e.g., FPRP) using static pore volumes, else dynamic pore volumes will be used.
- Type:** String  
**Default value:** BO: YES, COMP: NO
25. **FLAT\_VFP\_EXTRAPOLATION\_FOR RATIOS:** If set to YES, the default value for the fifth field of the [WVFPEXP](#) keyword is “WG”, else it is “NONE”.
- Type:** String  
**Default value:** BO: NO, COMP: YES
26. **PREVENT\_SWITCH\_TO\_UNSTABLE\_THP:** If set to YES, prevents a well from changing from rate control to THP control when it is constrained to operate on the unstable side of its VFP curve, regardless of the [WVFPEXP](#) keyword settings.
- Type:** String  
**Default value:** BO: NO, COMP: YES
27. **USE\_TOLERANCE\_FOR\_EQUALITY\_ACTIONX\_CHECKS:** If set to YES, ECHELON will apply a small tolerance when evaluating equalities and non-strict inequalities in the [ACTIONX](#) triggering conditions.
- Type:** String  
**Default value:** YES
28. **POTENTIAL\_REGION\_AVERAGES\_SATURATION\_THRESHOLD:** Saturation threshold below which region phase potentials will be averaged by pore volume and not saturation-weighted pore volume.
- Type:** Float  
**Default value:** 0
29. **WPIMULT\_ACCUMULATE\_EXCEPTION:** If set to YES, ECHELON will have an exception when treating several [WPIMULT](#) keywords defined for the entire well within the same timestep and same origin (meaning all come from SCHEDULE or same [ACTIONX](#) body): only

the last one will be taken into account. In all other cases, multipliers have cumulative effects. If set to NO, ECHELON will always accumulate multipliers.

**Type:** String

**Default value:** BO: YES, COMP: NO

30. **CHECK RATIOS IN WTEST:** If set to YES, When performing a well test ECHELON checks both lower limit rates and ratios (WCT, GOR, WGR), while if set to NO, only checks the former.

**Type:** String

**Default value:** YES

31. **USE CELL DENSITY FOR INJECTING CONNECTIONS:** If set to YES, when computing the volumetric flow between the wellbore and a perforated cell for an injecting connection, use the cell density rather than the wellbore density. This is an exception to the usual rule of using upstream densities.

**Type:** String

**Default value:** BO: YES, COMP: N/A

32. **TREAT WELLBORE HC AS GAS FOR WDFAC:** If set to YES in compositional models, ECHELON will consider all hydrocarbon phases within the wellbore to be gas when computing the non-Darcy effect in injecting connections. This may improve stability in cases where phase flips occur in the wellbore, at the expense of model fidelity.

**Type:** String

**Default value:** BO: N/A, COMP: YES

33. **CONSTANT UNDERSAT COMPRESSIBILITY EXTRAPOLATION:** If set to YES, in black-oil models with live oil and/or wet gas, the top-most and bottom-most undersaturated branches of the PVT tables are extrapolated with constant compressibility. If set to NO, linear extrapolation between the two top-most and two bottom-most undersaturated branches is performed.

**Type:** String

**Default value:** BO: NO, COMP: N/A

34. **EXTEND WINJmix AVAILABILITY:** By default, gas availability does not extend to items of WINJmix, and an item's availability can exceed the gas it produces. See [WINJmix](#) for details.

**Type:** String

**Default value:** BO: N/A, COMP: NO

35. **APPORTION FUEL SALE TO SEPARATOR STAGES:** If set to YES, the volumes of gas required for both FUEL and SALE are allocated to the separator stages based on their respective volumetric rates. This effectively reduces the reinjection volume for each stage associated with SALE and FUEL.

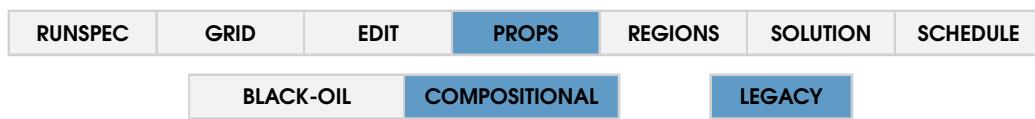
**Type:** String

**Default value:** BO: N/A, COMP: NO

### Example

This examples sets two specific [DEFAULTS](#) key value pairs

```
DEFAULTS
COMPO_REF_PRESS_PSLIT=NO
ADD_LOWER_PVT_TABLE_POINT=YES /
```



## 2.69 DENAQA

### Description

This keyword specifies the coefficients to be used in Ezrokhi's formula for the computation of aqueous phase density in [GASWAT](#) cases. Three coefficients should be entered for each component. If the keyword is not specified zero coefficients are assumed. The keyword is followed by NEOSR ([TABDIMS](#) ninth field) record, one for each equation of state.

The aqueous phase density is then computed as:

$$\log(\rho_w) = \log(\rho_{w,pure}) + \sum_{n=1}^{N_c-1} C_n(T) w_n$$

where

$w_n$  is the weight fraction of the component  $n$  excluding water,  $\rho_{w,pure}$  is the density of pure water and

$$C_n(T) = c_{1,n} + c_{2,n}T + c_{3,n}T^2$$

The  $c_{i,n}$  are the coefficients specified in this keyword.

### Record format

1. **Ezrokhi's coefficients:** coefficients to be used in the Ezrokhi formula, three for each component

**Type:** Float

#### Example 1

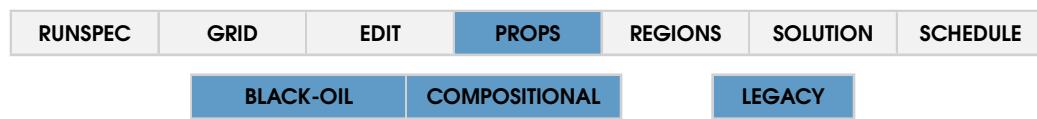
This example specifies Ezrokhi coefficients for density modification in a case with three components

```
DENAQA
0.10 -1.28e-05 -2.0e-06
0.11 -2.28e-05 -2.37e-06
0.12 -2.28e-05 -2.37e-06 /
```

#### Example 2

This example specifies Ezrokhi coefficients for density modification in a case with three components and two equations of state

```
DENAQA
0.10 -1.28e-05 -2.0e-06
0.11 -2.28e-05 -2.37e-06
0.12 -2.28e-05 -2.37e-06 /
0.10 -1.28e-05 -2.0e-06
0.11 -2.28e-05 -2.37e-06
0.12 -2.28e-05 -2.37e-06 /
```



## 2.70 DENSITY

### Description

The **DENSITY** keyword is used to specify the density of oil, water, and gas phases at surface conditions for each pressure region (alternatively, the **GRAVITY** keyword can be used). There is a single pressure region by default. The keyword **TABDIMS** can be used to define more pressure regions.

Each record specifies exactly three fluid densities at surface conditions for a specific pressure region, terminated with a slash character. In compositional formulation, however, only water density is used: the surface densities of oil and gas phases are computed from the equation of state.

### Record format

Field	Default	Units	Description
1	BO FIELD: 37.457 BO METRIC: 600.0 COMP FIELD: 37.4568 COMP METRIC: 600.0	[lb/ft <sup>3</sup> ], [kg/m <sup>3</sup> ]	Oil density at surface conditions
2	BO FIELD: 62.4 BO METRIC: 1000.0 COMP FIELD: 62.3664 COMP METRIC: 999.014	[lb/ft <sup>3</sup> ], [kg/m <sup>3</sup> ]	Water density at surface conditions
3	FIELD: 0.062428 METRIC: 1.00	[lb/ft <sup>3</sup> ], [kg/m <sup>3</sup> ]	Gas density at surface conditions

### Example 1

All three phase surface densities are used for the black-oil model, for example in the case of two pressure regions:

```
DENSITY
640.00 1020.00 1.03 /
610.00 1021.00 1.04 /
```

### Example 2

Only water surface density is used in the case of the compositional model. The other two values might be set to default or a dummy value without any effect on simulation.

```
DENSITY
1* 1010.00 999 /
```



## 2.71 DEPTH

### Description

This keyword may be used to set the depth of the center of each grid block. It is followed by one value for each grid cell in the input box, which by default is the entire grid, following natural ordering with index along I running faster, then along J and last along K. Repeat counts may be used for repeated values. A slash (/) terminates the record.

**Units:** ft (FIELD), m (METRIC)

### Example

This is an example of how depths of grid block centers can be defined for a 30x30x3 reservoir.

```
DEPTH  
900*2000 900*2020 900*2060/
```



## 2.72 DIMENS

### Description

This keyword defines the size of the simulation grid by three integers, namely NXRES, NYRES and NZRES. followed by a single record. **DIMENS** is required in any ECHELON simulation model.

### Example

To define the grid dimensions for a model with  $45 \times 45 \times 120$  cells the keyword is:

```
DIMENS  
 45 45 120 /
```



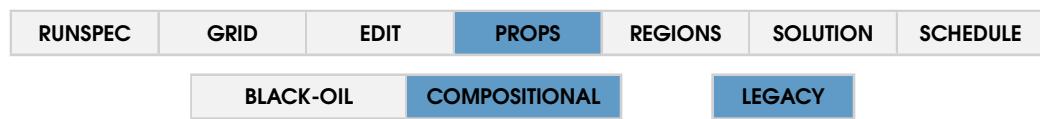
## 2.73 DISGAS

### Description

Specifies that, in black-oil runs, standard gas is allowed to dissolve in the oil phase at reservoir conditions. This activates the live-oil option.

### Example

```
RUNSPEC  
DISGAS
```



## 2.74 DNGL

### Description

This keyword defines the partial densities of natural liquidated gas (NGL) for compositional runs that use gas plant table (see keyword [GPTABLEN](#) and [Section 14.2](#) in the Technical Description) with NGL. This keyword is followed by only one record consisting of  $N_c$  values, one value for each component (see [COMPS](#) keyword), with a terminating slash.

Units for NGL component densities are kg/sm<sup>3</sup> (METRIC) or lb/stb (FIELD).

The provided densities are used in calculating the molar volume of the fluid mixture.

### Example

This example defines the NGL densities in a compositional model with 7 components:

```
DNGL  
48.1 45.2 38.5 25.4 33.2 36.3 39.4 /
```



## 2.75 DPGRID

### Description

This keyword can be used in dual media simulations to copy values from matrix to fracture cells. In dual media simulation, the first NZ/2 layers (see [DIMENS](#)) are for the matrix while the second NZ/2 layers define fracture cells [Chapter 5](#).

Using [DPGRID](#) values for 3D property arrays such as [PORO](#), [NTG](#), [PERMX](#), [PERMY](#), [PERMZ](#) are copied to fracture cells whenever they are not set by the user. The grid geometry is also duplicated thus geometry information such as [ZCORN](#) only needs to be supplied for the first half of the grid.



## 2.76 DRILPRI

### Description

This keyword can be used to set the formula used by the simulator to sort production wells in a prioritized drilling queue, where wells are brought on stream to meet targets set by [GCONPROD](#) or [GCONPRI](#) keywords.

The priority formula is defined as follows:

$$\text{Priority} = \frac{a_0 + a_1 Q_o + a_2 Q_w + a_3 Q_g}{b_0 + b_1 Q_o + b_2 Q_w + b_3 Q_g}$$

where  $Q_o$ ,  $Q_w$ ,  $Q_g$  are oil, water, and gas potential production rates, respectively, while coefficients  $a_i, b_i$  for  $i = 0, 1, 2, 3$  are provided by the user throughout this keyword. Note that none of the coefficient can be negative.

The keyword contains one record, as described below.

- The first entry is the minimum time interval between drilling priority calculation,
- Entries 2-9 are the  $a_i$  and  $b_i$  for  $i = 0, 1, 2, 3$  for the first priority formula.

It is worth noticing that this formula works only for production wells: injection wells are prioritized only by their injection potential.

### Record format

Field	Name	Type	Default	Units	Description
1	DT	Float	0	[Day], [Day]	Minimum interval type between successive drilling priority calculations. Using zero means updating every timestep
2	A0	Float	0.0		$a_0$ coefficeint
3	A1	Float	0.0	[Day/bbl], [Day/sm <sup>3</sup> ]	$a_1$ coefficeint
4	A2	Float	0.0	[Day/bbl], [Day/sm <sup>3</sup> ]	$a_2$ coefficeint
5	A3	Float	0.0	[Day/Mscf], [Day/sm <sup>3</sup> ]	$a_3$ coefficeint
6	B0	Float	0.0		$b_0$ coefficeint
7	B1	Float	0.0	[Day/bbl], [Day/sm <sup>3</sup> ]	$b_1$ coefficeint
8	B2	Float	0.0	[Day/bbl], [Day/sm <sup>3</sup> ]	$b_2$ coefficeint
9	B3	Float	0.0	[Day/Mscf], [Day/sm <sup>3</sup> ]	$b_3$ coefficeint

### Example

```
DRILPRI
--Qo/(1+Qw)
30.0  0.0  1.0  0.0  0.0  1.0  0.0  1.0  0.0  /
```



## 2.77 DRSDT

### Description

This keyword sets a maximum rate at which the gas-solution ratio ( $R_s$ ) is allowed to increase in a cell (note: the rate at which  $R_s$  can decrease is unrestricted). The value is by default equal to infinity, meaning that instantaneous thermodynamic equilibrium between the gas and oil phases is assumed.

It is possible to specify if the rate limit should apply to all cells, or only to cells with free gas. It must be noted that limiting the  $R_s$  increase rate is a heuristic approach to account for incomplete contact between oil and gas phases at the grid-block scale, and both options (application to all cells, or only to cells with free gas) can lead to unphysical and inconsistent behavior. For example, if applied to all cells, free gas may develop in an initially undersaturated oil cell due to inflow from another undersaturated oil cell with a slightly higher amount of dissolved gas. On the other hand, if only applied to cells with free gas, any free gas flow to an undersaturated cell would instantaneously dissolve.

### Record format

#### 1. RATE\_LIMIT:

**Type:** Float

**Units:** Mscf/stb/day (FIELD), sm<sup>3</sup>/sm/day<sup>3</sup> (METRIC)

**Default value:** inf (FIELD), inf (METRIC)

#### 2. APPLY\_TO:

**Type:** String

**Default value:** ALL

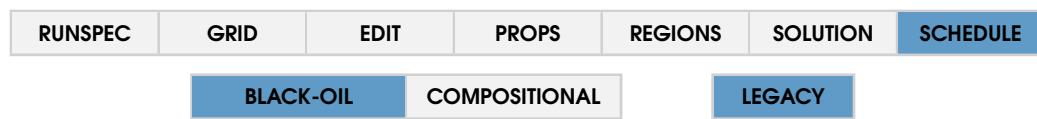
**Allowed values:**

Name	Description
ALL	Applies to all cells
FREE	Only applies to cells with free gas

### Example

DRSDT is used to prevent any increase in solution-gas ratio in all cells

```
DRSDT
 0 ALL /
```



## 2.78 DRVDT

### Description

This keyword sets a maximum rate at which the vaporized oil ratio ( $R_v$ ) is allowed to increase in a cell (note: the rate at which  $R_v$  can decrease is unrestricted). The value is by default equal to infinity, meaning that instantaneous thermodynamic equilibrium between the gas and oil phases is assumed.

While the analogous [DRSDT](#) keyword allows the user to decide if the rate limit applies to all cells or only to cells with free gas, the [DRVDT](#) keyword automatically applies the rate limit to all cells.

### Record format

#### 1. RATE\_LIMIT:

**Type:** Float

**Units:** stb/Mscf/day (FIELD), sm<sup>3</sup>/sm/day<sup>3</sup> (METRIC)

**Default value:** inf (FIELD), inf (METRIC)

### Example

[DRVDT](#) is used to prevent any increase in vaporized oil ratio in all cells

```
DRVDT  
0 /
```



## 2.79 DUALPERM

### Description

The **DUALPERM** keyword is used to define a dual-permeability system where the main cell-to-cell flow and flow to the wells is through both matrix and fractures [Chapter 5](#). Matrix-fracture flow also occurs from the matrix to fractures in each cell. For dual porosity systems, use the **DUALPORS** keyword. No record data is associated with this keyword. In dual media systems, both cells are normally assigned to have the same bulk geometry. The number of layers (NZ) on the **DIMENS** keyword must be doubled in the data file as compared to the equivalent single-porosity media. The first half of the double-layered grid is used to characterize the matrix media and the second half to characterize the fractures (the secondary porosity system). The grid properties such as porosity, permeability, etc., should be defined separately by the user. It is possible to input geometric data for both the matrix and fracture grid; however, this can result in inconsistencies as matrix and fracture cells could have different geometries and depths. Use of the **DPGRID** keyword in the **GRID** section) is recommended to force matrix geometry to be copied to the fracture cells. Besides the geometry (e.g. **COORD**, **ZCORN**), the **DPGRID** also copies properties from the matrix to the fractures for other grid properties such as **PERMX**, **PERMY**, **PERMZ**, **PORO**, and **NTG**. Fracture data should then be included to overwrite the copied data. The **BOX** keyword can be used to set the grid input boxes separately for matrix and fracture properties. It is important to ensure that sufficient fracture data is input to completely overwrite the copied matrix values. **SIGMA** values should also be defined in the first half of the grid (matrix) to define matrix-fracture transmissibility.

### Example

```
RUNSPEC  
DUALPERM
```



## 2.80 DUALPORO

### Description

The [DUALPORO](#) keyword is used to define a dual porosity system where the main cell-to-cell flow and flow to the wells is through fractures only [Chapter 5](#). Matrix flow occurs only from the matrix to fractures in each cell. For dual-permeability systems, see the [DUALPERM](#) keyword. No record data is associated with this keyword. In dual media systems, both cells are normally assigned to have the same bulk geometry. The number of layers (NZ) on the [DIMENS](#) keyword must be doubled in the data file as compared to the equivalent single-porosity media. The first half of the double-layered grid is used to characterize the matrix media and the second half to characterize the fractures (the secondary porosity system). The grid properties such as porosity, permeability, etc., should be defined separately by the user. It is possible to input geometric data for both the matrix and fracture grid; however, this can result in inconsistencies as matrix and fracture cells could have different geometries and depths. Use of the [DPGRID](#) keyword in the [GRID](#) section) is recommended to force matrix geometry to be copied to the fracture cells. Besides the geometry (e.g. [COORD](#), [ZCORN](#)), the [DPGRID](#) also copies properties from the matrix to the fractures for other grid properties such as [PERMX](#), [PERMY](#), [PERMZ](#), [PORO](#), and [NTG](#). Fracture data should then be included to overwrite the copied data. The [BOX](#) keyword can be used to set the grid input boxes separately for matrix and fracture properties. It is important to ensure that sufficient fracture data is input to completely overwrite the copied matrix values. [SIGMA](#) values should also be defined in the first half of the grid (matrix) to define matrix-fracture transmissibility.

### Example

```
RUNSPEC  
DUALPORO
```



## 2.81 DX

### Description

This keyword can be used to set the length of the cells along the I (X) direction in a block-centered geometry.

It is followed by one value for each grid cell in the input box, which by default is the entire grid, provided according to a natural ordering with index along I running faster, then along J and last along K. Input is terminated by a slash character while repeat counts may be used for repeated values.

In a block-centered geometry it is necessary to provide [DX](#) values for all grid cells, then filling a 3D array which can be manipulated by other keywords (e.g.[ADD](#)).

Units are m (METRIC) or ft (FIELD).

**Units:** ft (FIELD), m (METRIC)

### Example

```
DX  
300*10 /
```



## 2.82 DXV

### Description

This keyword can be used to define cell length along I (X) in a block-centered geometry grid by providing NXRES values (see [DIMENS](#) keyword in RUNSPEC) in a single, slash-terminated record. **DXV** sets **DX** values for all the grid cells and cells with the same I index have the same **DX**. Notably, as for many other keywords for 3D Arrays, it is possible to use repeat counts for repeated values.

Repeat counts are used to setting repeated values, e.g. for the first three rows.

Units are m (METRIC) or ft (FIELD).

### Example

**DXV** is used to set a tartan-type spacing in a reservoir grid where NXRES equals 23:

```
DXV  
3*1000 3*500 3*200 5*100 3*200 3*500 3*1000 /
```



## 2.83 DY

### Description

This keyword can be used to set the length of the cells along J (Y) direction in a block-centered geometry.

It is followed by one value for each grid cell in the input box, which by default is the entire grid, provided according to a natural ordering with index along I running faster, then along J and last along K. Input is terminated by a slash character while repeat counts may be used for repeated values.

In a block-centered geometry it is necessary to provide [DY](#) values for all grid cells, then filling a 3D array which can be manipulated by other keywords (e.g.[ADD](#)).

Units are m (METRIC) or ft (FIELD).

**Units:** ft (FIELD), m (METRIC)

### Example

```
DY  
300*10 /
```



## 2.84 DYV

### Description

This keyword can be used to define cell length along J (Y) in a block-centered geometry grid by providing NYRES values (see [DIMENS](#) keyword in RUNSPEC) in a single, slash-terminated record. **DYV** sets **DY** values for all the grid cells and cells with the same J index have the same **DY**. Notably, as for many other keywords for 3D Arrays, it is possible to use repeat counts for repeated values.

Units are m (METRIC) or ft (FIELD).

### Example

**DYV** is used to set a tartan-type spacing in a reservoir grid where NYRES equals 23:

```
DYV  
3*1000 3*500 3*200 5*100 3*200 3*500 3*1000 /
```

Repeat counts are used to setting repeated values, e.g. for the first three rows.



## 2.85 DZ

### Description

This keyword can be used to set the thickness of the cells along K (Z) direction in a block-centered geometry.

It is followed by one value for each grid cell in the input box, which by default is the entire grid, provided according to a natural ordering with index along I running faster, then along J and last along K. Input is terminated by a slash character while repeat counts may be used for repeated values.

In a block-centered geometry it is necessary to provide [DZ](#) values for all grid cells, then filling a 3D array which can be manipulated by other keywords (e.g.[ADD](#)).

Units are m (METRIC) or ft (FIELD).

**Units:** ft (FIELD), m (METRIC)

### Example

```
DZ  
300*10 /
```



## 2.86 DZV

### Description

This keyword can be used to define cell thickness in a block-centered geometry grid by providing NZRES values (see [DIMENS](#) keyword in RUNSPEC) in a single, slash-terminated record. [DZV](#) sets [DZ](#) values for all the grid cells and cells with the same K index have the same [DZ](#). Notably, as for many other keywords for 3D Arrays, it is possible to use repeat counts for repeated values.

Units are m (METRIC) or ft (FIELD).

### Example

[DZV](#) is used to set thickness in a reservoir grid where NZRES equals 23:

```
DZV  
3*1000 3*500 3*200 5*100 3*200 3*500 3*1000 /
```

Repeat counts are used to setting repeated values, e.g. for the first three rows.



## 2.87 EDITNNC

### Description

The `EDITNNC` keyword can be used to multiply the transmissibility generated for any existing non-neighbor connection. Each line following the `EDITNNC` keyword specifies previously defined non-neighbor connection pairs to be modified. Each NNC modification is terminated with a slash (/). The keywords is terminated with a single slash (/) after all records. Any NNC with a transmissibility less than  $10^{-6}$  is ignored (see `MINNNCT`).

Users can define non-neighbor connections via the `NNC` keyword. Non-neighbor connections are also generated automatically for several conditions such as faulting via corner point offset, pinchouts, dual-media, LGRs and numerical aquifers.

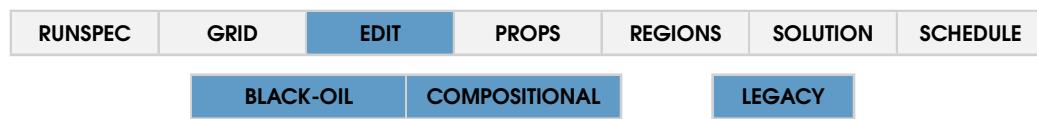
### Record format

Field	Name	Type	Minimum	Maximum	Description
1	I1	Integer	1	NX	I index for the first cell of NNC to be edited
2	J1	Integer	1	NY	J index for the first cell of NNC to be edited
3	K1	Integer	1	NZ	K index for the first cell of NNC to be edited
4	I2	Integer	1	NX	I index for the second cell of NNC to be edited
5	J2	Integer	1	NY	J index for the second cell of NNC to be edited
6	K2	Integer	1	NZ	K index for the second cell of NNC to be edited
7	TRANS_MULT	Float	0		Transmissibility multiplier between two defined NNC cells

### Example

Three previously defined non-neighbor connection transmissibilities are reduced.

```
EDITNNC
--I1 J1 K1 I2 J2 K2 Trans
 9 9 10 10 9 20 0.10/
 10 9 10 11 9 20 0.10/
 11 9 10 12 9 20 0.10/
/
```



## 2.88 EDITNNCR

### Description

The EDITNNCR keyword can be used to replace the transmissibility generated for existing non-neighbor connections. Each line following the EDITNNCR keyword specifies previously defined non-neighbor connection pairs to be modified. Each NNC modification is terminated with a slash (/), and the keyword is ended with an additional slash on its own line. Any NNC with transmissibility less than  $10^{-6}$  is ignored (see [MINNNCT](#)).

Users can define non-neighbor connections via the [NNC](#) keyword. Non-neighbor connections are also generated automatically for several conditions such as faulting via corner point offset, pinchouts, dual-media, LGRs and numerical aquifers. This keyword is commonly supplied from pre-processors which may have a different means to calculate the NNC transmissibility compared to the default method in ECHELON.

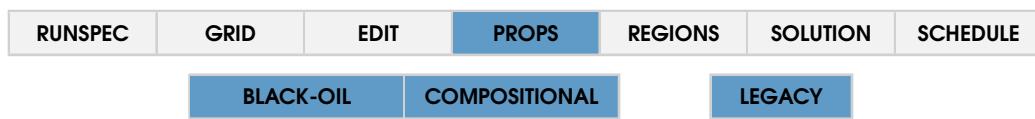
### Record format

Field	Name	Type	Description
1	I1	Integer	I index for the first cell of NNC to be edited
2	J1	Integer	J index for the first cell of NNC to be edited
3	K1	Integer	K index for the first cell of NNC to be edited
4	I2	Integer	I index for the second cell of NNC to be edited
5	J2	Integer	J index for the second cell of NNC to be edited
6	K2	Integer	K index for the second cell of NNC to be edited
7	TRANS	Float	Transmissibility value between two defined NNC cells

### Example

Overwrite previously defined non-neighbor connection transmissibilities.

```
EDITNNCR
--I1 J1 K1 I2 J2 K2 Trans
 9 9 10 10 9 20 3.0/
 10 9 10 11 9 20 3.5/
 11 9 10 12 9 20 4.0/
/
```



## 2.89 EHYSTR

### Description

The EHYSTR keyword defines the relative permeability and capillary pressure hysteresis models and parameters to be used when the HYSTER flag is selected in the SATOPTS keyword in the PROPS section.

The keyword has a single record. Some parameters can be specialized by saturation region using the EHYSTRR keyword.

### Record format

1. **PC\_CURVATURE:** Curvature parameter of the Killough capillary pressure hysteresis model.

**Type:** Float

**Default value:** 0.1

**Allowed values:**

2. **KR\_HYST\_MODEL:** Integer specifying the relative permeability hysteresis model to be used.

**Type:** Integer

**Default value:** 0

**Allowed values:**

Name	Description
0	Modified Carlson model used for the non-wetting phases (gas-to-oil, and oil-to-water), no hysteresis used for wetting phases (water-to-oil and oil-to-gas. Drainage curves used).
1	Modified Carlson model used for the non-wetting phases (gas-to-oil, and oil-to-water), no hysteresis used for wetting phases (water-to-oil and oil-to-gas. Imbibition curves used).
2	Killough model used for the non-wetting phases (gas-to-oil, and oil-to-water), no hysteresis used for wetting phases (water-to-oil and oil-to-gas. Drainage curves used).
3	Killough model used for the non-wetting phases (gas-to-oil, and oil-to-water), no hysteresis used for wetting phases (water-to-oil and oil-to-gas. Imbibition curves used).
4	Killough model used for both wetting and non-wetting phases.
10	Original Carlson model used for the gas-to-oil relative permeability hysteresis. No hysteresis used for oil-to-water and wetting phases (water-to-oil and oil-to-gas. Drainage curves used).
11	Original Carlson model used for the gas-to-oil relative permeability hysteresis. No hysteresis used for oil-to-water (Drainage curves used) and wetting phases (water-to-oil and oil-to-gas. Imbibition curves used).

3. **KR\_CURVATURE:** Killough relative permeability model curvature parameter.

**Type:** Float

**Default value:** 0.1

**Allowed values:**

4. **LAND\_MODIFIER:** Modifier to the Land trapping model for nonwetting phase, used with the Killough and the original Carlson model.

**Type:** Float

**Default value:** 0.1

5. **HYSTER\_SCOPE:** Flag defining the hysteresis model scope.

**Type:** String**Default value:** BOTH**Allowed values:**

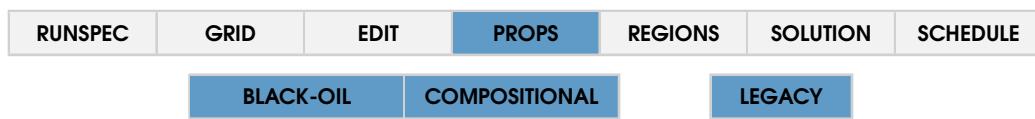
Name	Description
KR	Limited to relative permeability.
PC	Limited to capillary pressure.
BOTH	Applies to both relative permeability and capillary pressure.

6. *Reserved*
7. *Reserved*
8. *Reserved*
9. *Reserved*
10. *Reserved*
11. *Reserved*
12. *Reserved*
13. *Reserved*
14. **LAND\_PARAMETER:** Land parameter (C), to be used with the original Carlson model. If set to 0, the parameter will be calculated internally by the simulator to match ISGCR from the imbibition relative permeability curves. This is ignored when the hysteresis model is different from the original Carlson model.  
**Type:** Float  
**Default value:** 0
15. **LINEAR\_FRAC:** Fraction of the gas saturation range between Sgmax and Sgcrt where the relationship between flowing gas saturation and gas saturation is linearized (as opposed to coming from the original Carlson model). This is ignored when the hysteresis model is different from the original Carlson model.  
**Type:** Float  
**Default value:** 0.1

**Example**

In this example, we are using the original Carlson model applied to the gas phase relative permeability, while the oil and water phases do not undergo hysteresis. Capillary hysteresis is disabled. The Land parameter is set to C=2, and the linear fraction is set to 1e-3.

```
EHYSTR
1* 10 2* KR 8* 2 0.001 /
```



## 2.90 EHYSTRR

### Description

The `EHYSTRR` keyword allows for redefining relative permeability and capillary pressure hysteresis parameters per saturation region. Note that the `EHYSTR` keyword is still required.

One record per saturation region is expected.

### Record format

1. **PC\_CURVATURE:** Curvature parameter of the Killough capillary pressure hysteresis model.  
**Type:** Float  
**Default value:** 0.1  
**Allowed values:**
2. **KR\_CURVATURE:** Killough relative permeability model curvature parameter.  
**Type:** Float  
**Default value:** 0  
**Allowed values:**
3. **LAND\_MODIFIER:** Modifier to the Land trapping model for nonwetting phase, used with the Killough and the original Carlson model.  
**Type:** Float  
**Default value:** 0.1  
**Allowed values:**
4. **LAND\_PARAMETER:** Land parameter (C) to be used with the original Carlson model. If set to 0, the parameter will be calculated internally by the simulator to match ISGCR from the imbibition relative permeability curves. This is ignored when the hysteresis model is different from the original Carlson model.  
**Type:** Float
5. **LINEAR\_FRAC:** Fraction of the gas saturation range between Sgmax and Sgcrt where the relationship between flowing gas saturation and gas saturation is linearized (as opposed to coming from the original Carlson model). This is ignored when the hysteresis model is different from the original Carlson model.  
**Type:** Float

### Example

In this example with 2 saturation regions, we are overriding the Land parameter and the linear fraction.

```
EHYSTRR
3* 2 0.001 /
3* 4 0.001 /
```

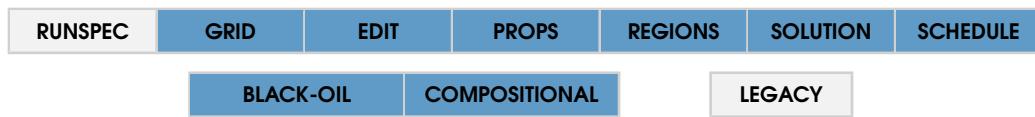


## 2.91 ENDACTIO

### Description

The ENDACTIO keyword terminates a set of commands to be executed when conditions of the previous ACTIONX keyword are triggered.

The keyword has no data, and terminating slash (/) is not required.



## 2.92 ENDBOX

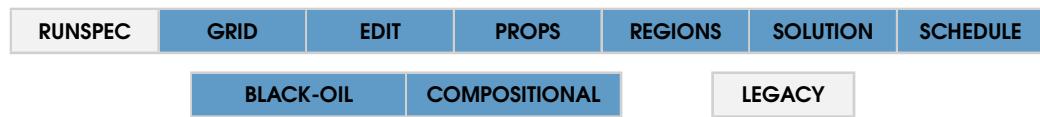
### Description

This keyword resets the current input box to the entire reservoir. It follows a `BOX` keyword.

#### Example

In this example `BOX` is used to define a subgrid of 4 x 4 x 3 cells, where various properties can be set/modified, and `ENDBOX` resets the input volume to the entire grid:

```
BOX
  16 19 23 26 10 12 /
ENDBOX
```



## 2.93 ENDFIN

### Description

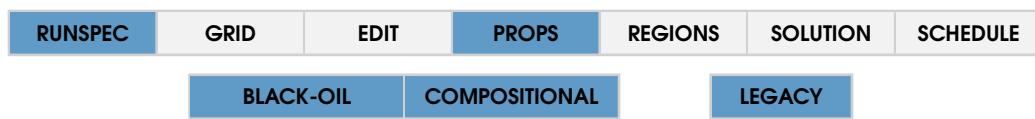
This keyword can be used to close input of data for local grid set by [CARFIN](#) or [REFINE](#) keyword.

### Example

[CARFIN](#) is used to define an LGR and [PERMZ](#) is locally updated:

```
CARFIN
  LGR1 21 23 15 17 1 10 9 9 10 1 /
EQUALS
  PERMZ 1000 1 9 1 9 1 10 /
  PERMZ 10000 4 6 4 6 1 10 /
/
ENDFIN
```

The input stream for LGR1 is turned off using [ENDFIN](#).



## 2.94 ENDSCALE

### Description

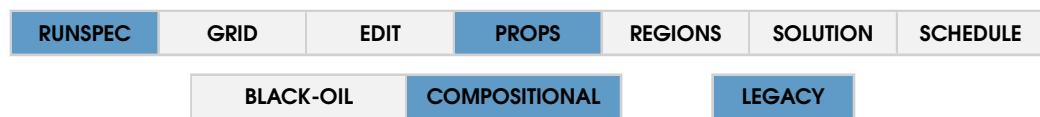
This keyword turn on the End Point Scaling (EPS) option in the simulation. The keyword is followed by an empty record with a terminating slash character.

EPS is described in the simulator technical documentation (see [Section 10.3](#) and [Section 10.4](#))

### Example

Turning on end point scaling in RUNSPEC

```
ENDSCALE  
/
```



## 2.95 EOS

### Description

This keyword specifies the type of equation of state that is used in a compositional simulation. The types of equations of state currently supported, as stated in [Section 7.4](#) in Technical Documentation, are Peng-Robinson, Redlich-Kwong and Soave-Redlich-Kwong. These are indicated by the strings “PR”, “RK”, and “SRK”, respectively. If multiple equations of state are used, a type must be specified for each of them.

### Record format

1. **EOS\_TYPE:** Type of cubic eos equation

**Type:** String

#### Example 1

This example specifies the use of the Peng-Robinson equation of state in a compositional simulation.

```
EOS  
PR /
```

#### Example 2

This example specifies the use of the Peng-Robinson equation of state in a compositional simulation with three EOS regions.

```
EOS  
PR /  
PR /  
PR /
```



## 2.96 EOSNUM

### Description

Use of the EOSNUM keyword in the region section assigns cells to specific regions for the equation of state (EOS) calculations. The EOSNUM keyword is followed by a single, slash terminated record. This record consists of one integer for each cell in the current input box, to specify the EOSNUM region to which it belongs. The input sequence follows a natural ordering with I running faster followed first by J and then K. Integer values are bounded by the ninth item of RUNSPEC TABDIMS keyword, which is the maximum number of input EOS regions. Repeat counts may be used for repeated values, e.g. 10\*2 sets. The data following the keyword(s) must be terminated by a slash (/). Notably, if a cell EOSNUM is not set the default value (one) is used.

Also note that all cells within specified equilibration regions EQLNUM should share the same values for PVTNUM and/or EOSNUM to ensure initial hydrostatic equilibrium. ECHELON can also handle different EOS regions for surface and subsurface flow. Reports in the PRT file provide in-place values for the entire reservoir as well as each defined FIPNUM region. The corresponding EOS for the surface regions is entered using the EOSS keyword.

By default, the EOS number defined by EOSNUM for cells with well completions is used for calculating the volumetric flow rates of that well. If a well has completed cells in different EOS regions, the EOS number from the lowest completion is selected for use in calculating volumetric flows. ECHELON also uses wellbore values for calculating the completion level reports. It is possible to select a different EOS to be used in the surface volumetric calculations by specifying the EOS number to be used on FIELDSEP or SEPCOND keywords. When using EOSNUM, if a fluid-in-place region consists of multiple EOS cells, then the total moles are calculated for all the cells in that region that belong to the same EOSNUM and then the flash calculation is applied to each separate EOS grouping.

### Example

EOSNUM is used here to assign region 1 for the first 10,000 cells and region 2 for the second 10,000 cells for the grid box of interest.

```
EOSNUM
 10000*1  10000*2 /
```



## 2.97 EQLDIMS

### Description

The [EQLDIMS](#) keyword specifies parameters for the generation of the initial state of the system through vertical hydrostatic equilibration. These parameters include the number of separate equilibration regions as well as the number of depth nodes that are internally generated to specify the depth variation of reservoir properties. See also the [EQUIL](#) keyword, which is used to give the parameters constraining each equilibration region.

### Record format

Field	Name	Type	Default	Description
1	NTEQUIL	Integer	1	The number of separate hydrostatic equilibration regions for the model. The region numbers for each cell are specified by <a href="#">EQLNUM</a> .
2	NDNODES	Integer	BO: 100 COMP: 50	The number of nodes in the tables constructed to give the variation of reservoir properties with depth during vertical equilibration.
3				<i>Reserved</i>
4	NTTRVD	Integer		The number of tables giving the vertical variation of tracer concentration with depth, specified by the <a href="#">TVDP</a> keyword.

### Example

The following overrides the number of depth nodes used in vertical equilibration to 200 for higher resolution and sets the number of tracer vs. depth tables to 5.

```
EQLDIMS
1* 100 1* 5 /
```



## 2.98 EQLENUM

### Description

The [EQLENUM](#) keyword is used to specify the vertical equilibration region to which each cell belongs. This facility is used to model reservoirs with isolated, non-communicating compartments that may contain fluids of differing composition, pressure, contact depths, etc. Care should be taken that all the cells in each equilibration region also have the same value for [PVTNUM](#) and/or [EOSNUM](#), otherwise an error will be issued. Also note that the total number of equilibration regions (i.e. the maximum values of [EQLDIMS](#)) should be specified in the first field of the [EQLDIMS](#) keyword.

### Example

For a  $4 \times 4 \times 3$  model, the following places the left half in the first equilibration region and the right half in the second equilibration region:

```
EQLENUM
1 1 2 2   1 1 2 2   1 1 2 2   1 1 2 2
1 1 2 2   1 1 2 2   1 1 2 2   1 1 2 2
1 1 2 2   1 1 2 2   1 1 2 2   1 1 2 2
/

```



## 2.99 EQLOPTS

### Description

The [EQLOPTS](#) keyword enables options for the threshold pressure feature. The keyword should be followed by a single record, optionally containing either or both of the options specified in the table below.

### Record format

Name	Description
THPRES	Enable the use of threshold pressures between equilibration regions using the <a href="#">THPRES</a> keyword and/or threshold values for named faults with the <a href="#">THPRESFT</a> keyword.
IRREVER	When using threshold pressures between equilibration regions, this keyword indicates that a separate value will be specified for each direction.

#### Example 1

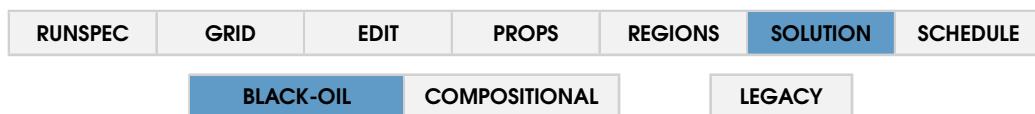
To enable the symmetric threshold pressure option:

```
EQLOPTS  
THPRES /
```

#### Example 2

To enable a nonsymmetric threshold pressure between equilibration regions:

```
EQLOPTS  
THPRES IRREVER /
```



## 2.100 EQLSPECS

### Description

The [EQLSPECS](#) keyword is used to provide information regarding the fluid type and contact information for each equilibration region in the model. It should be followed by NTEQUIL slash-terminated records, each containing key-value pairs. NTEQUIL is the number of vertical equilibration regions specified in the first field of the [EQLDIMS](#) keyword. These records may be left empty, in which case the default values will be used for the corresponding region. The keyword is currently only supported in black-oil models.

In initializing a model in vertical hydrostatic equilibrium using the [EQUIL](#) keyword, data from multiple keywords is taken into account. For example, [RSVD](#), [RVVD](#), [PBVD](#) or [PDVD](#) may be used to provide the solution gas-oil ratio, oil-gas ratio, bubble-point pressure, or dew-point pressure, respectively. These four keywords provide the black-oil fluid composition as a function of depth. The [EQUIL](#) keyword has fields to set the depth of the gas-oil contact and the pressure and depth of a datum point.

If all of these data are supplied, the conditions for the vertical equilibrium calculation may be overdetermined. For example, if [PBVD](#) and the gas-oil contact depth are provided, the reservoir pressure must match the bubble-point pressure at the contact depth. Any provided datum pressure and depth may be inconsistent with that pressure.

In cases such as this, the [EQLSPECS](#) may be used to specify which of the potentially inconsistent data should be honored, and which will be recalculated from the honored data to maintain consistency.

### Record format

Name	Value Type	Default	Description
FLUIDSYSTEM	String	BUBBLE_POINT	Specifies the type of fluid system for each equilibration region. When specified, it must be one of "BUBBLE_POINT" or "DEW_POINT".
HONORTYPE	String	DATUM_PLUS_GOC	Specifies which data to honor when contact data is conflicting. When specified, it must be one of "GOC_PLUS_COMP", "DATUM_PLUS_COMP" or "DATUM_PLUS_GOC". <ul style="list-style-type: none"> <li>■ GOC_PLUS_COMP: the gas-oil contact depth and composition are honored, while the pressure at the datum depth is computed to be consistent with these data</li> <li>■ DATUM_PLUS_COMP: the datum pressure and fluid composition are honored, while the gas-oil-contact depth is computed to be consistent with the provided data pressure and composition</li> <li>■ DATUM_PLUS_GOC: the datum pressure and gas-oil contact depth are honored, while the composition is adjusted to ensure that the bubble or dew-point is reached at the contact depth</li> </ul>

**Example**

For a model with two equilibration regions and a gas-oil contact at the bubble point:

```
EQLSPECs
FLUID_SYSTEM="BUBBLE_POINT" HONOR_TYPE="DATUM_PLUS_GOC" /
FLUID_SYSTEM="BUBBLE_POINT" HONOR_TYPE="GOC_PLUS_COMP" /
```



## 2.101 EQLZCORN

### Description

This keyword can be used to set new values to corner points depth array ([ZCORN](#)). The modification can be continuous with respect to the adjacent cells or discontinuous, depending on the settings in items 8 to 11 of each record.

The corner points of the cells to be modified are selected considering a box defined by six integers (fields 2 to 7 in the table) subject to the following constraints:

$$0 \leq I\text{MIN} \leq I\text{MAX} \leq NX$$

$$0 \leq J\text{MIN} \leq J\text{MAX} \leq NY,$$

$$0 \leq K\text{MIN} \leq K\text{MAX} \leq NY.$$

If in any record these indexes are defaulted, they are set to the values which were used for the previous operation within the current keyword or, for the first operation, to a previously defined box. If no box was defined the operation is applied to the whole reservoir.

### Record format

1. **Constant:** New value for the z-coordinates of the cell corner points.  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
2. **I<sub>MIN</sub>:** First cell to be updated along the I-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** 1
3. **I<sub>MAX</sub>:** Last cell to be updated along the I-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** NX
4. **J<sub>MIN</sub>:** First cell to be updated along the J-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** 1
5. **J<sub>MAX</sub>:** Last cell to be updated along the J-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** NY
6. **K<sub>MIN</sub>:** First cell to be updated along the K-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** 1
7. **K<sub>MAX</sub>:** Last cell to be updated along the K-direction

- Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** NZ
8. **IMIN\_A:** IMIN-1 or IMIN  
**Type:** Integer  
**Default value:** IMIN-1 if IMIN > 1
  9. **IMAX\_A:** IMAX+1 or IMAX  
**Type:** Integer  
**Default value:** IMAX+1 if IMAX < NX
  10. **JMIN\_A:** JMIN-1 or JMIN  
**Type:** Integer  
**Default value:** JMIN-1 if JMIN > 1
  11. **JMAX\_A:** JMAX+1 or JMAX  
**Type:** Integer  
**Default value:** JMAX+1 if JMAX < NY
  12. **KMIN\_A:** KMIN-1 or KMIN  
**Type:** Integer  
**Default value:** KMIN-1 if KMIN > 1
  13. **KMAX\_A:** KMAX+1 or KMAX  
**Type:** Integer  
**Default value:** KMAX+1 if KMAX < NZ
  14. **OPERATION:** Action: TOP or BOTTOM  
**Type:** String  
**Default value:** TOP

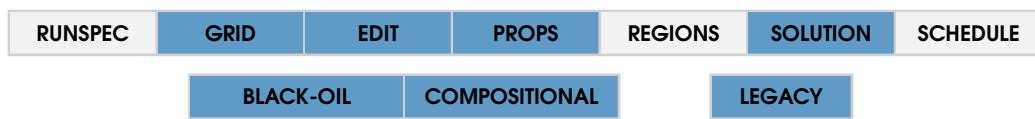
**Allowed values:**

Name	Description
ALL	modify both top and bottom corners z-coordinates of all cells
TOP	modify both top and bottom corners z-coordinates of all cells except for cells in the bottom layer where only the top corners are modified
BOTTOM	modify both top and bottom corners z-coordinates of all cells except for cells in the top layer where only the bottom corners are modified

**Example**

In this example, **EQLZCORN** is used to assign new corner points in a 10x10x5 model

```
EQLZCORN
5000.0 1 10 1 10 1 1 / Set the top of the model to 5000 ft
5500.0 4 6 7 8 5 5 4* BOTTOM / Set the bottom of a region to 5500
/
```



## 2.102 EQUALREG

### Description

This keyword can be used to set a constant value for a target 3D array, or a subset of, using a region 3D array as filter. The keyword can be followed by an arbitrary number of records defined as in the table, with an empty record having only the slash (/) character to terminate the input.

The [EQUALREG](#) operation is repeated for every record, copying values from the source 3D array into the destination 3D array, filtering using by default [MULTNUM](#). Alternatively it is possible to choose [FLUXNUM](#) or [MULTNUM](#) as region 3D array used to filter cells.

### Available 3D arrays

Available 3D arrays for [EQUALREG](#) keyword on a section basis are:

#### GRID

[DX](#), [DY](#), [DZ](#), [PERMX](#), [PERMY](#), [PERMZ](#), [MULTX](#), [MULTY](#), [MULTZ](#), [PORO](#), [NTG](#), [FLUXNUM](#), [MULTNUM](#), [OPERNUM](#)

#### EDIT

[PORV](#), [DEPTH](#), [TRANX](#), [TRANY](#), [TRANZ](#)

#### PROPS

[SWL](#), [SWCR](#), [SWU](#), [SGL](#), [SGCR](#), [SGU](#), [KRW](#), [KRO](#), [KRG](#), [KRWR](#), [KRGR](#), [KRORW](#), [KRORG](#), [ISWL](#), [ISWCR](#), [ISWU](#), [ISGL](#), [ISGCR](#), [ISGU](#), [IKRW](#), [IKRO](#), [IKRG](#), [IKRWR](#), [IKRGR](#), [IKRORW](#), [IKRORG](#), [PCW](#), [PCG](#), [IPCW](#), [IPCG](#)

#### REGIONS

[SATNUM](#), [PVTNUM](#), [FIPNUM](#), [ROCKNUM](#), [MISCTNUM](#), [EOSNUM](#), [EQLNUM](#)

#### SOLUTION

[PRESSURE](#), [SWAT](#), [SGAS](#), [RV](#), [RS](#), [TBLK](#), [SOIL](#), [PBUB](#), [PDEW](#), [SALT](#)

### Record format

Field	Name	Type	Default	Description
1	Target	String		Target 3D Array
2	Constant	Float		Constant to reset target 3D array values
3	Filter	Integer		region number to filter grid cells
4	Region	Integer	M	3D region array used as filter; it can be M for <a href="#">MULTNUM</a> , F for <a href="#">FLUXNUM</a> , or O for <a href="#">OPERNUM</a>

### Example 1

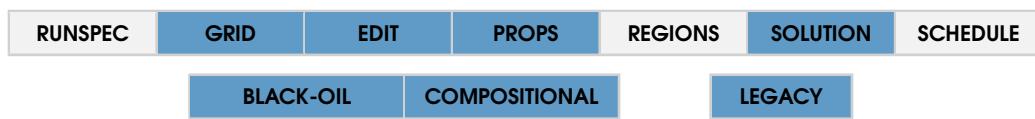
[EQUALREG](#) is used in [GRID](#) section to set [PERMX](#) to 1.0 for [MULTNUM](#) cells with value equal to 4

```
COPYREG
  PERMX 1 4 /
  /
```

**Example 2**

**EQUALREG** is used in **PROPS** section to set **SWL** to 0.4 for cells where **FLUXNUM** equals 4, and 0.15 for cells where **OPERNNUM** equals 5

```
EQUALREG
  SWL 0.4 5 F /
  SWL 0.15 5 O /
/
```



## 2.103 EQUALS

### Description

This keyword can be used to set equal to a constant a given 3D array inside a set of grid cells, or for the entire grid the 3D array refers to. The keyword can be followed by an arbitrary number of records defined as in the table, with an empty record having only the slash (/) character to terminate the input.

The `EQUALS` operation is repeated for every record, setting values of 3D arrays in a box of cells defined by six integers (fields 3 to 8 in the table) subject to the following constraints:

$$1 \leq I\text{MIN} \leq I\text{MAX} \leq NX,$$

$$1 \leq J\text{MIN} \leq J\text{MAX} \leq NY,$$

$$1 \leq K\text{MIN} \leq K\text{MAX} \leq NZ.$$

If `EQUALS` is used for global grid arrays, `NX=NXRES`, `NY=NYRES` and `NZ=NZRES`. If `EQUALS` is used within a local grid refinement definition (`CARFIN/ENDFIN` block) or within a local grid refinement editing (`REFINE/ENDFIN` block) then the 3D array at hand is inside the local refinement and the cell box is bounded by local grid dimension (i.e `NXREF`, `NYREF` and `NZREF`). Similarly, inside a `BOX/ENDBOX` block `NX`, `NY` and `NZ` are set according to `BOX` record. Notably, if you define a cell box in one record, then the next record inherits that cell box limits as its default values for fields 3 to 8.

### Available 3D arrays

Available 3D arrays for `EQUALS` keyword on a section basis are:

#### GRID

`DX`, `DY`, `DZ`, `PERMX`, `PERMY`, `PERMZ`, `MULTX`, `MULTY`, `MULTZ`, `PORO`, `MULTPV`, `NTG`, `FLUXNUM`, `MULTNUM`, `OPERNUM`, `ACTNUM`

#### EDIT

`PORV`, `DEPTH`, `TRANX`, `TRANY`, `TRANZ`

#### PROPS

`SWL`, `SWCR`, `SWU`, `SGL`, `SGCR`, `SGU`, `KRW`, `KRO`, `KRG`, `KRWR`, `KRGR`, `KRORW`, `KRORG`, `ISWL`, `ISWCR`, `ISWU`, `ISGL`, `ISGCR`, `ISGU`, `IKRW`, `IKRO`, `IKRG`, `IKRWR`, `IKRGR`, `IKRORW`, `IKRORG`, `PCW`, `PCG`, `IPCW`, `IPCG`

#### REGIONS

`SATNUM`, `PVTNUM`, `FIPNUM`, `ROCKNUM`, `MISCTNUM`, `EOSNUM`, `EQLNUM`

#### SOLUTION

`PRESSURE`, `SWAT`, `SGAS`, `RV`, `RS`, `TBLK`, `SOIL`, `PBUB`, `PDEW`, `SALT`

#### Record format

Field	Name	Type	Default	Minin	Maxin	Description
1	3D array	String				target 3D array to be updated
2	Constant	Float				constant used in the operation
3	IMIN	Integer	1	1	NX	First cell to be updated along the I-direction
4	IMAX	Integer	NX	1	NX	Last cell to be updated along the I-direction
5	JMIN	Integer	1	1	NY	First cell to be updated along the J-direction
6	IMAX	Integer	NY	1	NY	Last cell to be updated along the J-direction
7	KMIN	Integer	1	1	NZ	First cell to be updated along the K-direction
8	KMAX	Integer	NZ	1	NZ	Last cell to be updated along the K-direction

### Example 1

In this example, defined in section [GRID](#), we set [PERMX](#) and [PORO](#) for the whole grid (the first and second record), [PERMX](#) and [PORO](#) are then set to a different value for a box of cells (the third and fourth record). Please note that [PORO](#) is set to 0.2 for the cells in the box defined in the previous record.

```

EQUALS
PERMX 200 /
PORO 0.3 /
PERMX 0.2 1 20 1 15 16 16 /
PORO 0.05 /
/

```

### Example 2

In this example we use [EQUALS](#) to define [SATNUM](#) and [EQLNUM](#) in the [REGIONS](#) section.

```

EQUALS
SATNUM 1 /
EQLNUM 1 /
SATNUM 1 1 20 1 20 1 15 /
SATNUM 2 1 20 1 20 1 15 /
/

```

It is worth noticing that the values for the 3D array in the [REGIONS](#) section are integers.



## 2.104 EQUAL\_FRAC

### Description

This keyword can be used to set the static or dynamic properties of fractures within fracture or stimulated rock volume media. This keyword is a deprecated keyword and even though it is supported for backward compatibility, users are encouraged to use [MODIFY\\_FRAC\\_PROPS](#).

The properties that can be modified using this keyword are static properties, e.g. permeabilities (PERMX, PERMY, PERMZ), porosity (PORO); solution states, e.g. SWAT, SGAS, PRESSURE, RS, RV; region numbers, e.g. ROCKNUM and SATNUM. These properties can be changed in hydraulic fracture (HF), stimulated rock volume (SRV) or the entire LGRs around a fracture by using (ALL). It is followed by a single slash-terminated record containing an arbitrary number of key-value pairs for the form NAME=value. The valid mnemonics for NAME and their associated values are enumerated in the table below. This keyword can be followed by an arbitrary number of templates definition and it is terminated with an empty record having only the slash (/) character.

### Record format

Name	Value Type	Description
well_name	String	Well name
frac_number	Integer	Fractures number to be modified
region	String	Regions to modify in each fracture, the options can be hydraulic fracture ('HF'), stimulated rock volume ('SRV') or the entire LGRs around a fracture ('ALL) by using the relevant acronyms.
media	String	The media to be modified in case of a dual porosity model, which can be 'MATRIX' or 'FRACTURE'.
SIGMA	Float	Sigma value for the fracture media in case of dual porosity model
PERMX/PERMY/PERMZ	Float	Permeability of the fracture to be modified
PORO	Float	Porosity of the fracture to be modified
SWAT/SGAS	Float	Saturation to be modified. Special care should be taken because this can cause discontinuity in the solution and convergence problem
PRESSURE	Float	Pressure to be modified. Special care should be taken because this can cause discontinuity in the solution and convergence problem
SATNUM	Integer	The saturation function to be used in the fracture
ROCKNUM	Float	The rock compaction table to be used in the fracture

### Example

In this example, the saturation function and rock compaction for all the hydraulic fractures in well 'P1' are set. The rock compaction table 3 is used for fracture 5 and 7.

EQUAL\_FRAC

```
well_name=P1 region=HF SATNUM=2 ROCKNUM=2 /
well_name=P1 region=HF ROCKNUM=3 frac_number=5 /
well_name=P1 region=HF ROCKNUM=3 frac_number=7 /
/
```



## 2.105 EQUIL

### Description

The EQUIL keyword is used to specify the parameters which constrain the calculation of the initial state of the reservoir, assuming that the fluids are in vertical hydrostatic equilibrium. This keyword is followed by NTEQUIL (see TABDIMS keyword) records, one for each equilibration region.

The initialization process under equilibrium conditions for both black-oil and compositional models is documented in [Chapter 12](#) inside Technical Documentation.

### Record format

1. **DATUM\_DEPTH:** Datum depth  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
2. **DATUM\_PRES:** Datum pressure  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)
3. **WOC\_DEPTH:** Water-Oil contact (WOC) depth  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
4. **WOC\_PC:**  $p_{cow}$  at the WOC depth  
**Type:** Integer  
**Units:** psi (FIELD), bar (METRIC)
5. **GOC\_DEPTH:** Gas-oil contact (GOC) depth. For undersaturated gas-condensate reservoir or dry gas reservoir GOC depth must match WOC depth  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
6. **GOC\_PC:**  $p_{cgo}$  at the GOC depth  
**Type:** Integer  
**Units:** psi (FIELD), bar (METRIC)
7. **BO\_INIT\_TYPE:** Type of equilibration for black-oil simulations  
**Type:** Integer  
**Default value:** 0  
**Allowed values:**

Name	Description
> 0	Specifies that an $R_s$ vs. depth ( <a href="#">RSVD</a> ) or $P_b$ vs. depth table ( <a href="#">PBVD</a> ) will be used to determine the solution gas-oil ratio in undersaturated oil. If this option is specified, one of these tables must be provided.
<= 0	Specifies that the $R_s$ for oil below the GOC should be taken as the saturated $R_s$ value at the contact depth. No <a href="#">RSVD</a> or <a href="#">PBVD</a> table is required.

8. **BO\_WG\_INIT\_TYPE:** Type of equilibration for black-oil simulations with wet gas  
**Type:** Integer
9. **NDIV:** Number of subdivisions used in determining the saturation of each cell when interpolating from the vertical equilibration tables.  
**Type:** Integer  
**Default value:** BO: -5, COMP: 0

**Allowed values:**

Name	Description
NDIV=0	cells are treated as tilted and they are split into 2*NDIV levels, above and below the center of the cell. The simulator computes cell saturation as a pore volume-weighted average of the saturations in these levels
NDIV>0	cells are treated as tilted and they are split into 2*NDIV levels, above and below the center of the cell. The simulator computes cell saturation as a pore volume-weighted average of the saturations in these levels
NDIV <=	cells are treated as horizontal and then split into 2 NDIV +1 equally spaced layers. Fluid saturations are set for the cell using the average of the saturations in these layers, This improves the volumetric accuracy but does not lead necessarily to an equilibrium solution

10. **COMP\_INIT\_TYPE:** compositional initialisation mode**Type:** Integer**Default value:** 1**Allowed values:**

Name	Description
1	Continuous hydrocarbon column without a gas-oil contact in the reservoir. This includes supercritical fluids where the phase transition between vapor and liquid is smooth.
2	Gas-oil contact with vapor composition at that depth, Pressure at GOC is dew-point pressure.
3	Gas-oil contact with liquid composition at that depth, Pressure at GOC is bubble point pressure.

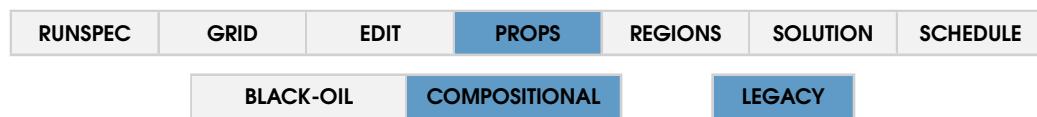
11. **HONOR\_DATUM\_PRES:** Modify saturation pressure if COMP\_INIT\_TYPE is not 1**Type:** Integer**Allowed values:**

Name	Description
1	if $ p_{datum} - p_{sat}  \geq 1\text{ atm}$ then $p_{datum} = p_{sat}$
0	$p_{datum}$ is retained anyway..

**Example**

[EQUIL](#) keyword used to initialize a black-oil model with [RSVD](#).

```
--      DATUM    DATUM    OWC      OWC      GOC      GOC      RSVD      RVVD      SOLN
--      DEPTH    PRESS    DEPTH    PCOW     DEPTH    PCOG     TABLE     TABLE     METH
EQUIL
      2355.00  234.46  2395.0  0.00   2355.0  0.000      1       1*       0      /
```



## 2.106 FACTLI

### Description

This keyword specifies, for each equilibration region, a multiplicative factor to be applied to the approximate critical temperature computed from Li's correlation.

The critical temperature of the hydrocarbon mixture in a cell is required to determine whether the mixture is to be labeled as oil or gas when single phase. Li's correlation being an approximation, the multiplicative factor may be needed to prevent mislabeling. If the factor is less than one, cells will more easily be labeled as gas, whereas if it is more than one, cells will more easily be labeled as oil.

The multiplicative factor is set to 1 by default, except when supercritical initialization is used, in which case it is automatically set to a value ensuring that at the GOC, the critical temperature matches the temperature.

### Record format

1. **FACTLI:** Component critical temperatures

**Type:** Float

### Example

This example specifies the Li critical temperature correction factors in a model with two equilibration regions.

```
FACTLI  
0.9 0.95 /
```



## 2.107 FAULTS

### Description

The FAULTS keyword provides a means to assign a name to a series of connected cell pairs to approximate a fault trajectory. Each line of the keyword specifies the face connections between cell pairs by defining the cell I, J, K ranges of interest as well as the cell faces (X, Y, Z) for which the user wants to adjust transmissibility (*e.g.*, to approximate fault damage). Once the faults are defined, the transmissibility of all cell pair faces assigned to a named fault can subsequently be modified by using the keyword [MULTFLT](#). [MULTFLT](#) provides a convenient way of modifying the transmissibility along the entire cell-pair faces defined by the FAULTS keyword. This keyword is commonly supplied by pre-processors in which the faults defined in building the grid are output as named faults for subsequent modification of fault transmissibility.

The initial generation of each cell pair connection transmissibility is governed by the standard geometric transmissibility calculations and does not depend on the fault definitions provided by the use of this keyword. Subsequent use of a [MULTFLT](#) keyword (in the [GRID](#), [EDIT](#) or [SCHEDULE](#) sections) modifies the calculated transmissibility values across the named fault pairs. Such fault definitions are often prepared via geologic modeling preprocessors. The keyword can also be used to control vertical transmissibility by using Z faces (*e.g.*, a mineralized horizontal fracture between geologic zones). [MULTFLT](#) would also modify any non-neighbor connection defined across fault segments.

Each connection line is terminated with a slash (/). After the last fault connection, a single slash (/) terminates the list. The example illustrates the requirement for consistency in defining cell ranges based on the cell faces being assigned.

### Record format

Field	Name	Type	Description
1	Fault Name	String	Fault Name (maximum of 8 characters)
2	IX1	Integer	Starting I-coordinate of cells along the fault.
3	IX2	Integer	Ending I-coordinate of cells along the fault. Must equal item 2 (starting I) if item 8 is X.
4	IY1	Integer	Starting J-coordinate of cells along the fault.
5	IY2	Integer	Ending J-coordinate of cells along the fault. Must equal item 4 (starting J) if item 8 is Y.
6	IZ1	Integer	Starting K-coordinate of cells along the fault.
7	IZ2	Integer	Ending K-coordinate of cells along the fault. Must equal item 6 (starting K) if item 8 is Z.
8	Fault Face	String	Must be a string X, Y, or Z (I, J, and K are also acceptable)

**Example**

A single fault (named FAULT\_A) is defined along the X or Y faces trending in the y-direction from Y cells 20 to 30. There is a small step change in the fault at Y=20. Comments illustrate the requirement for consistency in defining cell ranges based on the cell faces being assigned. Similarly, IZ1 must equal IZ2 if a Z face is being defined.

```
FAULTS
--Name      IX1  IX2  IY1  IY2  IZ1  IZ2  FACE
'FAULT_A'   9    9    10   20   1    5    X / --IX1 = IX2 if face is X
'FAULT_A'   9    10   20   20   1    5    Y / --IY1 = IY2 if face is Y
'FAULT_A'   10   10   21   30   1    4    X / --IX1 = IX2 if face is X
/
```



## 2.108 FBHPDEF

### Description

This keyword defines the default BHP limit for production and injection wells to be used when none is specified for the well. It does not overwrite any existing control defined for a well, that is if a BHP limit has been specified with keywords [WCONPROD](#), [WCONHIST](#), [WCONINJE](#) or [WCONINJH](#), it will be used as a limit and it will not be overwritten by [FBHPDEF](#) keyword.

The keyword must be terminated with a trailing slash (/).

### Record format

1. **BHP\_PROD:** BHP limit for production wells. For history matching, the default BHP in compositional runs is the same as that used for black-oil.

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** BO: 14.7 (FIELD), 1.01 (METRIC)

COMP: 1469.59 (FIELD), 101.32 (METRIC)

2. **BHP\_INJ:** BHP limit for injection wells

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** BO: 1E5 (FIELD), 6895 (METRIC)

COMP: 14695.9 (FIELD), 1013.25 (METRIC)

### Example

In this example, the default BHP limit of production wells is set to 150 and the default BHP limit of injection wells is set to 1200.

```
FBHPDEF  
150 1200 /
```



## 2.109 FIELD

### Description

The [FIELD](#) keyword indicates that field units are used in specifying all quantities in this simulation dataset. No record data is associated with this keyword.

### Example

```
FIELD
```

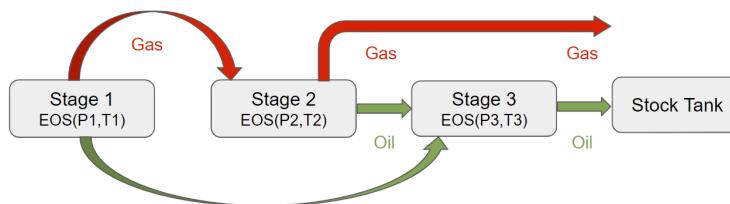


## 2.110 FIELDSEP

### Description

The **FIELDSEP** keyword is used to define the properties of the field-level liquid-vapor separator. The separator consists of any number of stages, each of which has a controlled temperature and pressure. The inlet of the separator consists of a stream of incoming hydrocarbons. Inside the separator, the liquid is segregated from vapor by gravity and exits through the lower outlet, while the vapor exits the upper outlet. The outlets can be directed to the stock tank or to another separator stage. By default, the vapor outlet is connected to the stock tank, while the liquid is directed to the next stage if it exists. This default stage layout is shown in Figure 2.1.

The keyword is followed by any number of slash-terminated records each of which defines the conditions and outlet destinations for one stage of the separator. The format of the record is shown below.



**Figure 2.1: Default connection topology for a typical separator.**

### Record format

1. **STAGE\_INDEX:** Index of the separator stage, starting with 1.  
**Type:** Integer
2. **STAGE\_TEMP:** Temperature of this stage of the separator.  
**Type:** Float  
**Units:** Fahrenheit (FIELD), Celsius (METRIC)  
**Default value:** 60 (FIELD), 15.56 (METRIC)
3. **STAGE\_PRES:** Pressure of this stage of the separator.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 14.6959 (FIELD), 1.01325 (METRIC)
4. **LIQUID\_DEST:** Destination stage for the liquid output of this stage. The default value of 0 implies the output will be directed to the next stage for all stages but the last. For the last, a zero implies the output of the stock tank. A value of -1 in any stage implies output to the stock tank. Directing intermediate stage liquids to the stock tank, however, will result in an inconsistent addition of oil volumes at different conditions.  
**Type:** Integer  
**Default value:** 0
5. **VAPOR\_DEST:** Destination stage for the vapor output of this stage. The default value of 0 implies the output will be directed to the stock tank, for which the volume is evaluated as that of an ideal gas at standard conditions. It is possible, although unusual, for the gas to be directed to another stage of the separator. In the case of gas reinjection from an intermediate stage, however, this adds complexity to the accounting of oil volumes. In particular, an “export” oil will be computed which is less than the total field production of oil by the amount of oil that

would have been produced from the vapor that would have been forwarded to the next stage if it were not used for reinjection.

**Type:** Integer

6. *Reserved*

7. **GAS\_PLANT\_TAB:** Gas plant table number.

**Type:** Integer

8. **SURF\_EOS\_NUM:** Surface equations of state number. If nonzero, this integer will specify the surface EOS to use for the flash calculation of each separator stage. If defaulted, fluid-in-place calculations will be performed by first summing the moles in each equation-of-state region, then flashing each region individually and accumulating the results from each region.

**Type:** Integer

9. **NGL\_TEMP:** Temperature at which the natural gas liquid density is evaluated.

**Type:** Float

**Units:** Fahrenheit (FIELD), Celsius (METRIC)

10. **NGL\_PRES:** Pressure at which the natural gas liquid density is evaluated.

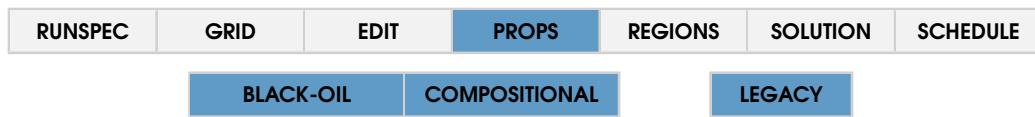
**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

### Example

The following gives conditions for a two-state separator with default topology:

```
FIELDSEP
1 90 350 /
2 60 14.7 /
/
```



## 2.111 FILLEPS

### Description

By default, ECHELON only reports to the INIT file [relative permeability and capillary pressure] endpoints that have been modified in the PROPS section, when then [ENDSCALE](#) keyword is present in the RUNSPEC section.

The [FILLEPS](#) keyword indicates that all endpoints, including non-modified ones (i.e., taken from the saturation tables associated to each cell), are to be reported.

See [Chapter 10](#).

### Example

```
FILLEPS
```



## 2.112 FIPNUM

### Description

This keyword is used to indicate which fluid-in-place region every grid block belongs to. It is followed by one integer value (fluid-in-place region number) for each grid cell in the input box, which by default is the entire grid, following natural ordering with index along I running faster, then along J and last along K. Repeat counts may be used for repeated values. A slash (/) should terminate the record. Integer values in the record should range from 1 to [NTFIP](#).

### Example

This example shows how 4 fluid-in-place regions can be defined for a 30x30x3 reservoir.

```
FIPNUM
600*1 300*2
600*3 300*2
600*4 300*2 /
```



## 2.113 FIPOWG

### Description

This keyword automatically creates a field-in-place region called “OWG” based on the depths of the cells. Cells with depths above the GOC in [EQUIL](#) are assigned to FIP index 1 (Gas zone). Cells with depths between the GOC and WOC are assigned to index 2 (Oil zone). All cells with a depth value below the WOC, specified in item 3 of [EQUIL](#) keyword, are assigned to index 3 (Water zone).

Reporting and UDQ support for FIPOWG is similar to FIPNUM and other FIP names as specified in [FIPXXX](#) keyword.

### Example

```
FIPOWG
```



## 2.114 FIPSEP

### Description

The **FIPSEP** keyword is used to define the properties of a liquid-vapor separator for fluid-in-place (FIP) regions. Each separator consists of any number of stages, each of which has a controlled temperature and pressure. The inlet of the separator consists of a stream of incoming hydrocarbons. Inside the separator, the liquid is segregated from vapor by gravity and exits through the lower outlet, while the vapor exits the upper outlet. The outlets can be directed to the stock tank or another separator stage. By default, the vapor outlet is connected to the stock tank, while the liquid is directed to the next stage if it exists. This default stage layout is shown in Figure 2.2.

The keyword is followed by any number of slash-terminated records each of which defines the conditions and outlet destinations for one stage of a FIP separator. The format of the record is shown below.

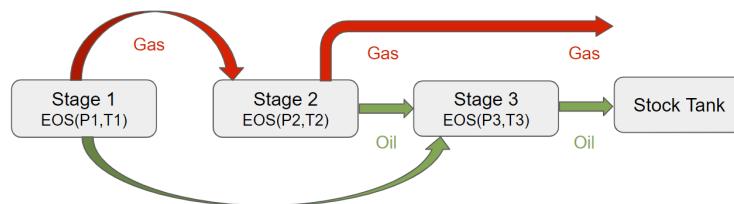


Figure 2.2: Default connection topology for a typical separator.

### Record format

1. **FIP\_REGION:** Fluid-in-place region for the separator stage specified in this record.  
**Type:** Integer
2. **STAGE\_INDEX:** Index of the separator stage, starting with 1.  
**Type:** Float  
**Default value:** 60 (FIELD), 15.56 (METRIC)
3. **STAGE\_TEMP:** Temperature of this stage of the separator.  
**Type:** Float  
**Units:** Fahrenheit (FIELD), Celsius (METRIC)  
**Default value:** 14.6959 (FIELD), 1.01325 (METRIC)
4. **STAGE\_PRES:** Pressure of this stage of the separator.  
**Type:** Integer  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 0
5. **LIQUID\_DEST:** Destination stage for the liquid output of this stage. The default value of 0 implies the output will be directed to the next stage for all stages but the last. For the last, a zero implies the output of the stock tank. A value of -1 in any stage implies output to the stock tank. Directing intermediate stage liquids to the stock tank, however, will result in an inconsistent addition of oil volumes at different conditions.  
**Type:** Integer
6. **VAPOR\_DEST:** Destination stage for the vapor output of this stage. The default value of 0 implies the output will be directed to the stock tank, for which the volume is evaluated as that of an ideal gas at standard conditions. It is possible, although unusual, for the gas to be directed to another stage of the separator. In the case of gas reinjection from an intermediate stage,

however, this adds complexity to the accounting of oil volumes. In particular, an “export” oil will be computed which is less than the total field production of oil by the amount of oil that would have been produced from the vapor that would have been forwarded to the next stage if it were not used for reinjection.

**Type:** Integer

7. *Reserved*

8. **GAS\_PLANT\_TAB:** Gas plant table number.

**Type:** Integer

9. **SURF\_EOS\_NUM:** Surface equations of state number. If nonzero, this integer will specify the surface EOS to use for the flash calculation of each separator stage. If defaulted, fluid-in-place calculations will be performed by first summing the moles in each equation-of-state region, then flashing each region individually and accumulating the results from each region.

**Type:** Integer

10. **NGL\_TEMP:** Temperature at which the natural gas liquid density is evaluated.

**Type:** Integer

**Units:** Fahrenheit (FIELD), Celsius (METRIC)

11. **NGL\_PRES:** Pressure at which the natural gas liquid density is evaluated.

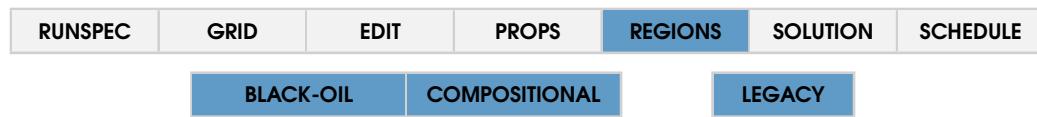
**Type:** Integer

**Units:** psi (FIELD), bar (METRIC)

### Example

The following gives conditions for a two-state separator with default topology which should be used for fluid-in-place region 3:

```
FIPSEP
3 1 90 350 /
3 2 60 14.7 /
/
```



## 2.115 FIPXXX

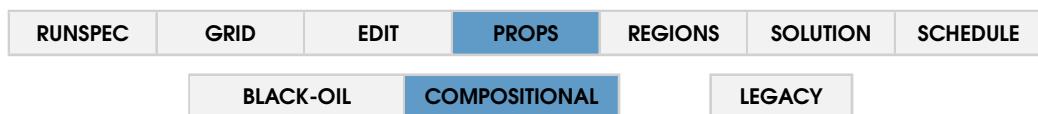
### Description

This keyword allows users to define more than one set of regions than [FIPNUM](#). The XXX can be replaced with any fip name other than NUM. Fip names can be any length but only the first 3 chars are considered significant. Similar to FIPNUM, it is followed by one integer value - fluid-in-place region number - for each grid cell in the input box, which by default is the entire grid, following natural ordering with index along I running faster, then along J and last along K. Repeat counts may be used for repeated values. A slash (/) should terminate the record. Integer values in the record should range from 1 to [NTFIP](#).

### Example

This example shows how 4 fluid-in-place regions can be defined for a 30x30x3 reservoir for a FIP named ABC

```
FIPABC  
600*1 300*2  
600*3 300*2  
600*4 300*2 /
```



## 2.116 FLUIDSPLIT

### Description

This keyword enables the specification of compositional fluid split properties for modeling multiple reservoirs with varying numbers of components. Simulating coupled reservoirs requires managing hydrocarbon fluids with diverse properties. To address this complexity, we leverage the “super component fluid” concept. This approach involves representing reservoir fluids as a distinct fluid with a novel set of pseudo components, facilitating the mixing of different fluids while preserving their properties.

The data contains three records, and each record should be terminated by a slash (/). The first record contains three items, the second record is the list of the component names, and the third record is a three-column table.

FLUIDSPLIT should be used in conjunction with the [WFNUIDSPLIT](#) keyword, which allows the association of the table with wells.

### Record 1 format

1. **FLUID\_TYPE:** A type of a fluid

#### Allowed values:

Name	Value Type	Description
SIMUL_COMP	String	The simulation fluid is the source
SUPER_COMP	String	The super component fluid is the source

2. **TABLE\_TYPE:** A type of the splitting table

#### Allowed values:

Name	Value Type	Description
USER	String	A user specified mapping
REGION	String	A region based mapping

3. **TABLE\_ID:** When the table type is USER, users are required to specify a table name to associate production and injection wells with the corresponding split tables.

In the case of the REGION table type, both the reservoir name and a PVT region number must be provided to associate regional wells with the split table, following the RESERVOIR\_NAME:EOS\_NUM format. The EOS region number can be defaulted, permitting the table's use across all EOS regions.

### Record 2 format

1. **COMPONENT\_NAMES:** The component names matching [CNAMES](#).  
The names should match the fluid type from the first record.

### Record 3 format

1. **COMPONENT\_NAME:** The component name of a source fluid
2. **SPLIT\_COEFF:** Split coefficient
3. **COMPONENT\_NAME:** The component name of a destination fluid

**Example 1**

This example specifies a table to map the simulation components to the super component fluid. The option USER indicates that the name SPLIT1 is used to link wells to the table (see [WFLUIDSPLIT](#)).

```
FLUIDSPLIT
SIMUL_COMP USER RES2_MAS /
'C02' 'N2' 'C1' 'C2' 'C3' 'C4-6' 'C7+1' 'C7+2' 'C7+3' /
'C02' 1.0 'C1' /
'N2' 1.0 'C1' /
'C1' 1.0 'C1' /
'C2' 1.0 'C2' /
'C3' 1.0 'C3' /
'C4-6' 0.40 'C4' /
'C4-6' 0.35 'C5' /
'C4-6' 0.25 'C6' /
'C7+1' 1.0 'C7+' /
'C7+2' 1.0 'C7+' /
'C7+3' 1.0 'C7+' /
/
```

**Example 2**

This example specifies a table to map the super component fluid to the simulation components. The option REGION RES2:3 indicates that all wells from the EOS region 3 of the reservoir RES2 will use this table (see [WFLUIDSPLIT](#)).

```
FLUIDSPLIT
SUPER_COMP REGION RES2:3 /
'C02' 'N2' 'C1' 'C2' 'C3' 'C4-6' 'C7+1' 'C7+2' 'C7+3' /
'C1' 0.05 'C02' /
'C1' 0.01 'N2' /
'C1' 0.94 'C1' /
'C2' 1.0 'C2' /
'C3' 1.0 'C3' /
'C4' 1.0 'C4-6' /
'C5' 1.0 'C4-6' /
'C6' 1.0 'C4-6' /
'C7+' 0.40 'C7+1' /
'C7+' 0.40 'C7+2' /
'C7+' 0.20 'C7+3' /
/
```

The third word RES2:3 can be replaced by RES2. In this scenario, a well might use this table as a default if the EOS region number specification is missing. Detailed descriptions take precedence, meaning a RES2:3 will be used specifically for region 3. However, if tables are not provided for other regions, RES2 can serve as a default for those regions.



## 2.117 FLUXNUM

### Description

This keyword defines inside [GRID](#) section a region 3D array, that is to say a set of positive integer values, one for each reservoir grid cell. It is then possible to use these values as a filter to select cells where various properties in [GRID](#), [EDIT](#), [PROPS](#), [SOLUTION](#) and [REGIONS](#) can be manipulated by various keywords, that is to say:

1. [COPYREG](#), [EQUALREG](#), [ADDREG](#), [MULTIREG](#).
2. [MULTREGP](#), [MULTREGT](#).

[FLUXNUM](#) values are bounded by the fourth item of [REGDIMS](#) keyword. The keyword is followed by a single record terminated by a slash character.

In dual media simulations ([DUALPORO](#) or [DUALPERM](#) keyword in [RUNSPEC](#)) [FLUXNUM](#) is defined only for the first medium (matrix), that is to say for the first NZRES/2 layers, in which case the simulator copies the values from matrix cells to fracture cells. It is possible to define specific [FLUXNUM](#) values for all fracture cells using field 117 of the [OPTIONS](#) keyword.

### Example

[FLUXNUM](#) is used here to define three regions in a reservoir grid with 300 cells:

```
FLUXNUM
 100*1  100*2  100*3 /
```



## 2.118 FMLOG

### Description

See keyword [FSLOG](#), which has replaced the FMLOG keyword.

FMLOG is still acknowledged for backward compatibility.



## 2.119 FNS

### Description

This keyword activates the FNS-ECHELON coupling (see Chapter 22 in the ECHELON Technical Description). Other coupling options and information should be specified with [FNS\\_WELLINFO](#) and [COUPLING\\_TYPE](#). The facility network models can be loaded with [FNS\\_INCLUDE](#).

### Example

```
RUNSPEC  
FNS
```



## 2.120 FNS\_INCLUDE

### Description

This keyword defines the connection between ECHELON and one or more production/injection networks, along with the strategy used for the initialization of the network model. This keyword requires one record per connected network and must be terminated by an empty record (/).

### Record format

1. FNS input file (with relative path to the current DATA file).

**Type:** String

2. Flag to activate the 'warm' initialization option.

**Type:** String

**Default value:** NO

**Allowed values:**

Name	Description
YES	FNS uses the converged solution at the last coupling point for initialization. This is done only if no new wells are added and the topology of the network is unchanged with respect to the previous coupling point.
NO	FNS uses a proprietary algorithm for initialization that does not rely on the last converged solution.

3. Name of the network model. The default value is "NET1". This field is required when multiple network models are used. This label should be used when specifying coupling information at wells in [FNS\\_WELLINFO](#).

**Type:** String

**Default value:** NET1

### Example

Three FNS network models are linked to ECHELON and labeled as "net1", "net2" and "net3". FNS relies on the "warm" initialization strategy to solve "net1" while the proprietary initialization algorithm is used for both "net2" and "net3".

```

FNS_INCLUDE
-- filePath          restart?    netName
'./Network/NET1.DATA'    YES        net1 /
'./Network/NET2.DATA'    NO         net2 /
'./Network/NET3.DATA'    NO         net3 /
/

```



## 2.121 FNS\_WELLINFO

### Description

This keyword specifies the coupling settings between ECHELON wells (defined with [WELSPECS](#)) and FNS well nodes (defined in the FNS DATA files loaded with [FNS\\_INCLUDE](#)). This keyword requires one record per ECHELON well / FNS well node and must be terminated with an empty record (/).

### Record format

1. ECHELON well name. This string should correspond to the name of a well that was specified before in the SCHEDULE with [WELSPECS](#).

**Type:** String

2. FNS well node name. This string should correspond to a network node defined in an FNS network model loaded with [FNS\\_INCLUDE](#).

**Type:** String

3. Coupling location.

**Type:** String

**Allowed values:**

Name	Description
BOTTOM_HOLE	The FNS well node corresponds to the bottom hole of the ECHELON well
WELL_HEAD	The FNS well node corresponds to the head of the ECHELON well

4. Constraint type.

**Type:** String

**Allowed values:**

Name	Description
BHP	The FNS solution is used to set a well BHP limit in ECHELON
THP	The FNS solution is used to set a well THP limit in ECHELON
OIL_RATE	The FNS solution is used to set a well oil rate limit in ECHELON
GAS_RATE	The FNS solution is used to set a well gas rate limit in ECHELON
WATER_RATE	The FNS solution is used to set a well water rate limit in ECHELON
LIQUID_RATE	The FNS solution is used to set a well liquid rate limit in ECHELON

5. Network name. This field is required when ECHELON is coupled to multiple FNS models. In this case, the label should be consistent with the one used in [FNS\\_INCLUDE](#). The default entry is "NET1"

**Type:** String

**Default value:** NET1

6. Gas lift handling.

**Type:** String

**Default value:** NO

**Allowed values:**

Name	Description
NO	The gas lift rate is not transported downstream in the network. This is the default behavior.
FLO	The gas lift rate is added to the formation volume gas and transported downstream. The gas lift rate does not modify the ALQ values of the VFP tables downstream.
ALQ	The gas lift rate is used as an ALQ value to interpolate the VFP table of the branch attached to this node. The gas lift rate is not further transported downstream.

7. Well closure for invalid IPR.

**Type:** String

**Default value:** YES

**Allowed values:**

Name	Description
YES	If a valid IPR cannot be generated in the stable region for THP-coupled producers, the well is shut and can be revived only with a specific schedule command, e.g. <a href="#">WTEST</a> . This is the default behavior.
NO	If a valid IPR cannot be generated in the stable region for THP-coupled producers, the well is stopped until the next coupling time when a new attempt to generate a valid IPR will be made.

8. IPR generation method. To compute a well IPR, in general ECHELON performs 10 well solves equally spaced along the pressure axis between the lower and upper pressure bounds. However, for well-head coupled producers having their THP at maximum rate higher than their THP at minimum rate, the well solves are equally spaced along the rate axis instead. This item allow the user to choose the IPR generation method in wells coupled to FNS at WELL\_HEAD.

**Type:** String

**Default value:** PRES

**Allowed values:**

Name	Description
PRES	The well IPRs are computed using pressure as primary variable. More specifically, the IPR is evaluated for 10 pressure values, equally spaced between lower and upper pressure bounds.
RATE	The well IPR is generated with a rate solve. More specifically, the IPR is evaluated for 10 rate values, equally spaced between lower and upper rate bounds. Note that RATE IPR generation method can be used only when the coupling location is set at "WELL_HEAD".

9. Inoperable well handling. This option allows to shut a well once the corrisponding well node is marked inoperable by FNS.

**Type:** String

**Default value:** OPEN

**Allowed values:**

Name	Description
OPEN	Try to keep the well open even if for a specific coupling period it is marked inoperable by FNS. If the constraint type is either BHP or THP, the calculated pressure is passed to the reservoir and used as a constraint in the following coupling period (note that the well may be shut by the reservoir if the well cannot operate at that pressure). If the constraint type is RATE the well is marked as STOP for the following coupling period.
SHUT	SHUT the well with a PHYSICAL closure reason if the corresponding well node in FNS is inoperable. This option may be used to avoid huge oscillations in well production profile.

**Example**

Two FNS well nodes belonging to different network models are coupled to their corresponding ECHELON wells. The FNS solution is accounted for in ECHELON using additional THP limits for both wells.

```
FNS_WELLINFO
-- Res. well FNS node    Coupling loc   constraint      netName
WGP1V02        WGP1V02_TH    WELL_HEAD      THP          net1      /
WGP2V02        WGP2V02_TH    WELL_HEAD      THP          net2      /
/
```



## 2.122 FORMOPTS

### Description

The **FORMOPTS** keyword is used to modify several options in the formulation of the compositional equations. The keyword is followed by a single slash-terminated record containing mnemonics whose presence enables the corresponding formulation option. In a compositional simulation all these options are turned off by default.

These options are described below.

### Record format

Name	Description
HCSCAL	In compositional models, near-critical mixing is enabled by default to avoid a discontinuity in overall component mobilities that would result from changes in phase labeling. However, another discontinuity may result if the values of the relative permeability for oil and gas differ at connate water saturation. To avoid this problem, the HCSCAL option imposes the following additional scalings to eliminate this discontinuity. $k_{rog}^{(nc)} = \text{Li}^{VE} \left( k_{rog}^{(in)}, k_{rg}^{(in)}, E_o \right)$ $k_{rgo}^{(nc)} = \text{Li}^{VE} \left( k_{rg}^{(in)}, k_{rog}^{(in)}, E_g \right)$
NOHCSCAL	Disables the HCSCAL option described above.
NOPCSPT	By default, the simulator uses a weighted hydrocarbon pressure as primary variable. The oil and gas phase pressures are computed using a saturation-weighted splitting of the oil-gas capillary pressure. $p_o = p + \frac{S_g}{S_o + S_g} P_{cog}$ $p_g = p - \frac{S_o}{S_o + S_g} P_{cog}$ When the NOPCSPT is given, primary variable becomes the oil pressure.
SINGLEP	When computing the density used for the gravitational head between each cell, the saturation-weighted average is used for each phase. When near the critical point, however, this can sometimes cause convergence difficulties as the labeling for the single phase may oscillate between liquid and vapor. When enabled, this option treats both single-phase hydrocarbon densities interchangeably, which can sometimes improve convergence in these cases.

### Example

The following enables the single-phase hydrocarbon weighting for gravity-head calculations between cells:

```
FORMOPTS
  SINGLEP /
```



## 2.123 FRAC\_STAGE

### Description

This keyword is used in the context of defining planar fracture template, defined by [PLANAR\\_FRACTURE\\_TEMPLATE](#). It defines the location of the planar fracture along the well trajectory, which is defined by [WELL\\_TRAJECTORY](#) keyword, based on a measured depth. It also gives the flexibility to modify the geometry of each fracture individually. Note that the geometry is taken from the template by default.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template. If this item is defaulted, this keyword applies to all wells already defined in the [SCHEDULE](#) section  
**Type:** String  
**Default value:** '\*'
2. **MD:** Measured depth of the fracture in this well that is modified. This entry cannot be defaulted.  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)
3. **HL\_LEFT:** Left half-length of the planar fracture at this measured depth can be set by user. If defaulted, the value will be taken from the planar fracture template.  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** None (FIELD), None (METRIC)
4. **HL\_RIGHT:** Right half-length of the planar fracture at this measured depth can be set by user. If defaulted, the value will be taken from the planar fracture template.  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** None (FIELD), None (METRIC)
5. **H\_UP:** Upper height of the planar fracture at this measured depth can be set by user. If defaulted, the value will be taken from the planar fracture template.  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** None (FIELD), None (METRIC)
6. **H\_DOWN:** Lower height of the planar fracture at this measured depth can be set by user. If defaulted, the value will be taken from the planar fracture template.  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** None (FIELD), None (METRIC)

**Example**

In this example, three fractures are defined along the well P1 trajectory. The fracture geometry of the first fracture is completely modified and new half-length and height have been defined for it. In the second fracture only the half-length is modified. In the last fracture no modification has been done on the fracture geometry meaning that the half-length and height are taken from the values defined in the fracture template (in [PLANAR\\_FRACTURE\\_TEMPLATE](#)).

```
FRAC_STAGE
--name      MD      HL_LEFT   HL_RIGHT   H_UP    H_DOWN
P1        200.0    50.0     100.0     25.0    30.0 /
P1        250.0    80.0     80.0      /       /
P1        300.0    /         /         /       /
/
```



## 2.124 FSLOG

### Description

This keyword allows outputting various levels of diagnostics related to the iterative group rate balance procedure, FNS-coupling, and PID control strategies. The keyword applies to both single and multiple reservoir coupling cases. The output is saved in a file with extension **.FSLOG**. The verbosity level for the output can also be specified.

Multiple records can be specified in this keyword with each record terminated by a slash (/). The set of all records must be terminated with an empty trailing (/), as shown in the example below.

### Record format

- CATEGORY:** Group name. The \* wildcard can be used for group pattern specification for including multiple groups.

#### Allowed values:

Name	Description
CATEGORY=PRODBAL	Diagnostics for the production group tree rate balance. Depending on the verbosity level, the output may include group tree hierarchy (LOW, MEDIUM, HIGH), allocation Info at every Newton (MEDIUM, HIGH), potential rates, guide rates, deliverable rates, allocation info both at Newton and group balance inner iteration levels (HIGH).
CATEGORY=INJBAL	Diagnostics for the injection group tree rate balance for all phases. Depending on the verbosity level, the output may include a group tree hierarchy (LOW, MEDIUM, HIGH), phase rates allocation Info at every Newton (MEDIUM, HIGH), potential rates, guide rates, deliverable rates, and allocation info both at Newton and group balance inner iteration levels (HIGH) for all injection phases.
CATEGORY=FNS	Diagnostics for the field network solver coupling with ECHELON. Only VERBOSITY=HIGH option is supported and the output includes network wells info, constraints imposed by FNS, and well status (Hydraulic failure, Pressure support, convergence failure)
CATEGORY=PID	Information regarding pressure maintenance feature using PID controls is outputted. Only the VERBOSITY=HIGH option is supported
CATEGORY=GASLIFTOPT	Information regarding gas lift optimization gradients before and after optimization. VERBOSITY=MEDIUM allows to print in the solver.log tables with gradients pre and post optimization. VERBOSITY=HIGH add additional info related to surplus, trading, donor, acceptor and convergence.

- VERBOSITY:** The control type for which the target value needs to be changed.

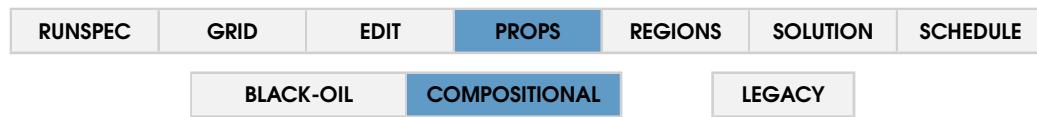
#### Allowed values:

Name	Description
VERBOSITY=LOW	See description of field CATEGORY for more details
VERBOSITY=MEDIUM	See description of field CATEGORY for more details
VERBOSITY=HIGH	See description of field CATEGORY for more details

**Example**

For example, to print diagnostics with medium verbosity for producer group rate balance, high verbosity for injection, network coupling and PID control.

```
FSLOG
CATEGORY=PRODBAL VERBOSITY=MEDIUM /
CATEGORY=INJBAL VERBOSITY=HIGH /
CATEGORY=FNS   VERBOSITY=HIGH /
CATEGORY=PID   VERBOSITY=HIGH /
CATEGORY=GASLIFTOPT VERBOSITY=HIGH /
/
```



## 2.125 FUGACITYMULT\_AQUEOUS

### Description

This keyword can optionally be used with livewater ([GASWAT](#), [OILWAT](#) or [LIVEWAT](#) keywords). It is followed by NEOSR slash terminated records, one for each reservoir equation of state region, each of them providing a constant fugacity multiplier for each component in the aqueous phase.

Two purposes are served. First of all, tuning the Soreide and Whitson EoS used in live water cases may be cumbersome. This keyword provides a very simple tuning of how hydrocarbon components dissolve in the aqueous phase and how the water component vaporizes. Using fugacity multipliers below 1 for a component would increase their presence in the aqueous phase, and using fugacity multipliers above one would decrease their presence.

Second, it can be used to match other reservoir simulators where hydrocarbon dissolution in the aqueous phase is considered but water vaporization neglected. In this case, a small fugacity multiplier for the water component (e.g.,  $10^{-6}$ ) can be used.

### Record format

1. **FUGACITYMULT\_AQ:** Constant multipliers to the fugacity coefficients of components in the aqueous phase at reservoir conditions.

**Type:** Float

### Example

This example specifies fugacity multipliers for the aqueous phase in a compositional model with live water and five hydrocarbon components plus water. In this case, we want to disable water vaporization.

```
FUGACITYMULT_AQUEOUS  
5*1 1e-6 /
```



## 2.126 FULLIMP

### Description

The FULLIMP keyword specifies that the Fully Implicit Method of time discretization should be used. This method is unconditionally stable, independent of timestep size. It is currently the default scheme in both black-oil and compositional simulations. No data records are associated with this keyword. See also [AIM](#) and [IMPES](#) for alternative time discretization schemes. These methods are discussed in [Chapter 3](#) of the ECHELON Technical Description.

### Example

```
RUNSPEC  
FULLIMP
```



## 2.127 GADVANCE

### Description

This keyword creates an additional gas source connected to a producing group. A gas consumer utilizes available gas from the ADVANCE source and then subtracts produced gas to satisfy the re-injection volumes. The ADVANCE source cannot be used for contractual obligations (see [GRUPFUEL](#) and [GRUPSALE](#)).

The keyword can be followed by an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

### Record format

1. **GROUP\_NAME:** Name of group, group template, or FIELD.
2. **STREAM\_NAME:** The stream name.  
The name links the ADVANCE source composition to the composition defined by the keyword [WELLSTRE](#).  
**Default value:** ""
3. **AVAILABLE\_RATE:** The maximum available gas rate.  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** (FIELD), 0.0 (METRIC)

### Example

In this example, the keyword specifies additionally available gas linked to groups with the prefix GRP. The additional sources have a limited available rate of 50000 Mscf/Day and have a fixed composition from STR1.

```
GADVANCE
'GRP*' STR1 50000 /
/
```



## 2.128 GAS

### Description

Specifies that a gas phase is requested in black-oil runs. If the `GAS` keyword is not present, then the `OIL` keyword is required. Note that a water phase is always present.

#### Example

```
RUNSPEC  
GAS
```



## 2.129 GASWAT

### Description

This keyword enables the modeling of vapor/aqueous equilibrium, allowing the solubility of components in the aqueous phase, as well as water vaporization. In particular, the Soreide and Whitson modification to the Peng-Robinson equation of state is adopted to account for component solubilities and water vaporization.

If the option is active the last component provided in the model is assumed to be water. Specific formulas are implemented for the computation of binary interaction coefficients of  $CO_2$ ,  $N_2$  and  $H_2S$  in the aqueous phase; to use such formulas the proper component name ( $CO_2$ ,  $N_2$  and  $H_2S$ ), must be provided by the user in the [CNAMES](#) keyword.

### Example

```
RUNSPEC  
GASWAT
```



## 2.130 GCONINJE

### Description

The GCONINJE keyword provides a set of field scheduler rate balance algorithm options for injector groups that allow specifying the primary mode of control, the phase to which the control applies, and the corresponding targets or fractional values of production rates from nominated groups. Different controls can be applied for different phases for the same injector group. Using this keyword, a user can also optionally set a value for the guide rates for the nominated phase that eventually determines the fraction of the parent group target to be allocated to a specified group. Furthermore, a group can be specified to be dependent or independent of any parent group controls.

The keyword may contain an arbitrary number of records, each record is terminated with a slash (/). Each record consists of multiple fields as specified below. The keyword itself is terminated with a trailing slash.

For detailed examples on the rate balance logic, refer to [Section 18.2](#) of Technical Description.

**Note:** For multi-reservoir coupling (see, for example, [Section 20.1](#)), this keyword must be specified in the field scheduler input file and will be ignored if specified in the individual reservoir input file.

### Record format

1. **GROUPNAME:** Group name. The \* wildcard can be used for group pattern specification for including multiple groups.

**Type:** String

**Default value:** '\*

2. **PHASE\_TO\_APPLY:** Specifies the injection phase for which the controls apply. The type of control is specified in *Field 3*.

**Type:** String

**Allowed values:**

Name	Description
OIL	Controls apply for oil injection.
WATER	Controls apply for water injection.
GAS	Controls apply for gas injection.

3. **PRIMARY\_CONTROL\_TYPE:** Specifies the nature of injection control.

**Type:** String

**Default value:** NONE

**Allowed values:**

Name	Description
RATE	Surface injection rate is controlled.
REIN	The production rate of a nominated group (refer to <i>Field 11</i> ) times a user-specified fractional value (refer to <i>Field 6</i> ) is set as the surface injection rate target.
RESV	Reservoir voidage injection rate of the nominated phase ( <i>Field 2</i> ) is controlled.
VREP	The reservoir volume injection rate of the nominated phase is controlled using the total voidage production rate of a nominated group (refer to <i>Field 12</i> ) times a user-specified fractional value (refer to <i>Field 7</i> ).
FLD	The group is controlled by its parent group and has no direct rate control.

4. **TARGET\_SURFACE\_RATE:** Specifies the surface rate of injection for the phase specified in *Field 2* and if control type is set to *RATE* in *Field 3*.

**Type:** Float

**Units:** stb/day or Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** None (FIELD), None (METRIC)

5. **TOTAL\_RESERVOIR\_VOLUME\_RATE:** Specifies the total reservoir volume rate target taking into account all injection phases for this group when primary control type is *RESV* in *Field 3*. The reservoir volume rate target for the designated phase in *Field 2* will be evaluated by subtracting the reservoir volume rates of all other phases from the specified total rate.

**Type:** Float

**Units:** rb/day (FIELD), rm<sup>3</sup>/day (METRIC)

**Default value:** None (FIELD), None (METRIC)

**Allowed values:**

6. **REINJECTION\_FRACTION:** Specifies the reinjection fractional value for *REIN* control in *Field 3*.

The reinjection fraction is applied to the available gas, calculated as produced gas minus the gas allocated for *SALE* and *FUEL*. The gas assigned to the group through *GADVANCE* is also considered part of the available gas.

When gas is taken for reinjection from a separator stage, *SALE* and *FUEL* rates are not allocated to that stage by default. This behavior can be modified by using *APPORTION\_FUEL\_SALE\_TO\_SEPARATOR\_STAGE* in the *DEFAULTS* keyword.

**Type:** Float

**Default value:** BO: None, COMP: 1

7. **VOIDAGE\_REPLACEMENT\_FRACTION:** Specifies the voidage replacement fractional value for *VREP* control in *Field 3*.

**Type:** Float

**Default value:** BO: None, COMP: 1

**Allowed values:**

8. **IS\_CONTROLLED\_BY\_PARENT\_GROUP:** Option for the group to be controlled by a parent group.

**Type:** String

**Default value:** YES

**Allowed values:**

Name	Description
NO	The group does not come under rate allocation control by a parent group and hence is treated as an independent injection group with its own target.
YES	The group comes under rate allocation control by its parent group. Hence, its injection rates are dictated by both its own target and also by the parent group's allocation.

9. **GUIDE\_RATE:** A constant that determines the fraction of the parent target to be allocated to the current child group.

**Type:** Float

**Default value:** EMPTY

**Allowed values:**

Name	Description
POSITIVE NUMBER	The value is used by a parent group to determine the allocation fraction for this group.
0	Potential rates are used for computing the parent allocation fraction for this group

10. **GUIDE\_RATE\_APPLICATION:** Describes to which control type specified in *Field 3* should the guide rate specified in *Field 9* be applied.

**Type:** String

**Allowed values:**

Name	Description
”	An empty string (Default) implies no associated guide rate
RATE	The guide rate specified in <i>Field 9</i> applies to control type RATE for surface injection rate balancing algorithm.

11. **NOMINATED\_GROUP\_REINJECTION:** The phase production rates of this group are used for reinjection calculations if *REIN* control is chosen in *Field 3*.

**Type:** String

**Default value:** The group set in the first field reinjects its own gas

**Allowed values:**

12. **NOMINATED\_GROUP\_VOIDAGE\_REPLACEMENT:** The phase production rates of this group are used for reinjection calculations if *VREP* control is chosen in *Field 3*. The default production group is itself.

**Type:** String

**Default value:** Self

**Allowed values:**

### Example

The following example provides the specification of controls and other options for various injector groups involved in the rate balance logic. Assuming the units of simulation are in FIELD, for group FIELD, the primary control type is reinjection for the GAS phase with a reinjection fraction of 1.0. Since the nominated group (field 11) is defaulted, the total GAS production of FIELD itself is used for reinjection.

For group GROUP1, the primary control on WATER phase injection is reservoir volume injection, with a target of 100 rb/day. For the same group GROUP1, the primary control on GAS phase injection is voidage replacement with a fractional value of 0.5 and the nominated phase (defaulted) is set to the GAS production rate from GROUP1. In this case, the voidage volume is replaced by WATER phase is computed first. The remaining voidage volume is to be replaced, if any, is performed using GAS injection.

For group GROUP3, the primary control type is set to surface gas injection with a target of 1000 Mscf/day. A guide rate value of 100 is specified that applies to surface gas injection.

```
GCONINJE
FIELD GAS REIN 2* 1 /
GROUP1 WATER RESV 1* 100 /
GROUP1 GAS VREP 3* 0.5 /
GROUP2 GAS RATE 1000 3* 1* 100 RATE /
/
```



## 2.131 GCONPRI

### Description

The keyword provides a set of operating limits for the control of production groups for balancing the production based on well prioritization.

The keyword defines different production upper limits and the procedures to choose which wells should be prioritized in case of violating the limit. Note that the priority limits are checked at each Newton step, whereas other options are checked at the end of each timestep.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **GROUPNAME:** Group name, template, or FIELD  
**Type:** String
2. **ORAT:** Oil production rate upper limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** No limit (FIELD), No limit (METRIC)
3. **OIL\_CONTROL:** Procedure if upper oil target is violated  
**Type:** String  
**Default value:** NONE  
**Allowed values:**

Name	Description
NONE	Do nothing
CON	Shut worst offending connections in worst offending wells
+CON	Shut the worst offending connection and all below it in the worst offending wells
WELL	Shut the worst offending wells
PRI	Control the group production balance based on wells prioritization using first formula in <a href="#">PRIORITY</a> or value provided in <a href="#">WELPRI</a>
PR2	Control the group production balance based on wells prioritization using second formula in <a href="#">PRIORITY</a> or value provided in <a href="#">WELPRI</a>

4. **WRAT:** Water surface rate upper limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** No limit (FIELD), No limit (METRIC)
5. **WAT\_CONTROL:** Procedure if violating water upper limit in item 4. The options are similar to item 3  
**Type:** String  
**Default value:** NONE
6. **GRAT:** Gas surface rate upper limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

- Default value:** No limit (FIELD), No limit (METRIC)
7. **GAS\_CONTROL:** Procedure if violating gas upper limit in item 6. The options are similar to item 3  
**Type:** String  
**Default value:** NONE
  8. **LRAT:** Liquid surface rate upper limit This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** No limit (FIELD), No limit (METRIC)
  9. **LIQ\_CONTROL:** Procedure if violating liquid upper limit in item 8. The options are similar to item 3  
**Type:** String  
**Default value:** NONE
  10. **RESV:** Upper reservoir volume production rate. This value can be specified using a user-defined argument ([UDA](#))  
If this limit is violated, PRI option is used to balance the group production  
**Type:** Float  
**Units:** rb/day (FIELD), rm<sup>3</sup>/day (METRIC)  
**Default value:** No limit (FIELD), No limit (METRIC)
  11. *Reserved*
  12. **WET\_GAS:** Wet gas upper limit production rate. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** No limit (FIELD), No limit (METRIC)
  13. **WGAS\_CONTROL:** Procedure if violating wet gas upper limit in item 12. The options are similar to item 3  
**Type:** String  
**Default value:** NONE
  14. **GAS\_BAL\_FR:** The upper limit for total molar production rate.  
This value can be specified using a user-defined argument ([UDA](#)).  
Procedure if violating this limit is to use the PRI option to balance the group production  
**Type:** Float  
**Default value:** No limit (FIELD), No limit (METRIC)
  15. *Reserved*
  16. *Reserved*
  17. *Reserved*

### Example

In this example, the field has an oil rate target of 8000 and a gas target of 3E6 that are achieved by priority balancing of the wells based on the first formula or the set value for the wells. The group PLAT-A also has oil target of 5000 and it will be reached by shutting the worst offending well as a workover.

```

GCONPRI
-- grp_name    orat          grat
  'FIELD'      8000   PRI  2*  3E6   PRI  /
  'PLAT-A'     5000   WELL  /
/

```



## 2.132 GCONPROD

### Description

The GCONPROD keyword provides a set of field scheduler rate balance algorithm options for producer groups that allow specifying the primary mode of control, the secondary limits on phase rates, and the operations that need to be done upon exceeding these rates. Using this keyword, a user can also optionally set a value for the guide rates that eventually determines the fraction of the parent group target to be allocated to a specified group. Furthermore, a group can be specified to be dependent or independent of any parent group controls.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). Each record consists of multiple fields as specified below. The keyword itself is terminated with a trailing slash.

For detailed examples on the rate balance logic, refer to [Section 18.2](#) of the *ECHELON Technical Manual*.

**Note:** For multi-reservoir coupling (see, for example, [Section 20.1](#)), this keyword will be ignored if specified in the individual reservoir SCHEDULE section.

### Record format

1. **GROUP\_NAME:** Group name. The \* wildcard can be used for group pattern specification for including multiple groups.

**Type:** String

**Default value:** ‘\*’

2. **PRIMARY\_CONTROL\_TYPE:** Specifies the primary control type for a group.

**Type:** String

**Default value:** NONE

**Allowed values:**

Name	Description
ORAT	Primary control type is using oil phase production
WRAT	Primary control type is using water phase production
GRAT	Primary control type is using gas phase production
LRAT	Primary control type is using liquid (oil + water) phase production
RESV	Primary control type is using reservoir voidage production
WGRA	Primary control type is using wet gas rate production (applies only for compositional simulation)
NONE	There is no primary control type

3. **OIL\_RATE:** Specifies the oil phase rate target when the primary control type is ORAT in *Field 2*. If not, this value will be considered as an upper limit of production.

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** None (FIELD), None (METRIC)

4. **WATER\_RATE:** Specifies the water phase rate target when primary control type is WRAT in *Field 2*. If not, this value will be considered as an upper limit of production.

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** None (FIELD), None (METRIC)

5. **GAS\_RATE:** Specifies the gas phase rate target when the primary control type is GRAT in

*Field 2.* If not, this value will be considered as an upper limit of production.

**Type:** Float

**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** None (FIELD), None (METRIC)

6. **LIQUID\_RATE:** Specifies the liquid phase rate target (oil + water rates) when the primary control type is *LRAT* in *Field 2*. If not, this value will be considered as an upper limit of production.

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

7. **DEFAULT\_OPERATION\_ON\_EXCEEDING\_LIMITS:** This specified the default workover operation to be performed when the production rate of any phase is violated.

The operation for exceeding water phase limit can be overridden using *Field 11* if *Field 2* is **not** set to *WRAT*.

The operation for exceeding gas phase limit can be overridden using *Field 12* if *Field 2* is **not** set to *GRAT*.

For reservoir voidage production control *RESV*, wet gas production rate control in compositional simulations *WGRA*, the only available operation upon exceeding the target (limit) is *RATE*.

The operation for exceeding liquid phase limit can be overridden using *Field 13* if *Field 2* is **not** set to *LRAT*.

**Type:** String

**Default value:** NONE

**Allowed values:**

Name	Description
RATE	The production rate is cutback to match the imposed limit
WELL	The well with the highest value of the production rates ratio (rate of violated phase/rate of preferred phase) is either plugged or surface shut-in
CON	The well connection with the highest value of the production rates ratio (rate of violated phase/rate of preferred phase) in the worst offending well is closed
+CON	The well connection with the highest value of the production rates ratio (rate of violated phase/rate of preferred phase) and all the connections below it in the worst offending well are closed
NONE	No operation is performed when the rate of the controlling phase is violated

8. **IS\_CONTROLLED\_BY\_PARENT\_GROUP:** Option for the group to be controlled by a parent group.

**Type:** String

**Default value:** YES

**Allowed values:**

Name	Description
NO	The group does not come under rate allocation control by a parent group and hence is treated as an independent producer group with its own target and limits.
YES	The group comes under rate allocation control by its parent group. Hence, its production rates are dictated by both its own target and limits and also by the parent group's allocation.

9. **GUIDE\_RATE:** A constant that determines the fraction of the parent target to be allocated to the current child group.

**Type:** Float

**Default value:** EMPTY

**Allowed values:**

Name	Description
POSITIVE NUMBER	The value is used by a parent group to determine the allocation fraction for this group.
0	Potential rates are used for computing the parent allocation fraction for this group

10. **GUIDE\_RATE\_APPLICATION:** Describes to which phase and how the guide rate value is specified in *Field 9* should be applied.

**Type:** String

**Allowed values:**

Name	Description
OIL	The guide rate value specified in field 9 applies directly for oil phase rate allocation
WAT	The guide rate value specified in field 9 applies directly for water phase rate allocation
GAS	The guide rate value specified in field 9 applies directly for gas-phase rate allocation
WGA	The guide rate value specified in field 9 applies directly for wet gas rate allocation (applies only for compositional simulation)
LIQ	The guide rate value specified in field 9 applies directly for liquid phase rate allocation
FORM	Uses the formula specified in keyword <a href="#">GUIDERAT</a> . The guide rate value specified in field 9 is ignored for this option.
”	An empty string (Default) implies no associated guide rate

11. **OPERATION\_ON\_EXCEEDING\_WATER\_LIMIT:** Operation to be performed when the production rate of the water phase is violated. See, description on *Field 7* for restrictions.

**Type:** String

**Default value:** NONE

**Allowed values:**

Name	Description
RATE	The water production rate is cutback to match the imposed limit
WELL	The well with the highest value of the production rates ratio (rate of water phase/rate of preferred phase) is either plugged or surface shut-in
CON	The well connection with the highest value of the production rates ratio (rate of water phase/rate of preferred phase) in the worst offending well is closed
+CON	The well connection with the highest value of the production rates ratio (rate of water phase/rate of preferred phase) and all the connections below it in the worst offending well are closed
NONE	No operation is performed when the rate of the water phase is violated

12. **OPERATION\_ON\_EXCEEDING\_GAS\_LIMIT:** Operation to be performed when the production rate of the gas phase is violated. See, description on *Field 7* for restrictions.

**Type:** String

**Default value:** NONE

**Allowed values:**

Name	Description
RATE	The gas production rate is cut back to match the imposed limit.
WELL	The well with the highest value of the production rates ratio (rate of gas phase/rate of preferred phase) is either plugged or surface shut-in.
CON	The well connection with the highest value of the production rates ratio (rate of gas phase/rate of preferred phase) in the worst offending well is closed.
+CON	The well connection with the highest value of the production rates ratio (rate of gas phase/rate of preferred phase) and all the connections below it in the worst offending well are closed.
NONE	No operation is performed when the rate of the gas phase is violated.

13. **OPERATION\_ON\_EXCEEDING\_LIQUID\_LIMIT:** Operation to be performed when the production rate of the liquid phase (oil + water) is violated. See, description on *Field 7* for restrictions.

**Type:** String

**Default value:** NONE

**Allowed values:**

Name	Description
RATE	Total liquid production rate (oil + water rates) is cutback to match the imposed limit.
WELL	The well with the highest value of the production rates ratio (rate of liquid phase/rate of preferred phase) is either plugged or surface shut-in.
CON	The well connection with the highest value of the production rates ratio (rate of liquid phase/rate of preferred phase) in the worst offending well is closed.
+CON	The well connection with the highest value of the production rates ratio (rate of liquid phase/rate of preferred phase) and all the connections below it in the worst offending well are closed.
NONE	No operation is performed when the rate of the liquid phase is violated.

14. **RESERVOIR\_VOLUME:** Specifies the reservoir voidage production rate target when the primary control type is *RESV* in *Field 2*. If not, this value will be considered as an upper limit for voidage production. See, description on *Field 7* for available operations for rate violation.  
**Type:** Float  
**Units:** rb/day (FIELD), rm<sup>3</sup>/day (METRIC)

15. *Reserved*

16. **WET\_GAS\_RATE:** For compositional simulations, this specifies the wet gas rate target when the primary control type is *WGRA* in *Field 2*. If not, this value will be considered as an upper limit of production.  
**Type:** Float

17. *Reserved*

18. **GAS\_BALANCE\_FRACTION:** Specifies a fraction value such that the gas production rate target is set to the specified fraction times the group's gas injection rate (surface volume) plus the fuel and sales gas rates.  
*Gas Production Rate<sub>target</sub> = Frac × Gas Injection Rate + (Fuel Gas + Sales Gas) Rates.*  
**Type:** Float

**Example**

The following example provides the specification of controls and other options for various producer groups involved in the rate balance logic. Assuming the units of simulation are in FIELD, for group FIELD, the primary control type is oil rate (ORAT) with a production target of 15000 stb/day. Secondary limits for group FIELD are specified for water rate (4000 stb/day) and gas rate (25000 Mscf/day). The operation is to be performed when any of the specified oil, water, or gas rates are exceeded is WELL.

For group GROUP1, the primary control type is the gas rate (GRAT), with a target of 5000 Mscf/day. There is no secondary limit on oil rate but on water rate set to 500 stb/day. The default operation to be performed on exceeding the gas rate target is set to CON. Although field 12 specifies the operation for gas rate violation to WELL, it will be **ignored** in this case since field 2 is set to GRAT and hence, the field 7 option is chosen over field 12. However, for the secondary water rate violation, the option CON specified in field 7 will be overridden by option 11 WELL. Furthermore, this group is set to be independent of any parent group control since field 8 is set to NO.

For group GROUP2, the primary control type is set to GRAT with a target of 1000 Mscf/day (field 5). The default procedure for exceeding this target is set to RATE. A guide rate value of 200 (field 9) is specified that applies to the oil phase (field 10). The equivalent gas rate guide rates are then obtained using the ratio of gas phase to oil phase rates for GROUP2 at the start of a timestep.

```
GCONPROD
FIELD ORAT    15000 4000 25000  1*      WELL /
GROUP1 GRAT    1*     500      5000  1*      CON   NO  2* WELL  WELL/
GROUP2 GRAT    2*           1000  1*      RATE   1* 200    OIL   3*  1000/
/
```



## 2.133 GDFILE

### Description

The `GDFILE` keyword is used to read corner point geometry from an EGRID file. EGRID files can be generated by ECHELON itself, or other simulators or geomodelling packages. The keyword is followed by the name of the file (including the extension) with a slash(/) to end the record.

### Record format

Field	Name	Type	Description
1	File name	String	Path and file name of the grid input file

### Example

This example loads a test.egrid file to define the initial grid geometry.

```
GDFILE
-- Path to EGRID file
'../grids/test.egrid' /
```



## 2.134 GDRILPOT

### Description

The keyword provides a minimum production or injection potential for a group. If the group potential drops below this limit, drilling queue (setup by using [QDRILL](#)) will be used to drill new wells to maintain the production or injection potential.

Note that only one production potential can be set for each group, however multiple injection potential limits may be defined for the same group.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **GROUP\_NAME:** Group name, template, or FIELD  
**Type:** String
2. **POTENTIAL\_TYPE:** Potential type that the target is applied to  
**Type:** String  
**Default value:** NONE  
**Allowed values:**

Name	Description
OPR	Oil production potential
WPRD	Water production potential
GPRD	Gas production potential
OINJ	Oil injection potential
WINJ	Water injection potential
GINJ	Gas injection potential

3. **MIN\_POT\_RATE:** Minimum potential rate for the type specified

**Type:** Float  
**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** No limit (FIELD), No limit (METRIC)

### Example

In this example, Field has an oil production potential target of 8000 STB/DAY and group 'INJ' has water and gas injection potential target of 5000 STB/DAY and 10000 MSCF/DAY, respectively.

```

GDRILPOT
-- grp_name    pot_type    limit
  'FIELD'      OPR        8000   /
  'INJ'        WINJ       5000   /
  'INJ'        GINJ       10000  /
/

```



## 2.135 GECON

### Description

This keyword defines economic limits for production groups.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** Group name or group name template  
**Type:** String
2. **OIL:** The lower economic limit for the oil rate. In case of violation, all the producers in the group will be SHUT or STOP depending on item 9 of the keyword [WELSPECS](#). A value of 0.0 switches off this limit.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
3. **GAS:** The lower economic limit for gas rate. In case of violation, all the producers in the group will be SHUT or STOP depending on item 9 of the keyword [WELSPECS](#). A value of 0.0 switches off this limit.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
4. **WCUT:** The upper economic limit for water cut. A value of 0.0 switches off this limit.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
5. **GOR:** The upper economic limit for the gas-oil ratio. A value of 0.0 switches off this limit.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
6. **WGR:** The upper economic limit for the water-gas ratio. A value of 0.0 switches off this limit.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/Mscf (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)
7. **WORKOVER:** Workover action if water cut, gas-oil ratio, water-gas ratio or gas-liquid ratio is violated  
**Type:** String  
**Default value:** NONE  
**Allowed values:**

Name	Description
NONE	Do nothing
CON	Shutin the worst offending completion in the worst offending well
+CON	Shutin the worst offending completion and all below in the worst offending well
WELL	Shutin or stop the worst offending well depending on item 9 of keyword <a href="#">WELSPECS</a>

8. **ENDRUN:** Flag to continue or stop the simulation

**Type:** Boolean

**Default value:** NO

**Allowed values:**

Name	Description
NO	The simulation continues
YES	The simulation will be stopped at the next report step in case all the producers are shut or stopped in this group for any reason, provided that the group had at least one producer opened previously.

9. **MAX\_SUB\_OPEN\_WELLS:** Maximum number of open wells subordinate to this group

**Type:** Integer

**Default value:** 0 (means no limit)

**Example**

This example sets limits for 3 groups. Group GRP1 has a minimum oil rate of 100 and a maximum possible water cut of 0.95. If the oil rate falls below 100, all the producers under that group will be SHUT or STOP depending on item 9 of [WELSPECS](#) keyword. If water cut rises above 0.95, the worst offending connection in the worst offending well will be closed.

Group GRP2 has a maximum possible gas-oil ratio of 0.8. If this limit is exceeded, the worst offending well will be shut.

If the oil production drops lower than 500 at FIELD level, the simulation will be stopped at the next report step.

```
GECON
GRP1 100 1* 0.95 2* CON /
GRP2 3* 0.8 1* WELL /
FIELD 500 5* YES /
/
```



## 2.136 GEFAC

### Description

This keyword sets the efficiency factor to account for inoperable times for a group. Equivalently, it quantifies the fractional time for which the group is operated. This factor is mainly used when calculating the cumulative rates for the specified group and the rates for a parent group. For group rate controls and balance, the specified target rates do not take efficiency factors into account and so should not be included.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

**Note:** For multi-reservoir coupling (see, for example, [Section 20.1](#)), this keyword must only be specified in the field scheduler input file and will be ignored if specified in the individual reservoir input file.

### Record format

1. **GROUP\_NAME:** Group name. The \* wildcard can be used for group pattern specification for including multiple groups.  
**Type:** String
2. **EFFICIENCY\_FACTOR:** The group efficiency factor. It must be a positive non-zero value.  
**Type:** Float  
**Default value:** 1.0
3. *Reserved*

### Example

```
GEFAC
'G*' 0.9 /
/
```



## 2.137 GINJGAS

### Description

The [GINJGAS](#) keyword can be used to control how the composition of injected gas is determined for a group. The keyword can be omitted for a group, and gas injection settings are inherited from a superior group.

GINJGAS should be used in conjunction with the keyword [GCONINJE](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

### Record format

- GROUP\_NAME:** Name of group, group template, or FIELD.

**Type:** String

- GAS\_NATURE:** The nature of the injected gas

**Type:** String

**Default value:** GRUP

**Allowed values:**

Name	Description
GAS	The gas composition corresponds to the field separator gas composition
STREAM	The gas composition is defined with the keyword <a href="#">WELLSTRE</a> . The stream name must be entered in item 3 of this keyword
MIX	The gas composition is defined as a mixture via the keywords <a href="#">WINJORD</a> , <a href="#">WINJMIX</a> , and <a href="#">WINJSUM</a> . The mixture name must be entered in item 3 of this keyword
GV	The gas composition corresponds to the gas composition produced by a specified group. The group name of the group must be entered in the item 3 of this keyword
WV	The gas composition corresponds to the gas composition produced by a specified well. The well name of the group must be entered in the item 3 of this keyword
GRUP	The gas composition that is defined for a superior group

- SOURCE\_NAME:** The name of the stream, mixture, group or well depending on the value specified in item 2

**Type:** String

- MAKE\_UP\_GAS:** Name of a well stream to be used as makeup gas, in case there is not enough gas for injection from the source specified with items 2 and 3. The makeup gas composition must be defined with the keyword [WELLSTRE](#)

**Type:** String

- SEPARATOR\_STAGE:** The number of the separator stage from which the composition of reinjection gas is taken. If zero, the composition available supply will be determined by summing the output from all separator stages.

**Type:** Integer

**Default value:** 0

**Example**

In this example, the nature of the injected gas of the group GRP1 is set to a stream whose name is CO2-STREAM. The gas composition should have been previously defined with the keyword [WELLSTRE](#). The group GRP2 utilizes gas from the FIELD level production.

```
GINJGAS
'GRP1' STREAM 'CO2-STREAM' /
'GRP2' GV 'FIELD' /
/
```



## 2.138 GINJGASOPTS

### Description

This keyword modifies the gas accounting behavior requested by the user through the [GINJGAS](#) and [WINJGAS](#) keywords.

The [WINJGAS](#) and/or [GINJGAS](#) keywords are used to associate a source to gas injection wells or groups, where the source can be a stream of limited availability (e.g., separator gas from a nominated group), or an external unlimited source defined whose composition is set in the [WELLSTRE](#) keyword. In the presence of a group hierarchy, any [GINJGAS](#) setting input in a higher group will propagate downwards, but the injected composition will be that of the lowest group nominated in [GINJGAS](#) or possibly at the well level in [WINJGAS](#). Notably, nomination of a well in the [WINJGAS](#) keyword cannot be undone.

The [GINJGASOPTS](#) keyword offers two extentions to the above behavior.

First, a user may want to inject a stream of finite availability with prescribed composition. A typical use-case would be when produced gas is reinjected following a treatment stripping some elements out. [GINJGASOPTS](#) allows overriding of the composition of injection streams.

Second, by default the overwritten composition, as well as any other [GINJGAS](#) parameters are propagated to child groups and wells not previously treated by [GINJGAS](#) or [WINJGAS](#). [GINJGASOPTS](#) allows the user to propagate [GINJGAS](#) settings to chid groups and wells even if previously nominated in [GINJGAS](#) or [WINJGAS](#). A typical use-case would be when the injection composition is set during history-matching from an unlimited source with prescribed composition, and forecast requires switching to a finite availability stream.

It is important to note that stream availabilities (relevant in the presence of When the [WAVAILIM](#) keyword) themselves are not modified by the [GINJGASOPTS](#) keyword.

Each record is followed by a slash, and the keyword is followed by a trailing slash.

### Record format

1. **GROUP\_NAME:** Group name  
**Default value:** Cannot be defaulted
2. **PROPAGATION\_TYPE:** Propagation type
  - ALL - propagate all properties of the group
  - MIXER - propagate [GINJGAS](#) properties of the group
  - COMP - propagate composition name of the group (see field 3 in this keyword)
  - NONE - do not propagate properties**Default value:** NONE
3. **COMPOSITION\_NAME:** Composition name overriding the composition of the injection source. The name should previously have been defined in the [WELLSTRE](#) keyword.  
**Default value:** No override

### Notes

While the possibility to override the composition of a source is only available through this keyword, the propagation feature is a shortcut for what could otherwise be achieved by setting [GINJGAS](#) for all groups and [WINJGAS](#) for all wells.

**Example**

An example, resetting all WINJGAS settings and utilizing the FIELD GINJGAS settings, along with the specification of the injected MYMIX composition.

- specify groups

```
GRUPTREE  
GROUP FIELD /  
/
```

- specify two injection compositions

```
WELLSTRE  
MIX 1.0 0.0 0.0 0.0 /  
MYMIX 0.5 0.5 0.0 0.0 /  
/
```

- injection properties

```
GINJGAS  
FIELD ST MIX /  
GROUP GV GROUP /  
/
```

- propagate FIELD properties first (top group in GRUPTREE): all groups

```
GINJGASOPTS  
FIELD MIXER /  
GROUP COMP MYMIX /  
/
```



## 2.139 GLIFTOPT

### Description

This keyword adds group-level constraints to the gas lift optimization option, previously activated with [LIFTOPT](#). For each group, the user can specify a gas lift rate limit and a total gas flow rate limit, which includes both the produced formation gas and the lift gas flowing to the processing facility.

The keyword contains one record per group. Each record is terminated with a slash (/). The keyword is terminated with a trailing slash.

### Record format

1. **GROUP\_NAME:** Name of the group or FIELD.  
**Type:** String
2. **MAXIMUM\_LIFT:** Maximum gas lift rate that can be supplied to the group. This constraint is always enforced: if the sum of the minimum gas lift rates of the children wells is larger than this value, wells are allocated their minimum rate in order of decreasing weighting factor (see [WLIFTOPT](#)). A negative or defaulted value makes this constraint inactive.  
**Type:** Float  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)
3. **MAXIMUM\_TOTAL\_GAS:** This value includes both the produced formation gas and the lift gas. A negative or defaulted value makes this constraint inactive.  
**Type:** Float  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

### Example

In this example, a maximum supply limit of gas lift is applied to GROUP1 and GROUP2. No gas lift limit is specified for FIELD. Also, a total gas limit is applied to FIELD and GROUP1 while none is specified for GROUP2.

```
GLIFTOPT
-- Group      Max      Max
-- Name Lift   tot gas
FIELD    1*     15000  /
GROUP1   1000   12000  /
GROUP2   1000   1*     /
/
```



## 2.140 GPMAINT

### Description

This keyword specifies a PI (proportional-integral) controller used to govern the production or injection of a group. Rates are adjusted to reach a target pressure in a specified region. The GPMAINT keyword overwrites the corresponding rate target for the group (specified with [GCONPROD](#) or [GCONINJE](#)), if present.

The keyword contains one record per PI control. Each record is terminated with a slash (/). The keyword is terminated with a trailing slash.

If the keyword is used in the Master DATA file, then the name of the reservoir with the specified region with maintained pressure must be specified in the field 9.

### Record format

1. **GROUP\_NAME:** Name of group or FIELD.
2. **CONTROL\_TYPE:** Group control type used to reach the process variable target.

#### Allowed values:

Name	Description
PROD	The RESV production rate of the group is controlled.
OINJ	The oil injection RESV rate of the group is controlled.
WINJ	The water injection RESV rate of the group is controlled.
GINJ	The gas injection RESV rate of the group is controlled.
OINS	The oil injection surface rate of the group is controlled.
WINS	The water injection surface rate of the group is controlled.
GINS	The gas injection surface rate of the group is controlled.
WGIN	The wet gas injection rate of the group is controlled.
NONE	The PID control is not active for the group.

3. **REGION\_ID:** Index of the region whose pressure is used as a process variable for the PID controller. If the keyword [PMANUM](#) is used, ECHELON uses this set for the PI controller. In this case, the default value is 1. If the keyword [PMANUM](#) is not used, ECHELON uses the [FIPNUM](#) region set for the PI controller. In this case, the default value is 0, which indicates the entire reservoir.
4. Reserved for future usage.
5. **TARGET:** The target pressure of the specified region.  
**Units:** psi (FIELD), bar (METRIC)
6. **PROPORTIONALITY\_CONSTANT:** The proportionality constant of the PI controller. Higher values yield a larger impact on the controlled rate.
7. **INTEGRAL\_CONSTANT:** The integral constant of the PI controller.
8. *Reserved*
9. **RESERVOIR\_NAME:** Name of the reservoir with target region

**Example**

In this example, the GPMAINT keyword is used to control the water surface injection rate of a group of injectors, 'GROUP 1', in such a way to achieve a constant field pressure of 1500 psi.

```
GPMAINT
-- Group   Flo    Region  Reserved Target Prop  Inte
-- Name    Target  Index           Const Const
'GROUP 1' WINS     0       1*      1500      30    70   /
/
```

In this example, the GPMAINT keyword is used in Master DATA file to control the gas surface injection rate of a group of injectors, 'GROUP 2', to achieve a constant pressure of 2500 psi of FIP region (or PMA region, if PMANUM is defined) 1 in coupled reservoir 'RES2'. Note: 'GROUP 2' may include wells from many reservoirs.

```
GPMAINT
-- Group   Flo    Region  Reserved Target Prop  Inte  Reserved  Reservoir
-- Name    Target  Index           Const Const      name
'GROUP 2' GINS     1       1*      2500      30    70   1*      RES2  /
/
```



## 2.141 GPTABLE

### Description

The [GPTABLE](#) keyword is used to provide a table specifying the recovery factor for the oil phase. A gas plant tables replace the EOS-based flash calculation in specific separator stages. Gas plant tables further allow accounting for a natural gas liquids (NGL) stream in addition to gas, oil and water, see [GPTABLEN](#).

The gas plant table approach involves simpler calculations. Each table specifies the phase recovery fraction for each component as a function of the input molar fraction of a heavy component.

1. Gas plant table number
2. Lower component index of the heavy mole (defaults to the last component)
3. Upper component index of the heavy mole (defaults to the last component)
4. Heavy mole fraction
5. Oil recovery fraction for each component

The table is terminated by a slash. Defaulting items 2 and 3 means the recovery fractions are only depending on the mole fraction of the last component.

### Example

The following examples define a gas plant table with oil recovery factor for each component for two different heavy mole fractions.

```
GPTABLE
1 1* 1*
--C6+ N2::C1 C2 C3 C4 C5 C6+
0.0 0 0.0 0.03 0.98 1.0 --oil recovery at C6+=0.0
0.8 0 0.1 0.04 0.95 1.0 --oil recovery at C6+=0.8
/
```



## 2.142 GPTABLE3

### Description

The [GPTABLE3](#) keyword allows specification of recovery factors for each phase individually, i.e. oil, NGL, and gas phase. Each table specifies the phase recovery fraction for each component as a function of the input molar fraction of a heavy component. In this case the summation of recovery factors for each component can be less than one, which means some moles were knocked out during the separation process in that stage.

Note that the summation of recovery factors for a component should never exceed one.

1. Gas plant table number
2. Lower component index of the heavy mole (defaults to the last component)
3. Upper component index of the heavy mole (defaults to the last component)
4. Heavy mole fraction
5. Oil recovery fraction for each component
6. NGL recovery fraction for each component
7. Gas recovery fraction for each component

The table is terminated by a slash. Defaulting items 2 and 3 means the recovery fractions are only depending on the mole fraction of the last component.

### Table columns

#### Example

The following examples define a gas plant table that each component has a constant recovery factor for varying heavy mole fractions

```
GPTABLE3
1 1* 1*
--C6+ N2::C1 C2 C3 C4 C5 C6+
0.0    0   0.0  0.0  0.1  0.9  1 --oil recovery at C6+=0.0
      0   0.1  0.2  0.7  0.0  0 --NGL recovery at C6+=0.0
      1   0.9  0.7  0.1  0.1  0 --Gas recovery at C6+=0.0
0.8    0   0.0  0.0  0.1  0.9  1 --oil recovery at C6+=0.8
      0   0.1  0.2  0.7  0.0  0 --NGL recovery at C6+=0.8
      1   0.9  0.9  0.1  0.1  0 --Gas recovery at C6+=0.8
/
```



## 2.143 GPTABLEN

### Description

The [GPTABLEN](#) keyword provides a table specifying the recovery factor for the oil phase and a natural gas liquids (NGL) stream. A gas plant table can replace the EOS-based flash calculation in specific separator stages.

The gas plant table approach involves simpler calculations. Each table specifies the phase recovery fraction for each component as a function of the input molar fraction of a heavy component.

1. Gas plant table number
2. Lower component index of the heavy mole (defaults to the last component)
3. Upper component index of the heavy mole (defaults to the last component)
4. Heavy mole fraction
5. Oil recovery fraction for each component
6. NGL recovery fraction for each component

The table is terminated by a slash. Defaulting items 2 and 3 means the recovery fractions are only depending on the mole fraction of the last component.

### Example

The following examples define a gas plant table with NGL recovery factor.

```
GPTABLEN
1 1* 1*
--C6+  N2 :: C1   C2     C3    C4    C5    C6+
0.0      0    0.0    0.0   0.1   0.9   1 --oil recovery at C6+=0.0
                  0    0.1    0.2   0.7   0.0   0 --NGL recovery at C6+=0.0
0.8      0    0.0    0.0   0.1   0.9   1 --oil recovery at C6+=0.8
                  0    0.1    0.3   0.8   0.0   0 --NGL recovery at C6+=0.8
/
```



## 2.144 GRAVITY

### Description

As an alternative to [DENSITY](#), the **GRAVITY** keyword is used to specify the gravity of oil, water, and gas phases at surface conditions for each pressure region. There is a single pressure region by default. The keyword [TABDIMS](#) can be used to define additional pressure regions.

Each record specifies exactly three fluid gravities at surface conditions for a specific pressure region, terminated with a slash character. In compositional formulation, however, only water gravity is used: the surface densities of oil and gas phases are computed from the equation of state.

### Record format

Field	Name	Type	Default	Description
1	Oil API gravity	Float	45.5	Oil gravity in API units
2	Water-specific gravity	Float	1.0	Water-specific gravity (reference is pure water)
3	Gas gravity	Float	0.7773	Gas gravity (reference is air)

#### Example 1

All three phase surface gravities are used for a black-oil model with two pressure regions:

```
GRAVITY
46.00 1.01 0.73 /
45.00 1.02 0.77 /
```

#### Example 2

Only water surface gravity is used in the case of the compositional model. The other two values may be set to default or a dummy value without any effect on the simulation.

```
GRAVITY
1* 1.03 999.99 /
```



## 2.145 GRIDFILE

### Description

This keyword controls the output of cell geometry in an EGRID or GRID file. It is followed by a single record with a trailing slash to end the record.

### Record format

Field	Name	Type	Default	Description
1	GRID	Integer	0	Trigger for GRID file output; 0 means no GRID is written, 1 or 2 means a GRID file with corner point coordinates for all cells, no matter if active or not, is written. Other values work like using 0.
2	EGRID	Integer	0	Trigger extensible grid (EGRID) file output. EGRID is written if the value of this field is 1

### Example

Turning on EGRID and GRID output:

```
GRIDFILE  
1 1 /
```



## 2.146 GRIDOPTS

### Description

This keyword triggers options from grid data interpretation. It is followed by a single record, with a terminating slash character.

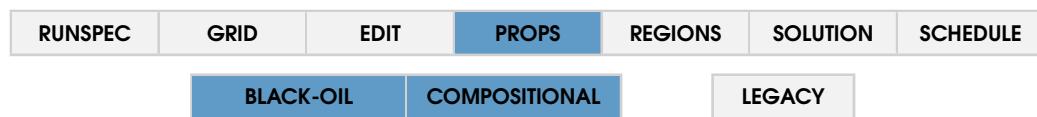
### Record format

1. **USE\_MULT\_MINUS:** Allowed to set `MULTX-`, `MULTY-` and `MULTZ-` multipliers.  
**Type:** String  
**Default value:** NO
2. *Reserved*

### Example

`GRIDOPTS` turns on `MULTZ-`, `MULTY-` and `MULTX-` in the simulation

```
GRIDOPTS  
YES /
```



## 2.147 GROCK

### Description

The `GROCK` keyword is used to specify rock properties needed for coupled fluid and geomechanical simulation, i.e. the grain compressibility and the drained bulk modulus (see [Chapter 23](#) in the Technical Documentation).

The keyword is followed by NTPVT slash-terminated records, where NTPVT is the number of PVT regions specified in the second field of the `TABDIMS` keyword. Each record contains a value for the grain compressibility,  $c_s$  followed by a value for the drained bulk modulus  $K_d$ .

Note that if the coupling with ABAQUS is enabled in `RUNSPEC` section, this keyword cannot be defaulted.

### Record format

1. **Cs:** Grain compressibility

**Type:** Float

**Units:** 1/psi (FIELD), 1/bar (METRIC)

2. **Kd:** Drained bulk modulus

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

### Example

```
GROCK
--cs      Kd
1E-5    1E6  /
```



## 2.148 GRUPFUEL

### Description

This keyword serves to reduce an available gas rate from the production groups to satisfy non-field operations, such as using gas for fueling.

GRUPFUEL should be used in conjunction with the keyword [WTAKEGAS](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

Note: there are no limitations for GRUPFUEL, it can be used either in black-oil and compositional reservoir models.

### Record format

1. **GROUP\_NAME:** Name of group, group template, or FIELD.
2. **CONSTANT\_FUEL\_RATE:** The gas rate used for FUEL.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Minimum:** 0
3. *Reserved*

### Example

In this example, the keyword specifies a contractual fuel stream and allows to consume gas from group GRP1.

```
GRUPFUEL
'GRP1' 1000 /
/
```



## 2.149 GRUPRIG

### Description

The purpose of this keyword is to allocate drilling rigs and workover rigs to specific groups. A rig that is assigned to a superior group (or the Field) will be accessible for use by all wells in its subordinate groups. This allows multiple groups sharing the same rig if necessary.

If the value in the keyword [WORKLIM](#) is greater than zero, a workover rig is necessary to conduct automatic workovers and opening new wells in the context of drilling queue. The availability of workover rigs determines the pace at which automatic workovers can be performed. After a workover/drilling rig is assigned to a well, it becomes unavailable for other workovers for the duration specified in the [WORKLIM](#) keyword. If all workover/drilling rigs that can be assigned to a particular well are not available until the end of the timestep, the workover/drilling on that specific well is delayed until a rig becomes available in its group or higher level groups.

Automatic workover can be the result of using the following keywords, [WECON](#), [CECON](#), [GECON](#), [GCONPROD](#), [GCONPRI](#). Note that manual changes of a well or a connection status does not require any rig.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

- GROUPNAME:** Group name, group template

**Type:** String

- WORKOVER\_RIG:** workover rig id

**Type:** Integer

- DRILL\_RIG:** Drilling rig id

**Type:** Integer

- ADD\_REMOVE:**

**Type:** String

**Default value:** ADD

**Allowed values:**

Name	Description
ADD	Add the rig id to the list of relevant available rigs
REM	Remove the rig id from the list of relevant available rigs

### Example

In this example, a workover rig and a drilling rig is added at the FIELD level. Also, another drilling rig is added to GROUP-A.

```

GRUPRIG
-- group_name    workover_rig    drilling_rig
'FIELD'          1              1   /
'GROUP-A'        1*            2   /
/

```



## 2.150 GRUPSALE

### Description

This keyword serves to reduce an available gas rate from the production groups to satisfy non-field operations, such as using gas for sale to customers.

GRUPSALE should be used in conjunction with the keyword [WTAKEGAS](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

Note: there are no limitations for GRUPSALE, it can be used either in black-oil and compositional reservoir models.

### Record format

1. **GROUP\_NAME:** Name of group, group template, or FIELD.
2. **CONSTANT\_SALE\_RATE:** The gas rate used for SALE.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Minimum:** 0
3. *Reserved*

### Example

In this example, the keyword specifies a contractual fuel stream and allows to consume gas from group GRP1.

```
GRUPSALE
  'GRP1' 1000  /
  /
```



## 2.151 GRUPTARG

### Description

The keyword allows to change the target, secondary limits and guide rate values set for production groups using [GCONRPROD](#).

This keyword may contain an arbitrary number of records, each record is terminated with a slash (/). Each record consists of multiple fields as specified below. The keyword itself is terminated with a trailing slash.

For detailed examples of the rate balance logic, refer to [Section 18.2](#) of the *ECHELON Technical Manual*.

### Record format

- GROUP\_NAME:** Group name. The \* wildcard can be used for group pattern specification for including multiple groups.

**Type:** String

**Default value:** '/\*'

- PRIMARY\_CONTROL\_TYPE:** The control type for which the target value needs to be changed.

**Type:** String

**Default value:** NONE

**Allowed values:**

Name	Description
ORAT	The control type is oil rate production.
WRAT	The control type is water rate production.
GRAT	The control type is gas rate production.
LRAT	The control type is liquid rate (oil + water rates) production.
GUID	The guide rate value for the phase specified in <i>Field 9</i> in <a href="#">GCONPROD</a> is changed.

- TARGET\_RATE:** The target value for the control type specified in *Field 2* is changed and set to this value.

**Type:** Float

**Default value:** None (FIELD), None (METRIC)

### Example

```
GEFAC
'G*'
    ORAT    1500 /
GROUP1
    GRAT    5000 /
/
```



## 2.152 GRUPTREE

### Description

This keyword defines tree structure for multilevel group control. The tree can consist of an arbitrary number of levels. The group FIELD occupies the top of this tree. The group without a parent group will be automatically assigned to a parent group FIELD.

Groups may contain wells and/or other groups as children. Wells can be assigned to a group using the keyword [WELSPCS](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

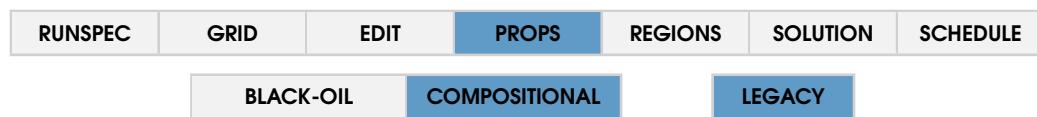
### Record format

1. **CHILD\_NAME:** Name of the child group  
**Type:** String
2. **PARENT\_NAME:** Name of the parent group  
**Type:** Integer

### Example

In this example, the FIELD (level 0) has 2 child groups, PLAT1 and PLAT2 (level 1). PLAT1 has 2 child groups GAS1 and GAS2 (level 2), while PLAT2 has 1 child group GAS3 (level 2).

```
GRUPTREE
PLAT1 FIELD /
PLAT2 FIELD /
GAS1 PLAT1 /
GAS2 PLAT1 /
GAS3 PLAT2 /
/
```



## 2.153 GSF

### Description

The **GSF** keyword is used to specify tables for interpolating the gas relative permeability and gas-water capillary pressure as a function of gas saturation. Each table consists of three columns for  $S_g$ ,  $k_{rg}$ , and  $p_{cwo}$ , respectively, with strictly monotonically increasing gas saturation. Each table should be terminated with a slash (/) character. It is possible to use repeated counts in the second and third column of the table: in such lines missing  $k_{rg}$  and/or  $p_{cwo}$  values are defined by interpolation.

The keyword is only available with the **GASWAT** option, and must be used in conjunction with the **WSF** keyword.

The total number of tables should be the same as the number of saturation regions (NTSFUN) specified in the **TABDIMS** keyword (first field). It is possible to default an entire table, provided it is not the first. A copy of the previous table is used in this case.

The simulator uses SGFN tables to define the critical gas saturation  $S_{gcr}$ , which is the maximum table gas saturation with a zero gas relative permeability (see [Section 10.2](#) in the Technical Description). For this purpose any relative permeability value below a threshold of  $10^{-6}$  is set to zero. The threshold value, which can be modified using **TOLCRIT** keyword, may impact the definition of  $S_{gcr}$ .

### Table columns

1. **SGAS:** Gas saturation  
Subsequent values in this column must strictly increase
2. **KRG:** Gas relative permeability  
Subsequent values in this column must increase or remain constant
3. **PCGW:** Gas-water capillary pressure  
Subsequent values in this column must increase or remain constant  
**Units:** psi (FIELD), bar (METRIC)

### Example

GSF is used here to define gas relative permeability and gas-water capillary pressure. ECHELON selects 0.06 as  $S_{gcr}$  because 0.00000007 is less than  $10^{-6}$ , while capillary pressure for  $S_g$  equals 0.1 and 0.2 are interpolated.

```
GSF
0      0      0
0.06   0.00000007  0.1
0.1    0.001    1*
0.2    0.1      1*
0.4    0.5      0.5
0.6    0.7      1
0.8    0.9      3
/
```



## 2.154 GUIDERAT

### Description

By default, allocation of wells under guide rate balancing ([GCONPROD](#) keyword) is performed using, as guide rates, well phase potentials computed at the beginning of each timestep.

The [GUIDERAT](#) keyword provides a way to change the guide rate equation, as well as modify its calculation options. The equation applies to the production guide rates calculation performed for all wells and groups except:

1. production wells having a constant guide rate defined with keyword [WGRUPCON](#),
2. groups where the GUIDE\_RATE\_APPLICATION (item 10 of keyword [GCONPROD](#)) is not set to FORM.

At the beginning of a timestep, the guide rates ( $gr_p$ ) for a given well/group with nominated phase  $p$  are computed as:

$$gr_p = \frac{(Q_p)^A}{B+C\cdot(R_1)^D+E\cdot(R_2)^F}$$

where  $Q_p$  is the nominated phase potential,  $R_1$  and  $R_2$  are potential ratios of secondary phases, and  $A$ ,  $B$ ,  $C$  and  $D$  are user-supplied coefficients.

Guide rates are calculated at the beginning of each timestep starting after a user-prescribed time interval  $\Delta t_{gr}$  from the previous time it was calculated. If  $\Delta t_{gr} = 0$ , guide rates are updated every timestep.

It is also possible to define damping factor  $gr_{damp}$  which can be used to prevent allocation oscillations. The guide rate actually used for allocation  $gr_{used}$  is computed as:

$$gr_{used} = gr_{damp} \cdot gr_{calc} + (1 - gr_{damp}) \cdot gr_{prev}$$

where  $gr_{calc}$  is the guide rate computed with the prescribed equation and  $gr_{prev}$  is the previously computed guide rate.

The analog keyword to modify the injection guide rates equation is [GUIDERATI](#).

### Record format

1. **MIN\_INTERVAL:** This determines how often the guide rates are calculated. A zero value means it is calculated for each timestep.  
**Type:** Float  
**Units:** Day (FIELD), Day (METRIC)  
**Default value:** 0.0
2. **NOMINATED\_PHASE:**  
**Type:** String  
**Default value:** NONE  
**Allowed values:**

Name	Description
OIL	$GR_p$ is the oil phase guide rate. $R_1$ = water to oil ratio, $R_2$ = gas to oil ratio
LIQ	$GR_p$ is the liquid phase guide rate. $R_1$ = water cut, $R_2$ = gas to liquid ratio
GAS	$GR_p$ is the gas phase guide rate. $R_1$ = water to gas ratio, $R_2$ = oil to gas ratio
RES	$GR_p$ is the reservoir fluid volume guide rate. $R_1$ = water to oil ratio, $R_2$ = gas to oil ratio
NONE	The formula is not applied

3. **A:** The exponent for the phase potential  $Q_p$   
**Type:** Float  
**Minimum:** -3.0  
**Maximum:** 3.0  
**Default value:** 0.0
4. **B:** The constant at the denominator of the equation  
**Type:** Float  
**Minimum:** 0.0  
**Default value:** 0.0
5. **C:** The coefficient used for the first phase ratio  $R_1$   
**Type:** Float  
**Minimum:** 0.0  
**Default value:** 0.0
6. **D:** The exponent for the first phase ratio  $R_1$   
**Type:** Float  
**Minimum:** -3.0  
**Maximum:** 3.0
7. **E:** The coefficient used for the second phase ratio  $R_2$   
**Type:** Float
8. **F:** The exponent for the second phase ratio  $R_2$   
**Type:** Float  
**Minimum:** -3.0  
**Maximum:** 3.0

9. **INCR\_OR\_NOT:** Whether the guide rates are allowed to increase,  
**Type:** String  
**Default value:** YES  
**Allowed values:**

Name
YES
NO

10. **GRDAMP:** Damping factor  $grdamp$ .  
**Type:** Float  
**Default value:** 1.0
11. **FREE\_GAS:** Whether to use only free gas or total gas in the potential ratio  
**Type:** String  
**Allowed values:**

Name	Description
YES	Only use free gas
NO	Use total (free and dissolved) gas

12. **MIN\_RATE:** Minimum guide rate  $GR_{min}$ .  
**Type:** Float

**Default value:** 1e-6

**Example**

```
GUIDERAT
-- dt phase      A      B      C      D      E      F      increase?    damp
 1*   OIL       1.0    1.0   12.0    2.0    0.0    0.0      NO      0.1  /
```



## 2.155 GUIDERATI

### Description

By default, allocation of injector wells under guide rate balancing ([GCONINJE](#) keyword) is performed using, as guide rates, well phase potentials computed at the beginning of each timestep.

The [GUIDERATI](#) keyword provides a way to change the guide rate formula, as well as modify its calculation options. The formula applies to the well injection guide rates only (i.e., not to the group guide rates):

At the beginning of a timestep, the guide rate ( $gr$ ) for a given injector well is calculated with either of the formulas below, depending on the injected phase

$$gr_w = B \cdot (Q_w)^A$$

$$gr_g = D \cdot (Q_g)^C$$

$$gr_o = F \cdot (Q_o)^E$$

$$gr_r = H \cdot (Q_r)^G$$

Guide rates are calculated at the beginning of each timestep starting after a user-prescribed time interval  $\Delta t_{gr}$  from the previous time it was calculated. If  $\Delta t_{gr} = 0$ , guide rates are updated every timestep.

It is also possible to define damping factor  $gr_{damp}$  which can be used to prevent allocation oscillations. The guide rate actually used for allocation  $gr_{used}$  is computed as:

$$gr_{used} = gr_{damp} \cdot gr_{calc} + (1 - gr_{damp}) \cdot gr_{prev}$$

where  $gr_{calc}$  is the guide rate computed with the prescribed formula and  $gr_{prev}$  is the previously computed guide rate.

The analog keyword to modify the production guide rates formula is [GUIDERAT](#)

### Record format

1. **DELTA\_T:** The minimum timestep between subsequent guide rate evaluations

**Type:** Float

**Units:** Day (FIELD), Day (METRIC)

**Default value:** 0

2. **PHASE:** Allowed values are:

**Type:** Enum

**Default value:** NONE

**Allowed values:**

Name	Description
RAT	The guide rate is computed using the formula corresponding to the injected phase
RES	The guide rate is computed using the formula corresponding to the reservoir volume
NONE	Guide rates are set equal to the phase potential, without using any formula

3. **A:** The exponent for the water phase potential

**Type:** Float

**Minimum:** -3

**Maximum:** 3

**Default value:** 0

4. **B:** The constant for the water phase potential  
**Type:** Float  
**Minimum:** 0  
**Default value:** 0
5. **C:** The exponent for the gas phase potential  
**Type:** Float  
**Minimum:** -3  
**Maximum:** 3  
**Default value:** 0
6. **D:** The constant for the gas phase potential  
**Type:** Float  
**Minimum:** 0  
**Default value:** 0
7. **E:** The exponent for the oil phase potential  
**Type:** Float  
**Minimum:** -3  
**Maximum:** 3  
**Default value:** 0
8. **F:** The constant for the oil phase potential  
**Type:** Float  
**Minimum:** 0  
**Default value:** 0
9. **G:** The exponent for the reservoir volume potential  
**Type:** Float  
**Minimum:** -3  
**Maximum:** 3  
**Default value:** 0
10. **H:** The constant for the reservoir volume potential  
**Type:** Float  
**Minimum:** 0  
**Default value:** 0
11. **INCR\_OR\_NOT:** Flag setting whether the guide rate can increase or not  
**Type:** Enum  
**Default value:** YES  
**Allowed values:**

Name	Description
YES	Guide rates are allowed to increase
NO	Guide rates cannot increase
12. **GRDAMP:** Damping factor  
**Type:** Float  
**Minimum:** 0  
**Maximum:** 1  
**Default value:** 1

#### Example

```
GUIDERATI
--dt phase A B C D E F G H increase? damp
      0   RAT  1  1  1  1  1  1  1  1*    0.3 /
```



## 2.156 HXFIN

### Description

This keyword sets the ratio of the cells along the I-direction in a local grid refinement. It is followed with a single slash terminated record, with NXR (see [CARFIN](#) and [NXFIN](#) keywords) strictly positive floating point numbers. These numbers are used to define local cell ratios inside host cells. It is possible to default [HXFIN](#) values for all cells inside a given coarse cell: in this case, the host cell is evenly split across LGR. Notably, [HXFIN](#) can be used inside [CARFIN/ENDFIN](#) blocks.

### Record format

Field	Name	Type	Description
1	IRATIO	Float	Local cell ratio along the I-direction

### Example

In this example [HXFIN](#) is used to define the ratios of cell spacing along I following [NXFIN](#) definitions:

```
CARFIN
OP12 24 26 47 49 10 20 9 9 10 /

NXFIN
5 2 2 /
HXFIN
2.0 2.0 3.0 1.0 1.0 2* 3.0 1.0 /
ENDFIN
```

Two local cells ratios are defaulted, which means that along I coarse cells with I-index 25 are evenly split.



## 2.157 HYFIN

### Description

This keyword sets the ratio of the cells along the J-direction in a local grid refinement. It is followed with a single slash terminated record, with NYR (see [CARFIN](#) and [NYFIN](#) keywords) strictly positive floating point numbers. These numbers are used to define local cell ratios inside host cells. It is possible to default [HYFIN](#) values for all cells inside a given coarse cell: in this case, the host cell is evenly split across LGR. Notably, [HYFIN](#) can be used inside [CARFIN/ENDFIN](#) blocks.

### Record format

Field	Name	Type	Repeat	Description
1	JRATIO	Float	NYR	Local cell ratio along the K-direction

### Example

In this example [HYFIN](#) is used to define the ratios of cell spacing along J following [NYFIN](#) definitions:

```
CARFIN
OP12 24 26 47 49 10 20 9 9 10 /

NYFIN
5 2 2 /
HYFIN
2.0 2.0 3.0 1.0 1.0 2* 3.0 1.0 /
ENDFIN
```

Two local cells ratios are defaulted, which means that along J coarse cells with J-index 25 are evenly split.



## 2.158 HZFIN

### Description

This keyword sets the ratio of the cells along the K-direction in a local grid refinement. It is followed with a single slash terminated record, with NZR (see [CARFIN](#) and [NZFIN](#) keywords) strictly positive floating point numbers. These numbers are used to define local cell ratios inside host cells. It is possible to default [HZFIN](#) values for all cells inside a given coarse cell: in this case, the host cell is evenly split across LGR. Notably, [HZFIN](#) can be used inside [CARFIN/ENDFIN](#) blocks.

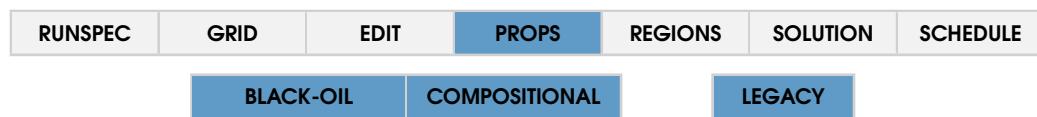
### Record format

Field	Name	Type	Repeat	Description
1	KRATIO	Float	NZR	Local cell ratio along the K-direction

### Example

In this example [HZFIN](#) is used to define the ratios of cell spacing along K following [NZFIN](#) definitions:

```
CARFIN
    OP12 24 26 47 49 10 13 9 9 10 /
NZFIN
    2 2 6 /
HZFIN
    2* 1.0 2.0 1.0 1.0 2.0 2.0 3.0 3.0 /
ENDFIN
```



## 2.159 IKRG

### Description

The IKRG keyword allows the user to rescale the vertical axes for imbibition gas-oil relative permeability input (*e.g.* SGOF tables assigned by the IMBNUM keyword). The imbibition gas relative permeability axis is rescaled to a modified highest gas relative permeability value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The highest gas relative permeability is the value at the highest gas saturation in the imbibition gas-oil relative permeability tables. IKRG can be used for cases with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

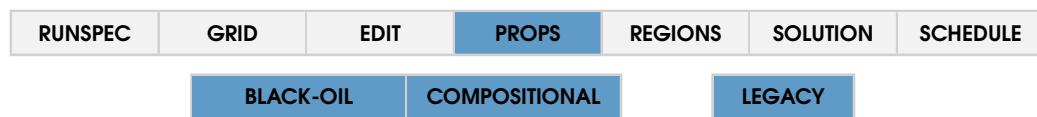
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.3

### Example

IKRG is used here to assign maximum imbibition gas relative permeability values. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
IKRG
10000*0.85 10000*0.82 /
```



## 2.160 IKRGR

### Description

The IKRGR keyword allows the user to rescale the vertical axes for imbibition gas-oil relative permeability input (*e.g.* SGOF tables assigned by the IMBNUM keyword). The gas relative permeability axis is rescaled to a modified imbibition gas relative permeability value at the critical saturation of the displacing phase on a cell-by-cell basis. For example, oil would be the displacing phase for gas-oil tables. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. IKRGR can be used for cases with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The Technical Description Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

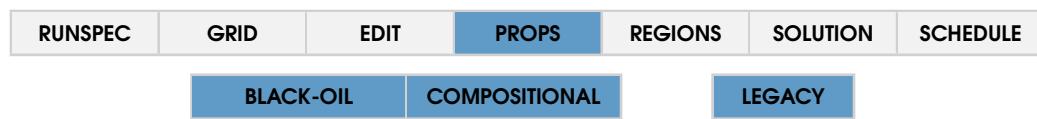
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.4

### Example

IKRGR is used here to assign imbibition gas relative permeability values at the critical saturation of the displacing phase (*e.g.*, at critical oil saturation for gas-oil tables). This model has an upper zone of 10000 cells and a lower zone of the same size.

```
IKRGR
10000*0.85 10000*0.82 /
```



## 2.161 IKRO

### Description

The IKRO keyword allows the user to rescale the vertical axes for imbibition relative permeability input (*e.g.* SWOF tables assigned by the IMBNUM keyword). The oil relative permeability axis is rescaled to a modified highest imbibition oil relative permeability value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The highest oil relative permeability is the value at the highest oil saturation in the water-oil and gas-oil relative permeability tables. IKRO can be used for cases with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

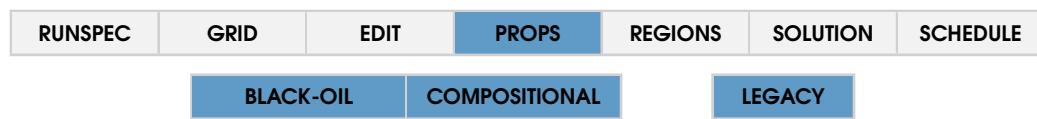
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.5

### Example

IKRO is used here to assign maximum imbibition oil relative permeability values. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
IKRO
10000*0.70 10000*0.68 /
```



## 2.162 IKRORG

### Description

The IKRORG keyword allows the user to rescale the vertical axes for imbibition oil relative permeability input (e.g. SGOF tables assigned by the IMBNUM keyword). The imbibition oil relative permeability axis is rescaled to a modified oil relative permeability at critical gas saturation on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. IKRORG can be used for cases with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (e.g. SWL), and capillary pressure (e.g. PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

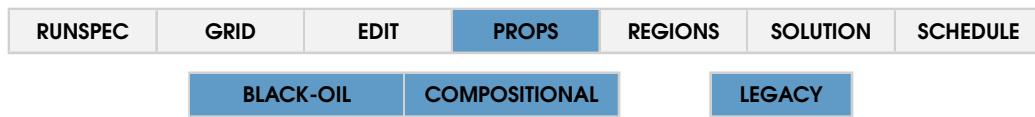
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.6

### Example

IKRORG is used here to assign the imbibition oil relative permeability at critical gas saturation. This model has an upper zone of 10000 cells and lower zones of 10000 cells, with 5000 ones where the values from the tables are used.

```
IKRORG
 10000*0.50  5000*0.48  5000* /
```



## 2.163 IKRORW

### Description

The IKRORW keyword allows the user to rescale the vertical axes for imbibition oil relative permeability input (*e.g.* SWOF tables assigned by IMBNUM). The imbibition oil relative permeability axis is rescaled to a modified oil relative permeability at critical water saturation on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. IKRORW can be used for cases with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

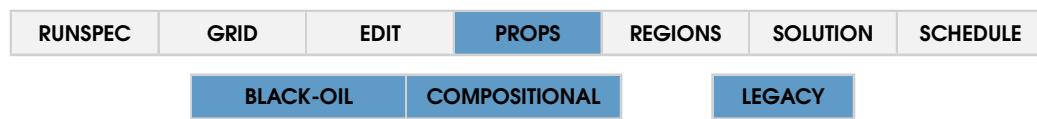
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.7

### Example

IKRORW is used here to assign imbibition oil relative permeability at critical water saturation. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
IKRORW
 10000*0.50  10000*0.48 /
```



## 2.164 IKRW

### Description

The IKRW keyword allows the user to rescale the vertical axis for imbibition water relative permeability input (*e.g.* SWOF tables assigned by IMBNUM). The water relative permeability axis is rescaled to a modified highest imbibition water relative permeability value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The highest water relative permeability is the value at the highest water saturation in the table. IKRW can be used for cases with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

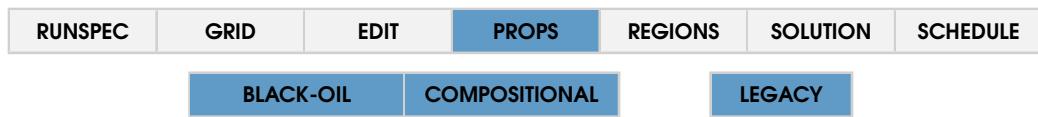
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.8

### Example

IKRW is used here to assign the maximum imbibition water relative permeability. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
IKRW
10000*1.00 10000*0.98 /
```



## 2.165 IKRWR

### Description

The IKRWR keyword allows the user to rescale the vertical axis for imbibition water relative permeability input (*e.g.* SWOF tables assigned by IMBNUM). The water relative permeability axis is rescaled to a modified imbibition water relative permeability value at residual oil saturation on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. IKRWR can be used for cases with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.9

### Example

IKRWR is used here to assign the imbibition water relative permeability at residual oil saturation. This model has an upper zone of 10000 cells and lower zones of the same size.

```
IKRWR
10000*0.35 10000*0.32 /
```



## 2.166 IMBNUM

### Description

The IMBNUM keyword in the REGION section is used to assign imbibition saturation tables for cases using hysteresis ([SATOPTS](#) with the HYSTER option specified). The values assigned must be positive integer values (>=1) corresponding to input saturation function table numbers. Input must follow natural I, J, K ordering. Integer values are bounded by the first item of [TABDIMS](#) in the RUNSPEC section which is the number of input saturation tables. Repeat counts may be used for repeated values. The keyword is followed by a single record terminated by the slash character (/). The number of values must correspond to the entire grid or the number corresponding to a prior defined [BOX](#) cell range.

### Example

IMBNUM is used here to assign table 2 for the first 10000 cells and table 4 for the next 10000 for a model with 20000 cells.

```
IMBNUM  
 10000*2  10000*4 /
```



## 2.167 IMPES

### Description

The IMPES keyword specifies that the Implicit Pressure/Explicit Saturation of time discretization should be used. This method is only conditionally stable, requiring timestep size to be limited to avoid unphysical oscillations. It is available only in compositional simulations. No data records are associated with this keyword. See also [FULLIMP](#) and [AIM](#) for other time discretization options. These methods are discussed in [Chapter 3](#) of the ECHELON Technical Description.

### Example

```
RUNSPEC  
IMPES
```



## 2.168 INIT

### Description

The INIT keyword specifies whether the output file containing initial grid data will be saved. No data records are associated with this keyword.



## 2.169 INTERFAC

### Description

**INTERFAC** keyword should be put in the SCHEDULE section after all the [WELSPECS](#) and [COMPDAT](#) keywords and at least one [WCONPROD](#) or [WCONINJE](#) for each well.

This keyword allows to activate the coupling with the external tool RESOLVE for Integrated Production Modelling. It may contain two records and it is ended with a final slash (/). The two records are string names of output files used for debugging purposes. For more information check [Chapter 24](#) of the Echelon Technical Description related to GAP coupling using RESOLVE.

Keywords after **INTERFAC** are statically read and parsed before the execution of the coupling with GAP. Therefore, keyword events after the INTERFAC can be executed during the coupling period if the date of their execution overlaps with the scheduled coupling window defined inside RESOLVE. Keywords that are beyond the coupling window set in the RESOLVE schedule will be not executed.

### Record format

Field	Type	Description
1	String	User defined name for the log file where to store messages for debugging (i.e. ECHELON IPRs and RESOLVE commands)
2	String	User defined name for the bin file where to store messages for debugging

### Example

This example will allow ECHELON to couple with GAP by means of RESOLVE. Messages for debugging will be stored and logged in RESOLVE\_COUPLING.log

```
INTERFAC
```

```
'RESOLVE_COUPLING.log' /
```



## 2.170 IPCG

### Description

The IPCG keyword allows the user to rescale the vertical capillary pressure axis for imbibition gas-oil capillary pressure input (*e.g.* SGOF tables assigned by IMBNUM). The capillary pressure axis is rescaled to a modified highest imbibition capillary pressure value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The highest imbibition capillary pressure is the value at the largest gas saturation in the table. IPCG can be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling. The IPCG keyword should not be used when using the J-function option JFUNC. The IPCG values should have the same sign as the table imbibition capillary pressure at the highest gas saturation.

Additional endpoint arrays are allowed for water saturations (*e.g.* SWL), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint capillary pressure arrays.

Array	Description
PCW	Maximum water-oil drainage capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure
PCG	Maximum gas-oil drainage capillary pressure
IPCG	Maximum gas-oil imbibition capillary pressure

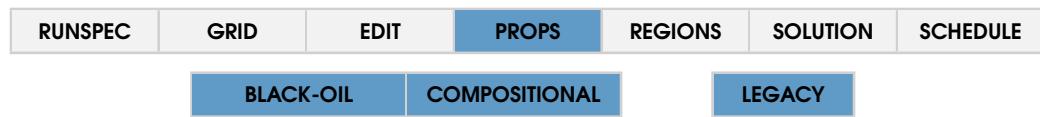
Table 2.10

**Units:** psi (FIELD), bar (METRIC)

### Example

IPCG is used here in a dual media case to assign the maximum imbibition gas-oil capillary pressure for flow in the matrix (top reservoir half) and the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
IPCG
 9000*20.0  9000*1.0 /
```



## 2.171 IPCW

### Description

The IPCW keyword allows the user to rescale the vertical capillary pressure axis for imbibition water-oil capillary pressure input (*e.g.* SWOF tables assigned by IMBNUM). The capillary pressure axis is rescaled to a modified highest imbibition capillary pressure value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The highest imbibition capillary pressure is the value at the smallest water saturation in the table. IPCW can be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling. The IPCW keyword should not be used when using the J-function option JFUNC or when defining initial saturations via the SWATINIT array. The IPCW values should have the same sign as the table imbibition capillary pressure at connate (lowest) water saturation.

Additional endpoint arrays are allowed for water saturations (*e.g.* SWL), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint capillary pressure arrays.

Array	Description
PCW	Maximum water-oil drainage capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure
PCG	Maximum gas-oil drainage capillary pressure
IPCG	Maximum gas-oil imbibition capillary pressure

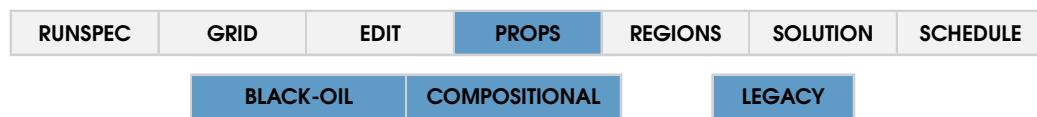
Table 2.11

**Units:** psi (FIELD), bar (METRIC)

### Example

IPCW is used here in a dual media case to assign the maximum imbibition oil-water capillary pressure for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
IPCW
 9000*20.0  9000*1.0 /
```



## 2.172 ISGCR

### Description

The ISGCR keyword allows the user to rescale the horizontal saturation axis for imbibition gas-oil relative permeability tables (e.g. SGOF tables assigned by IMBNUM). The saturation axis is rescaled to a modified imbibition critical gas saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical imbibition gas saturation is the largest gas saturation for which gas relative permeability is zero in the imbibition relative permeability table. Relative permeability is zero at this saturation. ISGCR can be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling. The manual also describes consistency requirements such as ISGL<=ISGCR.

Additional endpoint arrays are allowed for capillary pressures (e.g. PCW), relative permeability (e.g. KRW) and low-salinity flooding (e.g. LSWL). Following are the possible endpoint saturation arrays.

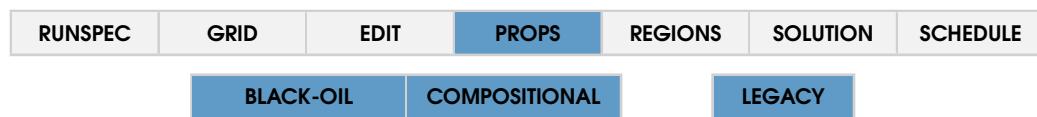
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.12

### Example

ISGCR is used here in a dual media case to assign imbibition critical gas saturation for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
ISGCR
 9000*0.05  9000*0.01 /
```



## 2.173 ISGL

### Description

The ISGL keyword allows the user to rescale the horizontal saturation axis for imbibition gas-oil relative permeability tables (*e.g.* SGOF tables assigned by IMBNUM). The saturation axis is rescaled to a modified lowest imbibition gas saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Lowest imbibition gas saturation is the smallest gas saturation in the imbibition relative permeability table. Relative permeability is zero at this saturation. ISGL can only be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling. The manual also describes consistency requirements such as ISGL=<ISGCR. ISGL is commonly set to zero.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

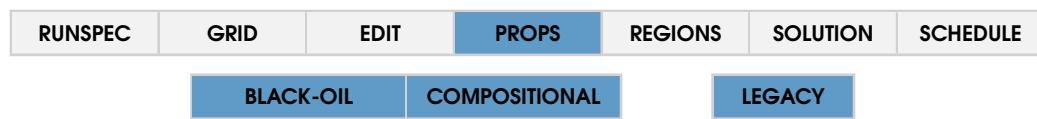
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.13

### Example

ISGL is used here in a dual media case to assign lowest gas saturation for flow in the matrix (top reservoir half) and for the fractures (bottom one-half of cells). This model has 9000 matrix cells and 9000 fracture cells.

```
ISGL
 9000*0.0  9000*0.0 /
```



## 2.174 ISGU

### Description

The ISGU keyword allows the user to rescale the horizontal saturation axis for imbibition gas-oil relative permeability tables (*e.g.* SGOF tables assigned by IMBNUM). The saturation axis is rescaled to a modified highest possible gas saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest imbibition gas saturation is the maximum gas saturation in the imbibition relative permeability table. Gas relative permeability should be greater than zero at this saturation. ISGU can only be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling. The manual also describes end-point consistency requirements. ISGU is commonly set to a value of 1.0-ISWL

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

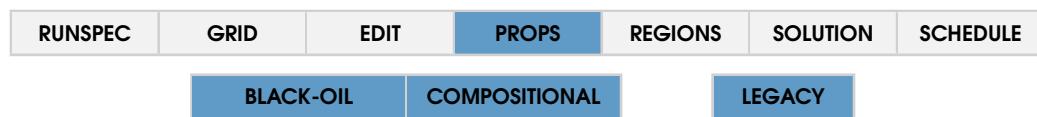
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.14

### Example

ISGU is used here to assign the highest gas saturation for gas-oil relative permeability. This model has 10000 cells.

```
ISGU
10000*0.80 /
```



## 2.175 ISOGCR

### Description

The ISOGCR keyword allows the user to rescale the horizontal saturation axis for imbibition gas-oil relative permeability tables (e.g. SGOF tables assigned by IMBNUM). The saturation axis is rescaled to a modified imbibition critical(residual) oil-in-gas saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Imbibition critical(residual) oil-in-gas saturation is the largest oil saturation for which oil relative permeability is zero in the imbibition gas-oil relative permeability table. Oil relative permeability is zero at this saturation. ISOGCR can only be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for capillary pressures (e.g. PCW), relative permeability (e.g. KRW) and low-salinity flooding (e.g. LSWL). Following are the possible endpoint saturation arrays.

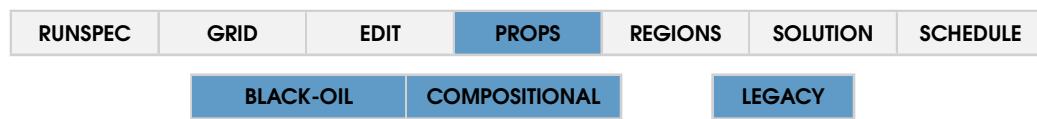
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.15

### Example

ISOGCR is used here in a dual media case to assign imbibition critical oil-in-gas saturation for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
ISOGCR
 9000*0.25  9000*0.05 /
```



## 2.176 ISOWCR

### Description

The ISOWCR keyword allows the user to rescale the horizontal saturation axis for imbibition water-oil relative permeability tables (*e.g.* SWOF tables assigned by IMBNUM). The saturation axis is rescaled to a modified imbibition critical(residual) oil-in-water saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Imbibition critical(residual) oil-in-water saturation is the largest oil saturation for which oil relative permeability is zero in the imbibition water-oil relative permeability table. Oil relative permeability is zero at this saturation. ISOWCR can only be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

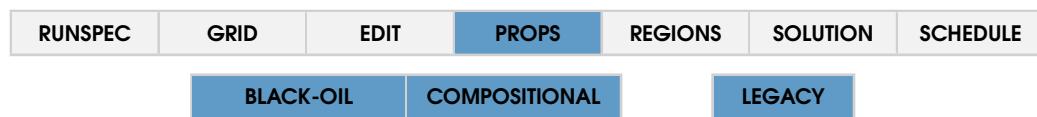
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.16

### Example

ISOWCR is used here in a dual media case to assign imbibition critical oil-in-water saturation for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
ISOWCR
 9000*0.25  9000*0.05 /
```



## 2.177 ISWCR

### Description

The ISWCR keyword allows the user to rescale the horizontal saturation axis for imbibition water-oil relative permeability tables (*e.g.* SWOF tables assigned by IMBNUM). The saturation axis is rescaled to a modified imbibition critical water saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical imbibition water saturation is the largest water saturation for which water relative permeability is zero in the imbibition relative permeability table. Relative permeability is zero at this saturation. ISWCR can be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling. The manual also describes consistency requirements such as ISWL<=ISWCR.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.17

### Example

ISWCR is used here in a dual media case to assign imbibition critical water saturation for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
ISWCR
 9000*0.28  9000*0.05 /
```



## 2.178 ISWL

### Description

The ISWL keyword allows the user to rescale the horizontal saturation axis for imbibition water-oil relative permeability tables (*e.g.* SWOF tables assigned by IMBNUM). The saturation axis is rescaled to a modified lowest imbibition water saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The lowest imbibition water saturation is the smallest water saturation in the imbibition relative permeability table. Relative permeability is zero at this saturation. ISWL is used only for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling. The manual also describes consistency requirements such as ISWL<=ISWCR.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

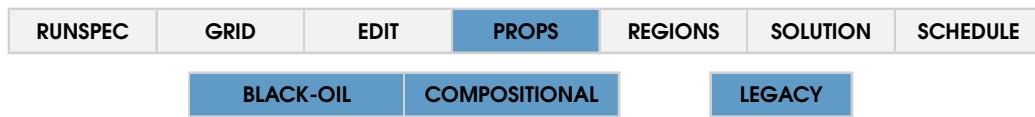
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.18

### Example

ISWL is used here in a dual media case to assign lowest imbibition water saturation for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
ISWL
 9000*0.26  9000*0.04 /
```



## 2.179 ISWLPC

### Description

The ISWLPC keyword allows the user to rescale the horizontal saturation axis for imbibition water-oil capillary pressure (*e.g.* SWOF tables assigned by IMBNUM). The saturation axis is rescaled to a modified lowest (connate) water saturation value for imbibition water-oil capillary pressure on a cell-by-cell basis. Water-oil imbibition relative permeabilities tables are not impacted by this keyword. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The lowest (connate) water saturation is the smallest water saturation in the imbibition water-oil capillary pressure table. Capillary pressure is a maximum at this saturation. ISWLPC can be used for hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables or by ISWL values input for water-oil relative permeability. The Technical Description Chapter 10 highlights the details for end-point scaling. The manual also describes consistency requirements such as ISWL<=ISWCR.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* ISWL). Following are the possible endpoint saturation arrays.

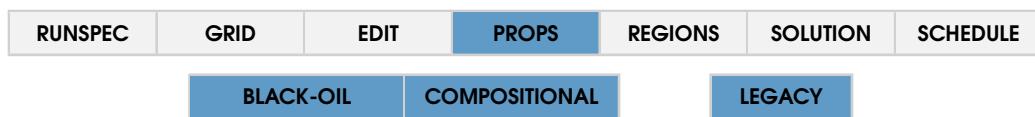
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.19

### Example

ISWLPC is used here in a dual media case to assign lowest (connate) water saturation for water-oil capillary pressure in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
ISWLPC
 9000*0.22  9000*0.0 /
```



## 2.180 ISWU

### Description

The ISWU keyword allows the user to rescale the horizontal saturation axis for water-oil relative permeability tables (*e.g.* SWOF tables assigned by SATNUM). The saturation axis is rescaled to a modified imbibition highest possible water saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest imbibition water saturation is the maximum water saturation in the imbibition relative permeability table. Water relative permeability should be greater than zero at this saturation. ISWU can be used for cases with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual Chapter 10 describes the details for end-point scaling. The manual also describes end-point consistency requirements. ISWU is commonly set to a value of 1.0.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

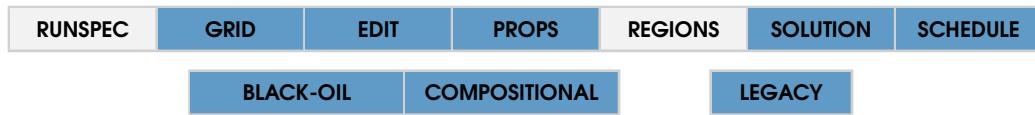
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.20

### Example

ISWU is used here to assign highest water saturation for water-oil relative permeability. This model has 10000 cells.

```
ISWU
10000*1.0 /
```



## 2.181 IWORK

### Description

The `IWORK` keywords are used to specify temporary integer values for each cell. The keyword name is followed immediately by an integer indicating the array, number, e.g. “IW`ORK1`”, “IW`ORK2`”, etc. These array values are not directly utilized in themselves, but are used as intermediate storage in computing complex expressions for other cell-based input. `IWORK` can be the source or target array for other keywords such as `OPERATE`, `OPERATER`, `ADD`, `EQUALS`, `MINVALUE`, `MAXVALUE`, `MULTIPLY`, `MULTIREG`, etc. `IWORK` values are not carried over between sections.

The maximum number of work arrays is specified in the 9<sup>th</sup> field of the `REGDIMS` keyword. See also `WORK` for double-precision temporaries

### Example

The following is used to set SATNUM as a function of permeability.

```

EQUALS
  IWORK1 1 /
  IWORK2 4 /
/

OPERATE
  -- compute IWORK1 depending on the magnitude of PERMX
  IWORK1 6* IFGT PERMX 1e-4 2 /
  IWORK1 6* IFGT PERMX 1e-3 3 /
  IWORK1 6* IFGT PERMX 1e-2 4 /
  -- compute IWORK1 depending on the magnitude of PERMZ
  IWORK1 6* IFGT PERMZ 1e-4 8 /
  IWORK1 6* IFGT PERMZ 1e-3 12 /
  IWORK1 6* IFGT PERMZ 1e-2 16 /
  SATNUM 6* COPY IWORK1 /
  SATNUM 5* ADDX IWORK1 0 /
/

```



## 2.182 JFUNC

### Description

The [JFUNC](#) or [JFUNCR](#) keywords can be used in models with endpoint scaling, to define capillary pressure using Leverett J-functions. This is an alternative to scaling the capillary pressure through the [PCW](#) and [PCG](#) vectors. When using the Leverett J-function, capillary pressure is scaled in each cell based on its petrophysical properties as:

$$p_{cow}(S_w) = C \cdot J_{ow}(S_w) \sigma_{ow} \cdot \phi^\alpha / k^\beta$$

$$p_{cog}(S_g) = C \cdot J_{og}(S_g) \sigma_{og} \cdot \phi^\alpha / k^\beta$$

$J_{ow}$  and  $J_{og}$  are the J-functions of saturation provided as user input in place of the capillary pressure curves in the [PROPS](#) section (either as tables or as Corey type equations).

The terms  $k$  and  $\phi$  are the representative permeabilities and porosity for each cell. The terms  $\sigma_{ow}$  and  $\sigma_{og}$  are oil-water and gas-oil surface tension, measured in dynes/cm,  $a$  and  $b$  are dimensionless exponents.  $C$  is a conversion factor which has a value of 0.318316 for [METRIC](#) units and 4.61678 for [FIELD](#) units).

The Leverett J-function can be activated through the [JFUNC](#) or [JFUNCR](#) keywords in the [GRID](#) section. [JFUNC](#) sets equation quantities for the entire reservoir (although each cell is still scaled for its own permeability and porosity). [JFUNCR](#) allows scaling on a saturation table basis, meaning that different interfacial tensions and exponents can be assigned for each independent set of saturation tables.

The user must provide the surface tensions  $\sigma_{ow}$  and  $\sigma_{og}$ . The default exponents  $\alpha$  and  $\beta$  are 0.5 as per the historical literature definitions. The default permeability used in the equation is  $= (k_x \cdot k_y)^{1/2}$  Alternatively, the user can define different  $\alpha$  and  $\beta$  exponents as well as choosing which permeability is used in the equation ( $k_x$ ,  $k_y$  or  $k_z$ ). The J-function option is provided as a convenience for the user. Input data are provided in a single, slash terminated, record, following the record format below.

It is worth noticing that the same capillary pressures could be achieved through regular endpoint scaling using appropriate [PCW](#) and [PCG](#) cell-by-cell end-point scaling values. Any [PCW](#) and [PCG](#) end-point scaling vectors will be ignored when the [JFUNC](#) is active. The [ENDSCALE](#) keyword should be present in the [RUNSPEC](#) section.

### Record format

Field	Name	Type	Description
1	TYPE FLAG	String	Phases for Application of JFUNC: WATER for water-oil, GAS for gas-oil, BOTH (default) for both sets.
2	OW Surface Tension	Float	Oil-water surface tension in dynes/cm (no default)
3	OG Surface Tension	Float	Oil-gas surface tension in dynes/cm (no default)
4	Porosity Exponent	Float	Exponent for porosity term (default 1/2)
5	Permeability Exponent	Float	Exponent for permeability term (default 1/2)
6	Perm Direction	String	Perm definition in equation: XY(default), X, Y, Z

### Example

```
JFUNC
BOTH 20.0 16.0 0.50 0.50 XY/
```



## 2.183 JFUNCNR

### Description

The [JFUNCNR](#) or [JFUNC](#) keywords can be used in models with endpoint scaling, to define capillary pressure using Leverett J-functions. This is an alternative to scaling the capillary pressure through the [PCW](#) and [PCG](#) vectors. When using the Leverett J-function, capillary pressure is scaled in each cell based on its petrophysical properties as:

$$p_{cow}(S_w) = C \cdot J_{ow}(S_w) \sigma_{ow} \cdot \phi^\alpha / k^\beta$$

$$p_{cog}(S_g) = C \cdot J_{og}(S_g) \sigma_{og} \cdot \phi^\alpha / k^\beta$$

$J_{ow}$  and  $J_{og}$  are the J-functions of saturation provided as user input in place of the capillary pressure curves in the [PROPS](#) section (either as tables or as Corey type equations).

The terms  $k$  and  $\phi$  are the representative permeabilities and porosity for each cell. The terms  $\sigma_{ow}$  and  $\sigma_{og}$  are oil-water and gas-oil surface tension, measured in dynes/cm,  $a$  and  $b$  are dimensionless exponents.  $C$  is a conversion factor which has a value of 0.318316 for [METRIC](#) units and 4.61678 for [FIELD](#) units).

The Leverett J-function can be activated through the [JFUNC](#) or [JFUNCNR](#) keywords in the [GRID](#) section. [JFUNC](#) sets equation quantities for the entire reservoir (although each cell is still scaled for its own permeability and porosity). [JFUNCNR](#) allows scaling on a saturation table basis, meaning that different interfacial tensions and exponents can be assigned for each independent set of saturation tables.

The keyword is followed by NTSFUN (set in [TABDIMS](#) first field) records, each of them written according to the format defined here below. In each record, the user must provide the surface tensions  $\sigma_{ow}$  and  $\sigma_{og}$ . The default exponents  $\alpha$  and  $\beta$  are 0.5 as per the historical literature definitions. The default permeability used in the equation is  $= (k_x \cdot k_y)^{1/2}$  Alternatively, the user can define different  $\alpha$  and  $\beta$  exponents as well as choosing which permeability is used in the equation ( $k_x$ ,  $k_y$  or  $k_z$ ). The J-function option is provided as a convenience for the user. The same capillary pressures could be achieved through regular endpoint scaling using appropriate [PCW](#) and [PCG](#) cell-by-cell end-point scaling values. Any [PCW](#) and [PCG](#) end-point scaling vectors will be ignored when the [JFUNC](#) is active. The [ENDSCALE](#) keyword should be present in the [RUNSPEC](#) section.

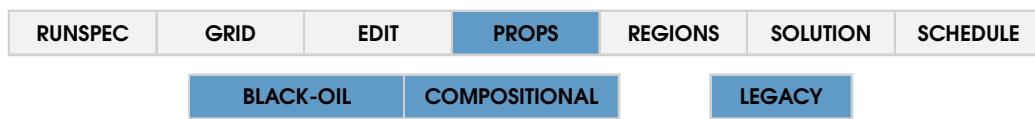
### Record format

Field	Name	Type	Description
1	TYPE FLAG	String	Phases for Application of JFUNC: WATER for water-oil, GAS for gas-oil, BOTH (default) for both sets.
2	OW Surface Tension	Float	Oil-water surface tension in dynes/cm (no default)
3	OG Surface Tension	Float	Oil-gas surface tension in dynes/cm (no default)
4	Porosity Exponent	Float	Exponent for porosity term (default 1/2)
5	Permeability Exponent	Float	Exponent for permeability term (default 1/2)
6	Perm Direction	String	Perm definition in equation: XY(default), X, Y, Z

**Example**

Set different J-function parameters by saturation table set (2 sets in this example)

```
JFUNC R
BOTH  20.0   16.0   0.50   0.50   XY/
BOTH  22.0   17.0   0.25   1.00   XY/
```



## 2.184 KRG

### Description

The KRG keyword allows the user to rescale the vertical axes for gas-oil relative permeability input (*e.g.* SGOF tables assigned by the SATNUM keyword). The gas relative permeability axis is rescaled to a modified highest gas relative permeability value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest gas relative permeability is the value at the highest gas saturation in the gas-oil relative permeability tables. KRG can be used for cases with or without hysteresis (see SATOPTS). These represent drainage values for cases with hysteresis. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

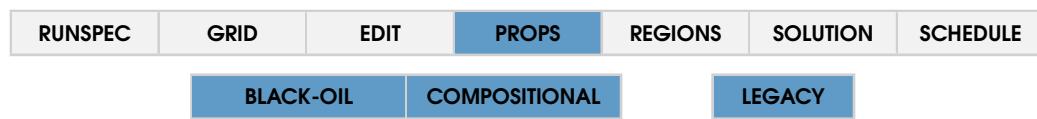
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.21

### Example

KRG is used here to assign maximum gas relative permeability values. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
KRG
10000*0.85 10000*0.82 /
```



## 2.185 KRGR

### Description

The KRGR keyword allows the user to rescale the vertical axes for gas-oil relative permeability input (*e.g.* SGOF tables assigned by the SATNUM keyword). The gas relative permeability axis is rescaled to a modified gas relative permeability value at the critical saturation of the displacing phase on a cell-by-cell basis. For example, oil would be the displacing phase for gas-oil tables. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. KRGR can be used for cases with or without hysteresis (see SATOPTS). These represent drainage values for cases with hysteresis. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.22

### Example

KRGR is used here to assign gas relative permeability values at the critical saturation of the displacing phase (*e.g.*, at critical oil saturation for gas-oil tables). This model has an upper zone of 10000 cells and a lower zone of the same size.

```
KRGR
10000*0.85 10000*0.82 /
```



## 2.186 KRNUMMF

### Description

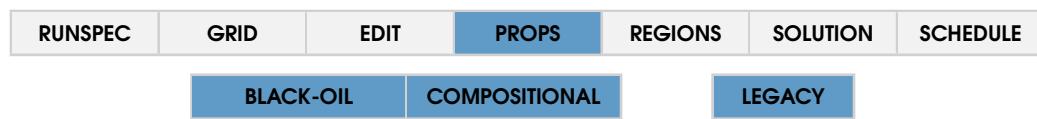
The optional **KRNUMMF** keyword in the **REGION** section can be used in dual-media cases (**DUALPORO** or **DUALPERM**) to assign alternative saturation tables for matrix-to-fracture flow (top **NZ**/2 layers of cells) and fracture-to-matrix flow (bottom **NZ**/2 layers of cells). The values assigned must be positive integer values corresponding to a saturation table number. Any values here would overwrite the default tables assigned with **SATNUM**. The corresponding keyword for hysteresis **IMBNUMMF** is not supported.

**KRNUMMF** values are bounded by the first item of **TABDIMS** in the **RUNSPEC** section which is the number of input saturation tables. The keyword is followed by a single record terminated by the slash character. The number of values must correspond to the entire grid or the number corresponding to a defined **BOX** cell range.

### Example

**KRNUMMF** is used here in dual media case to assign table 3 for flow from the matrix to fracture (top reservoir half) and table 4 for flow from the fractures to the matrix (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
KRNUMMF  
9000*3 9000*4 /
```



## 2.187 KRO

### Description

The KRO keyword allows the user to rescale the vertical axes for relative permeability input (e.g. SWOF tables assigned by the SATNUM keyword). The oil relative permeability axis is rescaled to a modified highest oil relative permeability value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest oil relative permeability is the value at the highest oil saturation in the water-oil and gas-oil relative permeability tables. KRO can be used for cases with or without hysteresis (see SATOPTS). These represent drainage values for cases with hysteresis. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (e.g. SWL), and capillary pressure (e.g. PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

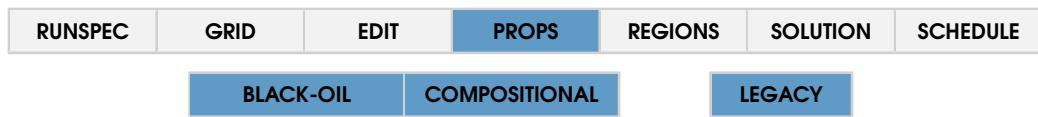
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.23

### Example

KRO is used here to assign maximum oil relative permeability values. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
KRO
10000*0.70 10000*0.68 /
```



## 2.188 KRORG

### Description

The KRORG keyword allows the user to rescale the vertical axes for oil relative permeability input (e.g. SGOF tables assigned by the SATNUM keyword). The oil relative permeability axis is rescaled to a modified oil relative permeability at critical gas saturation on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. KRORG can be used for cases with or without hysteresis (see SATOPTS). These represent drainage values for cases with hysteresis. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (e.g. SWL), and capillary pressure (e.g. PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

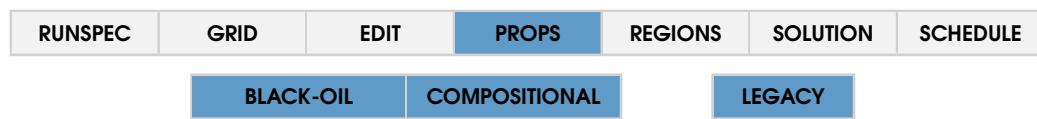
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.24

### Example

KRORG is used here to assign the oil relative permeability at critical gas saturation. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
KRORG
10000*0.50  10000*0.48 /
```



## 2.189 KRORW

### Description

The KRORW keyword allows the user to rescale the vertical axes for oil relative permeability input (e.g. SWOF tables assigned by SATNUM). The oil relative permeability axis is rescaled to a modified oil relative permeability at critical water saturation on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. KRORW can be used for cases with or without hysteresis (see SATOPTS). These represent drainage values for cases with hysteresis. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (e.g. SWL), and capillary pressure (e.g. PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

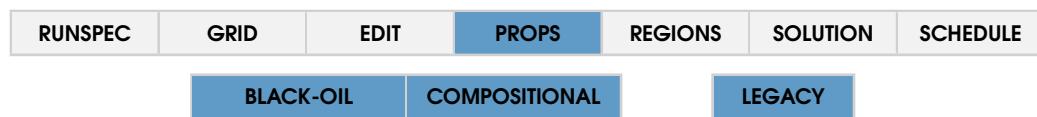
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.25

### Example

KRORW is used here to assign oil relative permeability at critical water saturation. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
KRORW
10000*0.50  10000*0.48 /
```



## 2.190 KRW

### Description

The KRW keyword allows the user to rescale the vertical axis for water relative permeability input (*e.g.* SWOF tables assigned by SATNUM). The water relative permeability axis is rescaled to a modified highest water relative permeability value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest water relative permeability is the value at the highest water saturation in the table. KRW can be used for cases with or without hysteresis (see SATOPTS). These represent drainage values for cases with hysteresis. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

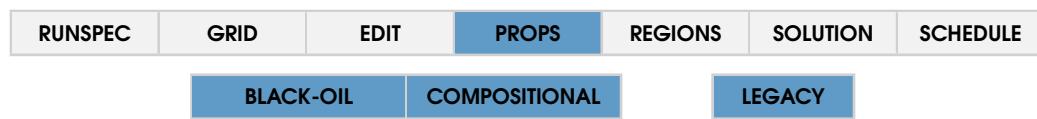
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.26

### Example

KRW is used here to assign the maximum water relative permeability. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
KRW
10000*1.00 10000*0.98 /
```



## 2.191 KRWR

### Description

The KRWR keyword allows the user to rescale the vertical axis for water relative permeability input (*e.g.* SWOF tables assigned by SATNUM). The water relative permeability axis is rescaled to a modified water relative permeability value at residual oil saturation on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. KRWR can be used for cases with or without hysteresis (see SATOPTS). These represent drainage values for cases with hysteresis. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for saturations (*e.g.* SWL), and capillary pressure (*e.g.* PCW). Following are the possible endpoint capillary pressure and relative permeability arrays.

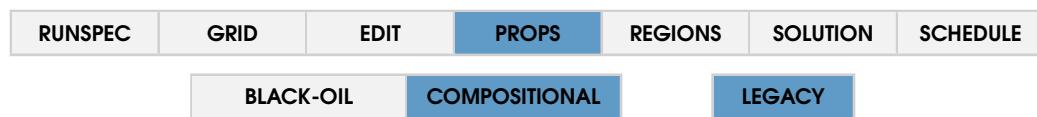
Array	Description
KRG	Gas drainage water relative permeability
KRGR	Gas drainage relative permeability at critical saturation of displacing phase
KRO	Maximum drainage oil relative permeability
KRORG	Oil-in-gas drainage relative permeability at critical saturation of displacing phase
KRORW	Oil-in-water drainage relative permeability at critical saturation of displacing phase
KRW	Maximum water drainage relative permeability
KRWR	Water drainage relative permeability at residual oil-in-water saturation
PCG	Maximum gas-oil drainage capillary pressure
PCW	Maximum water-oil drainage capillary pressure
IKRG	Gas imbibition water relative permeability
IKRGR	Gas imbibition relative permeability at critical saturation of displacing phase
IKRO	Maximum imbibition oil relative permeability
IKRORG	Oil-in-gas imbibition relative permeability at critical saturation of displacing phase
IKRORW	Oil-in-water imbibition relative permeability at critical saturation of displacing phase
IKRW	Maximum water imbibition relative permeability
IKRWR	Water imbibition relative permeability at residual oil-in-water saturation
IPCG	Maximum gas-oil imbibition capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure

Table 2.27

### Example

KRWR is used here to assign the water relative permeability at residual oil saturation. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
KRWR
10000*0.35 10000*0.32 /
```



## 2.192 LBCCOEF

### Description

This keyword allows modification of default values of Lorentz-Bary-Clark coefficients used for viscosity computation. The number of coefficients that can be set is five. If a coefficient is not provided, then the default value is used.

### Record format

1. **LBCCOEF:** Component Lorentz-Bary-Clark coefficients.

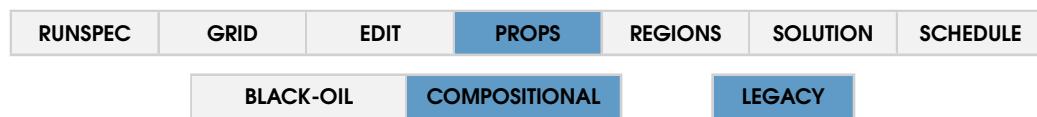
The default values used by the simulator are 0.1023, 0.023364, 0.058533, -0.040758 and 0.0093324

**Type:** Float

### Example

This example specifies the Lorentz-Bary-Clark coefficients for a compositional simulation

```
LBCCOEF  
0.1 0.02 0.05 -0.05 0.01 /
```



## 2.193 LBCCOEFR

### Description

This keyword allows modification of default values of Lorentz-Bary-Clark coefficients used for viscosity computation for different equations of state regions. Five (5) coefficients are set for each equation of state region; if a coefficient is not provided, the default value is used.

The keyword is followed by NEOSR ([TABDIMS](#) ninth field) record.

### Record format

1. **LBCCOEFR:** Component Lorentz-Bary-Clark coefficients.

The default values used by the simulator are 0.1023, 0.023364, 0.058533, -0.040758 and 0.0093324

**Type:** Float

### Example

This example specifies the Lorentz-Bary-Clark coefficients for a compositional simulation with two equation of state regions

```
LBCCOEFR
0.1 0.02 0.05 -0.05  0.01  /
1* 0.02 0.05  /
```



## 2.194 LIFTOPT

### Description

This keyword activates the gas lift optimization option and sets some important parameters to control the optimization algorithm. At the beginning of every timestep, ECHELON optimizes the allocation of gas lift of a set of wells prescribed with [WLIFTOPT](#) in such a way maximize the oil production and avoid violation of the group constraints. (see Reservoir Management chapter in ECHELON Technical Description).

This keyword contains one single record terminated by a slash.

### Record format

1. **INCREMENT\_SIZE:** The size of the gas lift increments that are exchanged during the optimization routine is used to compute the incremental and decremental gradients. In general, the gas lift rate assigned to a well is increased or decreased by multiples of the gas lift increment unless maximum/minimum gas lift bounds are assigned in [WLIFTOPT](#). A value for this Item is always required.

**Type:** Float

**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

2. **MINIMUM\_GRADIENT:** Threshold for the economic viability of incremental gas lift allocation. At each optimization iteration, a lift increment is subtracted from those wells having a weighted decremental gradient lower than this value. Also, no gas lift increments are added to those wells having a weighted incremental gradient lower than this value.

**Type:** Float

**Units:** stb/Mscf (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0 (FIELD), 0 (METRIC)

### Example

In this example, the gas lift optimization option is activated using an increment size of 100 Mscf/d and no minimum economic gradient.

```
LIFTOPT
-- incr min
-- size grad
100    1*    /
```



## 2.195 LIVEWAT

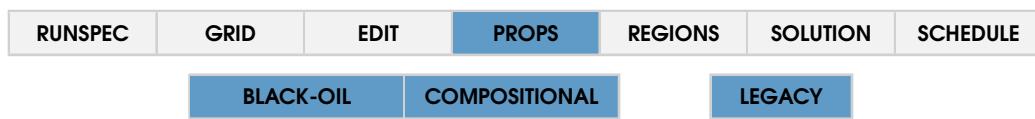
### Description

This keyword enables the modeling of vapor/liquid/aqueous equilibrium, allowing the solubility of components in the aqueous phase, as well as water vaporization in the vapor phase and dissolution in the liquid phase. In particular, the Soreide and Whitson modification to the Peng-Robinson equation of state is adopted to account for component solubilities and water vaporization.

If the option is active the last component provided in the model is assumed to be water. Specific formulas are implemented for the computation of binary interaction coefficients of  $CO_2$ ,  $N_2$  and  $H_2S$  in the aqueous phase; to use such formulas the proper component name ( $CO_2$ ,  $N_2$  and  $H_2S$ ), must be provided by the user in the [CNAMES](#) keyword.

### Example

```
RUNSPEC  
LIVEWAT
```



## 2.196 LKRO

### Description

The LKRO keyword allows the user to rescale the vertical axes for low salinity oil relative permeability input (e.g. SWOF tables assigned by [LSNUM](#) or the equivalent [LSSLTWNUM](#) keyword). The oil relative permeability axis is rescaled to a modified highest oil relative permeability value on a cell-by-cell basis. Values are expected for each cell in the current input [BOX](#) following the natural I, J, K grid ordering. The highest oil relative permeability is the value at the highest oil saturation in the low-salinity tables. [LKRO](#) can be used for cases without hysteresis and with low-salinity [LOWSLALT](#). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for low-salinity water saturations (e.g. [LSWL](#)), and water-oil capillary pressure (e.g. [LPCW](#)). Following are the possible low-salinity endpoint capillary pressure and relative permeability arrays.

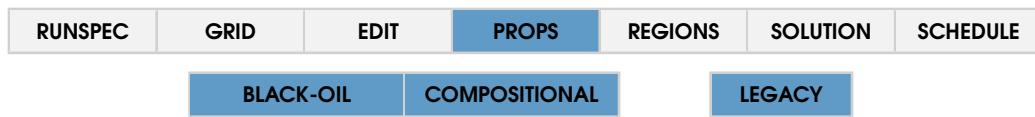
Array	Description
<a href="#">LKRO</a>	Maximum low-salinity oil relative permeability
<a href="#">LKRORG</a>	Low-salinity oil-in-gas relative permeability at critical gas saturation
<a href="#">LKRORW</a>	Low-salinity oil-in-water relative permeability at critical water saturation
<a href="#">LKRW</a>	Maximum low-salinity water relative permeability
<a href="#">LKRWR</a>	Low-salinity water relative permeability at residual oil saturation
<a href="#">LPCW</a>	Maximum low-salinity water-oil capillary pressure

Table 2.28

### Example

[LKRO](#) is used here to assign the low-salinity maximum oil relative permeability. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LKRO
 10000*0.70  10000*0.68 /
```



## 2.197 LKRORG

### Description

The LKRORG keyword allows the user to rescale the vertical axes for low salinity oil relative permeability input (e.g. SGOF tables assigned by LSNUM or the equivalent LSLTWNUM keyword). The oil relative permeability axis is rescaled to a modified oil relative permeability at low salinity critical gas saturation on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. LKRORG can be used for cases without hysteresis and with low-salinity LOWSALT. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for low-salinity water saturations (e.g. LSWL), and water-oil capillary pressure (e.g. LPCW). Following are the possible low-salinity endpoint capillary pressure and relative permeability arrays.

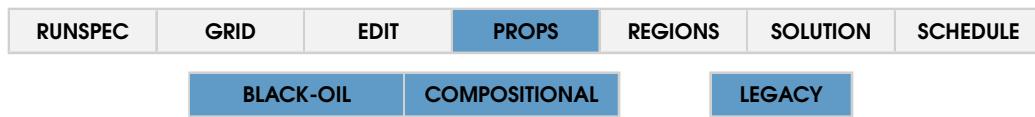
Array	Description
LKRO	Maximum low-salinity oil relative permeability
LKRORG	Low-salinity oil-in-gas relative permeability at critical gas saturation
LKRORW	Low-salinity oil-in-water relative permeability at critical water saturation
LKRW	Maximum low-salinity water relative permeability
LKRWR	Low-salinity water relative permeability at residual oil saturation
LPCW	Maximum low-salinity water-oil capillary pressure

Table 2.29

### Example

LKRORG is used here to assign the low-salinity oil relative permeability at critical gas saturation. This model has an upper zone of 10000 cells and lower zones of the same size.

```
LKRORG
10000*0.70 10000*0.68 /
```



## 2.198 LKRORW

### Description

The LKRORW keyword allows the user to rescale the vertical axes for low salinity oil relative permeability input (e.g. SWOF tables assigned by LSNUM or the equivalent LSLTNUM keyword). The oil relative permeability axis is rescaled to a modified oil relative permeability at low salinity critical water saturation on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. LKRORW can be used for cases without hysteresis and with low-salinity LOWSALT. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for low-salinity water saturations (e.g. LSWL), and water-oil capillary pressure (e.g. LPCW). Following are the possible low-salinity endpoint capillary pressure and relative permeability arrays.

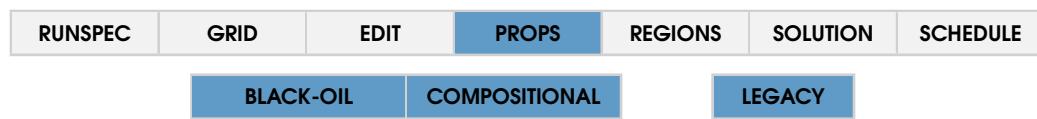
Array	Description
LKRO	Maximum low-salinity oil relative permeability
LKRORG	Low-salinity oil-in-gas relative permeability at critical gas saturation
LKRORW	Low-salinity oil-in-water relative permeability at critical water saturation
LKRW	Maximum low-salinity water relative permeability
LKRWR	Low-salinity water relative permeability at residual oil saturation
LPCW	Maximum low-salinity water-oil capillary pressure

Table 2.30

### Example

LKRORW is used here to assign the low-salinity oil relative permeability at critical water. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LKRORW
10000*0.50 10000*0.48 /
```



## 2.199 LKRW

### Description

The LKRW keyword allows the user to rescale the vertical axis for low salinity water relative permeability input (*e.g.* SWOF tables assigned by LSNUM or the equivalent LSLTWNUM keyword). The water relative permeability axis is rescaled to a modified highest water relative permeability value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest water relative permeability is the value at the highest water saturation in the low-salinity table. LKRW can be used for cases without hysteresis and with low-salinity LOWSALT. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for low-salinity water saturations (*e.g.* LSWL), and water-oil capillary pressure (*e.g.* LPCW). Following are the possible low-salinity endpoint capillary pressure and relative permeability arrays.

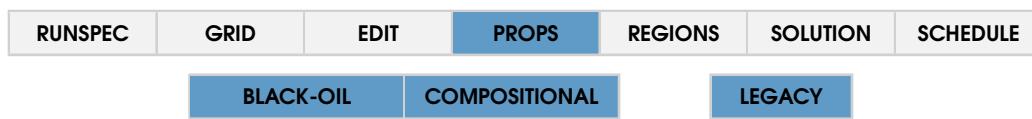
Array	Description
LKRO	Maximum low-salinity oil relative permeability
LKRORG	Low-salinity oil-in-gas relative permeability at critical gas saturation
LKRORW	Low-salinity oil-in-water relative permeability at critical water saturation
LKRW	Maximum low-salinity water relative permeability
LKRWR	Low-salinity water relative permeability at residual oil saturation
LPCW	Maximum low-salinity water-oil capillary pressure

Table 2.31

### Example

LKRW is used here to assign the low-salinity maximum water relative permeability. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LKRW
 10000*1.00  10000*0.98 /
```



## 2.200 LKRWR

### Description

The LKRWR keyword allows the user to rescale the vertical axis for low salinity water relative permeability input (*e.g.* SWOF tables assigned by [LSNUM](#) or the equivalent [LSSLTNUM](#) keyword). The water relative permeability axis is rescaled to a modified water relative permeability value at low-salinity residual oil saturation on a cell-by-cell basis. Values are expected for each cell in the current input [BOX](#) following the natural I, J, K grid ordering. [LKRWR](#) can be used for cases without hysteresis and with low-salinity [LOWSLT](#). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for low-salinity water saturations (*e.g.* [LSWL](#)), and water-oil capillary pressure (*e.g.* [LPCW](#)). Following are the possible low-salinity endpoint capillary pressure and relative permeability end-point arrays.

Array	Description
<a href="#">LKRO</a>	Maximum low-salinity oil relative permeability
<a href="#">LKRORG</a>	Low-salinity oil-in-gas relative permeability at critical gas saturation
<a href="#">LKRORW</a>	Low-salinity oil-in-water relative permeability at critical water saturation
<a href="#">LKRW</a>	Maximum low-salinity water relative permeability
<a href="#">LKRWR</a>	Low-salinity water relative permeability at residual oil saturation
<a href="#">LPCW</a>	Maximum low-salinity water-oil capillary pressure

Table 2.32

### Example

[LKRWR](#) is used here to assign the low-salinity water relative permeability at residual oil saturation. This model has an upper zone of 10000 cells and lower zones of the same size.

```
LKRWR
 10000*0.35  10000*0.32  /
```



## 2.201 LOAD

### Description

This keyword is a component of the ECHELON restart facility, documented in detail in [Chapter 13](#) of ECHELON Technical Description.

This keyword can be used to restart the simulation from a SAVE file in a fast mode. It is followed by a single record with two fields, the base name of the SAVE file and the report number chosen to restart the simulation. The available report numbers can be found in the log file of the ECHELON simulation which generated the SAVE file (i.e Saved simulator state to report 1 (01 Jan 1992 00:00)).

The LOAD keyword should be the first keyword to appear in the DATA file. Information from the RUNSPEC to the SOLUTION sections should be omitted since they are stored in the SAVE file. So the restart data file should contain only the LOAD keyword, SUMMARY and SCHEDULE sections.

Note that to restart an ECHELON Reservoir Coupling run the previous statements are valid and necessary to be implemented in all the coupled DATA files, while the Master DATA file does not require edits.

See also [Chapter 13](#) in the Technical Description and keywords [SAVE](#), [SAVENOW](#), [RESTART](#) and [SKIPREST](#).

### Record format

Field	Name	Type	Description
1	SAVE FILE	String	Save file root name
2	REPORT	Integer	The report number from which the simulation will be restarted

### Example

An example of how to fast restart from report number 22 of Save file MODEL.SAVE.

```
LOAD
MODEL    22 /
```

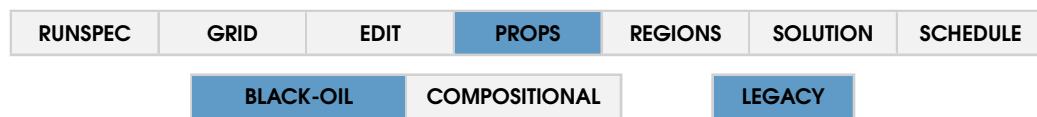


## 2.202 LOWSALT

### Description

Adding the LOWSALT keyword to the [RUNSPEC](#) section activates the low salinity model. This option approximates low salinity flooding via relative permeabilities and capillary pressure curves which are interpolated between high and low salinity extremes as a function of the water salinity. See the Technical Manual and the [LSALTFNC](#) keyword for a description of the interpolation method. Water, oil-in-water and oil-in-gas relative permeabilities, as well as water capillary pressure, can have both low and high salinity relative permeability curves. The low salinity saturation tables are associated with grid block regions via the [LSNUM](#) keyword and high salinity via [SATNUM](#). The low salinity model is compatible with two- and three-point end-point scaling. The [BRINE](#) option should also be active when simulating low-salinity flooding.

Although low salinity flooding is compatible with relative permeability and capillary pressure hysteresis, only the high salinity saturation tables undergo hysteresis. It is therefore not suggested to combine both options.



## 2.203 LPCW

### Description

The **LPCW** keyword allows the user to rescale the vertical capillary pressure axis for low salinity water-oil capillary pressure input (*e.g.* **SWOF** tables assigned by **LSNUM** or the equivalent **LSLTWNUM** keyword). The capillary pressure axis is rescaled to a modified highest capillary pressure value on a cell-by-cell basis. Values are expected for each cell in the current input **BOX** following the natural I, J, K grid ordering. The highest capillary pressure is the value at the smallest water saturation in the low-salinity table. **LPCW** can be used for cases without hysteresis and with low-salinity **LOWSALT**. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The **LPCW** keyword should not be used when using the J-function option **JFUNC** or when defining initial saturations via the **SWATINIT** array. The **LPCW** values should have the same sign as the table capillary pressure at connate (lowest) water saturation.

Additional endpoint arrays are allowed for low-salinity water saturations (*e.g.* **LSWL**), and relative permeability (*e.g.* **LKRW**). Following are the possible low-salinity endpoint capillary pressure and relative permeability arrays.

Array	Description
<b>LPCW</b>	Maximum low-salinity water-oil capillary pressure
<b>LKRO</b>	Maximum low-salinity oil relative permeability
<b>LKRORG</b>	Low-salinity oil-in-gas relative permeability at critical gas saturation
<b>LKRORW</b>	Low-salinity oil-in-water relative permeability at critical water saturation
<b>LKRW</b>	Maximum low-salinity water relative permeability
<b>LKRWR</b>	Low-salinity water relative permeability at residual oil saturation

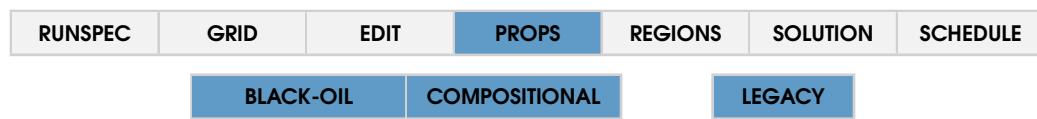
Table 2.33

**Units:** psi (FIELD), bar (METRIC)

### Example

**LPCW** is used here to assign the low-salinity maximum oil-water capillary pressure. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LPCW
10000*20.0 10000*15.0 /
```



## 2.204 LSALTFNC

### Description

The LSALTFNC keyword provides weighting factors for interpolation of low-salinity relative permeability tables as a function of water salinity. Low salinity is activated via the [LOWSLT](#) option in the [RUNSPEC](#) section. One table should be provided for each saturation function, whose number is specified by the item 3 (NTSFUN) field of the [TABDIMS](#) keyword. Each table consists of two columns for salt concentration vs relative permeability weighting factor. At least two rows should be defined for each table and each table should be terminated by a slash (/). Salt concentration should increase monotonically in each table and the relative permeability weighting factor (column 2) should decrease monotonically. Note that each grid block should be assigned a high salinity table number via the [SATNUM](#) keyword and a low salinity table via the [LSNUM](#) keyword.

For the second column (relative permeability weighting factor), a value of 0 means that only high salinity tables (assigned by [SATNUM](#)) will be used for relative permeability at the specified concentration and a value of 1 means that only the low-salinity table (assigned by [LSNUM](#)) will be used. Values must be in the range of 0 to 1.

Slash-terminated tables should be provided after the keyword for each defined table. Any table other than the first can consist of a null table. In this case, the table for that saturation region will default to the previous table.

The keyword expects a table corresponding to each saturation table region (NTSFUN set on the [TABDIMS](#) keyword); however, only the input values corresponding to the [LSNUM](#) table numbers are used. Any table defaulted (after the 1st table) is copied from the previous table. See the example.

### Example

This example has 4 saturation tables defined. Tables 1 and 3 are assigned to grids via [SATNUM](#); therefore, only placeholders are required for those tables. The desired interpolation factors are required for tables assigned to grids via the [LSNUM](#) keyword. These are tables 2 and 4 in this example.

```

LSALTFNC
--table 1 is not used in this case as it corresponds to a SATNUM table
--conc interp unused
 0    1.0      1*
15    0.0      1*
/
--table 2 corresponds to an LSNUM table
--conc interp unused
 0    1.0      1*
10    0.5      1*
15    0.0      1*
/
--table 3 not used in this case as it corresponds to a SATNUM table
--conc interp unused
 0    1.0      1*
22    0.0      1*
/
--table 4 corresponds to an LSNUM table
--conc interp unused
 0    1.0      1*
11    0.7      1*
22    0.0      1*
/

```



## 2.205 LSNUM

### Description

The LSNUM (or equivalent [LWSLTNUM](#) keyword in the [REGION](#) section is used to assign the low-salinity saturation tables for cases using low-salinity water ([LOWSALT](#) in [RUNSPEC](#)). The high salinity tables are defined by the [SATNUM](#) values. Table weighting factors are specified in the [LSALTFNC](#) keyword.

The values assigned must be positive integer values (>=1) corresponding to an input saturation function table number. Input must follow natural I, J, K ordering. Integer values are bounded by the first item of [TABDIMS](#) in the [RUNSPEC](#) section which is the number of input saturation tables. Repeat counts may be used for repeated values. The keyword is followed by a single record terminated by the slash character (/). The number of values must correspond to the entire grid or the number corresponding to a prior defined [BOX](#) cell range.

### Example

LSNUM is used here to assign table 2 as the low salinity table for the first 10000 cells and table 4 for the next 10000 for a model with 20000 cells.

```
LSNUM  
10000*2 10000*4 /
```



## 2.206 LSOGCR

### Description

The LSOGCR keyword allows the user to rescale the horizontal saturation axis for the low-salinity oil relative permeability tables (e.g. SGOF tables assigned by LSNUM or the equivalent LSLTNUM keyword) when using the low-salinity option (LOWSALT). The saturation axis is rescaled to a modified critical oil-in-gas saturation value for low-salinity on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical oil-in-gas saturation is the largest oil saturation for which oil relative permeability is zero in the gas-oil relative permeability table. LSOGCR can be used for cases without hysteresis and with low salinity LOWSALT. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes consistency requirements such as LSWL <= LSWCR. When using the low-salinity option, the high salinity tables are assigned by the SATNUM keyword with its corresponding end-point keywords such as SWL.

Additional endpoint arrays are allowed for low-salinity capillary pressures (e.g. LPCW) and low-salinity relative permeability (e.g. LKRW). Following are the possible low-salinity endpoint saturation arrays.

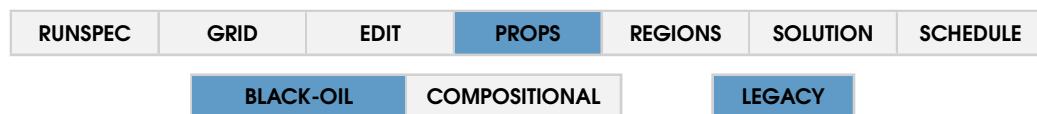
Array	Description
LSWL	Drainage lowest water saturation for low-salinity tables
LSWLP	Drainage lowest water saturation for low-salinity capillary pressure
LSWCR	Drainage critical water saturation for low-salinity tables
LSWU	Drainage upper (maximum) water saturation for low-salinity tables
LSOWCR	Drainage critical oil saturation in water-oil tables for low-salinity tables
LSOGCR	Drainage critical oil saturation in gas-oil tables for low-salinity tables

Table 2.34

### Example

LSOGCR is used here to assign critical oil-in-gas saturation for low salinity tables. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LSOGCR
 10000*0.15  10000*0.12  /
```



## 2.207 LSOWCR

### Description

The LSOWCR keyword allows the user to rescale the horizontal saturation axis for the low-salinity water-oil relative permeability tables (*e.g.* SWOF tables assigned by LSNUM or the equivalent LSLTNUM keyword) when using the low-salinity option (LWSALT). The saturation axis is rescaled to a modified critical oil-in-water saturation value for low-salinity on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical oil-in-water saturation is the largest oil saturation for which oil relative permeability is zero in the relative permeability table. LSOWCR can be used for cases without hysteresis and with low salinity LWSALT. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes consistency requirements such as LSWL <= LSOWCR. When using the low-salinity option, the high salinity tables are assigned by the SATNUM keyword with its corresponding end-point keywords such as SWL.

Additional endpoint arrays are allowed for low-salinity capillary pressures (*e.g.* LPCW) and low-salinity relative permeability (*e.g.* LKRW). Following are the possible low-salinity endpoint saturation arrays.

Array	Description
LSWL	Drainage lowest water saturation for low-salinity tables
LSWLP	Drainage lowest water saturation for low-salinity capillary pressure
LSWCR	Drainage critical water saturation for low-salinity tables
LSWU	Drainage upper (maximum) water saturation for low-salinity tables
LSOWCR	Drainage critical oil saturation in water-oil tables for low-salinity tables
LSOGCR	Drainage critical oil saturation in gas-oil tables for low-salinity tables

Table 2.35

### Example

LSOWCR is used here to assign critical oil-in-water saturation for low salinity tables. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LSOWCR
 10000*0.25  10000*0.22  /
```



## 2.208 LSWCR

### Description

The LSWCR keyword allows the user to rescale the horizontal saturation axis for the low-salinity water-oil relative permeability tables (*e.g.* SWOF tables assigned by LSNUM or the equivalent LSLTWNUM keyword) when using the low-salinity option (LOWSALT). The saturation axis is rescaled to a modified critical water saturation value for low-salinity on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical water saturation is the largest water saturation for which water relative permeability is zero in the relative permeability table. LSWCR can be used for cases without hysteresis and with low salinity LOWSALT. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes consistency requirements such as LSWL <= LSWCR. When using the low-salinity option, the high salinity tables are assigned by the SATNUM keyword with its corresponding end-point keywords such as SWL.

Additional endpoint arrays are allowed for low-salinity capillary pressures (*e.g.* LPCW) and low-salinity relative permeability (*e.g.* LKRW). Following are the possible low-salinity endpoint saturation arrays.

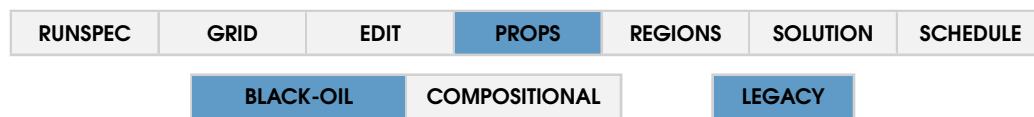
Array	Description
LSWL	Drainage lowest water saturation for low-salinity tables
LSWLP	Drainage lowest water saturation for low-salinity capillary pressure
LSWCR	Drainage critical water saturation for low-salinity tables
LSWU	Drainage upper (maximum) water saturation for low-salinity tables
LSOWCR	Drainage critical oil saturation in water-oil tables for low-salinity tables
LSOGCR	Drainage critical oil saturation in gas-oil tables for low-salinity tables

Table 2.36

### Example

LSWCR is used here to assign lowest (connate) water saturation for low salinity tables. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LSWCR
 10000*0.20  10000*0.18  /
```



## 2.209 LSWL

### Description

The LSWL keyword allows the user to rescale the horizontal saturation axis for the low-salinity water-oil relative permeability tables (*e.g.* SWOF tables assigned by **LSNUM** or the equivalent **LSTLWNUM** keyword) when using the low-salinity option (**LOWSALT**). The saturation axis is rescaled to a modified lowest (connate) water saturation value for low-salinity on a cell-by-cell basis. Values are expected for each cell in the current input **BOX** following the natural I, J, K grid ordering. The lowest (connate) water saturation is the smallest water saturation in the relative permeability table. Relative permeability is zero at this saturation. LSWL can be used for cases without hysteresis and with low-salinity **LOWSALT**. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes consistency requirements such as **LSWL <= LSWCR**. When using the low-salinity option, the high-salinity tables are assigned by the **SATNUM** keyword with its corresponding end-point keywords such as **SWL**.

Additional endpoint arrays are allowed for low-salinity capillary pressures (*e.g.* **LPCW**) and low-salinity relative permeability (*e.g.* **LKRW**). Following are the possible low-salinity endpoint saturation arrays.

Array	Description
<b>LSWL</b>	Drainage lowest water saturation for low-salinity tables
<b>LSWLPC</b>	Drainage lowest water saturation for low-salinity capillary pressure
<b>LSWCR</b>	Drainage critical water saturation for low-salinity tables
<b>LSWU</b>	Drainage upper (maximum) water saturation for low-salinity tables
<b>LSOWCR</b>	Drainage critical oil saturation in water-oil tables for low-salinity tables
<b>LSOGCR</b>	Drainage critical oil saturation in gas-oil tables for low-salinity tables

Table 2.37

### Example

**LSWL** is used here to assign lowest (connate) water saturation for low salinity tables. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LSWL
 10000*0.18  10000*0.16  /
```



## 2.210 LSWLPC

### Description

The LSWLPC keyword allows the user to rescale the horizontal saturation axis for the low-salinity water-oil capillary pressure tables (*e.g.* SWOF tables assigned by LSNUM or the equivalent LSLTNUM keyword) when using the low-salinity option (LOWSALT). The capillary pressure axis is rescaled to a modified lowest (connate) water saturation value for low salinity on a cell-by-cell basis. Water-oil relative permeability tables are not impacted by this keyword. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The lowest (connate) water saturation is the smallest water saturation in the capillary pressure table. Capillary pressure is a maximum at this saturation. LSWLPC can be used for cases without hysteresis and with low-salinity LOWSALT. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes consistency requirements such as LSWL<=LSWCR. When using the low-salinity option, the high-salinity tables are assigned by the SATNUM keyword with its corresponding end-point keywords such as SWL.

Additional endpoint arrays are allowed for low-salinity capillary pressures (*e.g.* LPCW) and low-salinity relative permeability (*e.g.* LKRW). Following are the possible low-salinity endpoint saturation arrays.

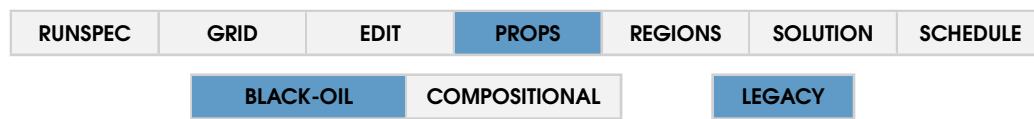
Array	Description
LSWL	Drainage lowest water saturation for low-salinity tables
LSWLPC	Drainage lowest water saturation for low-salinity capillary pressure
LSWCR	Drainage critical water saturation for low-salinity tables
LSWU	Drainage upper (maximum) water saturation for low-salinity tables
LSOWCR	Drainage critical oil saturation in water-oil tables for low-salinity tables
LSOGCR	Drainage critical oil saturation in gas-oil tables for low-salinity tables

Table 2.38

### Example

LSWLPC is used here to assign lowest (connate) water saturation for low salinity water-oil capillary pressure tables. This model has upper zones of 10000 cells and a lower zone of the same size.

```
LSWLPC
 10000*0.17  10000*0.15 /
```



## 2.211 LSWU

### Description

The LSWU keyword allows the user to rescale the horizontal saturation axis for the low-salinity water-oil relative permeability tables (e.g. SWOF tables assigned by LSNUM or the equivalent LSLTWNUM keyword) when using the low-salinity option (LOWSALT). The saturation axis is rescaled to modified highest possible water saturation for low salinity on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. The highest water saturation is the maximum water saturation in the low-salinity relative permeability table. Relative permeability is zero at this saturation. LSWU can be used for cases without hysteresis and with low-salinity LOWSALT. Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes consistency requirements such as LSWL <= LSWCR. When using the low-salinity option, the high-salinity tables are assigned by the SATNUM keyword with its corresponding end-point keywords such as SWL.

Additional endpoint arrays are allowed for low-salinity capillary pressures (e.g. LPCW) and low-salinity relative permeability (e.g. LKRW). Following are the possible low-salinity endpoint saturation arrays.

Array	Description
LSWL	Drainage lowest water saturation for low-salinity tables
LSWLPC	Drainage lowest water saturation for low-salinity capillary pressure
LSWCR	Drainage critical water saturation for low-salinity tables
LSWU	Drainage upper (maximum) water saturation for low-salinity tables
LSOWCR	Drainage critical oil saturation in water-oil tables for low-salinity tables
LSOGCR	Drainage critical oil saturation in gas-oil tables for low-salinity tables

Table 2.39

### Example

LSWU is used here to assign the highest possible water saturation for low salinity tables. This model has an upper zone of 10000 cells and a lower zone of the same size.

```
LSWL
10000*1.0  10000*0.99 /
```



## 2.212 LTOSIGMA

### Description

The LX, LY and LZ coefficients represent the ( $f_{lx}$ ,  $f_{ly}$ , and  $f_{lz}$ ) terms in the fracture-matrix transmissibility calculation (see the [SIGMAV](#) keyword). For uniform fracture spacing in the x, y and z-directions ( $L_x$ ,  $L_y$ ,  $L_z$ ),  $\sigma$  has been shown to be equal to  $(f_{lx}/L_x^2 + f_{ly}/L_y^2 + f_{lz}/L_z^2)$  where the  $f_l$  terms are all equal to 4. Alternatively, some literature has proposed that the value of 4 in the equation be replaced with  $\pi^2$ . These coefficients are dimensionless. The permeability option XONLY uses the x-direction matrix perm in the  $k \cdot \sigma$  calculation for matrix-fracture transmissibility. The ALL option uses the term  $(f_{lx} \cdot k_x/L_x^2) + (f_{ly} \cdot k_y/L_y^2) + (f_{lz} \cdot k_z/L_z^2)$ .

### Record format

1. LX coefficient in sigma calculation

**Type:** Float

**Default value:** 4.0

2. LY coefficient in sigma calculation

**Type:** Float

**Default value:** 4.0

3. LZ coefficient in sigma calculation

**Type:** Float

**Default value:** 4.0

4. Reserved

5. Determines which permeabilities are used in matrix-fracture transmissibility calculations

**Type:** String

**Allowed values:**

Name	Description
XONLY	Use the x-permeability only in matrix-fracture transmissibility calculations
ALL	Use all three directional permeabilities in matrix-fracture transmissibility calculations

### Example

```
LTOSIGMA
9.87  9.87  0.0  1* ALL/
```

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SCHEDULE
		BLACK-OIL			COMPOSITIONAL	
					LEGACY	

## 2.213 LWSLTNUM

### Description

The LWSLTNUM (or equivalent [LSNUM](#) keyword in the [REGION](#) section) is used to assign the low-salinity saturation tables for cases using low-salinity water ([LOWSALT](#) in [RUNSPEC](#)). The high salinity tables are defined by the [SATNUM](#) values. Table weighting factors are specified in the [LSALTFNC](#) keyword.

The values assigned must be positive integer values (>=1) corresponding to an input saturation function table number. Input must follow natural I, J, K ordering. Integer values are bounded by the first item of [TABDIMS](#) in the [RUNSPEC](#) section which is the number of input saturation tables. Repeat counts may be used for repeated values. The keyword is followed by a single record terminated by the slash character (/). The number of values must correspond to the entire grid or the number corresponding to a prior defined [BOX](#) cell range.

### Example

LWSLTNUM is used here to assign table 2 as the low salinity table for the first 10000 cells and table 4 for the next 10000 for a model with 20000 cells.

```
LWSLTNUM  
10000*2 10000*4 /
```



## 2.214 LX

### Description

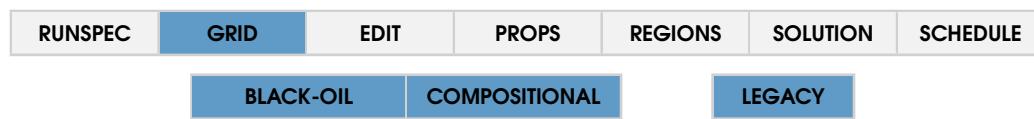
The LX values represent the ( $L_x$ ) term in the fracture-matrix transmissibility calculation when the [LTOSIGMA](#) keyword is present (see also the [SIGMAV](#) keyword). For uniform fracture spacing in the x, y and z-directions ( $L_x, L_y, L_z$ ),  $\sigma$  has been shown to be equal to  $4(1/L_x^2 + 1/L_y^2 + 1/L_z^2)$ . Alternatively, some literature has proposed that the value of 4 in the equation be replaced with  $\pi^2$ . This can be controlled with the [LTOSIGMA](#) keyword.

LX input is per natural grid ordering for the current input box and is required only for grid blocks in the first [NZ](#) /2 dual-media layers.

**Units:** ft (FIELD), m (METRIC)

### Example

```
LX  
10.0 10.0 5.0 50*15.0 20.0 20.0/
```



## 2.215 LY

### Description

The LY values represent the ( $L_y$ ) term in the fracture-matrix transmissibility calculation when the [LTOSIGMA](#) keyword is present (see also the [SIGMAV](#) keyword). For uniform fracture spacing in the x, y and z-directions ( $L_x, L_y, L_z$ ),  $\sigma$  has been shown to be equal to  $4(1/L_x^2 + 1/L_y^2 + 1/L_z^2)$ . Alternatively, some literature has proposed that the value of 4 in the equation be replaced with  $\pi^2$ . This can be controlled with the [LTOSIGMA](#) keyword.

LY input is per natural grid ordering for the current input box and is required only for grid blocks in the first [NZ](#) /2 dual-media layers.

**Units:** ft (FIELD), m (METRIC)

### Example

```
LY  
10.0  10.0   5.0  50*15.0  20.0  20.0/
```



## 2.216 LZ

### Description

The **LZ** values represent the ( $L_z$ ) term in the fracture-matrix transmissibility calculation when the **LTOSIGMA** keyword is present (see also the **SIGMAV** keyword). For uniform fracture spacing in the x, y and z-directions ( $L_x, L_y, L_z$ ),  $\sigma$  has been shown to be equal to  $4(1/L_x^2 + 1/L_y^2 + 1/L_z^2)$ . Alternatively, some literature has proposed that the value of 4 in the equation be replaced with  $\pi^2$ . This can be controlled with the **LTOSIGMA** keyword.

LY input is per natural grid ordering for the current input box and is required only for grid blocks in the first **NZ** /2 dual-media layers.

**Units:** ft (FIELD), m (METRIC)

### Example

```
LZ  
100.0 100.0 50.0 50*150.0 200.0 200.0/
```



## 2.217 MAPAXES

### Description

The MAPAXES keyword allows the definition of the grid origin and grid axes orientations relative to the map coordinates. This information normally comes from grid preprocessing programs and is stored in the simulation grid output file for use when generating consistent map views in post-processors. The keyword is optional.

The grid axes are specified by three map x,y pairs: 1)a map x,y point along the grid Y-axis, 2)the map x,y value at the grid origin and 3)a map x,y value along the grid X-axis. Units are defined with the [MAPUNITS](#) keyword. The keyword is terminated with a slash (/).

### Record format

Field	Name	Type	Description
1	X1	Float	Map X-coordinate of one point along grid y-axis
2	Y1	Float	Map Y-coordinate of one point along grid y-axis
3	X2	Float	Map X-coordinate at grid origin
4	Y2	Float	Map Y-coordinate at grid origin
5	X3	Float	Map X-coordinate of one point along grid x-axis
6	Y3	Float	Map Y-coordinate of one point along grid y-axis

### Example

The grid axes are specified by three map x,y pairs; 1)a map x,y point along the grid Y-axis, 2)a map x,y value at the grid origin and 3)a map x,y value along the grid X-axis

```
MAPAXES
503234.063181 6761075.871490
503234.063181 6760075.871490
504234.063181 6760075.871490 /
```



## 2.218 MAPUNITS

### Description

MAPUNITS is output by grid preprocessors to specify the units which define the grid origin ([MAPAXES](#) keyword). Unit options are FEET or METRES (note the use of the European spelling for METRES). The keyword is ended with a slash.

### Record format

Field	Name	Type	Description
1	Units	Integer	Unit used for MAPAXES definition (FEET or METRES)

### Example

Define the units used for map axes [MAPAXES](#)

```
MAPUNITS  
FEET /
```



## 2.219 MAXCONN

### Description

This keyword sets the maximum allowed amount of connections per grid cell, which is unlimited by default.

### Record format

1. **MAX\_CONN:** Maximum amount of connections

Type: Integer

#### Example

This example specifies that the grid will only allow a maximum of 9 connections per cell.

```
MAXCONN  
9 /
```



## 2.220 MAXTRANP

### Description

The MAXTRANP keyword sets an upper bound for transmissibility values calculated for pinchout connections (see [PINCH](#) and [PINCHREG](#)). It is followed by a record with a single non-negative number followed by the slash character. Note that the [MAXTRANZ](#) keyword does not apply to pinchouts.

### Record format

1. **MAXTRAN:** upper bound for vertical transmissibility

**Type:** Float

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

### Example

`MAXTRANP` sets a maximum value of 10,000 for pinchout transmissibility:

```
MAXTRANP  
10000 /
```



## 2.221 MAXTRANS

### Description

The [MAXTRANS](#) keyword can be used to limit the maximum static transmissibility,  $T_{\max}$  for cell-cell connections in the SCHEDULE section. When applied in the SCHEDULE section, transmissibility multipliers specified with the [MULTX](#), [MULTY](#), [MULTZ](#), [MULTREGT](#), and [MULTFLT](#) keywords are multiplicative. When combined, these can sometimes lead to unphysically large transmissibilities that make nonlinear convergence very difficult. By employing [MAXTRANS](#) to set an upper bound on cell-cell transmissibilities, nonlinear convergence can be greatly improved. Care should be taken when choosing this limit to ensure that any change in physical results are negligible.

Note that the transmissibility limit is applied at the last possible moment. That is if the original connection transmissibility between cells  $i$  and  $j$  is  $T_{ij}$  and two multipliers are applied: first  $\alpha_{ij}$  and then  $\beta_{ij}$  at a later time, the limited transmissibility would be

$$T_{ij}^{\text{lim}} = \min(T_{\max}, \alpha_{ij} \cdot \beta_{ij} \cdot T_{ij}).$$

The keyword should be followed by a single slash-terminated record containing a single value representing the maximum connection transmissibility. Zero or negative values imply no limit. The keyword takes effect in the next timestep after it appears in the SCHEDULE and remains in effect until it is changed with a subsequent application of the keyword.

### Record format

#### 1. TRANMAX:

**Type:** Float

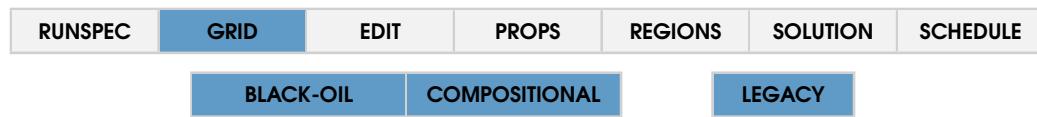
**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

### Example

```

SCHEDULE
DATES
1 JAN 2021
/
MAXTRANS
1.0e4 /
DATES
1 FEB 2021
/

```



## 2.222 MAXTRANZ

### Description

This keyword sets an upper bound for vertical transmissibility [TRANZ](#) keyword. It is followed by a record with a single non-negative number followed by the slash character. The keyword only applies to natural connections, in particular, it does not apply to pinched out connections. For that purpose, see the [MAXTRANP](#) keyword.

### Record format

1. **MAXTRAN:** upper bound for vertical transmissibility

**Type:** Float

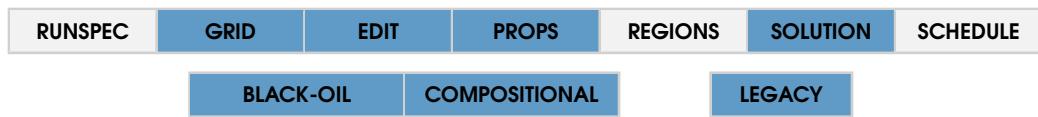
**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

**Default value:** 10<sup>2</sup> (FIELD), 10<sup>2</sup> (METRIC)

### Example

[MAXTRANZ](#) sets the maximum value for [TRANZ](#) to 10000:

```
MAXTRANZ  
10000 /
```



## 2.223 MAXVALUE

### Description

This keyword can be used to set a constant as an upper bound for the values of a given 3D array inside a set of grid cells or for the entire grid. Any 3D array value above the upper bound is set equal to the value specified with this keyword.

The keyword can be followed by an arbitrary number of records terminating with a slash, followed by an empty record terminated with a slash.

The [MINVALUE](#) operation is repeated for every record, setting values of 3D arrays in a box of cells defined by six integers (items 3 to 8) subject to the following constraints:

$$\begin{aligned} 1 &\leq \text{IMIN} \leq \text{IMAX} \leq \text{NX}, \\ 1 &\leq \text{JMIN} \leq \text{JMAX} \leq \text{NY}, \\ 1 &\leq \text{KMIN} \leq \text{KMAX} \leq \text{NZ}. \end{aligned}$$

If [MAXVALUE](#) is used for global grid arrays, NX=NXRES, NY=NYRES and NZ=NZRES. If [ADD](#) is used within a local grid refinement definition ([CARFIN/ENDFIN](#) block) or within a local grid refinement editing ([REFINE/ENDFIN](#) block) then the 3D array at hand is inside the local refinement and the cell box is bounded by local grid dimension (i.e. NXREF, NYREF and NZREF). Similarly, inside a [BOX/ENDBOX](#) block NX, NY and NZ are set according to [BOX](#) record.

Notably, if you define a cell box in one record, then the next record inherits that cell box limits as its default values for item 3 to 8.

Available 3D arrays for [MAXVALUE](#) keyword on a section basis are:

#### GRID

[DX](#), [DY](#), [DZ](#), [PERMX](#), [PERMY](#), [PERMZ](#), [MULTX](#), [MULTY](#), [MULTZ](#), [PORO](#), [MULTPV](#), [NTG](#), [FLUXNUM](#), [MULTNUM](#), [OPERNUM](#)

#### EDIT

[PORV](#), [DEPTH](#), [TRANX](#), [TRANY](#), [TRANZ](#),

#### PROPS

[SWL](#), [SWCR](#), [SWU](#), [SGL](#), [SGCR](#), [SGU](#), [KRW](#), [KRO](#), [KRG](#), [KRWR](#), [KRGR](#), [KRORW](#), [KRORG](#), [ISWL](#), [ISWCR](#), [ISWU](#), [ISGL](#), [ISGCR](#), [ISGU](#), [IKRW](#), [IKRO](#), [IKRG](#), [IKRWR](#), [IKRGR](#), [IKRORG](#), [PCW](#), [PCG](#), [IPCG](#)

#### Record format

1. **ARRAY\_NAME:** target 3D array  
**Type:** String
2. **VALUE:** constant used in the operation as the lower bound  
**Type:** Float
3. **IMIN:** First cell to be updated along the I-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** 1
4. **IMAX:** Last cell to be updated along the I-direction  
**Type:** Integer

**Minimum:** 1  
**Maximum:** NX  
**Default value:** NX

5. **JMIN:** First cell to be updated along the J-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** 1

6. **IMAX:** Last cell to be updated along the J-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** NY

7. **KMIN:** First cell to be updated along the K-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** 1

8. **KMAX:** Last cell to be updated along the K-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** NZ

### Example 1

In the first example, section **GRID, MAXVALUE** is used to set an upper bound of 10000 to **PERMX** for the whole grid (first record), an upper bound of 0.4 to **PORO** in the second record, an upper bound of 0.3 to **PORO** and an upper bound of 1000 to **PERMX** in a column of cells only

```
MAXVALUE
PERMX 10000 /
PORO 0.4 /
PORO 0.3 12 25 25 1 30 /
PERMX 1000 /
/
```

### Example 2

In the second example, **MAXVALUE** is used to set an upper bound for **SWL** in the **PROPS** section:

```
MAXVALUE
SWL 0.98 /
/
```



## 2.224 METRIC

### Description

The `METRIC` keyword indicates that metric units are used in specifying all quantities in this simulation dataset. No record data is associated with this keyword.

### Example

```
RUNSPEC  
METRIC
```



## 2.225 MINNNCT

### Description

This keyword can be used to set a cutoff to non-neighboring connection transmissibility, such that any non-neighboring connection with a transmissibility below the quoted value is deleted. This cut-off does apply to any non-neighboring connection defined using [NNC](#) in the grid section or implicitly calculated by the simulator along fault throw.

The keyword is optional and if it is not used, the simulator removes from the computation all non-neighboring connection with a value below  $10^{-6}$ , regardless the unit system.

### Record format

#### 1. NNCCUTOFF:

**Type:** Float

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

### Example

MINNNCT is used to set the cut-off to zero

```
MINNNCT  
/
```



## 2.226 MINPORV

### Description

This keyword is an alias for [MINPV](#).



## 2.227 MINPV

### Description

This keyword sets a threshold value for cell pore volume below which cells are made inactive and removed from the computation. The keyword is followed by a record with a single field (the pore volume threshold) terminating with a slash. Without `MINPV` the default value is 0.000001 regardless of the unit system.

Notably, it is possible to require the simulator to establish non-neighboring connections throughout cells made inactive using this keyword using `PINCH` or `PINCHOUT` keywords. `MINPVV` keyword provides similar functionality on a cell-by-cell basis.

### Record format

1. **PV\_THRESHOLD:** minimum pore volume threshold

**Type:** Float

**Units:** rb (FIELD), rm<sup>3</sup> (METRIC)

**Default value:** 1e-6 (FIELD), 1e-6 (METRIC)

### Example

```
MINPV  
1.e-15 /
```



## 2.228 MINPVV

### Description

This keyword defines a 3D array of pore volume thresholds. It is followed by a single record with a threshold value for each cell of the grid, with a slash character as the record terminator. The default pore volume threshold is 0.000001. Then, if a cell pore volume is below the specified threshold the cell is made inactive and removed from the computation.

Notably, it is possible to require the simulator to establish non-neighboring connections throughout cells made inactive using this keyword using [PINCH](#) or [PINCHOUT](#) keywords. [MINPV](#) keyword provides similar functionality for the whole grid.

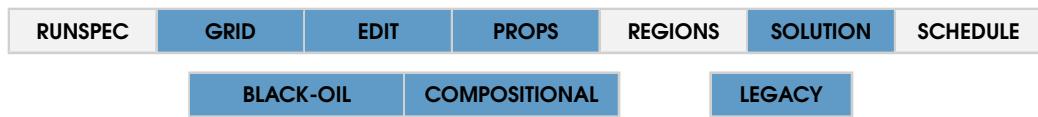
**Units:** rb (FIELD), rm<sup>3</sup> (METRIC)

### Example

[MINPVV](#) is used in a dual porosity (dual permeability) grid to set different pore volume thresholds for matrix and fractures. In the fracture, some of the cell thresholds in the lower layer are defaulted.

```
BOX
 1 120 1 45 1 60 /
MINPVV
 324000*100 /
ENDBOX

BOX
 1 120 1 45 61 120 /
MINPVV
 208800*100 115200* /
ENDBOX
```



## 2.229 MINVALUE

### Description

This keyword can be used to set a constant as a lower bound for the values of a given 3D array inside a set of grid cells or for the entire grid. Any 3D array value below the lower bound is set equal to the specified constant value.

The keyword can be followed by an arbitrary number of records terminated by a slash, followed by an empty record terminated with a slash.

The [MINVALUE](#) operation is repeated for every record, setting values of 3D arrays in a box of cells defined by six integers (items 3 to 8) subject to the following constraints:

$$1 \leq I\text{MIN} \leq I\text{MAX} \leq NX$$

$$1 \leq J\text{MIN} \leq J\text{MAX} \leq NY$$

$$1 \leq K\text{MIN} \leq K\text{MAX} \leq NZ$$

If [MINVALUE](#) is used for global grid arrays,  $NX=NXRES$ ,  $NY=NYRES$  and  $NZ=NZRES$ . If [ADD](#) is used within a local grid refinement definition ([CARFIN/ENDFIN](#) block) or within a local grid refinement editing ([REFINE/ENDFIN](#) block), then the 3D array at hand is inside the local refinement and cell box is bounded by local grid dimension (i.e  $NXREF$ ,  $NYREF$  and  $NZREF$ ). Notably, if you define a cell box in one record, then the next record inherits that cell box limits as its default values for items 3 to 8.

### Available 3D arrays

Available 3D arrays for [MINVALUE](#) keyword on a section basis are:

#### GRID

[DX](#), [DY](#), [DZ](#), [PERMX](#), [PERMY](#), [PERMZ](#), [MULTX](#), [MULTY](#), [MULTZ](#), [PORO](#), [NTG](#), [FLUXNUM](#), [MULTNUM](#), [OPERNUM](#)

#### EDIT

[PORV](#), [DEPTH](#), [TRANX](#), [TRANY](#), [TRANZ](#)

#### PROPS

[SWL](#), [SWCR](#), [SWU](#), [SGL](#), [SGCR](#), [SGU](#), [KRW](#), [KRO](#), [KRG](#), [KRWR](#), [KRGR](#), [KRORW](#), [KRORG](#), [ISWL](#), [ISWCR](#), [ISWU](#), [ISGL](#), [ISGCR](#), [ISGU](#), [IKRW](#), [IKRO](#), [IKRG](#), [IKRWR](#), [IKRGR](#), [IKRORW](#), [IKRORG](#), [PCW](#), [PCG](#), [IPCW](#), [IPCG](#)

### Record format

1. **ARRAY\_NAME:** target 3D array  
**Type:** String
2. **VALUE:** constant used in the operation as a lower bound  
**Type:** Float
3. **I<sub>MIN</sub>:** First cell to be updated along the I-direction  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** 1
4. **I<sub>MAX</sub>:** Last cell to be updated along the I-direction  
**Type:** Integer  
**Minimum:** 1

**Maximum:** NX

**Default value:** NX

5. **JMIN:** First cell to be updated along the J-direction

**Type:** Integer

**Minimum:** 1

**Maximum:** NY

**Default value:** 1

6. **IMAX:** Last cell to be updated along the J-direction

**Type:** Integer

**Minimum:** 1

**Maximum:** NY

**Default value:** NY

7. **KMIN:** First cell to be updated along the K-direction

**Type:** Integer

**Minimum:** 1

**Maximum:** NZ

**Default value:** 1

8. **KMAX:** Last cell to be updated along the K-direction

**Type:** Integer

**Minimum:** 1

**Maximum:** NZ

**Default value:** NZ

### Example 1

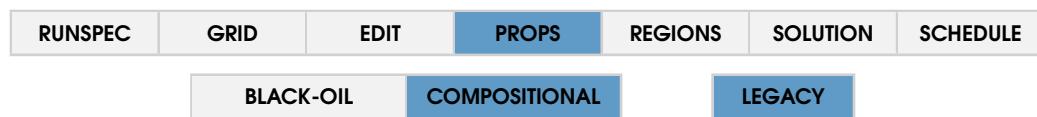
In the first example, section [GRID, MINVALUE](#) is used to set a lower bound of 0.01 to [PERMX](#) for the whole grid (first record), a lower bound of 0.001 to [PORO](#) in the second record and a lower bound of 0.01 to [PORO](#) in a column of cells only.

```
MINVALUE
PERMX 0.01 /
PORO 0.001 /
PORO 0.01 12 25 25 1 30 /
/
```

### Example 2

In the second example, [MINVALUE](#) is used to set a lower bound for [SWL](#) in the [PROPS](#) section:

```
MINVALUE
SWL 0.05 /
/
```



## 2.230 MISCEXP

### Description

This keyword sets the exponent of the surface tension ratio when [MISCIBLE](#) option is enabled (see [Section 10.9](#) in the Technical Description).

### Record format

1. **Type:** Float  
**Default value:** BO: , COMP: 0.25

#### Example

```
MISCEXP
 0.42  /
```



## 2.231 MISCIBLE

### Description

This keyword activates dependence of capillary pressure and relative permeability on surface tension according to the [PARACHOR](#) values (see [Section 10.9](#) in the Technical Description). [PARACHOR](#) must be entered when this keyword is enabled to compute surface tension, while a reference surface tension can be defined using [MISCSTR](#) or [MISCSTRR](#) keywords. By default, initial surface tension is used in each cell as a reference value.

### Example

```
MISCIBLE  
/
```



## 2.232 MISCTNUM

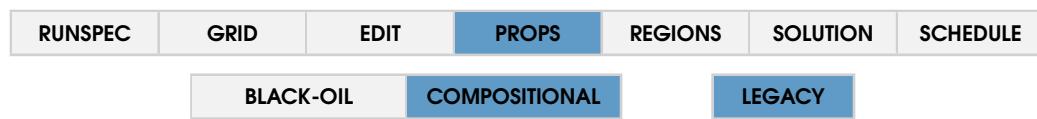
### Description

When **MISCIBLE** is on, this keyword allows to select saturation tables to be used as miscible curves in the interpolation, with **SATNUM** used to define for the cell at hand the immiscible relative permeability (see [Section 10.9](#) in the Technical Description). Notably, if **MISCTNUM** is not provided, straight lines, representing perfectly miscible curves for oil and gas, are used.

The associated record consists of an integer number for each cell, provided following a natural order with the I index running faster, followed by J and then K. End point scaling is not used for miscible curves.

### Example

```
MISCTNUM  
121*1 44*2 /
```



## 2.233 MISCSTR

### Description

In the miscibility model, activated using [MISCIBLE](#) keyword in RUNSPEC section, oil and gas relative permeability values are scaled using a reference surface tension  $\sigma_0$ . The details of the computation can be found in [Section 10.9](#), now the key point is the possibility to explicitly set  $\sigma_0$  using [MISCSTR](#), explicitly, by means of a reference pressure or using calculated saturation pressure values.

Notably, without [MISCSTR](#)  $\sigma_0$  is defined at the beginning of the simulation using the average surface tension in the model. Incidentally, this means that if we do not have two-phase conditions at initial conditions, and [MISCSTR](#) is not provided or its fields are defaulted, miscibility scaling is turned off for the rest of the simulation.

Input consists of a single record terminated by a slash character.

Note that this keyword cannot be used with [MISCSTRR](#).

### Record format

1. **SIGMA\_REF:** The reference surface tension ( $\sigma_0$ ). When the surface tension is larger than  $\sigma_0$ , immiscible relative permeability curves are used. If this value is defaulted, the average value of the initial surface tension over the reservoir is used.

**Type:** Float

**Units:** dynes/cm (FIELD), dynes/cm (METRIC)

2. *Reserved*

3. *Reserved*

4. **PREF:** To compute the reference surface tension, the reservoir fluid will be flashed to determine phase compositions used for initializing the reference surface tension. If this flash results in a single phase, the flash will be recomputed at the saturation pressure. If this pressure is provided, the computed surface tension overrides the value provided in field 1.

**Type:** Float

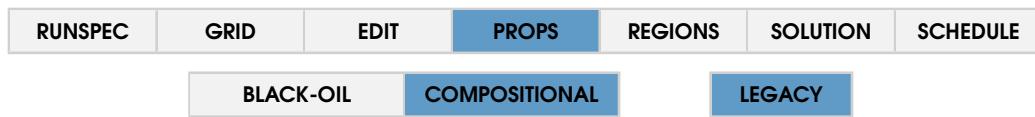
**Units:** psi (FIELD), bar (METRIC)

5. **USE\_PSAT:** The reference surface tension is computed at the saturation pressure. The reference surface tension calculated at the saturation pressure overrides any value specified with item 1 and any value computed at the reference pressure specified in item 4.

**Type:** Boolean

### Example

```
MISCSTR
0.01 /
```



## 2.234 MISCSTRR

### Description

In the miscibility model, activated using [MISCIBLE](#) keyword in RUNSPEC section, oil and gas relative permeability values are scaled using a reference surface tension  $\sigma_0$ . The details of the computation can be found in [Section 10.9](#), now the key point is the possibility to explicitly set  $\sigma_0$  using [MISCSTRR](#) on a saturation region basis. Then, the keyword is followed by one record for each model saturation region and each record defines a way to compute  $\sigma_0$ , namely explicitly, by means of a reference pressure or using calculated saturation pressure values.

Notably, without [MISCSTRR](#)  $\sigma_0$  is defined at the beginning of the simulation using the average surface tension in the model. Incidentally, this means that if we do not have two-phase conditions at initial conditions, and [MISCSTR](#) is not provided or its fields are defaulted, miscibility scaling is turned off for the rest of the simulation.

Note that this keyword cannot be used with [MISCSTR](#).

### Record format

- SIGMA\_REF:** Oil/Gas flow under immiscible conditions when surface tension between the two phases is  $\geq$  SIGMA\_REF. By default, ECHELON uses the initial average surface tension of the saturation region at hand.

**Type:** Float

**Units:** dynes/cm (FIELD), dynes/cm (METRIC)

- Reserved*

- Reserved*

- PREF:** To compute the reference surface tension, the reservoir fluid will be flashed to determine phase compositions used for initializing the reference surface tension. If this flash results in a single phase, the flash will be recomputed at the saturation pressure. If this pressure is provided, the computed surface tension overrides the value provided in field 1.

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

- USE\_PSAT:** The reference surface tension is computed at the saturation pressure. The reference surface tension calculated at the saturation pressure overrides any value specified with item 1 and any value computed at the reference pressure specified in item 4.

**Type:** Boolean

**Default value:** NO

### Example

```
MISCSTRR
0.2 1* 1* 1* /
0.2 1* 1* 1* /
0.2 1* 1* 1* /
```



## 2.235 MODIFY\_FRAC\_PROPS

### Description

This keyword can be used to modify the static or dynamic properties of fractures within a fracture or SRV (stimulated rock volume) media. The properties that can be modified using this keyword are static properties, e.g. permeabilities (PERMX, PERMY, PERMZ), porosity (PORO); solution states, e.g. SWAT, SGAS, PRESSURE, RS, SRV; region numbers, e.g. ROCKNUM and SATNUM. These properties can be changed in hydraulic fracture (HF), stimulated rock volume (SRV) or the entire LGRs around a fracture by using (ALL). It is followed by a single slash-terminated record containing an arbitrary number of key-value pairs for the form NAME=value. The valid mnemonics for NAME and their associated values are enumerated in the table below. This keyword can be followed by an arbitrary number of templates definition and it is terminated with an empty record having only the / character.

### Record format

Name	Value Type	Description
well_name	String	Well name
frac_number	Integer	Fractures number to be modified
region	String	Regions to modify in each fracture, the options can be hydraulic fracture ('HF'), stimulated rock volume ('SRV') or the entire LGRs around a fracture ('ALL) by using the relevant acronyms.
operation	String	The operation for modifying the current value of the fracture property by assigning ('ASSIGN'), adding ('ADD'), or multiplying ('MULTIPLY') it with the new value.
media	String	The media to be modified in case of a dual porosity model, which can be 'MATRIX' or 'FRACTURE'.
SIGMA	Float	Sigma value for the fracture media in case of dual porosity model
PERMX/PERMY/PERMZ	Float	Permeability of the fracture to be modified
PORO	Float	Porosity of the fracture to be modified
SWAT/SGAS	Float	Saturation to be modified. Special care should be taken because this can cause discontinuity in the solution and convergence problem
PRESSURE	Float	Pressure to be modified. Special care should be taken because this can cause discontinuity in the solution and convergence problem
SATNUM	Integer	The saturation function to be used in the fracture
ROCKNUM	Float	The rock compaction table to be used in the fracture

### Example 1

In this example, the saturation function and rock compaction for all the hydraulic fractures in well 'P1' are set. The rock compaction table 3 is used for fracture 5 and 7.

```
MODIFY_FRAC_PROPS
well_name=P1 region=HF SATNUM=2 ROCKNUM=2 operation=EQUAL /
well_name=P1 region=HF ROCKNUM=3 operation=EQUAL frac_number=5 /
well_name=P1 region=HF ROCKNUM=3 operation=EQUAL frac_number=7 /
/
```

**Example 2**

In this example, the permeabilities in all directions are multiplied by 10 within SRV and 100 within hydraulic fracture cells for all the fractures in well 'P1'

```
MODIFY_FRAC_PROPS
well_name=P1 region=SRV PERMX=10.0    PERMY=10.0    PERMZ=10.0
  operation=MULTIPLY /
well_name=P1 region=HF   PERMX=100.0   PERMY=100.0   PERMZ=100.0
  operation=MULTIPLY /
/
```

**Example 3**

In this example, the water saturation is increased by 0.2 in hydraulic fracture area for all the fractures in well 'P1'

```
MODIFY_FRAC_PROPS
well_name=P1  region=HF  SWAT=0.2 operation=ADD /
/
```



## 2.236 MULTFLT

### Description

Use of a **MULTFLT** keyword (in the **GRID**, **EDIT** or **SCHEDULE** sections) modifies the calculated transmissibility values across named faults defined by cell pairs using the **FAULT** keyword. Such fault definitions are often prepared via geologic modeling preprocessors. The initial generation of the cell pair connection transmissibility is governed by the standard geometric transmissibility calculations and does not depend on the fault definitions provided in the **FAULT** keyword. The presence of **MULTFLT** has a multiplicative behavior on the transmissibility values for the cell-pair connections across the named fault. Presence of any other transmissibility multipliers such as **MULTX**, **MULTY** or **MULTZ** for cells that also belong to a modified fault results in all multipliers being applied as a product.

In each data file section, a named fault should only have one **MULTFLT** modifier defined. If more than one has been given by the user, the last input value is applied. If multiple named fault trajectories go through the same cell face, then the product of all fault multipliers will be applied. Note that use of direct transmissibility assignments (**TRANX**, **TRANY** or **TRANZ**) would overwrite prior modifications of transmissibility using earlier **MULTFLT** keywords in the **GRID**, **EDIT** or **SCHEDULE** sections.

When **MULTFLT** is assigned in the **EDIT** or **SCHEDULE** section, the new fault transmissibility modifier would be applied, creating a multiplicative effect to those in the **GRID** section. The presence of fault transmissibility multipliers may impact pinchouts depending on the settings chosen on the **PINCH** or **PINCHR** keywords. Additionally, if the keyword **THPRESFT** in the **GRID** section is used to set a threshold pressure between cell pairs of previously named faults, ECHELON will apply the maximum threshold pressure defined for any grid-block pairs (*i.e.*, if cell pairs belong to more than one named fault)

**MULTFLT** can also be defined within LGRs by placing it within the **CARFIN** and **ENDFIN** LGR setup and then using local grid numbers.

### Record format

Field	Name	Type	Minimum	Description
1	Fault Name	String		Fault name (maximum of 8 characters)
2	Transmissibility Multiplier	Float	0	

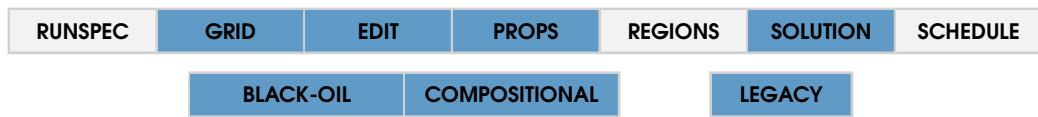
### Example

The transmissibility along two previously defined faults (**FAULT\_A** and **FAULT\_B** defined by **FAULT** keywords) are reduced by the factors defined here.

```

MULTFLT
'FAULT_A' 0.1/
'FAULT_B' 0.5/
/

```



## 2.237 MULTIPLY

### Description

This keyword can be used to multiply values of a given 3D array inside a set of grid cells or for the entire grid by a constant value. The keyword can be followed by an arbitrary number of records terminating with a slash, followed by an empty terminated with a slash.

The [MULTIPLY](#) operation is repeated for every record, setting values of 3D arrays in a box of cells defined by six integers (items 3 to 8) subject to the following constraints:

$$1 \leq I\text{MIN} \leq I\text{MAX} \leq NX,$$

$$1 \leq J\text{MIN} \leq J\text{MAX} \leq NY,$$

$$1 \leq K\text{MIN} \leq K\text{MAX} \leq NZ.$$

If [MULTIPLY](#) is used for global grid arrays,  $NX=NXRES$ ,  $NY=NYRES$  and  $NZ=NZRES$ . If [MULTIPLY](#) is used within a local grid refinement definition ([CARFIN/ENDFIN](#) block) or within a local grid refinement editing ([REFINE/ENDFIN](#) block), then the 3D array at hand is inside the local refinement and the cell box is bounded by local grid dimensions (i.e.  $NXREF$ ,  $NYREF$  and  $NZREF$ ). Similarly, inside a [BOX/ENDBOX](#) block  $NX$ ,  $NY$  and  $NZ$  are set according to [BOX](#) record.

Notably, if you define a cell box in one record, then the next record inherits that cell box limits and its default values for item 3 to 8.

Available 3D arrays for [MULTIPLY](#) keyword on a section basis are:

### GRID

[DX](#), [DY](#), [DZ](#), [PERMX](#), [PERMY](#), [PERMZ](#), [MULTX](#), [MULTY](#), [MULTZ](#), [PORO](#), [NTG](#), [FLUXNUM](#), [MULTNUM](#), [OPERNUM](#), [ACTNUM](#).

### EDIT

[PORV](#), [DEPTH](#), [TRANX](#), [TRANY](#), [TRANZ](#),

### PROPS

[SWL](#), [SWCR](#), [SWU](#), [SGL](#), [SGCR](#), [SGU](#), [KRW](#), [KRO](#), [KRG](#), [KRWR](#), [KRGR](#), [KRORW](#), [KRORG](#), [ISWL](#), [ISWCR](#), [ISWU](#), [ISGL](#), [ISGCR](#), [ISGU](#), [IKRW](#), [IKRO](#), [IKRG](#), [IKRWR](#), [IKRGR](#), [IKRORW](#), [IKRORG](#), [PCW](#), [PCG](#), [IPCG](#)

### REGIONS

[SATNUM](#), [PVTNUM](#), [FIPNUM](#), [ROCKNUM](#), [MISCTNUM](#), [EOSNUM](#), [EQLNUM](#)

### SOLUTION

[PRESSURE](#), [SWAT](#), [SGAS](#), [RV](#), [RS](#), [TBLK](#), [SOIL](#), [PBUB](#), [PDEW](#), [SALT](#)

### Record format

1. **3D array:** target 3D array to be updated  
**Type:** String
2. **Constant:** constant used in the operation  
**Type:** Float
3. **I MIN:** First cell to be updated along the I-direction  
**Type:** Integer

**Minimum:** 1  
**Maximum:** NX  
**Default value:** 1

4. **IMAX:** Last cell to be updated along the I-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NX  
**Default value:** NX

5. **JMIN:** First cell to be updated along the J-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** 1

6. **IMAX:** Last cell to be updated along the J-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NY  
**Default value:** NY

7. **KMIN:** First cell to be updated along the K-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** 1

8. **KMAX:** Last cell to be updated along the K-direction

**Type:** Integer  
**Minimum:** 1  
**Maximum:** NZ  
**Default value:** NZ

### Example 1

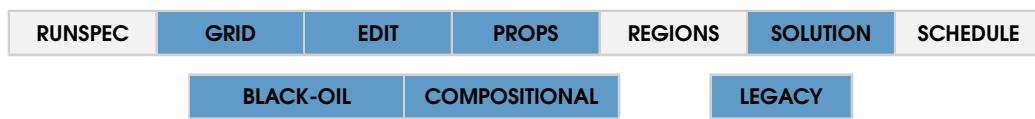
In the first example, section **GRID, PERMX** is multiplied by 100 in the whole grid (first record) and **PORO** is multiplied by 0.1 (the second record).

```
MULTIPLY
PERMX 100 /
PORO 0.1 /
/
```

### Example 2

In the second example, **MULTIPLY** is used to change **FIPNUM** in the **REGIONS** section. Note that the original value of **FIPNUM** is first multiplied by 2 in the whole grid and then by 4 in the box specified in the second record.

```
MULTIPLY
FIPNUM 2 /
FIPNUM 4 1 10 1 10 2 2 /
/
```



## 2.238 MULTIREG

### Description

This keyword can be used to multiply by a constant a target 3D array, or a subset of, using a region 3D array as filter. The keyword can be followed by an arbitrary number of records terminating with a slash, followed by an empty record terminated with a slash.

The [MULTIREG](#) operation is repeated for every record, copying values from the source 3D array into the destination 3D array, using by default [MULTNUM](#) to filter cells. Alternatively it is possible to choose [FLUXNUM](#) or [MULTNUM](#) as region 3D array used to filter cells.

### Available 3D arrays

Available 3D arrays for [MULTIREG](#) keyword on a section basis are:

#### GRID

[DX](#), [DY](#), [DZ](#), [PERMX](#), [PERMY](#), [PERMZ](#), [MULTX](#), [MULTY](#), [MULTZ](#), [PORO](#), [NTG](#), [FLUXNUM](#), [MULTNUM](#), [OPERNUM](#)

#### EDIT

[PORV](#), [DEPTH](#), [TRANX](#), [TRANY](#), [TRANZ](#)

#### PROPS

[SWL](#), [SWCR](#), [SWU](#), [SGL](#), [SGCR](#), [SGU](#), [KRW](#), [KRO](#), [KRG](#), [KRWR](#), [KRGR](#), [KRORW](#), [KRORG](#), [ISWL](#), [ISWCR](#), [ISWU](#), [ISGL](#), [ISGCR](#), [ISGU](#), [IKRW](#), [IKRO](#), [IKRG](#), [IKRWR](#), [IKRGR](#), [IKRORW](#), [IKRORG](#), [PCW](#), [PCG](#), [IPCW](#), [IPCG](#)

#### REGIONS

[SATNUM](#), [PVTNUM](#), [FIPNUM](#), [ROCKNUM](#), [MISCTNUM](#), [EOSNUM](#), [EQLNUM](#)

#### SOLUTION

[PRESSURE](#), [SWAT](#), [SGAS](#), [RV](#), [RS](#), [TBLK](#), [SOIL](#), [PBUB](#), [PDEW](#), [SALT](#)

### Record format

1. **Target:** Target 3D Array  
**Type:** String
2. **Constant:** Multiplicative constant  
**Type:** Float
3. **Filter:** Region number to filter grid cells  
**Type:** Integer
4. **Region:** 3D region array used as a filter.  
**Type:** Integer  
**Default value:** M

#### Allowed values:

Name	Description
M	<a href="#">MULTNUM</a> is used as filter
F	<a href="#">FLUXNUM</a> is used as filter
O	<a href="#">OPERNUM</a> is used as filter

**Example 1**

**MULTIREG** is used in **GRID** section to multiply by 10 **PERMX** for **MULTNUM** cells with value equal to 4

```
MULTIREG  
  PERMX 10 4 /  
 /
```

**Example 2**

**ADDREG** is used in **PROPS** section to half **SWL** for cells where **FLUXNUM** equals 4, and -double for cells where **OPERNNUM** equals 5

```
MULTIREG  
  SWL 0.5 5 F /  
  SOWCR 2.0 5 0 /  
 /
```



## 2.239 MULTNUM

### Description

This keyword defines a region 3D array for applying inter-region multipliers. The keyword is followed by a set of non-negative integer values, one for each reservoir grid cell. It is then possible to use these values as a filter to select cells where various properties in [GRID](#), [EDIT](#), [PROPS](#), [SOLUTION](#) and [REGIONS](#) can be manipulated using:

- [COPYREG](#), [EQUALREG](#), [ADDREG](#), [MULTIREG](#).
- [MULTREGP](#), [MULTREGT](#).

Notably, values for [MULTNUM](#) are bounded by the integer number given in the second field of [GRIDOPTS](#) keyword.

In dual media simulations ([DUALPORO](#) or [DUALPERM](#) keyword in [RUNSPEC](#)) [MULTNUM](#) is defined only for the first medium (matrix), that is to say for the first NZRES/2 layers, in which case the simulator copies the values from matrix cells to fracture cells. It is possible to define specific [MULTNUM](#) values for all fracture cells using field 117 of [OPTIONS](#) keyword.

### Example

[MULTNUM](#) is used to define three regions in a reservoir grid with 300 cells:

```
MULTNUM  
100*1 100*2 100*3 /
```



## 2.240 MULTPV

### Description

This keyword defines multipliers to modify the calculated pore volume in the [GRID](#) section or to multiply pore volumes which are directly input via [PORV](#) in the [EDIT](#) section. Calculated pore volume is the product of porosity, net-to-gross and bulk cell volume. This keyword can also be used in the [SCHEDULE](#) section to allow time-dependent changes to the pore volume values. When used in the [SCHEDULE](#) section, they modify the final values produced in either the [GRID](#) or [EDIT](#) sections. Values must be greater than or equal to zero. Cells having a pore volume value less than [MINPV](#) will be made inactive.

Modifying pore volume in the [SCHEDULE](#) section can result in discontinuities in pressure; thus large changes in pore volume with time should be done with care. When used in the [SCHEDULE](#) section, the multipliers are cumulative for the impacted grid cells.

MULTPV input is per natural I, J, K grid ordering for the current input [BOX](#). Repeat counts can be used for repeated values (*e.g.*, 10\*0.95). The keyword must end with a slash (/). The distribution of pore volume multipliers can be reported in the 3D graphic output (UNRST) file using the record [PORV-MOD](#) in the [RPTRST](#) keyword.

### Example

MULTPV is used here to define pore volume modifiers for 300 cells in the current input box:

```
MULTPV  
100*0.9 100*0.95 100*1.1 /
```



## 2.241 MULTREGP

### Description

This keyword can be used to scale pore volume for the cells belonging to a region. The regions to which the cells belong to should have been defined using 3D arrays, namely [MULTNUM](#), [FLUXNUM](#) or [OPERNUM](#). The keyword can be followed by an arbitrary number of records terminating with a slash, followed by an empty record terminated with a slash.

### Record format

1. **REGNUM:** An integer number selecting the region. Negative values can be used to select the entire region 3D array at hand.

**Type:** Integer

**Default value:** -1

2. **PVMULT:** Multiplier to apply to the pore volume.

**Type:** Float

**Allowed values:**

3. **REGION:** Specifies which region to use for connection selection.

**Type:** String

**Default value:** M

**Allowed values:**

Name	Description
M	Regions specified with REGNUM is defined with <a href="#">MULTNUM</a> keyword
O	Regions specified with REGNUM is defined with <a href="#">OPERNUM</a> keyword
F	Regions specified with REGNUM is defined with <a href="#">FLUXNUM</a> keyword

### Notes

- 0 value for **REGNUM** is not a defaulted value and is considered a valid region
- If the region specified is [MULTNUM](#) and **REGNUM** is more than the maximum value as defined in second item of [GRIDOPTS](#) then the software will generate an error
- If the region specified is [FLUXNUM](#) and **REGNUM** is more than the maximum value as defined in fourth item of [REGDIMS](#) then the software will generate an error
- If the specified value of **REGNUM** is not present in the corresponding 3D array, then the software warns about the same but will continue simulation allowing other valid records to be processed
- Default for **REGION** is [MULTNUM](#), but if [MULTNUM](#) is not specified and [FLUXNUM](#) is specified then default switches to [FLUXNUM](#). Similarly if [FLUXNUM](#) is also not specified, then default switches to [OPERNUM](#)

**Example 1**

MULTREGP is used in GRID section to multiply by 2.0 the pore volume for cells where MULTNUM=7 and for cells where FLUXNUM=6. Note that the pore volume for cells where both MULTNUM=7 and FLUXNUM=6 is scaled twice.

```
MULTREGP  
7 2.0 /  
6 2.0 F /  
/
```

**Example 2**

MULTREGP is used in GRID section to multiply by 2.0 the pore volume for cells where MULTNUM=6. In this case, the operation is not cumulative and only the last record operation is triggered

```
MULTREGP  
6 3.0 /  
6 2.0 /  
/
```



## 2.242 MULTREGT

### Description

This keyword can be used to scale the transmissibilities between cells belonging to two regions. The regions to which the cells belong to should have been defined using 3D arrays, namely [MULTNUM](#), [FLUXNUM](#) or [OPERNUM](#). The keyword can be followed by an arbitrary number of slash terminated records, followed by an empty record terminated with a slash.

### Record format

1. **REG\_I:** Integer identifying the first region.  
**Type:** Integer  
**Default value:** -1
2. **REG\_J:** Integer identifying the second region.  
**Type:** Integer  
**Default value:** -1
3. **MULTT:** This value is used to multiply the transmissibilities of all cells connecting first region to the second region  
**Type:** Float
4. **DIR:** Directions along which the multiplier is applied  
**Type:** String  
**Default value:** XYZ

#### Allowed values:

Name	Description
X	The multiplier is applied along the x-direction
Y	The multiplier is applied along the y-direction
Z	The multiplier is applied along the z-direction
XY	The multiplier is applied along the x-direction and y-direction
YZ	The multiplier is applied along the y-direction and z-direction
XZ	The multiplier is applied along the x-direction and z-direction
XYZ	The multiplier is applied along all directions

5. **NNC\_FLAG:** Cell connection selector

**Type:** String  
**Default value:** ALL  
**Allowed values:**

Name	Description
NNC	The multiplier is applied only to non-neighboring connections between the first and second region
NONNC	The multiplier is applied only to natural connections between first and second region
ALL	The multiplier is applied to all connections between the first and second region

6. **REGION:** Region 3D array selector

**Type:** String  
**Default value:** M  
**Allowed values:**

Name	Description
M	Regions specified with items REG_I and REG_J are defined with <b>MULTNUM</b> keyword
F	Regions specified with items REG_I and REG_J are defined with <b>FLUXNUM</b> keyword
O	Regions specified with items REG_I and REG_J are defined with <b>OPERNUM</b> keyword

## Notes

- If either **REG\_I** or **REG\_J** is negative, then that region is defaulted and all cells connected to the cells belonging to the non-defaulted region are scaled. This does not include the cell connections within the non-defaulted region
- If **REG\_I** and **REG\_J** are same, then the transmissibilities for all the cells belonging to that region are scaled including connections within that region
- 0 value for **REG\_I** or **REG\_J** is not a defaulted value and is considered a valid region
- MULTREGT defined in **GRID** or **EDIT** section leads to overwriting of **MULTT** for the pair of **REG\_I** and **REG\_J**
- MULTREGT defined in **SCHEDULE** section leads to **MULTT** repetitively getting multiplied for the pair of **REG\_I** and **REG\_J** as and when defined
- If the region specified is **MULTNUM** and either of **REG\_I** or **REG\_J** is more than the maximum value as defined in second item of **GRIDOPTS** then the software will generate an error
- If the region specified is **FLUXNUM** and either of **REG\_I** or **REG\_J** is more than the maximum value as defined in fourth item of **REGDIMS** then the software will generate an error
- If the specified value of either **REG\_I** or **REG\_J** is not present in the corresponding 3D array, then the software warns about the same but will continue simulation allowing other valid records to be processed
- Default for **REGION** is **MULTNUM**, but if **MULTNUM** is not specified and **FLUXNUM** is specified then default switches to **FLUXNUM**. Similarly if **FLUXNUM** is also not specified, then default switches to **OPERNUM**

## Example

**MULTREGT** is used in **GRID** section to multiply by 10 the transmissibility for all connections between cells with **MULTNUM=2** and cells with **MULTNUM=7**.

```
MULTREGT
 2 7 10  /
 /
```



## 2.243 MULTSIGV

### Description

This keyword can be used in dual-media systems DUALPORO or DUALPERM. This keyword defines multipliers to modify the user input SIGMAV values defined in the GRID section. This keyword can be used in the SCHEDULE section to allow time-dependent changes to the SIGMAV values.

MULTSIGV input is per natural grid ordering for the current input BOX and is required only for grid blocks in the first NZ/2 dual-media layers.

### Example

MULTSIGV is used here to define SIGMAV modifiers for 300 cells in the current input box:

```
MULTSIGV  
100*0.9 100*0.95 100*1.1 /
```



## 2.244 MULTX

### Description

The keyword defines a 3D array of transmissibility multipliers along X (I) direction of the reservoir, which means one non-negative number for each cell of the grid where the keyword is framed. Cell **MULTX** values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). The multipliers are used by the simulator to scale transmissibility calculated by the simulator for the X+ face of the cell at hand or for the corresponding **TRANX** defined in EDIT section.

Then, **MULTX** value for cell (i,j,k) scale the transmissibility between cell (i,j,k) and cell (i+1,j,k). If faults generate non-neighboring connections, then **MULTX** scales also non-neighboring transmissibility computed by the simulator along fault throw. **MULTX** values do not affect non-neighboring connections defined by the user using **NNC** keyword.

The default value of **MULTX** is 1.0.

The keyword can be used in GRID, EDIT and SCHEDULE sections:

- in the GRID section **MULTX** scales **TRANX** and fault-based non-neighboring connections transmissibility computed in the GRID section itself, while any transmissibility explicitly defined in the EDIT section is not affected by GRID **MULTX**
- in the EDIT section **MULTX** multiplies **TRANX** explicitly defined in the edit section, leaving unchanged **TRANX** computed in the **GRID** section,
- in the SCHEDULE section **MULTX** can be used to update transmissibility along the simulation.

### Example

This **MULTX** keyword sets **TRANX** to zero in a grid of 15 cells:

```
MULTX  
15*0.0 /
```

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SCHEDULE
		BLACK-OIL	COMPOSITIONAL	LEGACY		

## 2.245 MULTX-

### Description

The keyword defines a 3D arry of transmissibility multipliers along X (I) direction of the reservoir, which means one non-negative number for each cell of the grid where the keyword is framed. Cell **MULTX-** values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). The multipliers are used by the simulator to scale transmissibility calculated by the simulator for the X-face of the cell at hand or for the corresponding **TRANX** defined in EDIT section.

Then, **MULTX-** value for cell (i,j,k) scale the transmissibility between cell (i,j,k) and cell (i-1,j,k).

If faults generate non-neighboring connections, then **MULTX-** scales also non-neighboring transmissibility computed by the simulator along fault throw. **MULTX-** values do not affect non-neighboring connections defined by the user using **NNC** keyword.

The default value of **MULTX-** is 1.0.

The keyword can be used in GRID, EDIT and SCHEDULE sections:

- in the GRID section **MULTX-** scales **TRANX** and fault-based non-neighboring connections transmissibility computed in the GRID section itself, while any transmissibility explicitly defined in the EDIT section is not affected by GRID **MULTX-**
- in the EDIT section **MULTX-** multiplies **TRANX** explicitly defined in the edit section, leaving unchanged **TRANX** computed in the **GRID** section,
- in the SCHEDULE section **MULTX-** can be used to update transmissibility along the simulation.

It is woth noticing that **MULTX-** and **MULTX** are cumulative, namely the actual transmissibility multiplier defined for cell (i,j,k) **TRANX** is the product of **MULTX** for (i,j,k) and of **MULTX-** for (i+1,j,k)

### Example

This **MULTX-** keyword sets **TRANX** to zero in a grid of 15 cells:

```
MULTX-
15*0.0 /
```

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SCHEDULE
		BLACK-OIL	COMPOSITIONAL		LEGACY	

## 2.246 MULTY

### Description

The keyword defines a 3D array of transmissibility multipliers along Y (J) direction of the reservoir, which means one non-negative number for each cell of the grid where the keyword is framed. **MULTY** values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). The multipliers are used by the simulator to scale transmissibility calculated by the simulator for the Y+ face of the cell at hand or for the corresponding **TRANY** defined in EDIT section.

Then, **MULTY** for cell (i,j,k) scales the transmissibility between cell (i,j,k) and cell (i,j+1,k). If faults generate non-neighboring connections, then **MULTY** scales also non-neighboring transmissibility defined along fault throw. **MULTY** values do not affect **NNC** keyword definitions.

The default value of **MULTY** is 1.0.

The keyword can be used in GRID, EDIT and SCHEDULE sections:

- in the GRID section **MULTY** scales **TRANY** and fault-based non-neighboring connections transmissibility computed in the GRID section itself, while any transmissibility explicitly defined in the EDIT section is not affected by GRID **MULTY**
- in the EDIT section **MULTY** multiplies **TRANY** explicitly defined in the edit section, leaving unchanged **TRANY** computed in the **GRID** section,
- in the SCHEDULE section **MULTY** can be used to update transmissibility along the simulation.

### Example

This **MULTY** keyword sets **TRANY** to zero in a grid of 15 cells:

```
MULTY
15*0.0 /
```



## 2.247 MULTY-

### Description

The keyword defines a 3D array of transmissibility multipliers along Y (J) direction of the reservoir, which means one non-negative number for each cell of the grid where the keyword is framed. [MULTY-](#) values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). The multipliers are used by the simulator to scale transmissibility calculated by the simulator for the Y-face of the cell at hand or for the corresponding [TRANY](#) defined in EDIT section.

Then, [MULTY-](#) value for cell (i,j,k) scales the transmissibility between cell (i,j,k) and cell (i,j-1,k). If faults generate non-neighboring connections, then [MULTY-](#) scales also non-neighboring transmissibility defined along fault throw. [MULTY-](#) values do not affect [NNC](#) keyword definitions.

The default value of [MULTY-](#) is 1.0.

The keyword can be used in GRID, EDIT and SCHEDULE sections:

- in the GRID section [MULTY-](#) scales [TRANY](#) and fault-based non-neighboring connections transmissibility computed in the GRID section itself, while any transmissibility explicitly defined in the EDIT section is not affected by GRID [MULTY-](#)
- in the EDIT section [MULTY-](#) multiplies [TRANY](#) explicitly defined in the edit section, leaving unchanged [TRANY](#) computed in the [GRID](#) section,
- in the SCHEDULE section [MULTY-](#) can be used to update transmissibility along the simulation.

It is worth noticing that [MULTY-](#) and [MULTY](#) are cumulative, namely the actual transmissibility multiplier defined for cell (i,j,k) [TRANY](#) is the product of [MULTY](#) for (i,j,k) and of [MULTY-](#) for (i,j+1,k)

### Example

This [MULTY-](#) keyword sets [TRANY](#) to zero in a grid of 15 cells:

```
MULTY-
15*0.0 /
```



## 2.248 MULTZ

### Description

The keyword defines a 3D array of transmissibility multipliers along Z (K) direction of the reservoir, which means one non-negative number for each cell of the grid where the keyword is framed. [MULTZ](#) values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). The multipliers are used by the simulator to scale transmissibility calculated by the simulator for the Z+ face of the cell at hand or for the corresponding [TRANZ](#) defined in EDIT section.

Then, [MULTZ](#) value for cell (i,j,k) scales the transmissibility between cell (i,j,k) and cell (i,j,k+1). If faults generate non-neighboring connections, then [MULTZ](#) scales also non-neighboring transmissibility defined along fault throw. [MULTZ](#) values do not affect [NNC](#) keyword definitions.

The default value of [MULTZ](#) is 1.0.

The keyword can be used in GRID, EDIT and SCHEDULE sections:

- in the GRID section [MULTZ](#) scales [TRANZ](#) and fault-based non-neighboring connections transmissibility computed in the GRID section itself, while any transmissibility explicitly defined in the EDIT section is not affected by GRID [MULTZ](#)
- in the EDIT section [MULTZ](#) multiplies [TRANZ](#) explicitly defined in the edit section, leaving unchanged [TRANZ](#) computed in the [GRID](#) section,
- in the SCHEDULE section [MULTZ](#) can be used to update transmissibility along the simulation.

### Example

This [MULTZ](#) keyword sets [TRANZ](#) to zero in a grid of 15 cells:

```
MULTZ  
15*0.0 /
```

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SCHEDULE
		BLACK-OIL	COMPOSITIONAL	LEGACY		

## 2.249 MULTZ-

### Description

The keyword defines a 3D array of transmissibility multipliers along Z (K) direction of the reservoir, which means one non-negative number for each cell of the grid where the keyword is framed. [MULTZ-](#) values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). The multipliers are used by the simulator to scale transmissibility calculated by the simulator for the Z-face of the cell at hand or for the corresponding [TRANZ](#) defined in EDIT section.

Then, [MULTZ-](#) value for cell (i,j,k) scales the transmissibility between cell (i,j,k) and cel. If faults generate non-neighboring connections, then [MULTZ-](#) scales also non-neighboring transmissibility defined along fault throw. [MULTZ-](#) values do not affect [NNC](#) keyword definitions.

The default value of [MULTZ-](#) is 1.0.

The keyword can be used in GRID, EDIT and SCHEDULE sections:

- in the GRID section [MULTZ-](#) scales [TRANZ](#) and fault-based non-neighboring connections transmissibility computed in the GRID section itself, while any transmissibility explicitly defined in the EDIT section is not affected by GRID [MULTZ-](#).
- in the EDIT section [MULTZ-](#) multiplies [TRANZ](#) explicitly defined in the edit section, leaving unchanged [TRANZ](#) computed in the [GRID](#) section,
- in the SCHEDULE section [MULTZ-](#) can be used to update transmissibility along the simulation.

### Example

This [MULTZ-](#) keyword sets [TRANZ](#) to zero in a grid of 15 cells:

```
MULTZ-
15*0.0 /
```



## 2.250 MW

### Description

This keyword specifies the molecular weights of the hydrocarbon components in a compositional simulation. The number of molecular weights should be equal to the number of components in the simulation. If multiple equations of state are used, values must be specified for each of them.

### Record format

1. **COMP\_MW:** Components' molecular weights

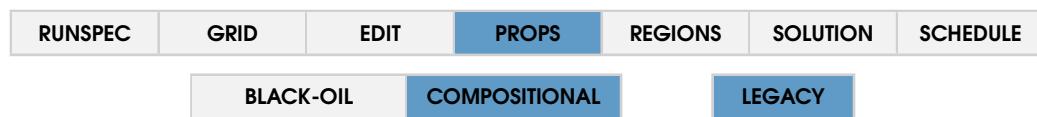
**Type:** Float

**Units:** lb/lb-moles (FIELD), kg/kg-moles (METRIC)

### Example

This example specifies the weights of the components for a compositional simulation with five components

```
MW  
44.01 28.01 16.04 30.07 66.86 /
```



## 2.251 MWS

### Description

This keyword specifies the molecular weights of the hydrocarbon components for the surface equation of state in a compositional simulation. The number of molecular weights should be equal to the number of components in the simulation. If multiple surface equations of state are used, values must be specified for each of them. If the keyword is not provided the values specified in [MW](#) are used.

### Record format

1. **COMP\_MWS:** Components molecular weights

**Type:** Float

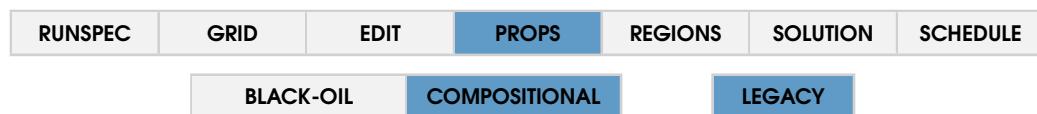
**Units:** lb/lb-moles (FIELD), kg/kg-moles (METRIC)

### Example

This example specifies the components weights for the surface equation of state in a compositional simulation with five components

MWS

```
44.01 28.01 16.04 30.07 66.86 /
```



## 2.252 NCOMPS

### Description

This keyword specifies the number of components in a compositional simulation and it should be consistent with the number of components specified with [COMPS](#) keyword in the RUNSPEC section, otherwise the simulation will stop and an error message is printed.

### Record format

1. **NUM\_COMP:** Number of hydrocarbon components

**Type:** Integer

#### Example

This example states that the simulation includes nine components. If it is not true, the simulation will end and an error message is printed.

```
NCOMPS  
9 /
```



## 2.253 NEWTRAN

### Description

This keyword indicates that the transmissibility calculations will be based on coordinates of corner points of grid blocks. It is the default method for corner point grids. The keyword is not supported for block-centered geometry.



## 2.254 NEXT

### Description

This keyword has the exact behavior of [NEXTSTEP](#), it is used to define an upper bound for following timesteps. See [NEXTSTEP](#) for details.



## 2.255 NEXTSTEP

### Description

This keyword sets an upper bound for new timestep in the next report, or after all report steps until the end of the simulation.

### Record format

1. **MAXNEXTTS:** Maximum length of the next timestep (after REPORT)

**Type:** Float

**Units:** Day (FIELD), Day (METRIC)

2. Logic for next report step.

**Type:** Integer

**Default value:** NO

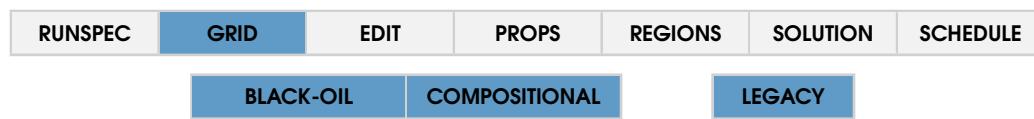
**Allowed values:**

Name	Description
YES	use this upper bound for all TSTEP or DATES afterward.
NO	use this upper bound only for the next TSTEP or DATES record.

### Example

NEXTSTEP set a maximum timestep of 2.07 days after all REPORT dates/times.

```
DATES
 1 JAN 2027 /
NETXTSTEP
 2.07 YES /
TSTEP
 2*10 /
DATES
 1 'JUL' 2027 /
 1 'SEP' 2027 /
 1 'DEC' 2027 /
/
END
```



## 2.256 NNC

### Description

The NNC keyword provides a way to define a connection transmissibility between two cells that are not standard I, J, K neighbors. Non-neighbor connections are also generated automatically for several conditions such as faulting via corner point offset, pinchouts, dual-media, LGRs and numerical aquifers.

Each line of data in this keyword defines a non-neighbor connection, specifying the I, J, K of the two cells to be linked and their connection transmissibility value. Each line of data is terminated by a slash (/). The keyword is ended via an additional slash (/). This keyword may appear multiple times in the GRID section. If a non-neighbor connection is defined between two cells that are neighbors, or for other simulator-generated non-neighbor connections, the values defined here are added to the existing transmissibility. Any NNC with a transmissibility less than  $1.0^{-6}$  is ignored (see [MINNNCT](#)).

### Record format

1. **First Cell I-coordinate:** I index for the first cell to be connected as an NNC  
**Type:** Integer
2. **First Cell J-coordinate:** J index for the first cell to be connected as an NNC  
**Type:** Integer
3. **First Cell K-coordinate:** K index for the first cell to be connected as an NNC  
**Type:** Integer
4. **Second Cell I-coordinate:** I index for the second cell to be connected as an NNC  
**Type:** String
5. **Second Cell J-coordinate:** J index for the second cell to be connected as an NNC  
**Type:** Integer
6. **Second Cell K-Coordinate:** K index for the second cell to be connected as an NNC  
**Type:** Integer
7. **Transmissibility of the NNC:** Transmissibility between two defined NNC cells  
**Type:** Float  
**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

### Example

Three non-neighbor connections are defined for cells from layer 10 to 20

```
NNC
--I1  J1   K1   I2   J2   K2  Trans
  9    9   10   10   9   20   2.5/
 10   9   10   11   9   20   2.75/
 11   9   10   12   9   20   3.0/
/
```



## 2.257 NNCGEN

### Description

The NNCGEN keyword provides a way to define a connection transmissibility between two cells in different grids (*e.g.*, the global grid and locally-refined grids (LGRs)). The format is similar to [NNC](#) but requires that the grid names be input. Non-neighbor connections are generated automatically between the coarse grid and LGRs; however, this keyword allows further modifications.

Each line of data in this keyword defines a non-neighbor connection, specifying the I, J, K of the two cells (respective to their own I, J, K numbering) to be linked and a transmissibility value assigned. Each line of data is terminated by a slash (/). The keyword is ended via an additional slash (/). This keyword may appear multiple times in the GRID section. If a non-neighbor connection is defined between two cells that are neighbors or have automatically generated non-neighbor connections, the values defined here are added to the existing transmissibility. Any NNC with a transmissibility less than  $1.0^{-6}$  is ignored (see [MINNNCT](#)).

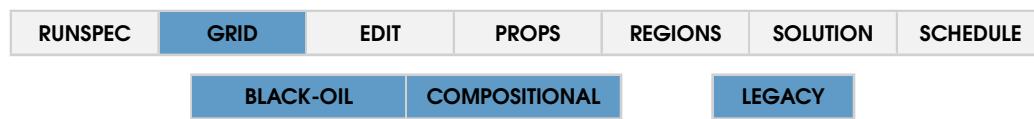
### Record format

1. **First Cell Grid Name:** Name of first grid to be connected  
**Type:** String
2. **First Cell I-coordinate:** I index for the first cell to be connected  
**Type:** Integer  
**Units:** Day (FIELD), Day (METRIC)
3. **First Cell J-coordinate:** J index for the first cell to be connected  
**Type:** Integer
4. **First Cell K-coordinate:** K index for the first cell to be connected  
**Type:** Integer
5. **Second Cell Grid Name:** Name of second grid to be connected  
**Type:** String
6. **Second Cell I-Coordinate:** I index for the second cell to be connected  
**Type:** Integer
7. **Second Cell J-Coordinate:** J index for the second cell to be connected  
**Type:** Integer
8. **Second Cell K-Coordinate:** K index for the second cell to be connected  
**Type:** Integer
9. **Transmissibility of the NNC:** Transmissibility between two defined cells  
**Type:** Float  
**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

### Example

Two non-neighbor connections are defined between global and local grids

```
NNCGEN
--first grid name and cell 2nd name grid and cell connection trans
GLOBAL 10 10 21          LGR_1 3 1 2           10.5 /
GLOBAL 11 12 21          LGR_2 4 1 1           20.5 /
/
```



## 2.258 NODPPM

### Description

By default, the input fracture permeability values ([PERMX](#), [PERMY](#), [PERMZ](#)), are multiplied by the fracture porosity ([PORO](#)) values. If the [NODPPM](#) keyword is used in the [GRID](#) section the input fracture permeability values are instead taken as effective fracture permeabilities and thus are not multiplied by the fracture porosity values. No record data is associated with this keyword.

Intrinsic fracture permeability for a single smooth planar fracture is related to fracture width squared (i.e.  $k_{fint} \propto w_f^2$ ). For uniformly spaced fractures of spacing L in a non-porous matrix, the effective permeability is given by  $k_{fe} = k_{fint} \cdot w_f / L$ . The term  $w_f / L$  is the effective porosity of the fractures ( $\phi_f$ ). Thus, the equation reduces to  $k_{fe} = k_{fint} \cdot \phi_f$ . The use of [NODPPM](#) means that input fracture permeability values are the  $k_{fe}$  values. Not using [NODPPM](#) implies that input fracture permeability values are the  $k_{fint}$  values and thus must be multiplied by the fracture porosity.

When using intrinsic permeability (i.e. the [NODPPM](#) keyword is not set), changes to fracture porosity will impact effective fracture permeability, possibly resulting in unintended consequences during history matching or ensemble forecasting. Thus, users may prefer to input effective permeability values and include the [NODPPM](#) keyword.



## 2.259 NOMIX

### Description

This keyword suppresses the interpolation of oil and gas permeability near the critical point.



## 2.260 NONNC

### Description

The generation of non-neighboring connections can be disabled using the `NONNC` keyword in the GRID or RUNSPEC sections. This may be desired because automatic generation of non-neighboring connections across faults with throw allows the fluid to flow laterally across the faults. This may not necessarily be supported by geology or production data (e.g. a fault may be sealing).

However, non-neighbor connections are also generated for several other conditions: pinchouts, dual-media, LGRs, numerical aquifers and explicit connections defined via keywords such as `NNC`. The `NONNC` keyword removes any NNCs, including those created between fracture and matrix in dual-media models, coarse grid to LGRs and numerical aquifers.



## 2.261 NOSIM

### Description

The `NOSIM` keyword can be included in the `RUNSEPC` or `SCHEDULE` section to prevent the simulation from running. The whole input file (and INCLUDE files) are processed, allowing the user to check for errors in the input without running the actual simulation. This keyword requires no data.

### Example

```
SCHEDULE
NOSIM
WELSPECS
--name group I   J   depth  phase dr   inflow head   FIP
    P1   G1     10  35 1200.0 1*    1*   GPP      /
    P2   G2     20  42 1700.0 1*    1*   4*       AVG     -1  /
/
```



## 2.262 NTG

### Description

The keyword defines the Net To Gross (NTG) ratio of the reservoir as a 3D array, which means one non-negative number for each cell. [NTG](#) is used to scale cell pore volume and the transmissibility along X and the y-directions, [TRANX](#) and [TRANY](#) respectively. Cell [NTG](#) values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). Notably, a zero [NTG](#) value makes cell inactive.

### Example

This [NTG](#) keyword sets porosity in a grid of 15 cells, with the eleventh made inactive.

```
NTG  
5*1.0 5*0.9 0.0 4*0.2/
```



## 2.263 NUPCOL

### Description

This keyword sets the maximum number of group balancing iterations at each timestep when any instruction of group control option is being used. By default, ECHELON balance group production and injection, adjusting well targets at each Newton iteration. This approach is very effective and usually efficient, but it may lead to slow convergence since the Jacobian matrix does not include the mutual well rates between groups.

Using `NUPCOL` force the simulator to fix the wells target after `MAX_ITER` iterations (see record Format below) and it may help the Newton convergence.

### Record format

1. **MAX\_ITER:** Maximum number of group balancing at each Newton iteration

**Type:** Integer

**Default value:** equals to the maximum number of Newton iterations

### Example

In this example, `NUPCOL` is used to set the maximum number of group balancing iteration at each timestep to 3, meaning that after the 3rd iteration no group balancing will be executed and the well rates are kept constant.

```
NUPCOL  
3 /
```



## 2.264 NXFIN

### Description

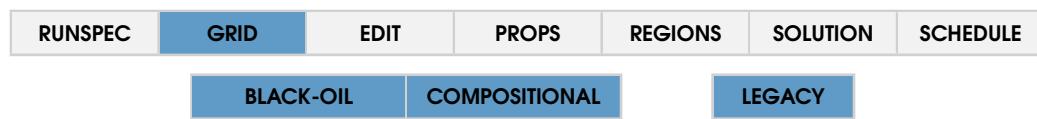
This keyword allows to define the number of divisions along the I-direction for the cells in the parent grid included in the local grid refinement.

The keyword can be used only inside a [CARFIN/ENDFIN](#) block and its followed by a single record with IMAX-IMIN +1 (see [CARFIN](#) keyword) integer values and a trailing slash character. The sum of those integer values equals NXR, the number of refinements along the I-direction as in [CARFIN](#).

### Example

In this example [NXFIN](#) is used to split cells in the host grid in an odd way:

```
CARFIN
    0P12 24 26 47 49 10 20 9 9 10 /
NXFIN
    5 2 2 /
ENDFIN
```



## 2.265 NYFIN

### Description

This keyword allows to define the number of divisions along the J-direction for the cells in the parent grid included in the local grid refinement.

The keyword can be used only inside a [CARFIN/ENDFIN](#) block and its followed by a single record with JMAX-JMIN +1 (see [CARFIN](#) keyword) integer values and a trailing slash character. The sum of those integer values equals NXR, the number of refinements along the J-direction as in [CARFIN](#).

### Example

In this example [NYFIN](#) is used to split cells in the host grid in an odd way:

```
CARFIN
    0P12 24 26 47 49 10 20 9 9 10 /
NYFIN
    5 2 2 /
ENDFIN
```



## 2.266 NZFIN

### Description

This keyword allows to define the number of divisions along the K-direction for the cells in the parent grid included in the local grid refinement.

The keyword can be used only inside a [CARFIN/ENDFIN](#) block and its followed by a single record with KMAX-KMIN +1 (see [CARFIN](#) keyword) integer values and a trailing slash character. The sum of those integer values equals NZR, the number of refinements along the I-direction as in [CARFIN](#).

### Example

In this example [NZFIN](#) is used to split cells in the host grid in and odd way:

```
CARFIN
    0P12 24 26 47 49 10 15 9 9 15 /
    NZFIN
        1 1 1 4 4 4    /
    ENDFIN
```



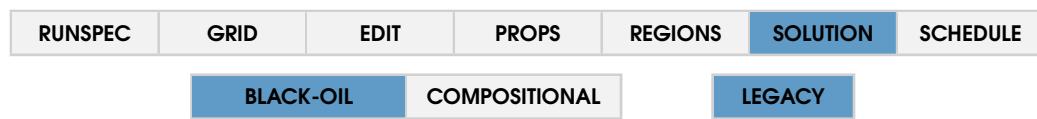
## 2.267 OIL

### Description

Specifies that an oil phase is requested in black-oil runs. If the [OIL](#) keyword is not present, then the [GAS](#) keyword is required. Note that a water phase is always present.

### Example

```
RUNSPEC  
OIL
```



## 2.268 OILAPI

### Description

This keyword is followed by a single record which includes one real value for each grid cell, which defines the initial oil API gravity in the reservoir using enumeration.

In the record values are given following IJK ordering with I index cycling faster, followed by J index and then by K index. Repeated counts can be used for repeated values.

The total number of oil API values is  $N_{XRES} \times N_{YRES} \times N_{ZRES}$ , with  $N_{XRES}$ ,  $N_{YRES}$  and  $N_{ZRES}$  as in [DIMENS](#) keyword.

UNITS: °API

### Example

[OILAPI](#) is used to set oil gravity in the cells in a  $20 \times 25 \times 5$  grid. Repeat counts are used following reservoir layering.

```
OILAPI
 500*35.0
 500*32.0
 500*28.0
 500*20.0
 500*15.0
/
```



## 2.269 OILWAT

### Description

This keyword enables the modeling of liquid/aqueous equilibrium, allowing the solubility of components in the aqueous phase, as well as water dissolution in the liquid phase. In particular, the Soreide and Whitson modification to the Peng-Robinson equation of state is adopted to account for component solubilities and water dissolution.

If the option is active, the last component provided in the model is assumed to be water. Specific formulas are implemented for the computation of binary interaction coefficients of  $CO_2$ ,  $N_2$  and  $H_2S$  in the aqueous phase; to use such formulas the proper component name ( $CO_2$ ,  $N_2$  and  $H_2S$ ), must be provided by the user in the [CNAMES](#) keyword.

### Example

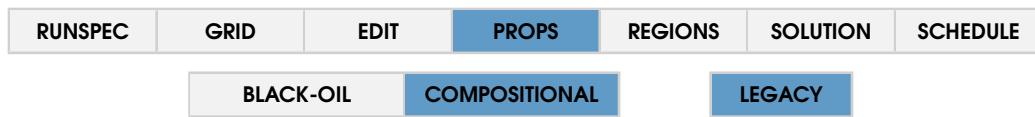
```
RUNSPEC  
OILWAT
```



## 2.270 OLDTRAN

### Description

This keyword indicates that the transmissibility calculations will be based on [DX](#), [DY](#), [DZ](#). It is the default method for block-centered grids. The keyword is not supported for corner point geometry.



## 2.271 OMEGAA

### Description

This keyword allows modification of default values of  $\Omega_{a_0}$  used in the equation of state. The keyword should be followed by NMEOS records, where NMEOS is the number of reservoir equations of state regions specified in the ninth field of [TABDIMS](#). Each record should contain NCOMP values for  $\Omega_{a_0}$ , where NCOMP is the number of components specified in the [NCOMP](#) keyword.

Note, this keyword is not necessary if the user wants to use default EOS values, namely 0.457235529 for Peng-Robinson and 0.4274802 for Soave-Riedlich-Kwong and Riedlich-Kwong.

### Record format

1. **OMEGAA:** (repeated NCOMP times)

Component  $\Omega_{a_o}$ .

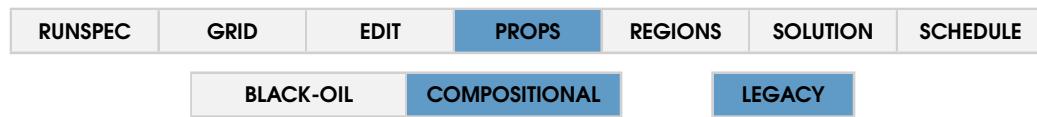
The default values used by the simulator are 0.457235529 for PENG-ROBINSON and 0.4274802 for REDLICH-KWONG and SOAVE-REDLICH-KWONG.

**Type:** Float

### Example

This example specifies the  $\Omega_{a_o}$  for a compositional simulation with five components:

```
OMEGAA  
0.012 0.138 0.1 0.163 0.271 /
```



## 2.272 OMEGAAS

### Description

This keyword allows modification of default values of  $\Omega_{a_o}$  used in the surface equation of state. The number of  $\Omega_{a_o}$  should be equal to the number of components in the simulation. If multiple surface equations of state are used, values must be specified for each of them. If the keyword is not provided the values specified in [OMEGAAs](#) are used or the default ones in case OMEGAA is not present.

### Record format

1. **OMEGAAS:** Component  $\Omega_{a_o}$ .

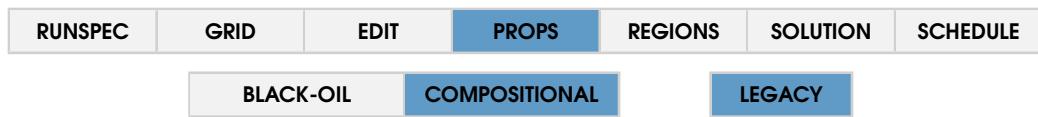
The default values used by the simulator are 0.457235529 for PENG-ROBINSON and 0.4274802 for REDLICH-KWONG and SOAVE-REDLICH-KWONG.

**Type:** Float

### Example

This example specifies the  $\Omega_{a_o}$  for the surface equation of state in a compositional simulation with five components

```
OMEGAAS  
0.012 0.138 0.1 0.163 0.271 /
```



## 2.273 OMEGAB

### Description

This keyword allows modification of default values of  $\Omega_{b_o}$  used in the equation of state. The number of  $\Omega_{b_o}$  should be equal to the number of components in the simulation. If multiple equations of state are used, [TAMDIMS](#) ninth field, values must be specified for each of them using slash terminated records.

Note, this keyword is not necessary if the user wants to use default EOS values, namely 0.457235529 for Peng-Robinson and 0.08664035 for Soave-Riedlich-Kwong and Riedlich-Kwong.

### Record format

1. **OMEGAB:** Component  $\Omega_{b_o}$ .

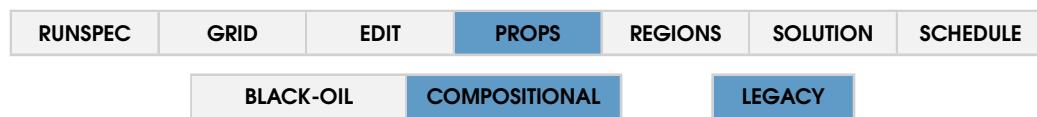
The default values used by the simulator are 0.077796074 for PENG-ROBINSON and 0.08664035 for REDLICH-KWONG and SOAVE-REDLICH-KWONG.

**Type:** Float

### Example

This example specifies the  $\Omega_{b_o}$  for a compositional simulation with five components

```
OMEGAB  
0.078 0.079 0.079 0.078 0.077 /
```



## 2.274 OMEGABS

### Description

This keyword allows modification of default values of  $\Omega_{b_o}$  used in the surface equation of state. The number of  $\Omega_{b_o}$  should be equal to the number of components in the simulation. If multiple surface equations of state are used, values must be specified for each of them. If the keyword is not provided the values specified in [OMEGAB](#) are used or the default ones in case OMEGAB is not present.

### Record format

1. **OMEGABS:** Component  $\Omega_{b_o}$ .

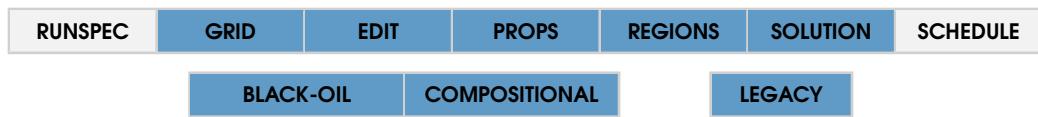
The default values used by the simulator are 0.077796074 for PENG-ROBINSON and 0.08664035 for REDLICH-KWONG and SOAVE-REDLICH-KWONG.

**Type:** Float

### Example

This example specifies the  $\Omega_{b_o}$  for the surface equation of state in a compositional simulation with five components

```
OMEGABS  
0.078 0.079 0.079 0.078 0.077 /
```



## 2.275 OPERATE

### Description

This keyword can be used to perform arithmetic operations on 3D arrays, including region 3D arrays. **OPERATE** is followed by an arbitrary number of records terminating by a slash, followed by an empty record terminated by a slash. A total of 13 fields, described in the Record format list, define each record.

More specifically,  $R$  is the final array modified by the keyword, IMIN/IMAX, JMMIN/JMAX and KMIN/KMAX define the block of cells where arithmetic operation is run, OPTYPE defines cell-wise operations on  $X$  array using  $\alpha$  and  $\beta$  as parameters.

Notably, the following constraints on fields 2 to 7 hold:

$$1 \leq \text{IMIN} \leq \text{IMAX} \leq \text{NX},$$

$$1 \leq \text{JMIN} \leq \text{JMAX} \leq \text{NY},$$

$$1 \leq \text{KMIN} \leq \text{KMAX} \leq \text{NZ},$$

where NX, NY and NZ are the current input box boundary (if **OPERATE** is non inside a **BOX/ENDBOX** block then NX=NXRES, NY=NYRES and NZ=NZRES)

### Available 3D arrays:

**OPERATE** keyword can be used to manipulate 3D arrays in the various section. These arrays can be used both as source ( $X$ ) and RESULT ( $R$ ), but it is not possible to use 3D source arrays in another section (e.g. using **PORO** to update **SWL**).

### GRID section

- **DX, DY, DZ, PERMX, PERMY, PERMZ, MULTX, MULTY, MULTZ, PORO, NTG, TOPS**

### EDIT section

- **PORV, DEPTH, TRANX, TRANY, TRANZ**

### PROPS section

- **SWL, SWU, SGL, SGU, SOWCR, SOGCR, SGRC,**
- **ISWL, ISWU, ISGL, ISGU, ISOWCR, ISOGCR, ISGRC,**
- **KRO, KRW, KRG, KRWR, KRORW, KRORG, KRGR,**
- **IKRO, IKRW, IKRG, IKRWR, IKRORW, IKRORG, IKRGR,**
- **SWLPC, ISWLPC,**
- **PCG, PCW.**

### REGIONS section

- **SATNUM, PVTNUM, EQLNUM, IMBNUM, FIPNUM, EOSNUM, OPERNUM**

### SOLUTION section

- **PRESSURE, SWAT, SGAS.**

### Record format

1. **R:** Result of the operation (see description for possible values)  
**Type:** String
2. **IMIN:** first cell in the block along I  
**Type:** Integer  
**Minimum:** 1

**Maximum:** NX

**Default value:** 1

3. **IMAX:** last cell in the block along I

**Type:** Integer

**Minimum:** 1

**Maximum:** NX

**Default value:** NX

4. **JMIN:** first cell in the block along J

**Type:** Integer

**Minimum:** 1

**Maximum:** NY

**Default value:** 1

5. **JMAX:** last cell in the block along J

**Type:** Integer

**Minimum:** 1

**Maximum:** NY

**Default value:** NY

6. **KMIN:** first cell in the block along K

**Type:** Integer

**Minimum:** 1

**Maximum:** NZ

**Default value:** 1

7. **KMAX:** last cell in the block along K

**Type:** Integer

**Minimum:** 1

**Maximum:** NZ

**Default value:** NZ

8. **OPTYPE:** type of operation (see description)

**Type:** String

**Allowed values:**

Name	Description
ABS	$R_i = \text{abs}(X_i)$
ADDX	$R_i = \alpha + X_i$
COPY	$R_i = X_i$
IFEQ	$R_i = \beta \text{ if } X_i = \alpha$
IFGT	$R_i = \beta \text{ if } X_i > \alpha$
IFGTE	$R_i = \beta \text{ if } X_i \geq \alpha$
IFLT	$R_i = \beta \text{ if } X_i < \alpha$
IFLTE	$R_i = \beta \text{ if } X_i \leq \alpha$
INV	$R_i = X_i^{-1}$
LOG10	$R_i = \log_{10}(X_i)$
LOG1E	$R_i = \ln(X_i)$
MAXLIM	$R_i = \min(X_i, \alpha)$
MINLIM	$R_i = \max(X_i, \alpha)$
MULP	$R_i = \alpha X_i^\beta$
MULTA	$R_i = \alpha X_i + \beta$
MULTIPLY	$R_i = X_i R_i$
MULX	$R_i = \alpha X_i$
POLY	$R_i = R_i + \alpha X_i^\beta$
SLOG	$R_i = 10^{(\alpha + \beta X_i)}$

9. **X:** Input for the operation (see description for possible values)

**Type:** String

10. **ALPHA:** needed if required by OPTYPE

**Type:** Float

11. **BETA:** needed if required by OPTYPE

**Type:** Float

### Example 1

**OPERNUM** can be used in GRID section:

```
OPERATE
  PERMX 1*    1*    1*    1*    1*    1*    'SLOG'  'PORO'  1.5  4.0 /
  PERMY 1*    1*    1*    1*    1*    1*    'COPY'   'PERMX'  /
  PERMZ 1*    1*    1*    1*    1*    1*    'COPY'   'PERMX'  /
  PERMZ 1*    1*    1*    1*    1*    1*    'MULTIPLY' 'NTG'   /
  /
```

### Example 2

**OPERNUM** can be used in the PROPS section to define a Land-type model for imbibition critical gas saturation:

```
OPERATE
  ISGCR  1*    1*    1*    1*    1*    1*    'MULTA'  'SGU'   1.5  1.0 /
  ISGCR  1*    1*    1*    1*    1*    1*    'INV'    'ISGCR'  /
  ISGCR  1*    1*    1*    1*    1*    1*    'MULTIPLY' 'SGU'   /
  /
```



## 2.276 OPERATOR

### Description

This keyword performs arithmetic operations on 3D arrays for a set of cells selected using a 3D region array type, by default [OPERNUM](#) values. [OPERATOR](#) is followed by an arbitrary number of records terminating with a slash, followed by an empty record terminated with a slash.

The format of the record allows to select a subset of cells using [OPERNUM](#) (by default) or [FIPNUM](#) while OPTYPE field defines the operation as described in the record format below.

#### Available 3D arrays:

[OPERATOR](#) keyword can be used to manipulate 3D arrays in the various section. These arrays can be used both as source (*X*) and result (*R*), but it is not possible to use 3D source arrays in another section (e.g. using [PORO](#) to update [SWL](#)).

#### GRID section

- [DX](#), [DY](#), [DZ](#), [PERMX](#), [PERMY](#), [PERMZ](#), [MULTX](#), [MULTY](#), [MULTZ](#), [PORO](#), [NTG](#), [TOPS](#)

#### EDIT section

- [PORV](#), [DEPTH](#), [TRANX](#), [TRANY](#), [TRANZ](#)

#### PROPS section

- [SWL](#), [SUW](#), [SGL](#), [SGU](#), [SOWCR](#), [SOGCR](#), [SGRC](#),
- [ISWL](#), [ISWU](#), [ISGL](#), [ISGU](#), [ISOWCR](#), [ISOGCR](#), [ISGRC](#),
- [KRO](#), [KRW](#), [KRG](#), [KRWR](#), [KRORW](#), [KRORG](#), [KRGR](#),
- [IKRO](#), [IKRW](#), [IKRG](#), [IKRWR](#), [IKRORW](#), [IKRORG](#), [IKRGR](#),
- [SWLPC](#), [ISWLPC](#),
- [PCG](#), [PCW](#).

#### REGIONS section

- [SATNUM](#), [PVTNUM](#), [EQLNUM](#), [IMBNUM](#), [FIPNUM](#), [EOSNUM](#), [OPERNUM](#)

#### SOLUTION section

- [PRESSURE](#), [SWAT](#), [SGAS](#).

### Record format

1. **R:** output 3D array  
**Type:** String
2. **RENUM:** integer value used as a cell selector for the OPTYPE operation  
**Type:** Integer  
**Default value:** 0
3. **OPTYPE:** type of operation (see Table 1)  
**Type:** String  
**Allowed values:**

Name	Description
ABS	$R_i = \text{abs}(X_i)$
ADDX	$R_i = \alpha + X_i$
COPY	$R_i = X_i$
IFEQ	$R_i = \beta \quad \text{if } X_i = \alpha$
IFGT	$R_i = \beta \quad \text{if } X_i > \alpha$
IFGTE	$R_i = \beta \quad \text{if } X_i \geq \alpha$
IFLT	$R_i = \beta \quad \text{if } X_i < \alpha$
IFLTE	$R_i = \beta \quad \text{if } X_i \leq \alpha$
INV	$R_i = X_i^{-1}$
LOG10	$R_i = \log_{10}(X_i)$
LOGE	$R_i = \ln(X_i)$
MAXLIM	$R_i = \min(\alpha, X_i)$
MINLIM	$R_i = \max(\alpha, X_i)$
MULP	$R_i = \alpha X_i^\beta$
MULTA	$R_i = \alpha X_i + \beta$
MULTIPLY	$R_i = R_i X_i$
MULTX	$R_i = \alpha X_i$
POLY	$R_i = R_i + \alpha X_i^\beta$
SLOG	$R_i = 10^{(\alpha + \beta X_i)}$

4. **X:** 3D array used as an argument for the selected OPTYPE

**Type:** String

5. **ALPHA:** parameter used in the selected OPTYPE

**Type:** Float

6. **BETA:** parameter used in the selected OPTYPE

**Type:** Float

7. **REGTYPE:** region selector

**Type:** Integer

**Default value:** OPERNUM

### Example

OPERNUM can be used in GRID section:

```
OPERATE
  PERMX 3 'SLOG' 'PORO' 1.5 4.0 /
  PERMY 3 'COPY' 'PERMX' /
  PERMZ 3 'COPY' 'PERMX' /
  PERMZ 1 'MULTIPLY' 'NTG' 'FIPNUM'/
  /
```



## 2.277 OPERNUM

### Description

This keyword defines inside [GRID](#) section a region 3D array, that is a set of positive integer values, one for each reservoir grid cell. [OPERNUM](#) can then be used by [OPERATER](#) to implement various arithmetic operations on cells filtered using [OPERNUM](#) values.

It is then possible to use these values as a filter to select cells where various properties in [GRID](#), [EDIT](#), [PROPS](#), [SOLUTION](#) and [REGIONS](#) can be manipulated by various keywords, that is to say:

- [COPYREG](#), [EQUALREG](#), [ADDREG](#), [MULTIREG](#)
- [MULTREGP](#), [MULTREGT](#)

In dual media simulations ([DUALPORO](#) or [DUALPERM](#) keyword in [RUNSPEC](#)) [OPERNUM](#) is defined only for the first medium (matrix), that is to say for the first NZRES/2 layers, in which case the simulator copies the values from matrix cells to fracture cells. It is possible to define specific [OPERNUM](#) values for all fracture cells using field 117 of [OPTIONS](#) keyword.

### Example

[OPERNUM](#) is used here to define three regions in a reservoir grid with 300 cells:

```
OPERNUM  
100*1 100*2 *100*3 /
```



## 2.278 OPTIONS

### Description

The [OPTIONS](#) keyword allows ECHELON to override the default behavior for some specific models. It applies to both blackoil and compositional runs. A specific option is activated by changing the numerical value of the corresponding field of the single record. Two options are supported by ECHELON.

31: By default or if set to 0, the FPR summary vector reports field pressure weighted by hydrocarbon pore volume (i.e., equal to FPRH). If set to a positive value, FPR will report pore volume weighed field pressure (i.e., equal to FPRP).

117: By default, in dual medium runs, MULTNUM, FLUXNUM, PINCHNUM and OPERNUM arrays only need to be specified for either the matrix or the fracture cells, and missing values will be copied from the other porosity. If this parameter value is set to 1, then MULTNUM values must also be specified for the fracture medium. If this parameter is set to 2 or greater, then all of MULTNUM, FLUXNUM, PINCHNUM and OPERNUM values must be specified for the fracture medium.

170: By default, when a grid is loaded using the [GDFILE](#) keyword, the ACTNUM array is also imported. Setting this parameter to 1 deactivated the ACTNUM import, meaning that active cells will solely be determined by ECHELON based on GRID and EDIT sections properties.

### Example

Sets option 117 to 1:

```
OPTIONS  
116* 1 /  
/
```



## 2.279 OVERBURD

### Description

This keyword defines the overburden pressure  $p_{OV}$  due to sediments load as a function of depth throughout a set of tables, one for each rock region specified by [ROCKNUM](#). Overburden pressure vs depth tables can be used if the rock compaction is turned on with [ROCKCOMP](#) in RUNSPEC section to replace the simpler rock compressibility model defined by [ROCK](#) keyword. Then, it is possible to use in the keywords [ROCKTAB](#) or [ROCKTABH](#) table of multipliers versus effective pressure,  $p_{eff} = p - p_{OV}$ , instead of the fluid pressure  $p$ . Then every time a rock compaction multiplier is computed  $p_{eff}$  is defined using  $p_{OV}$  at the cell depth according to the OVERBURD table and the current cell pressure  $p$ .

Some readers may be uncomfortable with the concept of effective pressure as defined above. It is possible to tabulate rock compaction tables in [ROCKTAB/ROCKTABH](#) versus the effective stress  $\sigma_{eff} = p_{OV} - p$ , provided that the OVERBURD\_OPT in RUNSPEC [ROCKOPTS](#) keyword is set to STRESS.

Rock compaction models may work with two types of multipliers, pore volume and transmissibility. Pore-volume multipliers are treated implicitly by the simulator. On the other hand, transmissibility multipliers are treated explicitly, using the pressure at the previously converged timestep. Notably, for black-oil runs, the transmissibility multiplier between cells is taken as an average of the connected block multipliers. For compositional runs, the transmissibility multiplier is based on the upstream value where the upstream cell is taken as the cell with highest pressure (disregarding gravity or capillary pressure effects).

The keyword is followed by NTABROCK slash terminated records, each of them consisting of a two-column table. NTABROCK is the number of rock compaction regions defined using [ROCKNUM](#).

Further insights on rock compaction modelling can be found in [ROCKTAB](#), [ROCKOPTS](#) documentation and in the Technical Description [Chapter 9](#)

### Table columns

1. **Depth:** The depth for which overburden pressures is defined (must increase monotonically)  
**Units:** ft (FIELD), m (METRIC)
2. **Overburden Pressure:** The overburden pressure  $p_{OV}$  values at the specific depths (must increase monotonically)  
**Units:** psi (FIELD), bar (METRIC)

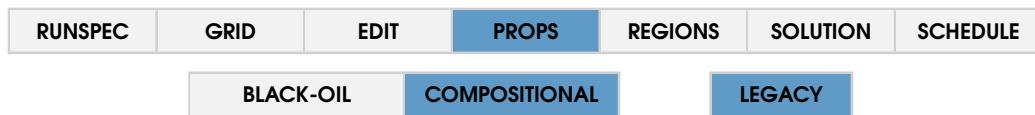
### Example

For a model with NTABROCK=2

```

OVERBURD
--depth overburden
2000    1000
4000    1600
6000    3200
/
2000    1500
4000    2100
6000    3700
/

```



## 2.280 PARACHOR

### Description

This keyword provides a parachor value for each component to be used for surface tension calculation when the [MISCIBLE](#) option is activated. The number of parachor values should be equal to the number of components in the simulation. If multiple equations of state are used, values must be specified for each of them.

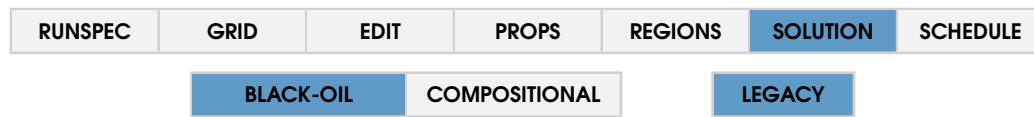
### Record format

1. **PARACHOR:** (repeated NCOMP times)  
Component parachor  
**Type:** Float  
**Units:** (dynes/cm)<sup>1/4</sup>.cc/gm-M (FIELD), (dynes/cm)<sup>1/4</sup>.cc/gm-M (METRIC)

### Example

This example specifies the PARACHOR for a compositional simulation with five components:

```
PARACHOR
76.4 97.4 80 165.4 290.4/
```



## 2.281 PBUB

### Description

The [PBUB](#) keyword is used to provide the initial bubble point pressure,  $P_b$ , for every cell in a model with an enumerated initial state. Alternatively, equivalent data can be provided as the solution gas-oil ratio,  $R_s$  with the [RS](#) keyword. However, both [PBUB](#) and [RS](#) cannot be provided in the same model. When [PBUB](#) is provided, the corresponding value for  $R_s$  is computed by inverting the table of  $P_b$  vs  $R_s$  provided in the [PVTO](#) keyword.

**Units:** psi (FIELD), bar (METRIC)

### Example

For a reservoir with  $10 \times 10 \times 5$  grid cells and [METRIC](#) units:

```
PBUB
100*202.1
100*203.3
100*204.5
100*205.7
100*206.9 /
```



## 2.282 PBVD

### Description

This keyword is used to tabulate the value of the bubble point pressure,  $P_b$ , versus depth for use in vertical equilibration with the [EQUIL](#) keyword. The equivalent data can alternatively be provided with the [RSVD](#) keyword.

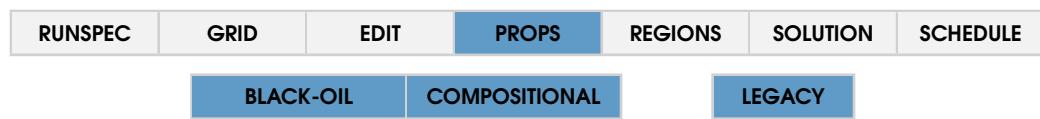
The data consists of two columns. The first gives the depth measured in feet ([FIELD](#)) or meters ([METRIC](#)). The second column is the bubble point pressure ( $P_b$ ) given in psi ([FIELD](#)) or bar ([METRIC](#)).

### Table columns

#### Example

For a single equilibration region, specified in metric units:

```
PBVD
-- Depth(m) Pb(bar)
 2478      301.2
 2635      285.6
/
```



## 2.283 PCG

### Description

The PCG keyword allows the user to rescale the vertical capillary pressure axis for gas-oil capillary pressure input (*e.g.* SGOF tables assigned by SATNUM). The capillary pressure axis is rescaled to a modified highest capillary pressure value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest capillary pressure is the value at the largest gas saturation in the table. PCG can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The PCG keyword should not be used when using the J-function option JFUNC or when defining initial saturations via the SWATINIT array. The PCG values should have the same sign as the table capillary pressure at the largest gas saturation.

Additional endpoint arrays are allowed for water saturations (*e.g.* SWL), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint capillary pressure arrays.

Array	Description
PCW	Maximum water-oil drainage capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure
PCG	Maximum gas-oil drainage capillary pressure
IPCG	Maximum gas-oil imbibition capillary pressure

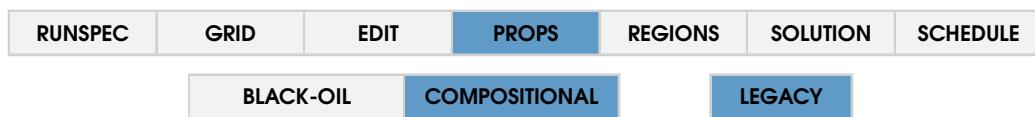
Table 2.40

Units: psi (FIELD), bar (METRIC)

### Example

PCG is used here in a dual media case to assign the maximum gas-oil capillary pressure for flow in the matrix (top reservoir half) and fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
PCG
 9000*15.0  9000*0.5 /
```



## 2.284 PCRIT

### Description

This keyword specifies the critical pressures of the hydrocarbon components in a compositional simulation. The number of critical pressures should be equal to the number of components in the simulation. If multiple equations of state are used, values must be specified for each of them using multiple slash terminated records.

### Record format

1. **P\_CRIT:** Component critical pressures

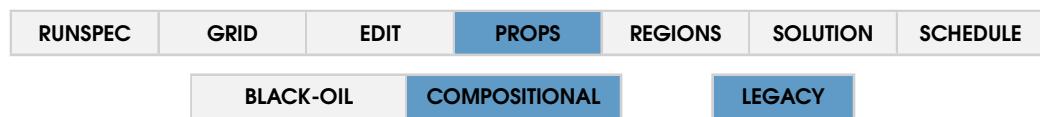
**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

### Example

This example specifies the critical pressures for a compositional simulation with five components

```
PCRIT  
1071.33 492.31 667.78 708.34 618.69 /
```



## 2.285 PCRITS

### Description

This keyword specifies the critical pressures of the hydrocarbon components for the surface equation of state in a compositional simulation. The number of critical pressures should be equal to the number of components in the simulation. If multiple surface equations of state are used, values must be specified for each of them. If the keyword is not provided the values specified in [PCRIT](#) are used.

### Record format

1. **P\_CRITS:** Component critical pressures

**Type:** Float

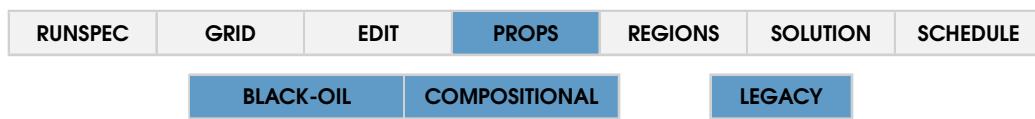
**Units:** psi (FIELD), bar (METRIC)

### Example

This example specifies the critical pressures for the surface equation of state in a compositional simulation with five components

PCRITS

```
1071.33 492.31 667.78 708.34 618.69 /
```



## 2.286 PCW

### Description

The PCW keyword allows the user to rescale the vertical capillary pressure axis for water-oil capillary pressure input (*e.g.* SWOF tables assigned by SATNUM). The capillary pressure axis is rescaled to a modified highest capillary pressure value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest capillary pressure is the value at the smallest water saturation in the table. PCW can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The PCW keyword should not be used when using the J-function option JFUNC or when defining initial saturations via the SWATINIT array. The PCW values should have the same sign as the table capillary pressure at connate (lowest) water saturation.

Additional endpoint arrays are allowed for water saturations (*e.g.* SWL), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint capillary pressure arrays.

Array	Description
PCW	Maximum water-oil drainage capillary pressure
IPCW	Maximum water-oil imbibition capillary pressure
PCG	Maximum gas-oil drainage capillary pressure
IPCG	Maximum gas-oil imbibition capillary pressure

Table 2.41

**Units:** psi (FIELD), bar (METRIC)

### Example

PCW is used here in a dual media case to assign the maximum oil-water capillary pressure for flow in the matrix (top reservoir half) and the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
PCW
 9000*20.0  9000*1.0 /
```



## 2.287 PDEW

### Description

The [PDEW](#) keyword is used to provide the initial dew-point pressure,  $P_d$ , for every cell in a model with an enumerated initial state. Alternatively, equivalent data can be provided as the vaporized oil-gas ratio,  $R_v$  with the [RV](#) keyword. However, both [PDEW](#) and [RV](#) cannot be provided in the same model. When [PDEW](#) is provided, the corresponding value for  $R_v$  is computed by inverting the table of  $P_d$  vs  $R_v$  provided in the [PVTG](#) keyword.

**Units:** psi (FIELD), bar (METRIC)

### Example

For a reservoir with  $10 \times 10 \times 5$  grid cells and [METRIC](#) units:

```
PDEW
100*158.1
100*156.9
100*155.7
100*154.5
100*153.3 /
```



## 2.288 PDVD

### Description

This keyword is used to tabulate the value of the dew-point pressure,  $P_d$ , versus depth for use in vertical equilibration with the [EQUIL](#) keyword. The equivalent data can alternatively be provided with the [RVVD](#) keyword.

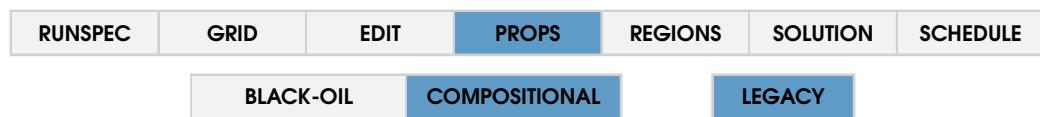
The data consists of two columns. The first gives the depth measured in feet ([FIELD](#)) or meters ([METRIC](#)). The second column is the dew-point pressure ( $P_d$ ) given in psi ([FIELD](#)) or bar ([METRIC](#)).

### Table columns

#### Example

For a single equilibration region, specified in metric units:

```
PVVD
-- Depth(m) Pb(bar)
 2478      301.2
 2635      285.6
/
```



## 2.289 PEDERSEN

### Description

In compositional models, the Lorentz-Bray-Clark (LBC) correlation is used for computing viscosities from phase composition, temperature and pressure. The `PEDERSEN` keyword enables the use of the Pedersen correlation (see [Section 7.4](#) in the Technical Description). The keyword has no associated data records. See also the `PETUNE` and `PETUNER` keywords, which can be used to tune the parameters of the correlation to better match laboratory viscosity data.

### Example

```
PROPS  
PEDERSEN
```



## 2.290 PEDITUNE

### Description

The `PEDITUNE` keyword is used to specify regression parameters for the viscosity correlation proposed by Pedersen and Fredenslund (1984)<sup>1</sup> for compositional simulations. This correlation utilizes the method of the corresponding states to provide an analytic function for the viscosity of a hydrocarbon mixture based on that of pure methane. The original correlation proposed fixed coefficients that gave reasonable agreement with experimentally measured viscosity across a wide range of oil qualities, but adjustment of these parameters can yield a closer fit to laboratory data for a given oil or gas. Third-party tools can be used to adjust these parameters to available data.

In the Pedersen viscosity model, the phase viscosity of the mixture is computed from viscosity of a reference hydrocarbon (methane in particular) viscosity  $\mu_o$  evaluated at a reference pressure  $p_o$  and reference temperature  $T_o$ .

$$\mu = \left( \frac{T_{c_m}}{T_{c_o}} \right)^{-1/6} \left( \frac{p_{c_m}}{p_{c_o}} \right)^{2/3} \left( \frac{MW_m}{MW_o} \right)^{1/2} \frac{\alpha_m}{\alpha_o} \mu_o ,$$

where  $\alpha$  is rotational coupling factor. In the above equation, the subscript  $m$  indicates mixture properties and subscript  $o$  indicate reference methane properties. The mixture molecular weight is given as a function of weight average ( $MW_w$ ) and number average ( $MW_n$ ) molecular weight

$$MW_m = MW_n + 1.304e^{-4} c_1 (MW_w^{2.303c_2} - MW_n^{2.303c_2}) .$$

The critical temperature and pressure of the mixture are computed as

$$T_{c_m} = \frac{\sum_i \sum_j w_i w_j \sqrt{T_{c_i} T_{c_j}} ((T_{c_i}/p_{c_i})^{1/3} + (T_{c_j}/p_{c_j})^{1/3})^3}{\sum_i \sum_j w_i w_j ((T_{c_i}/p_{c_i})^{1/3} + (T_{c_j}/p_{c_j})^{1/3})^3},$$

$$p_{c_m} = \frac{8T_{c_m}}{\sum_i \sum_j w_i w_j ((T_{c_i}/p_{c_i})^{1/3} + (T_{c_j}/p_{c_j})^{1/3})^3}$$

The coupling factors are computed as

$$\begin{aligned} \alpha_m &= 1 + c_5 b_{r_m}^{c_3} M W_m^{c_4} \\ \alpha_o &= 1 + c_6 b_{r_m}^{c_3} \end{aligned}$$

where  $b_r$  is ratio of methane density to critical density of methane.

Methane viscosity  $\mu_o$  is evaluated at pressure  $p_o$ , and temperature  $T_o$ , using correlations from Mcarty (1974)<sup>2</sup>.

$$p_o = \frac{p_{c_o} \alpha_o}{p_{c_m} \alpha_m}, \quad T_o = \frac{T_{c_o} \alpha_o}{T_{c_m} \alpha_m} .$$

The `PEDITUNE` keyword can be used to adjust constants  $c_1, \dots, c_6$ . They are provided in a single record terminated by a slash (/), and govern the viscosity for all equation-of-state (EOS) regions. The `PEDTUNER` keyword can be used instead to provide one set of parameters for each EOS region, allowing greater flexibility for models with multiple compartments containing different hydrocarbon mixtures.

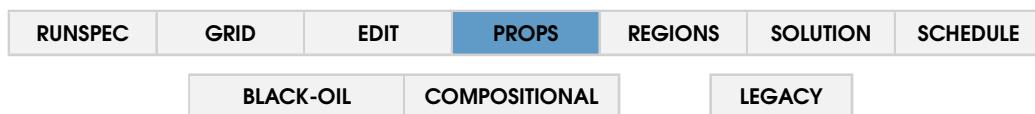
1. K. S. Pedersen, A. Fredenslund, P. L. Christensen, and P. Thomassen. Viscosity of crude oils. *Chemical Engineering Science*, 39(6):1011-1016, 1984.
2. R. McCarty. A modified Benedict-Webb-Rubin equation of state for methane using recent experimental data. *Cryogenics*, 14(5):276-280, 1974

### Record format

1. **C\_1:**  
**Minimum:** 0.1  
**Maximum:** 10.  
**Default value:** 1.0
2. **C\_2:**  
**Minimum:** 0,1  
**Maximum:** 10  
**Default value:** 1.0
3. **C\_3:**  
**Minimum:** -100  
**Maximum:** 100  
**Default value:** 1.847
4. **C\_4:**  
**Minimum:** -1000  
**Maximum:** 1.5  
**Default value:** 0.5173
5. **C\_5:**  
**Minimum:** -0.015  
**Maximum:** 0,1  
**Default value:** 7.378e-3
6. **C\_6:**  
**Minimum:** -0.2  
**Maximum:** 1.1  
**Default value:** 3.1e-2

#### Example

```
PEDTUNE
1.02 1.0 1.851 0.5171 1* 3.2e-2 /
```



## 2.291 PEDITUNER

### Description

The `PEDITUNER` keyword is used to specify regression parameters for the viscosity correlation proposed by Pedersen and Fredenslund (1984)<sup>1</sup> for compositional simulations. It generalizes the `PEDTUNE` keyword, which allows the user to specify one set of parameters,  $c_1, \dots, c_6$ , for the correlation for the whole reservoir. In contrast, `PEDITUNER` expects a slash-terminated record for each equation-of-state (EOS) region defined in the model. For reservoirs containing multiple compartments with distinct reservoir fluids, this generalization can allow a better match to laboratory data for each fluid.

For the definition of the adjustable parameters,  $c_1, \dots, c_6$ , see `PEDTUNE`. The number of EOS regions (and hence the number of expected records) is set in the nth field of `TABDIMS`.

### Record format

1. **C\_1:**  
**Minimum:** 0.1  
**Maximum:** 10  
**Default value:** 1.0
2. **C\_2:**  
**Minimum:** 0.1  
**Maximum:** 10  
**Default value:** 1.0
3. **C\_3:**  
**Minimum:** -100  
**Maximum:** 100  
**Default value:** 1.847
4. **C\_4:**  
**Minimum:** -1000  
**Maximum:** 1.5  
**Default value:** 0.5173
5. **C\_5:**  
**Minimum:** -0.015  
**Maximum:** 1  
**Default value:** 7.378e-3
6. **C\_6:**  
**Minimum:** -0.3  
**Maximum:** 1.1  
**Default value:** 3.1e-2

### Example

For a model containing two EOS regions:

```
PEDITUNER
1.02  1.0   1.851  0.5171  1*  3.2e-2 /
1.019  0.99  1.849  0.5173  1*  3.4e-2 /
```



## 2.292 PERMX

### Description

The keyword defines the permeability along X (I) direction of the reservoir as a 3D array, which means one non-negative number for each cell. Cell `PERMX` values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z).

**Units:** mDarcy (FIELD), mDarcy (METRIC)

### Example

This `PERMX` keyword sets permeability along the I-direction in a grid of 15 cells:

```
PERMX  
5*1000 5*0.1 200 4*1.0 /
```



## 2.293 PERMY

### Description

The keyword defines the permeability along Y (J) direction of the reservoir as a 3D array, which means one non-negative number for each cell. Cell **PERMY** values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z) .

**Units:** mDarcy (FIELD), mDarcy (METRIC)

### Example

This **PERMY** keyword sets permeability along Y (J) direction in a grid of 15 cells:

```
PERMY  
5*1000 5*0.1 200 4*1.0 /
```



## 2.294 PERMZ

### Description

The keyword defines the permeability along Z (K) direction of the reservoir as a 3D array, which means one non-negative number for each cell. Cell [PERMZ](#) values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z).

**Units:** mDarcy (FIELD), mDarcy (METRIC)

### Example

This [PERMZ](#) keyword sets vertical permeability (along K) in a grid of 15 cells:

```
PERMZ  
5*1000 5*0.1 200 4*1.0 /
```



## 2.295 PETOPTS

### Description

Using the PETOPTS keyword, the normal computation of cell connections, transmissibility values and pore volumes are disregarded. These are overridden with the user-specified non-neighboring connections transmissibility ([NNC](#)), standard cell transmissibility values ([TRANX](#), [TRANY](#), [TRANZ](#)) and pore volumes ([PORV](#)) imported from geomodelling preprocessors. The grid geometry (*e.g.*, [GRIDFILE](#)) is still required for post-processing displays. The only supported data item on this keyword is TRANPORV.

### Example

Specify that input for NNC, PORV and TRANX, TRANY, TRANZ values are to be provided from preprocessing software and should not be calculated by Echelon.

```
PETOPTS  
TRANPORV/
```



## 2.296 PICOND

### Description

The keyword controls the options of the Generalized Pseudo-Pressure (GPP) model that is used for modeling the gas mobility reduction due to condensate drop-out in the near wellbore region (see [Section 15.7](#) in the Technical Documentation). If entered in the [SCHEDULE](#) section, options apply to all wells for which the GPP model has been activated. Alternatively, the GPP option for individual wells can be entered using the keyword [WPICOND](#), which (if entered later in the [SCHEDULE](#) section) overwrites the options specified with this keyword. If neither [PICOND](#) nor [WPICOND](#) are provided, the default options specified below apply.

The GPP model may be enabled on a well-by-well basis in a number of ways:

- Setting field 8 of a [WELSPECS](#) record to “GPP”
- Setting field 9 of a [WELSPECCL](#) record to “GPP”
- Setting field 2 of a [WPICOND](#) record to “YES”

Alternatively, the GPP model can be activated for all wells using the keyword [PSEUPRES](#).

The keyword should be followed by one or more of the following items and should be terminated with a trailing slash.

### Record format

1. **MAX\_DP\_BELOW:** Maximum interval between pressure points below the saturation pressure.

**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:**  $4 \times P_{atm}$  (FIELD),  $4 \times P_{atm}$  (METRIC)

2. **MAX\_DP\_ABOVE:** Maximum interval between pressure points above the saturation pressure.

**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:**  $10 \times P_{atm}$  (FIELD),  $10 \times P_{atm}$  (METRIC)

3. **DAMP:** Blocking factor damping coefficient,  $D$ . This factor must be between 0.0 and 1.0 and allows damping the blocking factor,  $BF$ , by averaging it with its value computed from the previous timestep according to  $BF = D \times BF_{current} + (1.0 - D) \times BF_{previous}$ .

**Type:** Float  
**Minimum:** 0.0  
**Maximum:** 1.0

4. **VDRP:** Include velocity-dependent relative permeability in GPP calculations. Either YES or NO.

**Type:** String  
**Default value:** NO

5. **F\_LOW:** Multiplicative factor,  $f_{low}$ , which determines the lower pressure bound,  $p_{low}$ , to be used in the construction of the GPP table. This is expressed as a multiplier to the current pressure,  $p_{conn}$ , of the grid block containing the connection,  $p_{low} = f_{low} \times p_{conn}$

**Type:** Float  
**Minimum:** 0.0  
**Maximum:** 0.95  
**Default value:** 0.0

6. **F\_UP:** Multiplicative factor,  $f_{up}$ , which determines the upper pressure bound,  $p_{up}$ , to be used in the construction of the GPP table. This is expressed as a multiplier to the current pressure,  $p_{conn}$ , of the grid block containing the connection,  $p_{up} = f_{up} \times p_{conn}$   
**Type:** Float  
**Minimum:** 1.05  
**Maximum:** 2.0  
**Default value:** 1.1
7. **MAX\_DS:** Maximum change in water saturation of the grid block containing the connection which triggers a recalculation of the GPP table. This change is calculated as the absolute value of the difference between the current water saturation value and that when the table was last updated. This control may be disabled by specifying a negative value  
**Type:** Float  
**Default value:** 0.01
8. **MAX\_DP:** Maximum change in pressure of the grid block containing the connection which triggers a recalculation of the GPP table. This change is calculated as the absolute value of the difference between the current value and that when the table was last updated. This control may be disabled by specifying a negative value  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:**  $1 \times P_{atm}$  (FIELD),  $1 \times P_{atm}$  (METRIC)
9. **MAX\_DCOMP:** Maximum relative change in the composition of any component of the grid block containing the connection which triggers a recalculation of the GPP table. This change is computed as the absolute value of the difference between the current composition and the composition when the table was last updated divided by the previous value. This control may be disabled by specifying a negative value  
**Type:** Float  
**Default value:** 0.01
10. **MAX\_TIME:** Maximum simulation time change which triggers a recalculation of the GPP table. This change is calculated as the absolute value of the difference between the current simulation time value and the value when the table was last updated. This control may be disabled by specifying a negative value  
**Type:** Float  
**Units:** Day (FIELD), Day (METRIC)  
**Default value:** -1
11. **ADAPTIVE:** A positive value indicates that the interval between the pressure points in the vicinity of the saturation pressure should be further reduced to better capture non-linearity. The number of additional pressure points and their spacing is determined automatically depending on the minimum pressure step specified in item 14. A negative value deactivates the adaptive ordinate control  
**Type:** Float  
**Default value:** -1
12. **MIN\_DP:** Minimum pressure spacing for adaptive ordinate control.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:**  $0.1 \times P_{atm}$  (FIELD),  $0.1 \times P_{atm}$  (METRIC)

**Example**

In this example, the maximum interval between pressure points below the saturation pressure is set to 1.0 while the maximum interval between pressure points above the saturation pressure is set to 20. A damping coefficient of 0.5 is specified and velocity effects are included in the GPP calculation. These options apply to all wells for which the GPP model has been activated.

```
PICOND
dp_below  dp_above    damp   vdrp
  1.0      20.0     2*    0.5  YES
/
```



## 2.297 PIDCONTROL

### Description

This keyword specifies a PID (proportional-integral-derivative) controller used to govern the production or injection of a group. Rates are adjusted to reach a target value of a specified quantity (the process variable), e.g. average pressure or saturation of a region. Any field UDV can be used as a process variable and should be specified with the keyword [UDV](#) at least one timestep before the PID control. The PIDCONTROL keyword introduces an additional rate target for the group. If the same type of target is specified using [GCONPROD](#) or [GCONINJE](#), at every timestep the most constraining target is chosen.

The keyword contains one record per PID control. Each record is terminated with a slash (/). The keyword is terminated with a trailing slash.

### Record format

1. **GROUP\_NAME:** Name of group or FIELD.
2. **CONTROL\_TYPE:** Group control type used to reach the process variable target.

#### Allowed values:

Name	Description
PROD	The RESV production rate of the group is controlled.
OINJ	The oil injection RESV rate of the group is controlled.
WINJ	The water injection RESV rate of the group is controlled.
GINJ	The gas injection RESV rate of the group is controlled.
OINS	The oil injection surface rate of the group is controlled.
WINS	The water injection surface rate of the group is controlled.
GINS	The gas injection surface rate of the group is controlled.
WGIN	The wet gas injection rate of the group is controlled.
NONE	The PID control is not active for the group.

3. **PROCESS\_VARIABLE:** The quantity used as the process variable of the PID controller and for which a target is specified in Item 4. This value has to be specified using a user-defined argument ([UDA](#)). The UDA should be specified at least one timestep before.
4. **TARGET:** The target value of the process variable specified in Item 3, e.g. the desired pressure of a FIP region.
5. **PROPORTIONALITY\_CONSTANT:** The proportionality constant of the PID controller. Higher values yield a larger impact on the controlled rate.
6. **INTEGRAL\_CONSTANT:** The integral constant of the PID controller.  
**Default value:** 0
7. **DERIVATIVE\_CONSTANT:** The derivative constant of the PID controller.  
**Default value:** 0
8. **INITIAL\_CONTROL:** The initial value of the control. If not specified, ECHELON computes this value using the corresponding flowing rate of the group when the PID controller is introduced.
9. **ANTIWINDUP\_MODE:** The conditional integration algorithm used to avoid the windup of the PID controller when saturated, i.e. when the group cannot achieve the target specified by

the controller due to a more stringent constraint.

**Default value:** CONDITIONAL

**Allowed values:**

Name	Description
CONDITIONAL	The conditional integration algorithm is used. This is the default behavior.
RESET_ERROR	The integral error is reset when the error changes sign.
OFF	The anti-windup option is inactive and the integral error is always updated.

10. **RESPONSE\_TYPE:** This Item specifies the proportionality between the process variable error and the PID controller output.

**Allowed values:**

Name	Description
DIRECT	The PID controller output is directly proportional to the process variable error. This is the default behavior. The typical use case is when controlling reservoir pressure with injectors, because increasing the injection rate favors pressure support.
INVERSE	The PID controller output is inversely proportional to the process variable error. The typical use case is when controlling reservoir pressure with producers, because increasing the production rate tends speeds the depletion up.

11. **RESET\_WHEN\_NEGATIVE:** This Item specifies the PID controller behavior when the computed output is negative.

**Allowed values:**

Name	Description
YES	The PID controller is restarted when its output is negative. This is the default behavior.
NO	The PID controller is not restarted when its output is negative

### Example

In this example, the PIDCONTROL keyword is used to control the water surface injection rate of a group of injectors, 'GRP 1', in such a way to achieve a constant field pressure of 1500 psi. The field pressure is introduced as process variable using a field UDQ, which is defined one timestep before the PID controller. The output of the PID controller is set as directly proportional to the process variable error, i.e. if the difference between target pressure and field pressure increases the injection rate is also increased.

```

UDQ
DEFINE FUPR FPR /
/

TSTEP
1 /

PIDCONTROL
-- Grp   Flo   UDQ   Targ  Prop   Inte   Der    Init   Anti-   Resp.   Reset
-- Name  Targ           Const  Const  Const  Cntrl  windup      on -?
'GRP 1' WINS FUPR 1500   30    70    1*    1*    1*    DIRECT   1*/
/

```



## 2.298 PINCH

### Description

Corner point geometry grids are normally built within geomodeling software to follow horizons and layering as defined by geological and geophysical descriptions of the subsurface. The thickness of the simulation layers varies laterally, and in parts of the grid, layers may thin to a point where thickness is zero, or are thin enough that the pore volume of some cells is less than a defined threshold (e.g. the minimum pore volume [MINPV](#), [MINPVV](#), or [MINPORV](#)). In such cases, the automatically generated transmissibility values of all cells based on standard I, J, K numbering would result in no flow across the pinched-out interval. The pinchout could occur over multiple simulation layers.

The PINCH keyword allows the user to define a gap thickness and a pore volume threshold for which a non-neighbor connection would be automatically created. If the minimum pore volume default ( $1.0^{-6}$ ) is used, then gap thickness may be very small, whereas using a larger [MINPV](#), the gap thickness may increase. Users can define whether a gap should remain as a sealing boundary or whether the flow should be allowed across the gap.

It is possible to customize the logic of the computation of the transmissibility via [PINCH](#), either using the half transmissibility of the two connected cells or choosing to compute non-neighboring connection harmonically by averaging the transmissibility of all the cells made inactive via min-pore volume in the pinched-out gap. Instead of using the [MULTZ](#) multipliers defined for the cell above the gap, the user may choose to use the lowest [MULTZ](#) defined for the pinched cells. The use of the PINCH keyword can have a strong impact on simulated results.

Geomodelling packages used for developing corner point geometry will normally export the PINCH keyword along with the geometry definition ([ZCORN](#) and [COORD](#)). Including PINCH with defaults, triggers the logic to establish non-neighboring connections across gaps regardless of the gap thickness. It is also possible to set a cut-off on the transmissibility values created along pinched connections using the [MAXTRANP](#) keyword. It is important that users check for the presence of PINCH and review the options assigned to ensure the desired impact on simulated results.

### Record format

1. **Thickness Threshold:** The threshold gap thickness for which a non-neighbor connection would be automatically created. (Default 0.001)
 

**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** 0.001 (FIELD), 0.001 (METRIC)
2. **MINPV Option:** Define whether NNCs are created across cells that are inactive due to MINPV (GAP or NOGAP). GAP creates NNC connections for MINPV cells even if thickness is greater than the defined threshold.
 

**Type:** String  
**Default value:** GAP
3. **Max Empty Gap:** Maximum allowed empty gap allowed when calculating NNCs (default is  $10^{20}$ )
 

**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** (FIELD),  $10^{20}$  (METRIC)
4. **Transmissibility Method:** Options for transmissibility calculation (TOPBOT or ALL). TOPBOT (default) uses harmonic weighting of the top and bottom connected cells. ALL uses all cells between the connected active cells.
 

**Type:** String

**Default value:** TOPBOT

5. **MULTZ Option:** When item 4 is TOPBOT, this setting defines the method to use MULTZ when calculating NNCs across gaps (TOP or ALL). TOP (default) means MULTZ from the top cell is used in the NNC calculation. ALL means the minimum MULTZ for the top and all inactive cells between the connected cells are used in the calculation.

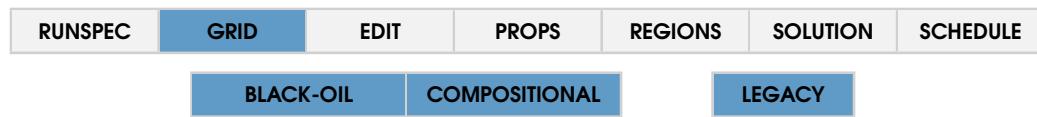
**Type:** String

**Default value:** TOP

### Example

This example has all 5 possible items defined (defaults could be denoted by a 1\* placeholder) 1) Pinchout threshold thickness, 2) Option for MINPV setting, 3) Max empty gap, 4) Transmissibility option, 5) Method for use of MULTZs

```
PINCH  
0.1      NOGAP     1.0      TOPBOT    ALL/
```



## 2.299 PINCHNUM

### Description

Use of the PINCHNUM keyword in the grid section assigns cells to specific regions for pinchout definition and computations. The associated [PINCHREG](#) keyword defines the criteria for connecting cells across pinchouts of [MINPV](#) cells in each pinchout region. The PINCHNUM keyword is followed by a single, slash terminated, record and this record consists of a list of positive integers, one for each grid cell in the current input box, to specify the PINCHNUM region integer to which cells belong.

Default values (e.g. 45\*) are treated as 1 and these cells are part of the PINCHREG region number one.

Note that an [OPTIONS](#) keyword in the [RUNSPEC](#) section supports option 117, which allows [MULTNUM](#) to be specified independently for the fracture and the matrix when [OPTIONS](#) item number 117 is set to a value of 1. When item number 117 is set to a value of 2, the [FLUXNUM](#), [PINCHNUM](#), and [OPERNUM](#) values may also be specified independently.

### Example

PINCHNUM is used here to assign region 1 for the first 10,000 cells and region 2 for the second 10,000 cells for the grid box of interest.

```
PINCHNUM  
10000*1 10000*2 /
```



## 2.300 PINCHREG

### Description

Corner point geometry grids are normally built within geomodeling software to follow horizons and layering as defined by geological and geophysical descriptions of the subsurface. The thickness of the simulation layers varies laterally, and in parts of the grid, layers may thin to a point where thickness is zero, or are thin enough that the pore volume of some cells is less than a defined threshold (e.g. the minimum pore volume [MINPV](#), [MINPVV](#), or [MINPORV](#)). In such cases, the automatically generated transmissibility values of all cells based on standard I, J, K numbering would result in no flow across the pinched-out interval. The pinchout could occur over multiple simulation layers.

The PINCHREG keyword allows the user to define a gap thickness and a pore volume threshold within each [PINCHNUM](#) region for which a non-neighbor connection would be automatically created. If the minimum pore volume default ( $1.0^{-6}$ ) is used, then gap thickness may be very small, whereas using a larger [MINPV](#), the gap thickness may increase. Users can define whether a gap should remain as a sealing boundary or whether flow should be allowed across the gap.

It is possible to customize the logic of the computation of the transmissibility within each [PINCHNUM](#) region via [PINCHREG](#), either using the half transmissibility of the two connected cells or choosing to compute non-neighboring connection harmonically by averaging the transmissibility of all the cells made inactive via min-pore volume in the pinched-out gap. Instead of using the [MULTZ](#) multipliers defined for the cell above the gap, the user may choose to use the lowest [MULTZ](#) defined for the pinched cells. The use of the PINCHREG keyword can have a strong impact on simulated results.

Geomodelling packages used for developing corner point geometry will normally export the [PINCH](#) or PINCHREG keywords along with the geometry definition ([ZCORN](#) and [COORD](#)). Including PINCHREG with defaults, triggers the logic to establish non-neighboring connections across gaps regardless of the gap thickness. It is also possible to set a cut-off on the transmissibility values created along pinched connections using the [MAXTRANP](#) keyword. Users must check for the presence of [PINCH](#) or PINCHREG and review the options assigned to ensure the desired impact on simulated results.

Input is expected for each [PINCHNUM](#) region in numerical order. Each line corresponds to one [PINCHNUM](#) region and each line is ended with a slash (/). The number of regions is defined by the fourth item on the [REGDIMS](#) keyword.

### Record format

1. **Thickness Threshold:** The threshold gap thickness for which a non-neighbor connection would be automatically created. (Default 0.001)
 

**Type:** Float  
**Default value:** 0.001 (FIELD), 0.001 (METRIC)
2. **MINPV Option:** Define whether NNCs are created across cells that are inactive due to MINPV (GAP or NOGAP). GAP creates NNC connections for MINPV cells even if thickness is greater than the defined threshold.
 

**Type:** String
3. **Max Empty Gap:** Maximum allowed empty gap allowed when calculating NNCs (default is  $1.0^{20}$ )
 

**Type:** Float  
**Default value:** (FIELD),  $10^{20}$  (METRIC)
4. **Transmissibility Method:** Options for transmissibility calculation (TOPBOT or ALL). TOP-BOT (default) uses harmonic weighting of the top and bottom connected cells. ALL uses all cells between the connected active cells.

**Type:** String

**Default value:** TOPBOT

5. **MULTZ Option:** When item 4 is TOPBOT, this setting defines the method to use MULTZ when calculating NNCs across gaps (TOP or ALL). TOP (default) means MULTZ from the top cell is used in the NNC calculation. ALL means the minimum MULTZ for the top and all inactive cells between the connected cells are used in the calculation.

**Type:** String

**Default value:** TOP

### Example

This example has all 5 possible items defined for two PINCHNUM regions. (Defaults could be denoted by a 1\* placeholder) 1) Pinchout threshold thickness, 2) Option for MINPV setting, 3) Max empty gap, 4) Transmissibility option 5) Method for use of MULTZs

```
PINCHREG
 0.1      NOGAP     1.0      TOPBOT   ALL/
 0.5      GAP       15.0     TOPBOT   TOP/
```



## 2.301 PLANAR\_FRACTURE\_TEMPLATE

### Description

This keyword can be used to define a template for planar fractures. This template can be applied to wells, see keyword [WELL\\_FRACTURE](#), with hydraulic fractures to define the geometry of fractures such as length, width, height and its stimulated reservoir volume(SRV). Note that some of these parameters can be modified for each fracture in the [FRAC\\_STAGE](#) keyword. It is followed by a single slash-terminated record containing an arbitrary number of key-value pairs for the form NAME=value. The valid mnemonics for NAME and their associated values are enumerated in the table below. This keyword can be followed by an arbitrary number of templates definition and it is terminated with an empty record having only the / character.

### Record format

Name	Value Type	Description
name	String	Template name
direction	String	Fractures orientation 'X' or 'Y'
half_length_left	Float	Fracture half-length to the left of wellbore
half_length_right	Float	Fracture half-length to the right of wellbore
height_up	Float	Fracture height from the wellbore to the top of the fracture
height_down	Float	Fracture height from the wellbore to the bottom of the fracture
n_layers_up	Integer	Number of layers for fracture height in the up direction
n_layers_down	Integer	Number of layers for fracture height in the down direction
top_layer	Integer	The top layer that a fracture is allowed to grow to
bottom_layer	Integer	The bottom layer that a fracture is allowed to grow to
width	Float	The fracture width
srv_width	Float	SRV width of the fracture
srv_length	Float	SRV length of the fracture from each fracture tip
increase_factor	Float	The factor defining increasing of LGR cells around a fracture, the higher the value - the less number of refinements
completion_location	String	Completion location within a cell. Since the measured depth along the trajectory is used to define the completion location, it is possible that their exact location will be close to cell corners. This option allows a user to choose between "EXACT" for keeping the exact location or "CENTER" for moving it to the center of the cell.
log_refinement	String	Refinement type around the wellbore and fracture tip. By default the refinements are created logarithmically, but a user can choose to have uniform refinement by setting this option to 'NO'.
tip_refinement	String	Allows a user to choose whether to refine the fracture tip ('YES') or not ('NO'). This option can help to have fewer cells in the LGR grids especially in models with many fractures.

**Example**

In this example, we defined a planar fracture template for fractures along 'X' direction. All fractures that this template applies to will have fracture half-length and heights as defined in the keyword, unless these parameters are modified in [FRAC\\_STAGE](#) keyword.

```
PLANAR_FRACTURE_TEMPLATE
  name='Template1'
  direction='X'
  half_length_left=150
  half_length_right=100
  height_up=50
  height_down=50
  width=2.0
  srv_width=15
  srv_length=10
  increase_factor=3
  tip_refinement='NO'
  log_refinement='NO'
  completion_location='CENTER' /
/
```



## 2.302 PLMIXNUM

### Description

This keyword is used to indicate which Polymer Flood Model function region every grid block belongs to. It is followed by one integer value for each grid cell in the input box, which by default is the entire grid, following natural ordering with index along I running faster, then along J and last - along K. Repeat counts may be used for repeated values. A slash (/) should be terminating the record. Integer values in the record should range from 1 to [NPLMIX](#) (see [REGDIMS](#) item 10).

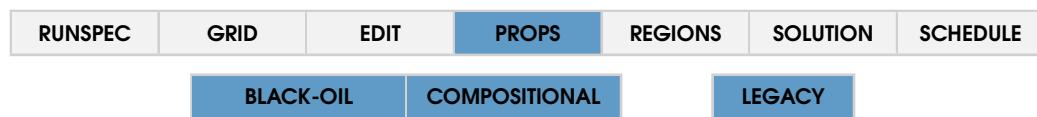
PLMIXNUM should be used in conjunction with the keywords [PLMIXPAR](#) and [PLYMAX](#).

### Example

The following example sets the first 200 and remaining 100 cells to polymer mixing regions 1 and 2 correspondingly.

```
PLMIXNUM
200*1
100*2 /

```



## 2.303 PLMIXPAR

### Description

This keyword specifies the Todd-Longstaff mixing parameter to compute effective water viscosity in the polymer model (see [Chapter 17](#) inside ECHELON Technical Description).

PLMIXPAR should be used in conjunction with the keywords [POLYMER](#) and [PLYMAX](#).

The keyword should contain [NPLMIX](#) records, each record must be terminated with a slash (/).

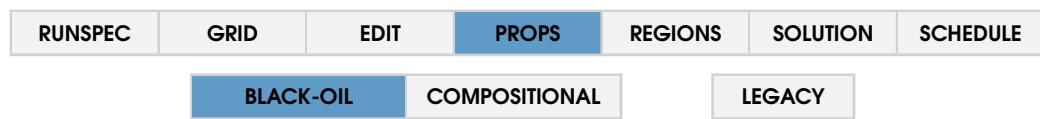
### Record format

1. **MIXING\_PARAMETER:** The Todd-Longstaff mixing parameter.

#### Example

The keyword specifies the Todd-Longstaff mixing parameter for [NPLMIX](#) = 2 regions

```
PLMIXPAR
 0.4  /
 1.0  /
```



## 2.304 PLSHVISC

### Description

This keyword specifies the polymer solution viscosity multiplier as a function of the phase shear rate. The data contains four values for [NTPVT](#) regions.

PLSHVISC should be used in conjunction with the keyword [POLYMER](#).

The keyword may contain up to [NPPVT](#) entries, each entry must be terminated with a slash (/).

Viscosity at non-zero shear rate is computed using the following equation (see [Chapter 17](#) of ECHELON Technical Description for details):

$$\mu_{w,\text{sh}} = \mu_w(C_s) + \frac{\mu_m(C_p, C_s) - \mu_w(C_s)}{1 + \left(\frac{\dot{\gamma}}{\dot{\gamma}_{1/2}}\right)^{P_\alpha-1}}$$

$$\dot{\gamma} = \frac{C_{uc}\gamma_c|u_w|}{\sqrt{Kk_{rw}\phi S_w}}$$

$$\dot{\gamma}_{1/2} = C_{\dot{\gamma}_{1/2}} \exp\left(k \frac{m_p}{m_w} 100\right)$$

Here a user must specify:

$C_{\dot{\gamma}_{1/2}}$  - SHEAR\_RATE\_HALF

$P_\alpha$  - SHEAR\_RATE\_POWER

$\gamma_c$  - SHEAR\_RATE\_NON\_IDEAL

$k$  - SHEAR\_RATE\_HALF\_EXP

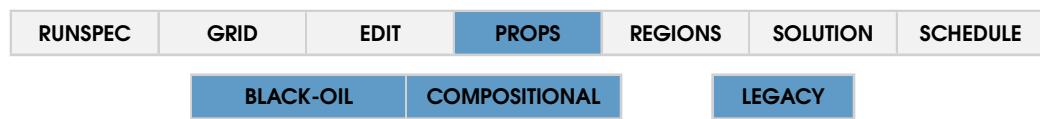
### Record format

1. **SHEAR\_RATE\_HALF:**  $C_{\dot{\gamma}_{1/2}}$   
**Units:** 1/Day (FIELD), 1/Day (METRIC)
2. **SHEAR\_RATE\_POWER:**  $P_\alpha$
3. **SHEAR\_RATE\_NON\_IDEAL:**  $\gamma_c$
4. **SHEAR\_RATE\_HALF\_EXP:**  $k$

### Example

The keyword provides data for [NTPVT](#) = 2 regions

```
PLSHVISC
1.0 2.0 1.0 5.0 /
1.1 2.1 1.0 5.0 /
```



## 2.305 PLYADS

### Description

This keyword specifies the adsorption of a polymer by rock as a function of the polymer concentration. The data should be entered as a two-column table for [NTSFUN](#) regions with at least two rows.

PLYADS should be used in conjunction with the keyword [POLYMER](#). For the Polymer Salt-Sensitive Flood Model, the keyword should be replaced by [PLYADSS](#).

The keyword may contain up to [NSSFUN](#) rows in a table, each table must be terminated with a slash (/).

### Record format

1. **CONCENTRATION:** The polymer concentration.  
The first entry should be zero, and values should increase monotonically down the column.  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)
2. **ADSORPTION:** The adsorption value.  
The first entry should be zero, and values should increase monotonically down the column.  
**Units:** lb/lb (FIELD), kg/kg (METRIC)

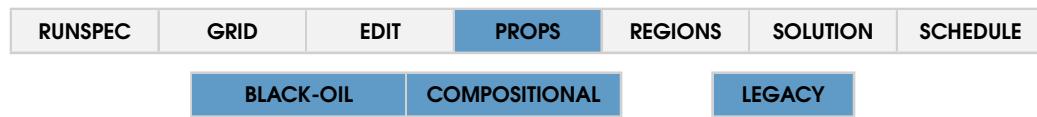
### Example

The keyword specifies [NTSFUN](#) = 2 tables

```

PLYADS
 0.0 0.000
 0.5 0.001
 1.0 0.002
/
-- copy from the previous table
/

```



## 2.306 PLYADSS

### Description

This keyword allows to specify the adsorption of a polymer by rock as a function of the polymer and brine concentrations. The data should be entered as a multi-column table for [NTSFUN](#) regions.

PLYADSS should be used in conjunction with the keywords [POLYMER](#), [BRINE](#), and [ADSALNOD](#).

The keyword may contain up to [NSSFUN](#) rows in a table, each table and every row must be terminated with a slash (/).

### Record format

1. **CONCENTRATION:** The polymer concentration.

The first entry in every row is reserved for the polymer concentration.

The very first entry should be equal to zero, and values should increase monotonically down the column for every table.

**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

2. **ADSORPTION:** The adsorption values.

The first entry row should be equal to zero.

The entries are the adsorbed polymer values corresponding to the brine concentrations from [ADSALNOD](#).

**Units:** lb/lb (FIELD), kg/kg (METRIC)

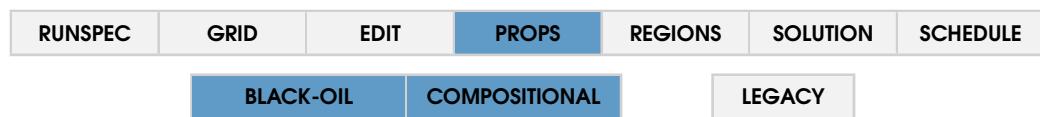
### Example

The keyword specifies [NTSFUN](#) = 2 tables.

```

PLYADSS
-- first region with 3 ADSALNOD entries
0.0 0.000 0.000 0.0000 /
1.0 0.001 0.002 0.0015 /
/
-- second region with 2 ADSALNOD entries
0.0 0.0000 0.0000 /
1.0 0.0001 0.0005 /
/

```



## 2.307 PLYDEG

### Description

This keyword specifies the polymer degradation half-life time (see [Chapter 17](#) in ECHELON Technical Description). The data should be entered as a single line table for [NTPVT](#) regions.

PLYDEG should be used in conjunction with the keywords [POLYMER](#).

The keyword should contain a single line for a region, each line must be terminated with a slash (/).

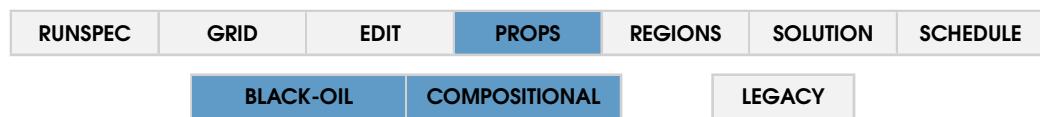
### Record format

1. **DEGRADATION\_HALF\_LIFE:** The degradation half-life time of solution polymer  
**Units:** Day (FIELD), Day (METRIC)
2. **DEGRADATION\_HALF\_LIFE\_ABSORBED:** The degradation half-life time of the adsorbed polymer  
**Units:** Day (FIELD), Day (METRIC)

### Example

The keyword specifies [NTPVT](#) = 2 tables

```
PLYDEG
 365 3650 /
 128 3650 /
/
```



## 2.308 PLYDEGT

### Description

This keyword specifies the polymer degradation half-life time as a function of the reservoir temperature (see [Chapter 17](#) in ECHELON Technical Description). The data should be entered as a three-column table for [NTPVT](#) regions with at least two rows.

PLYDEGT should be used in conjunction with the keywords [POLYMER](#), [RTEMP](#), and [TEMPVD](#). Note that it applies to isothermal simulations where the initial temperature distribution defined with the [RTEMP](#) or [TEMPVD](#) keywords does not change in time.

The keyword may contain up to [NPPVT](#) rows in a table, each table must be terminated with a slash (/).

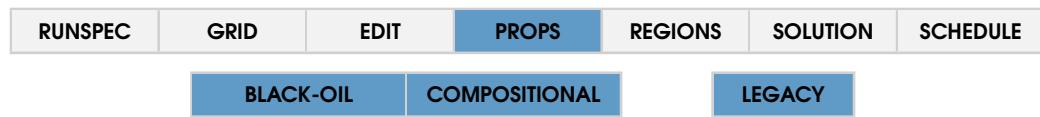
### Record format

1. **TEMPERATURE:** The polymer temperature.  
The values should increase monotonically down the column.  
**Units:** Fahrenheit (FIELD), Celsius (METRIC)
2. **DEGRADATION\_HALF\_LIFE:** The degradation half-life time of solution polymer  
**Units:** Day (FIELD), Day (METRIC)
3. **DEGRADATION\_HALF\_LIFE\_ABSORBED:** The degradation half-life time of the adsorbed polymer  
**Units:** Day (FIELD), Day (METRIC)

### Example

The keyword specifies [NTPVT](#) = 2 tables

```
PLYDEGT
 50  365  365
 100 128  128
/
 50  365  700
 100 256  500
 200 128  300
/
```



## 2.309 PLYMAX

### Description

This keyword specifies the maximum polymer and salt concentrations to compute effective water viscosity.

PLYMAX should be used in conjunction with the keywords [POLYMER](#), [BRINE](#), and [PLMIXPAR](#).

The keyword should have [NPLMIX](#) records, each record must be terminated with a slash (/).

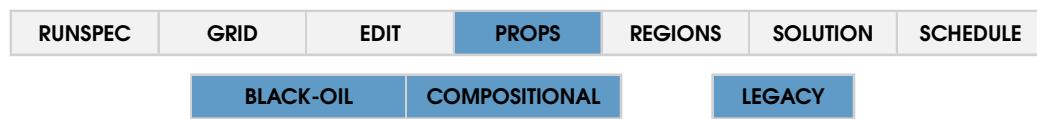
### Record format

1. **POLYMER\_CONCENTRATION:** The maximum polymer concentration.  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)
2. **SALT\_CONCENTRATION:** The maximum salt concentration.  
This value is ignored if [BRINE](#) is not specified.  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

### Example

The keyword specifies maximum mixing concentrations for [NPLMIX](#) = 2 regions

```
PLYMAX
 1.0 1.0 /
 0.5 1.0 /
```



## 2.310 PLYROCK

### Description

This keyword allows specifying the rock properties needed by the Polymer Flood Model. The keyword may contain up to [NTSFUN](#) rows, where every row represents a corresponding region. Each row is terminated with a slash (/). See [Chapter 17](#) inside ECHELON Technical Description for an insight into the different options.

PLYROCK should be used in conjunction with the keyword [POLYMER](#).

### Record format

#### 1. DEAD\_PORE:

The dead pore volume factor.  
The value must be greater than or equal to 0, and less than the maximum water saturation.

**Minimum:** 0

**Maximum:**  $S_w$

#### 2. RESIDUAL\_RESISTANCE:

The residual resistance factor.

**Minimum:** 0

**Maximum:** 1

#### 3. ROCK\_MASS\_DENSITY:

The rock mass density at reservoir conditions.  
This value is used to compute an amount of an adsorbed polymer.

**Units:** lb/rb (FIELD), kg/rm<sup>3</sup> (METRIC)

#### 4. DESORPTION\_INDEX:

The desorption index.

1 - desorption is allowed

2 - desorption is not allowed

#### 5. MAX\_ADSORPTION\_VALUE:

The maximum adsorption value.  
This value is used to compute the permeability reduction due to adsorbed polymer. The value must be strictly larger than zero.

**Units:** lb/lb (FIELD), kg/kg (METRIC)

### Example

This example sets polymer adsorption properties for [NTSFUN](#) = 2 regions.

```
PLYROCK
0.0 1.0 1880 2 1.0 /
0.2 0.5 2010 1 0.5 /
```



## 2.311 PLYSHLOG

### Description

This keyword specifies the polymer solution viscosity multiplier as a function of the phase shear rate. The data contains two entries for each [NTPVT](#) regions. The first entry specifies the reference values, and the second is a two-column table.

**PLYSHLOG** should be used in conjunction with the keyword [POLYMER](#). It must be paired with the keyword [SHRATE](#).

The keyword may contain up to  $2^*NPPV$  entries, each entry must be terminated with a slash (/).

Viscosity at non-zero shear rate is computed using the following equation (see [Chapter 17](#) section in ECHELON Technical Description for details):

$$\mu_{w,sh} = \mu_m(C_p, C_s) \frac{1 + (P - 1)M_{ref}}{P}.$$

Here  $\mu_m(C_p, C_s)$  is the polymer solution viscosity evaluated for polymer and salt concentrations ( $C_p, C_s$ ) at zero shear rate. The value  $P(C_p, C_s)$  can be understood as a viscosity multiplicator entered in [PLYVISC](#) or [PLYVISCS](#).

The shear viscosity factor,  $M_{ref}$ , is computed using the entered table (the second record) and the reference values (the first record) as:

$$M_{ref} = \frac{Z_{table} \cdot P_{ref} - 1}{P_{ref} - 1}.$$

Here the viscosity multiplier,  $M_{ref}$ , is computed using the reference values  $(C_{p,ref}, C_{s,ref})$  from the first record of **PLYSHLOG** and using the keywords [PLYVISC](#) or [PLYVISCS](#) to compute  $P_{ref}$ .

The shear factor values  $Z_{table}$  are tabulated as a function of shear rate,  $\dot{\gamma}$ , and given in the second record of **PLYSHLOG**.

### Record 1 format

1. **POLY\_CONC:** The polymer reference concentration.  
This value cannot be defaulted and must be a non-zero positive value.  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)
2. **SALT\_CONC:** The salt reference concentration.  
This value can be defaulted and should be a non-zero positive value when used in conjunction with [PLYVISCS](#).  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)
3. Reserved value, not currently used.

### Record 2 format

1. **SHEAR\_RATE:** The aqueous phase/polymer flow shear rate.  
The first entry must be a small positive value less than 1E-6.  
**Type:** Float  
**Units:** 1/Day (FIELD), 1/Day (METRIC)

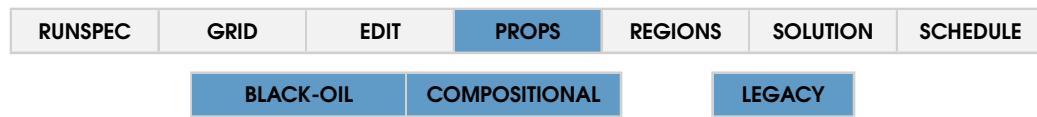
2. **SHEAR\_FACTOR:** Viscosity factor.

**Type:** Float

### Example

The keyword specifies [NTPVT](#) = 2 tables

```
PLYSHLOG
-- first entry (reference values)
0.2 0.0 0.0 /
-- second entry (two column table)
1.00E-06 1
1.00E-04 1.1
1.00E-02 1.2
1.00E+00 1.4
1.00E+02 1.7
1.00E+04 2.3
1.00E+06 3.3
1.00E+08 5.7
1.00E+10 14.3 /
-- next region info
0.1 0.0 0.0 /
1.00E-06 1
1.00E-02 1.2
1.00E+02 1.7
1.00E+06 3.3
1.00E+10 9.0 /
```



## 2.312 PLYVISC

### Description

This keyword specifies the water phase viscosity multiplier as a function of the polymer concentration. The data should be entered as a two-column table for [NTPVT](#) regions with at least two rows.

PLYVISC should be used in conjunction with the keyword [POLYMER](#). For the Polymer Salt-Sensitive Flood Model, the keyword should be replaced by [PLYVISCS](#). See [Chapter 17](#) inside ECHELON Technical Description.

The keyword may contain up to [NPPVT](#) rows in a table, each table must be terminated with a slash (/).

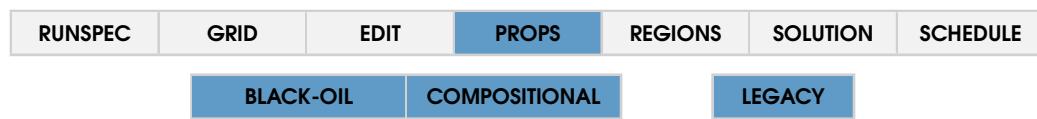
### Record format

1. **CONCENTRATION:** The polymer concentration.  
The first entry should be zero, and values should increase monotonically down the column.  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)
2. **VISCOSITY\_FACTOR:** The viscosity factor.  
The first entry should be 1.0, and values should not decrease down the column.  
The factor multiplies the water phase viscosity from [PVTW](#) by the entered value.

### Example

The keyword specifies [NTPVT](#) = 2 tables

```
PLYVISC
 0.0 1.0
 1.0 10.0
/
-- copy from the previous table
/
```



## 2.313 PLYVISCS

### Description

This keyword specifies the water phase viscosity multiplier as a function of the polymer and brine concentrations. The data should be entered as a multi-column table for [NTPVT](#) regions.

PLYVISCS should be used in conjunction with the keywords [POLYMER](#), [BRINE](#), and [SALTNODE](#).

The keyword may contain up to [NPPVT](#) rows in a table, each table and every row must be terminated with a slash (/).

### Record format

#### 1. CONCENTRATION: The polymer concentration.

The first entry in every row is reserved for the polymer concentration.

The very first entry should be equal to zero, and values should increase monotonically down the column for every table.

**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

#### 2. VISCOSITY\_FACTOR: The viscosity factors.

The first entry of the first row should be equal to 0.0, while the rest entries of the first row - 1.0. Values should not decrease down the column.

The entries are the viscosity multipliers corresponding to the brine concentrations from [SALTNODE](#).

The factor multiplies the water phase viscosity from [PVTW](#) by the entered value.

### Example

The keyword specifies [NTPVT](#) = 2 tables.

```
PLYVISCS
-- first region with 4 SALTNODE entries
0.0 1.0 1.0 1.0 1.0 /
1.0 2.0 3.0 4.0 5.0 /
/
-- second region with 2 SALTNODE entries
0.0 1.0 1.0 /
1.0 2.0 3.0 /
/
```



## 2.314 PMANUM

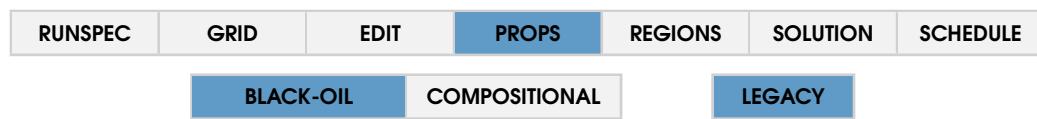
### Description

The PMANUM keyword in the REGION section is used to assign pressure maintenance regions to be used in conjunction with GPMAINT. Input must follow natural I, J, K ordering and must be lower than the maximum value specified with Item 14 in TABDIM5 in the RUNSPEC section. The default region index is 1. The keyword is followed by a single record terminated by the slash character (/).

### Example

PMANUM is used here to assign the index 2 for the first 10000 cells and the index 4 for the next 10000 for a model with 20000 cells.

```
PMANUM
 10000*2  10000*4 /
```



## 2.315 PMAX

### Description

This keyword indicates the maximum pressure that can be reached. This information is used in interpreting live oil PVT while using [PVCO](#).

### Record format

1. **MAX\_PRESS:** This value is used in getting live oil PVT properties in case of using [PVCO](#)

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

### Example

```
PMAX  
5000.0 /
```



## 2.316 POLYMER

### Description

The keyword POLYMER specifies the Polymer Flood Model (see [Chapter 17](#) inside ECHELON Technical Description for an insight on the different options). can be used.

No data records are associated with the keyword.

The keyword in conjunction with the keyword [BRINE](#) activates the Polymer Salt-Sensitive Flood Model.

### Example

```
RUNSPEC  
POLYMER
```



## 2.317 POLYMEROPTS

### Description

The `POLYMEROPTS` keyword can be used to adjust parameters related to the non-Newtonian polymer modeling options. It is followed by a single slash-terminated record containing two key-value pairs for the form NAME=value. The valid mnemonics for NAME, their associated possible and default values together with a brief description are enumerated in the table below.

Insights on the various parameters and how they are connected can be found in [Chapter 17](#). Note that all parameters are reported in the logging file.

### Record format

1. **BLOCK\_EFFECTIVE\_VELOCITY:** Defines how flow contributions from wells perforated in a given cell are taken into account when computing the flow velocity of said cell (in turn used to compute the non-Newtonian polymer viscosity)

**Type:** String

**Default value:** EFF

**Allowed values:**

Name	Description
CELL	Max. value between connection velocity at the cell representative radius and block velocity
WELL	Max. value between connection velocity at the well radius and block velocity
EFF	Max. value between connection velocity at the effective radius and block velocity
OFF	Disregard well contributions and compute the perforated cell velocity reconstructed from inter-cell flows only.

2. **CONNECTION\_EFFECTIVE\_VELOCITY:** Defines how the representative aqueous rate velocity at a well connection is computed (needed for well solves).

**Type:** String

**Default value:** EFF

**Allowed values:**

Name	Description
CELL	Use the velocity at the perforated cell representative radius. This results in a lower velocity (implicit calculation).
WELL	Use the velocity at the well radius. This results in a higher velocity (implicit calculation).
EFF	Use velocity at an effective radius. This results in an intermediate velocity (implicit calculation).
OFF	Use the perforated cell velocity for the well connection (explicit calculation)

**Example**

The keyword allows using MAX(cell, connection) polymer velocity for a perforated cell. The connection velocity for the formula above is computed on an effective radius. This value is used to evaluate cell properties, such as viscosity.

The implicit polymer inflow solver is switched OFF, and the connection velocity is taken from the connected cell. This value is used to evaluate inflow equations.

```
POLYMEROPTS  
BLOCK_EFFECTIVE_VELOCITY=EFF  
CONNECTION_EFFECTIVE_VELOCITY=OFF  
/
```



## 2.318 PORO

### Description

The keyword defines the porosity of the reservoir as a 3D array, which means one non-negative number for each cell. Cell **PORO** values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). Notably, a zero value makes cell inactive.

### Example

This **PORO** keyword sets porosity in a grid of 15 cells, with the eleventh made inactive.

```
PORO  
5*0.2 5*0.3 0.0 4*0.4/
```



## 2.319 PORV

### Description

The keyword defines the pore volume of the reservoir as a 3D array, which means one non-negative number for each cell. Cell **PORV** values can be defined in a single, slash terminated record, following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z) inside the input box (by default the whole grid).

Notably, this keyword is optional and **PORV** values can be defined in the EDIT section for a subset of grid cells using, e.g. **BOX/ENDBOX**. Wherever **PORV** is not defined, pore volume values computed in the GRID section are used as default.

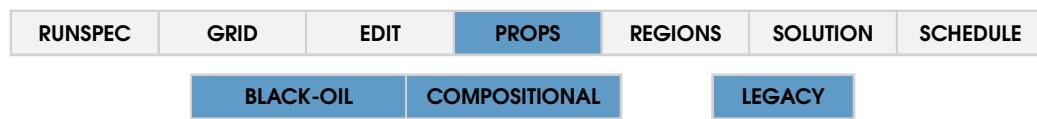
A zero **PORV** can be used to make a cell inactive, while cells set inactive in the GRID section because **PORO** and/or **NTG** are zero, become active if a positive pore volume is set using **in EDIT**; this does not hold for cells inactive because of **[[ATCNUM]PORV] in EDIT; this does not hold for cells inactive because of [[ATCNUM]** set to 0: they remain inactive even if a positive **PORV** is given in EDIT.

**Units:** rb (FIELD), rm<sup>3</sup> (METRIC)

### Example

We set explicitly **PORV** in a region of the reservoir defined using **BOX/ENDBOX**:

```
BOX
  1 88 1 92 10 17 /
EQUALS
  PORV 1.e6 /
/
ENDBOX
```



## 2.320 PPCWMAX

### Description

The PPCWMAX keyword is used in the **PROPS** section to set a limiting upper value for the **PCW** oil-water capillary end-point values. A PPCWMAX value is allowed for each water-oil saturation table. This is normally used in conjunction with the use of **SWATINIT** to overwrite the standard hydrostatic equilibrium saturations based on user-defined capillary pressures.

The **SWATINIT** keyword is used in the **PROPS** section to “force” a specified equilibrium initial water saturation of each cell in the reservoir rather than using standard hydrostatic equilibrium based on user-defined capillary pressures and fluid densities. The use of **SWATINIT** results in calculation of **PCW** endpoints such that the water saturation obtained by capillary equilibrium equals the desired saturation. In the regions of the model where the J-function model is active, or where user-input **PCW** values exist, these are disregarded, and priority is given to matching the desired water saturation. The modified capillary pressure curves affect the simulation beyond the initialization phase and thus extremely large and nonphysical capillary pressures may lead to undesired results.

See the Technical Description (Section 10.4) and the **SWATINIT** and **PCW** keywords for more details.

### Record format

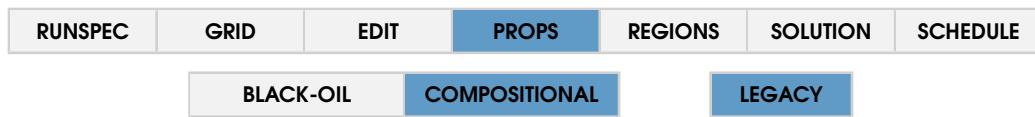
1. **PC\_MAX:** The maximum capillary pressure for the specific saturation region  
**Type:** Float  
**Default value:** no limit
2. **UPDATE\_SWCO:** If YES, **SWCO** should be updated to match the value provided in the **SWATINIT** keyword when the maximum capillary pressure is exceeded  
**Type:** String  
**Default value:** NO  
**Allowed values:**

Name	
YES	
NO	

### Example

This sets PPCWMAX values for a system with two input saturation tables. Connate saturations are not modified to honor input **SWATINIT** values.

```
PPCWMAX
 20  NO /
 25  NO /
```



## 2.321 PRCORR

### Description

This keyword activates the Peng-Robinson equation of state correction. No data records are associated with this keyword. The form for the Peng-Robinson and other cubic equations of state are given in [Section 7.4](#).

### Example

```
PROPS  
PRCORR
```



## 2.322 PRESSURE

### Description

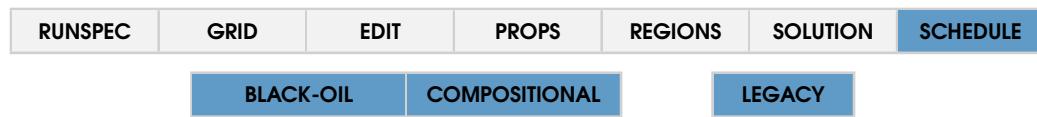
The [PRESSURE](#) keyword is used to specify the initial pressure of each cell in the reservoir when using an enumerated initial state rather than hydrostatic equilibrium. The keyword should be followed by a single record containing  $NX \times NY \times NZ$  values, i.e. one pressure for every cell in the reservoir. Similarly, values for [SWAT](#) should be given, as well as [SGAS](#) for simulations containing gas, [RS](#) for simulations with solution gas, and [RV](#) for simulations with vaporized oil. For compositional simulations, see also [XMY](#), [YMF](#), [ZMF](#), and [ZI](#) for providing the initial composition of the reservoir fluids as well as [TEMPI](#) or [RTEMP](#) for providing the initial temperature.

**Units:** psi (FIELD), bar (METRIC)

### Example

For a  $10 \times 10 \times 1$  reservoir with uniform pressure of 5000 psi in field units:

```
SOLUTION  
PRESSURE  
100*5000.0 /
```



## 2.323 PRIORITY

### Description

This keyword defines the coefficients that are used in calculating the production well priority formulas for group production priority, see [GCONPRI](#) keyword and [Section 18.5](#) in the Technical Description.

Priority formula is computed as follows:

$$\text{Priority} = \frac{a_0 + a_1 Q_o + a_2 Q_w + a_3 Q_g}{b_0 + b_1 Q_o + b_2 Q_w + b_3 Q_g}$$

where coefficients  $a_i, b_i$  for  $i = 0, 1, 2, 3$  are coefficients provided by the user and  $Q_o, Q_w, Q_g$  are oil, water, and gas potential production rates, respectively. The keyword allows defining two different priority formulas throughout two separate sets of coefficients.

The keyword is followed by one record, as described below.

- The first entry is the minimum time interval (days) between well priority calculation
- Entries 2-9 are the  $a_i, b_i$  for  $i = 0, 1, 2, 3$  for the first priority formula
- Entries 10-17 are the  $a_i, b_i$  for  $i = 0, 1, 2, 3$  for the second priority formula

Note, coefficients can only be positive and their default value is zero. At least one of coefficient per formula must be  $\geq 0$ .

### Example

```
PRIORITY
--qo/(1+qw)
10.0  0.0  1.0  0.0  0.0  1.0  0.0  1.0  0.0  /

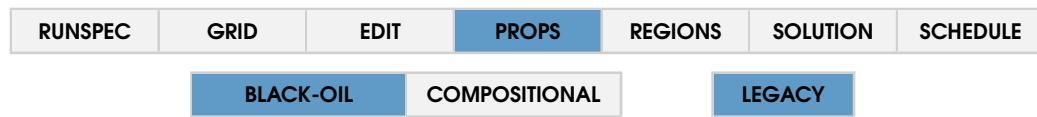
```



## 2.324 PSEUPRES

### Description

This keyword should be entered early in the [SCHEDULE](#) sections and it allows activation of the GPP model for all wells subsequently defined. When a new well is defined using the keyword [WELSPECS](#) or [WELSPECI](#) the inflow equation is automatically changed to GPP irrespective of the value assigned in item 8 or 9 of these keywords. The GPP model can be subsequently deselected on a per-well basis specifying NO in item 2 of keyword [WPICOND](#). Note however that [PSEUPRES](#) takes precedence over [WPICOND](#), that is if a well is later redefined in the [SCHEDULE](#) section using the keyword [WELSPECS](#) or [WELSPECI](#) the inflow equation will be automatically changed again to GPP.



## 2.325 PVCO

### Description

The **PVCO** keyword gives the PVT properties for live oil. In contrast to the more general **PVTO** keyword, this keyword assumes that the undersaturated compressibility and viscosibility for oil at a given gas-oil ratio,  $R_s$ , is independent of pressure. Therefore, rather than supplying a two-dimensional table as in **PVTO**, the user supplies only the formation volume factor, compressibility, viscosity, and viscosibility for each value of  $R_s$ .

The keyword is followed by one slash-terminated record for each PVT region included in the model. The format of this record is summarized in the table below.

### Table columns

1. **PBUB:** Oil bubble point pressure  
**Units:** psi (FIELD), bar (METRIC)
2. **RS:** Solution gas-oil ratio at the given bubble point pressure  
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)
3. **FVF:** Formation volume factor at the given bubble point pressure  
**Units:** rb/stb (FIELD), rm<sup>3</sup>/sm<sup>3</sup> (METRIC)
4. **VISCOSITY:** Viscosity of the oil at the given bubble point pressure  
**Units:** 1/psi (FIELD), 1/bar (METRIC)
5. **COMPRESSIBILITY:** The compressibility of undersaturated oil at the value of  $R_s$  given in field 2.  
**Units:** 1/psi (FIELD), 1/bar (METRIC)
6. **VISCOSIBILITY:** The viscosibility of undersaturation oil at the value of  $R_s$  given in field 2.  
**Units:** 1/psi (FIELD), 1/bar (METRIC)

### Example

For a model with two PVT regions:

PVCO						
--	Pbub	Rs	FVF	viscosity	compressibility	viscosibility
	500	0.20	1.01	1.18	1.1e-5	0.0
	1000	0.39	1.02	1.15	1.1e-5	0.0
	1500	0.58	1.03	1.12	1.1e-5	0.0
	2000	0.77	1.04	1.09	1.1e-5	0.0
	2500	0.95	1.06	1.06	1.1e-5	0.0
	3000	1.13	1.07	1.03	1.1e-5	0.0
	3500	1.30	1.09	0.99	1.1e-5	0.0
	4000	1.47	1.11	0.95	1.1e-5	0.0 /



## 2.326 PVDG

### Description

The [PVDG](#) keyword is used to provide a table of dry gas formation volume factor and viscosity vs. pressure for a dry gas in a black-oil simulation. Dry gas never releases liquid oil regardless of the pressures experienced in the reservoir during the simulation. For a wet gas, from which condensate may evolve, see the corresponding [PVTG](#) keyword.

The keyword is followed by several tables equal to the number of PVT regions specified in the [TABDIMS](#) keyword. Each table consists of three columns, as described below, and is terminated by a slash (/).

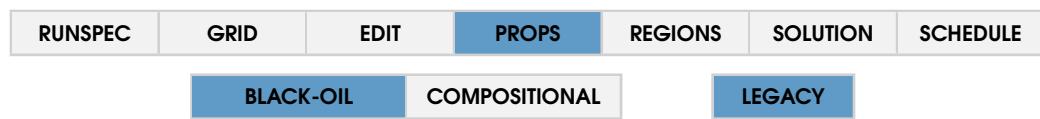
### Table columns

1. **PRESSURE:** Pressure of the gas phase  
**Units:** psi (FIELD), bar (METRIC)
2. **FVF:** Gas formation volume factor  
**Units:** rb/Mscf (FIELD), rm<sup>3</sup>/sm<sup>3</sup> (METRIC)
3. **VISCOSITY:** Gas viscosity  
**Units:** cPoise (FIELD), cPoise (METRIC)

### Example

PVDG		
1160.3	2.4888	0.01446
1356.1	2.1052	0.014928
1551.9	1.8216	0.015439
1747.7	1.6047	0.015991
1943.5	1.4344	0.016581
2139.3	1.2981	0.017206
2335.1	1.1872	0.01786
2530.9	1.0959	0.01854
2726.7	1.0197	0.01924
2922.5	0.95565	0.019954
3118.3	0.90125	0.020678
3314.1	0.85469	0.021408
3509.9	0.81452	0.022139
3705.7	0.77962	0.022869
3901.5	0.74908	0.023594
4097.3	0.72218	0.024313
4293.1	0.69833	0.025024
4488.9	0.67707	0.025727
4684.7	0.65801	0.026419
4880.5	0.64083	0.027101

/



## 2.327 PVDO

### Description

The [PVDO](#) keyword is used to provide a table of formation volume factor and viscosity vs. pressure for dead oil in a black-oil simulation. Dead oil never releases contained gas regardless of the pressures experienced in the reservoir during the simulation. That is, the simulator assumes that the pressure remains over the bubble point throughout the simulation. To provide a table for live oil, see the [PVTO](#) keyword.

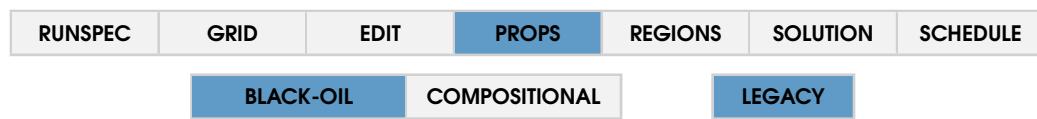
The keyword is followed by several tables equal to the number of PVT regions specified in the [TABDIMS](#) keyword. Each table consists of three columns, as described below, and is terminated by a slash (/).

### Table columns

1. **PRESSURE:** Pressure of the oil phase  
**Units:** psi (FIELD), bar (METRIC)
2. **FVF:** Oil formation volume factor  
**Units:** rb/stb (FIELD), rm<sup>3</sup>/sm<sup>3</sup> (METRIC)
3. **VISCOSITY:** Oil viscosity  
**Units:** cPoise (FIELD), cPoise (METRIC)

### Example

```
PVDO
 100  1.10  4.9
 400  1.05  5.0
 800  1.03  5.1 /
```



## 2.328 PVTG

### Description

The [PVTG](#) keyword is used to specify the table of formation volume factor and viscosity of wet gas versus pressure and the vaporized oil-gas ratio,  $R_v$ . During this simulation, values and derivatives of these quantities are computed by interpolating from the provided tables.

Each table consists of a number of records. Each record provides data for a single value of the vaporized oil-gas ratio,  $R_v$ , which is stored in the first column, followed by the corresponding dew-point pressure and the saturated values of formation volume factor,  $B_g$ , and viscosity,  $\mu_g$ . After the required values for saturated gas are provided, any number of values of pressure,  $B_g$ , and  $\mu_g$  can be provided for undersaturated gas at the same value of  $R_v$ .

At least one set of undersaturated data is required for the highest value of  $R_v$ .  $R_v$  should strictly increase with each successive record. Undersaturated values for pressure should exceed the dew-point pressure and be strictly increasing. If undersaturated data is *not* provided in a given record, the undersaturated values for that value of  $R_v$  are internally computed by interpolating or extrapolating from the undersaturated data that is provided. Each table is terminated by an empty record, i.e. an extra slash (/) after the last record. The number of tables should be the same as the number of PVT regions, which is provided in the second field of the [TABDIMS](#) keyword.

### Table columns

1. **RS:** Solution gas-oil ratio,  $R_s$   
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)
2. **PDEW:** Bubble-point pressure,  $P_b$   
**Units:** psi (FIELD), bar (METRIC)
3. **FVF:** Oil formation volume factor,  $B_o$   
**Units:** rb/stb (FIELD), rm<sup>3</sup>/sm<sup>3</sup> (METRIC)
4. **VISCOSITY:** Oil viscosity,  $\mu_o$   
**Units:** cPoise (FIELD), cPoise (METRIC)

**Example**

```

PVTG
-- PRES      RV      BG      VISC
-- PSIA      STB/MSCF  RB/MSCF  CPOISE
 629.00000  0.01882  5.73284  0.0150725  --Saturated
               0.00000  5.70007  0.0152329 / --Dry gas
 1366.00000  0.01898  2.55672  0.0163853  --Saturated
               0.00000  2.56020  0.0164003 / --Dry gas
 2247.00000  0.02740  1.54328  0.0189640  --Saturated
               0.01898  1.54659  0.0188042  --Undersat gas
               0.01882  1.54665  0.0188014  --Undersat gas
               0.00000  1.55405  0.0185095 / --Dry gas
 3045.00000  0.03922  1.16328  0.0223929  --Saturated
               0.02740  1.16575  0.0218867  --Undersat gas
               0.01898  1.16750  0.0215779  --Undersat gas
               0.01882  1.16754  0.0215720  --Undersat gas
               0.00000  1.17147  0.0209391 / --Dry gas
 3851.00000  0.05320  0.96247  0.0266911  --Saturated
               0.03922  0.96207  0.0257368  --Undersat gas
               0.02740  0.96172  0.0250658  --Undersat gas
               0.01898  0.96148  0.0246066  --Undersat gas
               0.01882  0.96148  0.0245977  --Undersat gas
               0.00000  0.96093  0.0236294 / --Dry gas
 4643.00000  0.06593  0.84905  0.0312274  --Saturated
               0.05320  0.84609  0.0300235  --Undersat gas
               0.03922  0.84285  0.0289941  --Undersat gas
               0.02740  0.84011  0.0281462  --Undersat gas
               0.01898  0.83815  0.0275580  --Undersat gas
               0.01882  0.83811  0.0275465  --Undersat gas
               0.00000  0.83375  0.0262825 / --Dry gas
 5427.00000  0.07439  0.77792  0.0354578  --Saturated
               0.06593  0.77466  0.0343478  --Undersat gas
               0.05320  0.76975  0.0332320  --Undersat gas
               0.03922  0.76436  0.0320262  --Undersat gas
               0.02740  0.75980  0.0310238  --Undersat gas
               0.01898  0.75656  0.0303230  --Undersat gas
               0.01882  0.75649  0.0303092  --Undersat gas
               0.00000  0.74924  0.0287849 / --Dry gas
 6238.00000  0.07973  0.72682  0.0395363  --Saturated
               0.07439  0.72416  0.0385072  --Undersat gas
               0.06593  0.71995  0.0376473  --Undersat gas
               0.05320  0.71359  0.0363630  --Undersat gas
               0.03922  0.70662  0.0349714  --Undersat gas
               0.02740  0.70073  0.0338103  --Undersat gas
               0.01898  0.69653  0.0329954  --Undersat gas
               0.01882  0.69645  0.0329794  --Undersat gas
               0.00000  0.68706  0.0311957 / --Dry gas
 6915.19306  0.08332  0.69492  0.0429773  --Psat
               0.07973  0.69289  0.0419527  --Undersat gas
               0.07439  0.68986  0.0413340  --Undersat gas
               0.06593  0.68506  0.0403603  --Undersat gas
               0.05320  0.67784  0.0389084  --Undersat gas
               0.03922  0.66991  0.0373376  --Undersat gas
               0.02740  0.66321  0.0360276  --Undersat gas
               0.01898  0.65843  0.0351079  --Undersat gas
               0.01882  0.65834  0.0350899  --Undersat gas
               0.00000  0.64767  0.0330739 / --Dry gas
 6938.00000  0.08332  0.69396  0.0430567  --Generated
               0.07973  0.69191  0.0420302  --Undersat gas
               0.07439  0.68887  0.0414104  --Undersat gas
               0.06593  0.68406  0.0404349  --Undersat gas
               0.05320  0.67680  0.0389804  --Undersat gas
               0.03922  0.66884  0.0374067  --Undersat gas
               0.02740  0.66210  0.0360943  --Undersat gas
               0.01898  0.65731  0.0351728  --Undersat gas
               0.01882  0.65721  0.0351548  --Undersat gas
               0.00000  0.64649  0.0331346 / --Dry gas
/

```



## 2.329 PVTNUM

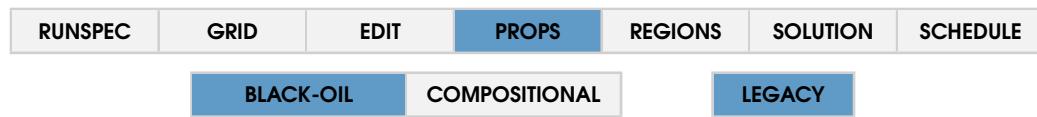
### Description

This keyword is used to indicate which PVT region every grid block belongs to. It is followed by a single, slash (/) terminated, record with one integer value - PVT region number - for each grid cell in the input box, which by default is the entire grid. [PVTNUM](#) values are provided following natural ordering with index along I running faster, then along J and last along K. Repeat counts may be used for repeated values. Integer values in the record should range from 1 to NTPVT (see [TABDIMS](#) keyword).

### Example

This example shows how 4 PVT regions can be defined for a 30x30x3 reservoir

```
PVTNUM
600*1 300*2
600*3 300*2
600*4 300*2 /
```



## 2.330 PVTO

### Description

The **PVTO** keyword is used to specify the table of formation volume factor and viscosity of live oil versus pressure and the solution gas-oil ratio,  $R_s$ . During this simulation, values and derivatives of these quantities are computed by interpolating from the provided tables.

Each table consists of a number of records. Each record provides data for a single value of the solution gas-oil ratio,  $R_s$ , which is stored in the first column, followed by the corresponding bubble point pressure and the saturated values of formation volume factor,  $B_o$ , and viscosity,  $\mu_o$ . After the required values for saturated oil are provided, any number of values of pressure,  $B_o$ , and  $\mu_o$  can be provided for undersaturated oil at the same value of  $R_s$ .

At least one set of undersaturated data is required for the highest value of  $R_s$ .  $R_s$  should strictly increase with each successive record. Undersaturation values for pressure should exceed the bubble point pressure and be strictly increasing. If undersaturated data is *not* provided in a given record, the undersaturated values for that value of  $R_s$  are internally computed by interpolating or extrapolating from the undersaturated data that is provided. Each table is terminated by an empty record, i.e. an extra slash (/) after the last record. The number of tables should be the same as the number of PVT regions, which is provided in the second field of the **TABDIMS** keyword.

### Table columns

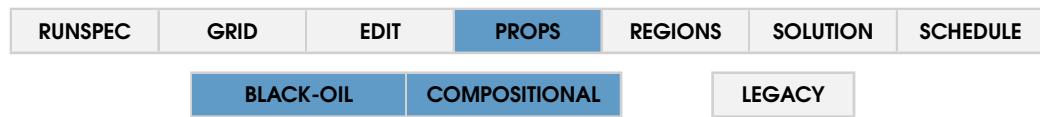
1. **RS:** Solution gas-oil ratio,  $R_s$   
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)
2. **PBUB:** Bubble-point pressure,  $P_b$   
**Units:** psi (FIELD), bar (METRIC)
3. **FVF:** Oil formation volume factor,  $B_o$   
**Units:** rb/stb (FIELD), rm<sup>3</sup>/sm<sup>3</sup> (METRIC)
4. **VISCOSITY:** Oil viscosity,  $\mu_o$   
**Units:** cPoise (FIELD), cPoise (METRIC)

### Example

```

PVTO
-- Rs      Pressure (bar)    Bo      muo
  9.306   1.013793103     1.0488  3.36    /
  22.474   13.79310345    1.0846  2.23    /
  28.509   30.27586207    1.0998  2.03    /
  37.104   46.82758621    1.1214  1.82    /
  47.163   67.5862069     1.1454  1.60    /
  54.478   83.5862069     1.1620  1.53    /
  63.440   103.9310345    1.1828  1.41    /
  70.023   121.5172414    1.1973  1.33    /
  75.693   140.0689655    1.2100  1.30    /
  78.790   150.4137931    1.2152  1.29    /
-- Undersaturated values for Rs=78.790
  167.1724138    1.2115  1.32
  179.5862069    1.2101  1.34
  183.9310345    1.2091  1.35
  199.3103448    1.2075  1.37
  208.0689655    1.2060  1.39
  215.6551724    1.2053  1.40
  231.9310345    1.2033  1.42    /
  /

```



## 2.331 PVTW

### Description

The `PVTW` keyword is used to provide coefficients for the analytic expressions used to compute water formation volume factor, viscosity, and their pressure derivatives. The keyword is followed by NTPVT (see keyword `TABDIMS`) slash-terminated records in the format given below, where NTPVT is given by the second field of the `TABDIMS` keyword.

Each record contains a reference pressure, the water formation volume factor,  $B_w$ , and the viscosity,  $\mu_w$  at that pressure. In addition, the user should provide the compressibility,  $C_w$ , defined as

$$C_w = -\frac{1}{B_w} \frac{\partial B_w}{\partial p},$$

and the viscosity,  $C_\mu$ , defined as

$$C_\mu = \frac{1}{\mu_w} \frac{\partial \mu_w}{\partial p}.$$

Then, formation volume factor and viscosity for water at pressure  $p$ ,  $B_w(p)$  and  $\mu_w(p)$  respectively, are computed as:

$$B_w(p) = B_w(p_{ref}) e^{-C_w \Delta p}$$

$$\mu_w(p) = \mu_w(p_{ref}) e^{C_\mu \Delta p},$$

with  $\Delta p = p - p_{ref}$ .

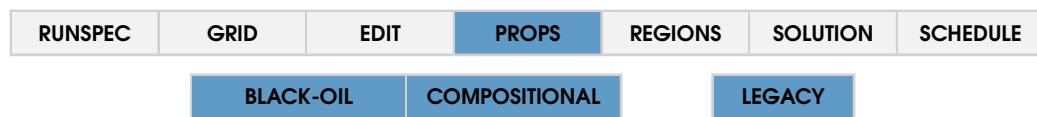
### Record format

1. **REF\_PRES:** Reference pressure  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** BO: 14.6959 (FIELD), 1.01325 (METRIC)  
COMP: (FIELD), (METRIC)
2. **FVF:** Formation volume factor  
**Units:** rb/stb (FIELD), rm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Default value:** 1.0 (FIELD), 1.0 (METRIC)
3. **COMPRESS:** Compressibility  
**Units:** 1/psi (FIELD), 1/bar (METRIC)  
**Default value:** BO: 0 (FIELD), 0 (METRIC)  
COMP: 2.72184e-06 (FIELD), 3.948e-5 (METRIC)
4. **VISCOSITY:** Viscosity  
**Units:** cPoise (FIELD), cPoise (METRIC)  
**Default value:** BO: 0.5, COMP: 0.3

**5. VISCOSIBILITY:** Viscosity**Units:** 1/psi (FIELD), 1/bar (METRIC)**Default value:** 0 (FIELD), 0 (METRIC)**Example**

For a model with a single PVT region:

```
PVTW
-- Pref      Bw      Cw      muw      Cmu
  3000.0    1.01    3.1e-6    0.4     0.0 /
```



## 2.332 PVTWSALT

### Description

This keyword allows specifying the region's brine water properties. The data should be entered as a two records multi-column table for NTPVT regions, each record is terminated by a slash (/). The first entry contains only two items and the second record is a five-column table with maximum NPPVT rows.

PVTWSALT should be used together with [BRINE](#) and [BDENSITY](#) keywords, where the latter optionally defines surface density of brine.

The keyword cannot be used with the Polymer Salt-Sensitive Flood Model, where properties are computed using [PLYVISCS](#) and [PVTW](#).

### Record 1 format

1. **REFERENCE\_PRES:** The reference pressure.  
The values should increase monotonically down the column.  
**Units:** psi (FIELD), bar (METRIC)
2. **REFERENCE\_CONC:** The reference salt concentration.  
This value has no impact on the simulation results, see the User Manual for details.  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

### Record 2 format

1. **SALT\_CONCENTRATION:** The salt concentration.  
Values should increase monotonically down the column.  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)
2. **VOLUME\_FACTOR:** The formation volume factor at the reference pressure.  
Values should not increase down the column.  
**Units:** rb/stb (FIELD), rm<sup>3</sup>/sm<sup>3</sup> (METRIC)
3. **COMPRESSIBILITY:** The compressibility.  
**Units:** 1/psi (FIELD), 1/bar (METRIC)
4. **VISCOSITY:** The viscosity at the reference pressure.  
**Units:** cPoise (FIELD), cPoise (METRIC)
5. **VISCOSIBILITY:** The viscosibility.  
**Units:** 1/psi (FIELD), 1/bar (METRIC)

**Example**

This example specifies two tables for `NTPVT` = 2.

```
PTWWSALT
-- first region table
4400      10 /
0          1.04    3.0E-6  0.76   0
5          1.02    2.9E-6  0.86   0
10         1.01    2.8E-6  0.96   0   /
-- second region table
4400      /
0          1.04    3.0E-6  0.8    0
6          1.02    2.9E-6  0.9    0
10         1.02    2.8E-6  1.0    0   /
```



## 2.333 QDRILL

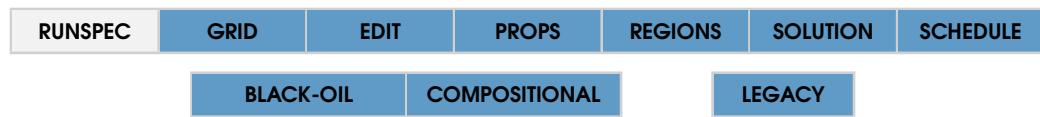
### Description

This keyword places wells into a sequential drilling queue which may be opened to maintain a group target as defined by keywords [GCONPROD](#) and [GCONINJE](#). The wells should have been previously defined as SHUT or STOP producers or injectors with keyword [WELSPECS](#).

The keyword should be followed by the names of the wells to be added to the drilling queue, terminated with a slash (/).

### Example

```
QDRILL  
P1 P2 P5 /
```



## 2.334 REFINE

### Description

This keyword can be used to edit 3D arrays inside a local grid refinement (LGR) previously defined using [CARFIN](#). It is followed by a single slash terminated record which provides the name of the LGR to be edited.

[REFINE](#) can be used in all sections but RUNSPEC and SUMMARY, using the following rules for 3D arrays to be updated and updaters:

#### GRID

- All 3D arrays can be updated, including [COORD](#) and [ZCORN](#),

#### EDIT

- [PORV](#), [TRANX](#), [TRANY](#), [TRANZ](#), [MULTPV](#), [MULTX](#), [MULTY](#), [MULTZ](#)], [DEPTH](#), [TOPS](#)

#### PROPS

- If the end-point scaling is enabled using [ENDSCALE](#), all horizontal and vertical 3D arrays for scaling can be modified, including [SWATINIT](#).

#### REGIONS

- All region 3D arrays can be updated inside a [REFINE](#) block,

#### SOLUTION

- All region 3D arrays can be updated inside a [REFINE](#) block,

#### SCHEDULE

- In the SCHEDULE section it is possible to modify various multipliers, namely [MULTX](#), [MULTY](#), [MULTX](#) and [MULTPV](#), together with region 3D arrays (e.f. [SATNUM](#)); notably modification of 3D arrays requires greate care.

It is possible to use as 3D array updaters [BOX](#), [COPY](#), [EQUALS](#), [MULTIPLY](#) and [COPYBOX](#).

### Record format

1. **LGRNAME:** Name of a previously defined LGR

**Type:** String

#### Example 1

GRID section: [REFINE](#) updates porosities:

```

REFINE
'LGR' /
EQUALS
PORO 1.0 /
/
ENDFIN
  
```

**Example 2**

EDIT section: **REFINE** is used to update **MULTY** in a slice of cells:

```
REFINE
'LGR' /
EQUALS
  MULTY 100.0 1 25 9 9 1 10 /
/
ENDFIN
```

**Example 3**

PROPS section: **REFINE** is used to set connate and critical water inside a slice of cells representing a fracture:

```
REFINE
'LGR' /
EQUALS
  SWL 0.0 .0 1 25 9 9 1 10 /
/
COPY
  'SWL' 'SWCR' /
/
ENDFIN
```

**Example 4**

REGIONS section: **REFINE** is used to make **FIPNUM** in LGR different from background **FIPNUM**:

```
EQUALS
  FIPNUM 1 /
/
REFINE
'LGR' /
ADD
  FIPNUM 1 /
/
ENDFIN
```

**Example 5**

SOLUTION section: **REFINE** is used to set **PRESSURE** inside LGR for an initialisation by enumeration; in the same **REFINE** block a black-oil tracer is initialized using **TBLKFOIP**

```
REFINE
  'LGR' /
EQUALS
  PRESSURE 200. 1 25 1 25 1 1 /
  PRESSURE 201. 1 25 1 25 2 2 /
  PRESSURE 202. 1 25 1 25 3 3 /
  PRESSURE 203. 1 25 1 25 4 4 /
  PRESSURE 204. 1 25 1 25 5 5 /
/
EQUALS
  TBLKFOIP 1.0 /
/
ENDFIN
```

**Example 6**

SCHEDULE section: to implement hydraulic fracturing **MULTY** is increased inside a slice of cells:

```
REFINE
  'LGR' /
EQUALS
  MULTY 100.0 1 25 9 9 1 10 /
/
ENDFIN
```



## 2.335 REGDIMS

### Description

This keyword is used to set the maximum values for 3D region arrays such as [FIPNUM](#). It is followed by a single record terminated by a slash character.

### Record format

1. **NFIP:** Maximum number of fluid in place regions for the model at hand. NFIP can be defined also using [TABDIMS](#) keyword 5<sup>th</sup> field, and, if it is defined in both places the largest value is used.  
**Type:** Integer  
**Default value:** 1
2. *Reserved*
3. *Reserved*
4. **NFLUX:** The maximum number of [FLUXNUM](#) regions. This value can be set also using the 11<sup>th</sup> field of [TABDIMS](#) keyword and, in case it is defined in both places, the largest one is used.  
**Type:** Integer  
**Default value:** 0
5. **NTRACK:** The maximum number of regions for [TRACK](#) keyword for region-based tracking. Note, [TRACK](#) is available only in compositional simulations, hence this value makes sense only in compositional models.  
**Type:** Integer  
**Default value:** 0
6. *Reserved*
7. **NOPER:** The maximum number of regions defined using [OPERNUM](#) keyword  
**Type:** Integer  
**Default value:** 0
8. **NWORK:** The maximum number of [WORK](#) arrays  
**Type:** Integer
9. **NIWORK:** The maximum number of [IWORK](#) arrays  
**Type:** Integer
10. **NPLMIX:** Number of polymer regions in the data-set  
**Type:** Integer  
**Default value:** 1

### Example

To set a maximum of 10 [FIPNUM](#) and 4 [OPERNUM](#):

```
REGDIMS
 10 5* 4  /
```



## 2.336 RESERVOIRS

### Description

**RESERVOIRS** keyword is needed in ECHELON Reservoir Coupling (ERC) main data files. This keyword, which defines the reservoir models available for the coupled simulation, is followed by as many records as the number of the reservoir models available in the ERC simulation, with an additional line for the closing slash (/).

In each record, the first item is the reservoir model data file. The second item is a user-defined name for the reservoir model, while the third item represents the number of ranks used to run this particular reservoir and should be chosen with great care to optimize hardware. Subsequent items, starting from the fourth, are optional and used when a user intends to share the same GPUs between reservoirs. In this case, a GPU ID should be specified for each rank of every reservoir. Matching numbers represent GPU sharing.

If GPU sharing is not used, the total number of GPUs that will be required to run the ERC simulation is the sum of the GPUs assigned to each reservoir model. This is the summation of all the third items in each record.

When the GPU sharing is activated, in case of NVIDIA GPUs it is essential to enable MPS (Multi-Process Service) to proficiently execute multiple processes concurrently within the same GPU.

Insights on ERC can be found in [Chapter 20](#) inside the Technical Description.

### Record format

Field	Name	Type	Description
1	Reservoir mode	String	Reservoir model input file.
2	Reservoir name	String	Reservoir name.
3	Number of ranks	Integer	Number of ranks to be used in the simulation for this reservoir model.
4	GPU ID(s)	Integer	GPU ID(s). This field is necessary only if GPU sharing is needed. If specified, the IDs must start with 1 and increase by at most 1. Item 3 determines how many GPU ID items should be specified (item 4th and successive).

### Example 1

Field Scheduler DATA file made by two reservoir DATA files RES1 and RES2. RES1 will be simulated with 1 GPU, RES2 with 2 GPUs. \*GPU sharing not active

```
RUNSPEC
RESERVOIRS
'RES1_MODEL.DATA'      'RES1'      1 /
'RES2_MODEL.DATA'      'RES2'      2 /
/
```

**Example 2**

Field Scheduler DATA file made by two reservoir DATA files RES1 and RES2. RES1 will be simulated with 1 GPU, RES2 with 1 GPU. \*GPU sharing is active. This means that RES1 and RES2 models are run on the same shared GPU.

```
RUNSPEC  
  
RESERVOIRS  
'RES1_MODEL.DATA'      'RES1'      1  1  /  
'RES2_MODEL.DATA'      'RES2'      1  1  /  
/
```

**Example 3**

Field Scheduler DATA file made by three reservoir DATA files RES1, RES2 and RES3. RES1 will be simulated with 1 GPU, RES2 with 1 GPU and RES3 with 2 GPUs. \*GPU sharing is active. RES1 and RES2 models are run on the same shared GPU (GPU ID 1), while for RES3 2 GPUs are asked separately (with ID 2 and 3).

```
RUNSPEC  
  
RESERVOIRS  
'RES1_MODEL.DATA'      'RES1'      1  1  /  
'RES2_MODEL.DATA'      'RES2'      1  1  /  
'RES3_MODEL.DATA'      'RES3'      2  2  3  /  
/
```



## 2.337 RESTART

### Description

This keyword is a component of the ECHELON restart facility, documented in detail in [Chapter 13](#) of ECHELON Technical Description.

This keyword can be used to restart the simulation from a SAVE file in a flexible mode. It is followed by a single record with two fields, the base name of the SAVE file and the report number chosen to restart the simulation. The available report numbers can be found in the log file of the ECHELON simulation which generated the SAVE file (i.e Saved simulator state to report 1 (01 Jan 1992 00:00)).

Note that to start an ECHELON Reservoir Coupling simulation using flexible restart it is necessary to use this keyword in each reservoir model DATA file SOLUTION section, but not in the main Field Scheduler DATA file.

See also [Chapter 13](#) in the Technical Description and keywords [SAVE](#), [SAVENOW](#), [LOAD](#), [SKIPREST](#).

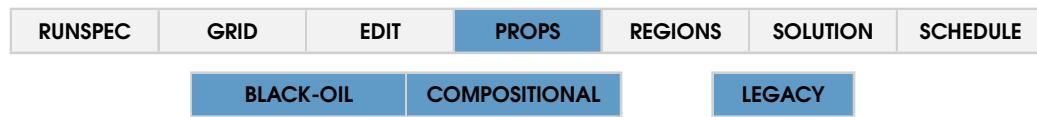
### Record format

Field	Name	Type	Description
1	SAVE FILE	String	Save file root name
2	REPORT	Integer	The report number from which the simulation will be restarted

### Example

An example of how to restart from report number 22 of Save file MODEL.SAVE.

```
RESTART
MODEL    22 /
```



## 2.338 RKTRMDIR

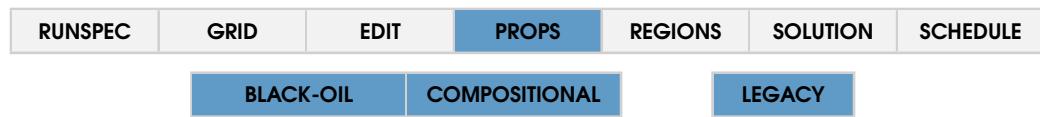
### Description

This keyword allows directional transmissibility multipliers in rock compaction table being used (either [ROCKTAB](#) or [ROCKTABH](#)). If this keyword is used, the third column is interpreted as a multiplier in the x-direction, fourth column is in y and the fifth column is the multiplier in the z-direction.

There is no data associated with this keyword.

### Example

```
PROPS
RKTRMDIR
```



## 2.339 ROCK

### Description

The [ROCK](#) keyword is used to specify the compressibility of the subsurface rock in each cell. This compressibility is given as

$$C_r = \frac{1}{PV} \frac{\partial(PV)}{\partial p},$$

where  $PV$  is the pore volume. Note that in contrast to the expressions for fluids,  $C_r$  does not include a negative sign. This reflects the fact that the pore volume increases with pore pressure, rather than decreasing.

The keyword is followed by NTPVT slash-terminated records, where NTPVT is the number of PVT regions specified in the second field of the [TABDIMS](#) keyword. Each record contains a value for the reference pressure,  $p_r$  followed by a value for  $C_r$ . Note that the dynamic pore volume is computed from these values as

$$PV_{dyn} = PV_{static} \left( 1 + \alpha + \frac{\alpha^2}{2} \right),$$

where  $PV_{dyn}$  is the dynamic pore volume,  $PV_{static}$  is the static pore volume and  $\alpha = C_r(p - p_r)$ .

### Record format

1. **REF\_PRES:** Reference pressure  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 14.7 (FIELD), 1.0132 (METRIC)
2. **ROCK\_COMP:** Rock compressibility  
**Units:** 1/psi (FIELD), 1/bar (METRIC)  
**Default value:** BO: 0 (FIELD), 0 (METRIC)  
COMP: 3.402e-6 (FIELD), 4.934e-5 (METRIC)

### Example

```
ROCK
3500.0  1.2e-6 /
```



## 2.340 ROCKCOMP

### Description

The [ROCKCOMP](#) keyword is used to set options for the use of rock compaction tables. It is used in conjunction with tables provided in the [ROCKTAB](#) or [ROCKTABH](#) keywords. The keyword is followed by a single record containing two fields, the first of which is used to select the hysteresis model to be employed, while the second specifies the number of compaction tables to be provided.

Further insights on rock compaction modelling can be found in [ROCKTAB](#), [ROCKOPTS](#) and [OVERBURD](#) documentation and in the Technical Description [Chapter 9](#)

### Record format

1. **HYST\_TYPE:** Mnemonic for the hysteresis model to be employed.

**Type:** String

**Allowed values:**

Name	Description
REVERS	Compaction is reversible. Pore volume is a simple function of pressure.
IRREVERS	Compaction is not reversible. The pore volume does not increase with increasing pressure.
HYSTER	Enables a hysteresis model for rock compaction. Hysteretic compaction tables should be provided with the <a href="#">ROCKTABH</a> keyword.

2. **NTABROCK:** The number of rock compaction tables.

**Type:** Integer

### Example

```
ROCKCOMP  
REVERS 3 /
```



## 2.341 ROCKNUM

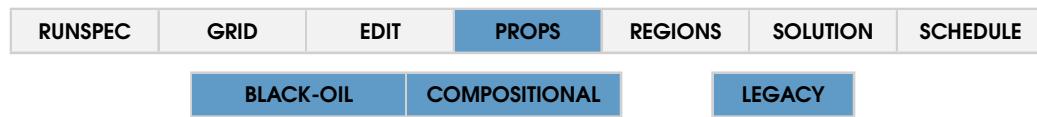
### Description

This keyword is used to indicate which saturation function region every grid block belongs to. It is followed by one integer value - saturation function region number - for each grid cell in the input box, which by default is the entire grid, following natural ordering with index along I running faster, then along J and last along K. Repeat counts may be used for repeated values. A slash (/) should be terminating the record. Integer values in the record should range from 1 to NTSFUN (first field in TABDIMS record).

### Example

This example shows how 4 saturation function regions can be defined for a 30 x 30 x 3 reservoir grid.

```
SATNUM  
600*1 300*2  
600*3 300*2  
600*4 300*2 /
```



## 2.342 ROCKOPTS

### Description

This keyword is used to set options relative to the usage of rock compaction.

### Record format

1. **OVERBURD\_OPT:** In the presence of the `OVERBURD` option, determines whether rock compaction tables are tabulated vs. pressure or vs. the effective stress

**Type:** String

**Default value:** PRESSURE

**Allowed values:**

Name	Description
PRESSURE	Interpret rock compaction table pressures as the fluid pressure minus the overburden. The tables will be negative if the overburden exceeds the fluid pressure.
STRESS	Interpret rock compaction tables pressures as stress, i.e. overburden minus fluid pressure. If the overburden exceeds the fluid pressure, the tabulated stress will thus be positive.

2. **REF\_PRES:** Rock compaction reference pressure. If set to STORE, the initial pressure is copied in the overburden array, such that in each cell the initial dynamic pore volumes are equal to the input static pore volumes.

**Type:** String

**Default value:** NOSTORE

**Allowed values:**

Name	Description
STORE	Copy the initial cell fluid pressures to the overburden array.
NOSTORE	Do not copy the initial cell fluid pressures to the overburden array.

3. **REGION:** Region mapping to the rock compaction tables.

**Type:** String

**Default value:** PVTNUM

**Allowed values:**

Name	Description
PVTNUM	Use the PVTNUM region to determine which table to use for each cell
SATNUM	Use the SATNUM region to determine which table to use for each cell
ROCKNUM	Use the ROCKNUM region to determine which table to use for each cell

4. **HYSTER\_INIT:** If set to DEFLATION, the simulator considers that the initial reservoir pressure corresponds to the minimum historical pressure, hence the simulation starts on the deflation curves. If set to ELASTIC, the simulator computes for each cell the minimum historical pressure such that the initial pore volume multiplier is equal to one; therefore, the simulation starts on the elastic curves.

**Type:** String

**Default value:** DEFLATION

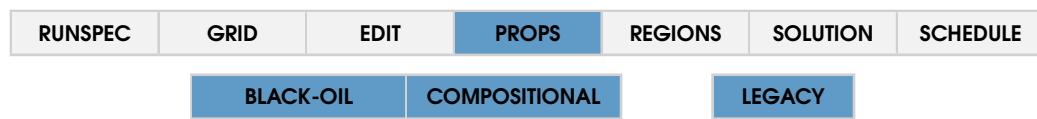
**Allowed values:**

Name	Description
DEFLATION	Begin simulation on the deflation compaction curves.
ELASTIC	Begin simulation on the elastic compaction curves such that the initial pore volume multiplier of each cell is one.

### Example

In this example, all mnemonics except the fourth are defaulted, and we activate the elastic initialization.

```
ROCKOPTS  
 3* ELASTIC /
```



## 2.343 ROCKTAB

### Description

The `ROCKTAB` keyword is used to provide a tabulation of pore volume and transmissibility multipliers versus pressure which result from rock compaction. The keyword is followed by NTABROCK (specified in the `ROCKCOMP` keyword) slash-terminated records, each representing a table for one `ROCKNUM` region.

Each table consists of either three or five columns of data, depending on whether or not directional transmissibility multipliers have been enabled with the `RKTRMDIR` keyword. The first column is either pressure or stress. Pressure should strictly increase down the column. Alternatively, if 'STRESS' has been enabled in the `ROCKOPTS` keyword, a strictly decreasing value of stress should be given in the first column.

The second column gives the pore volume multiplier associated with each value of pressure or stress. The third column gives a corresponding multiplier for transmissibility. If `RKTRMDIR` has been given, the third column corresponds to the x-direction multiplier and columns four and five are used to provide the y-direction and z-direction multipliers, respectively. If `RKTRMDIR` is not given, the third column is the last and gives an isotropic transmissibility multiplier.

Further insights on rock compaction modelling can be found in `OVERBURD`, `ROCKOPTS` documentation and in the Technical Description, [Chapter 9](#)

### Table columns

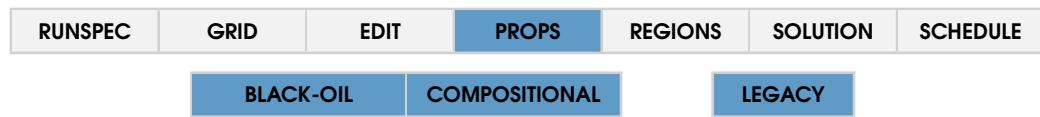
1. **PRESSURE:** Pressure (which must strictly increase down the column) or, if the STRESS option to `ROCKOPTS` is enabled, stress (which must monotonically decrease down the column).  
**Units:** psi (FIELD), bar (METRIC)
2. **PVMULT:** Pore volume multiplier
3. **TMULT:** Transmissibility multiplier. If the directional rock transmissibility multiplier has been enabled with the `RKTRMDIR` keyword, then this column represents the x-direction multiplier.
4. **TMULTY:** Y-direction transmissibility multiplier. This column is only present with directional rock transmissibility multipliers enabled with the `RKTRMDIR` keyword.
5. **TMULTZ:** Z-direction transmissibility multiplier. This column is only present with directional rock transmissibility multipliers enabled with the `RKTRMDIR` keyword.

### Example

The following is for a model with two `ROCKNUM` regions:

```

ROCKTAB
-- Pres    PVmult   Tmult
    1000    0.90    0.90
    2000    0.95    0.92
    3000    1.00    1.00
    5000    1.05    1.50 /
    1000    0.94    0.97
    2000    0.98    0.99
    3000    1.00    1.00
    5000    1.02    1.01 /
  
```



## 2.344 ROCKTABH

### Description

The `ROCKTABH` keyword is used to provide a tabulation of pore volume and transmissibility multipliers versus pressure which result from hysteretic rock compaction. The keyword is followed by `NTABROCK` (specified in the `ROCKCOMP` keyword) sets of slash-terminated records, each representing a branch for a table for one `ROCKNUM` region. Tables are separated by a null record.

Each record (i.e., hysteretic branch of a table) consists of either three or five columns of data, depending on whether or not directional transmissibility multipliers have been enabled with the `RKTRMDIR` keyword. The first column is either pressure or stress. Pressure should strictly increase down the column. Alternatively, if 'STRESS' has been enabled in the `ROCKOPTS` keyword, a strictly decreasing value of stress should be given in the first column.

The second column gives the pore volume multiplier associated with each value of pressure or stress. The third column gives a corresponding multiplier for transmissibility. If `RKTRMDIR` has been given, the third column corresponds to the x-direction multiplier and columns four and five are used to provide the y-direction and z-direction multipliers, respectively. If `RKTMRDIR` is not given, the third column is the last and gives an isotropic transmissibility multiplier.

Further insights on rock compaction modelling can be found in `OVERBURD`, `ROCKOPTS` documentation and in the Technical Description, [Chapter 9](#)

### Table columns

1. **PRESSURE:** Pressure (which must strictly increase down the column) or, if the STRESS option to `ROCKOPTS` is enabled, stress (which must monotonically decrease down the column).  
**Units:** psi (FIELD), bar (METRIC)
2. **PVMULT:** Pore volume multiplier
3. **TMULT:** Transmissibility multiplier. If the directional rock transmissibility multiplier has been enabled with the `RKTRMDIR` keyword, then this column represents the x-direction multiplier.
4. **TMULTY:** Y-direction transmissibility multiplier. This column is only present with directional rock transmissibility multipliers enabled with the `RKTRMDIR` keyword.
5. **TMULTZ:** Z-direction transmissibility multiplier. This column is only present with directional rock transmissibility multipliers enabled with the `RKTRMDIR` keyword.

**Example**

The following is for a model with two ROCKNUM regions:

```
ROCKTABH
-- Pres    PVmult Tmult
-- region 1
  1000      0.9      0.9
  6000      0.905    0.905 /
  2000      0.95     0.92
  6000      0.955    0.925 /
  3000      1         1
  6000      1.005    1.005 /
  5000      1.05     1.5
  6000      1.055    1.505 /
/
-- region 2
  1000      0.94     0.97
  6000      0.945    0.975 /
  2000      0.98     0.99
  6000      0.985    0.995 /
  3000      1         1
  6000      1.005    1.005 /
  5000      1.02     1.01
  6000      1.025    1.015 /
/
```



## 2.345 RPTONLY

### Description

This keyword limits the frequency of writing summary output. The default behavior is to write the summary output at every timestep. However, if this keyword exists the results are written at every report timestep.

This keyword can be used in [SCHEDULE](#) to change the frequency of writing summary outputs too. This option can be turned off by using [RPTONLYO](#).

### Example

There is no data associated with this keyword.

```
RPTONLY
```



## 2.346 RPTONLYO

### Description

This keyword turns off [RPTONLY](#) limits and ensures the summary output is written out at every timestep.

### Example

There is no data associated with this keyword.

```
RPTONLYO
```



## 2.347 RPTRST

### Description

The RPTRST keyword is used to report dynamic property values for each cell for 3D visualization in combination with a GRID or EGRID file. It is followed by a single record with a slash character at the end. Static properties are reported with the [INIT](#) keyword.

### Record format

Name	Description
AIM	Reports 2 for implicit cells, 1 for explicit
ALLPROPS	Alias for DEN, VISC, FVFINV, RELPERM, RK, PCAP, HYSTER
AMF	Aqueous phase mole fractions
BASIC	Controls the frequency of reporting properties to the UNRST file, by specifying BASIC= <i>n</i> , where <i>n</i> is one of the values below. 1. Generates output for each report step, but eliminates all previous reports 2. Generates output for each report step, keeping all reports 3. Creates output for one out of every FREQ report times 4. Creates a report at the start of each year (or every FREQ years, if provided) 5. Generates a report at the start of each month (or every FREQ months, if provided) 6. Generates a report every timestep
BCAD	Polymer adsorbed concentration
BCCN	Polymer concentration
BCIP	Polymer in place
BG	Gas formation volume factor
BGAS	Gas molar density in compositional simulations
BO	Oil formation volume factor
BOIL	Oil molar density
BSCN	Salt concentration
BSIP	Salt in place
BW	Water formation volume factor
BWAT	Water molar density
CELLIDX	Cell index
CFL	CFL number for each cell
CFL_A	Accumulation CFL number
CFL_C	Component CFL number
CFL_S	Saturation CFL number
CGAS	Gas compressibility
CNVG	Nonlinear convergence for the gas component in BO simulations
CNVO	Nonlinear convergence for the oil component in BO simulations
CNVW	Nonlinear convergence for the water component in BO simulations
COIL	Oil compressibility
CWAT	Water compressibility
DEN	Alias for DENO, DENG, DENW
DENG	Gas mass density
DENO	Oil mass density

DENW	Water mass density
DSTENDP	Pressure derivative of oil-gas surface tension
DVMFDP	Pressure derivative of the vapor mole fraction in compositional simulations
DWMFDP	Pressure derivative of the Water mole fraction in compositional simulations
FIP	Alias for FIPG, FIPO, FIPW, SFIPG, SFIPO, SFIPW
FIPG	The amount of gas in place as surface conditions for each cell
FIPO	The amount of oil in place as surface conditions for each cell
FIPW	The amount of water in place as surface conditions for each cell
FLOWS	Reservoir flow component of residual at surface condition in BO simulations
FMISC	Miscible interpolation parameter
FREQ	Frequency with which to report to the UNRST file
FVFINV	Inverse of oil, water, gas formation volume factors
GASPOT	Gas phase potential (depth corrected reservoir Gas pressure)
HYSTER	Alias for PRESMIN, and in case of hysteresis model also for SGASMAX, SOILMAX, SOILMIN, SWATMIN, SGTRAP, SGTRAPD
KRG	Gas relative permeability
KRO	Oil relative permeability
KRW	Water relative permeability
LIFACTG	Li factor for the gas phase in compositional models
LIFACTO	Li factor for the oil phase in compositional models
MASSRES	Component mass residual
OILAPI	American Petroleum institute grade for oil in black-oil models with API tracking
OILPOT	Oil phase potential (depth corrected reservoir Oil pressure)
PART	Partition number for each cell in multi-GPU runs. This can be used to visualize the distribution of cells to each GPU.
PCAP	Alias for PCOW, PCGO
PCG	Gas capillary pressure
PCGO	Gas-oil capillary pressure
PCO	Oil capillary pressure
PCOG	Oil-Gas capillary pressure
PCOW	Oil-water capillary pressure
PCW	Water capillary pressure
PERM	Permeability PERMX, PERMY, PERMZ
PGAS	Gas phase pressure
PLYADS	Adsorbed polymer
PMVA	The partial molar volume for aqueous phase in compositional simulations with three-phase equilibrium model
PMVG	The partial molar volume for each component in the vapor phase in compositional simulations
PMVO	The partial molar volume for each component in the liquid phase in compositional simulations
POIL	Oil pressure
POLY	Polymer concentration
PORO	Porosity
PORV	Pore volume at reference conditions
PORV_MOD	Multiplier from rock compaction applied to the static pore volume to get the dynamic pore volume (see <a href="#">ROCKCOMP</a> )
PRES	Alias for PRESSURE
PRESMIN	Minimum Pressure achieved in the cell (for irreversible compaction)

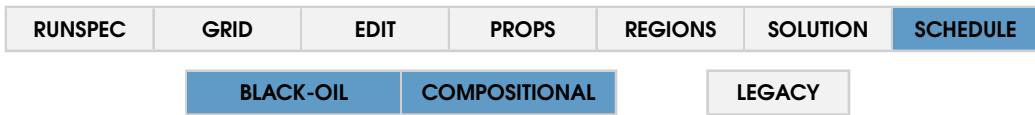
PRESSURE	Oil pressure (black-oil) or hydrocarbon pressure (compositional)
PRES_EFF	Effective pressure (Rock Compaction Option)
PSAT	Saturation pressure (i.e. bubble point or dew point)
PWAT	The water phase pressure
RELPERM	Alias for KWG, KRO, KRW
RESID	Residual contributions
RK	Water relative permeability reduction
ROCKC	Pore volume multiplier
ROCKNUM	ROCKNUM
RS	Solution gas-oil ratio
RSW	Dissolved gas fraction in water
RV	Vaporized oil-gas ratio
RVW	Vaporized oil fraction in water
RWG	Block water vaporized in gas
RWO	Block water dissolved in oil
SALT	Salinity of each cell in models with brine tracking
SATNUM	SATNUM
SDENO	The surface density of oil in simulations with API tracking
SFIP	Oil, water, and gas fluid-in-place at surface (separator) conditions
SFIPG	Gas fluid-in-place at surface conditions
SFIPO	Oil fluid-in-place at surface conditions
SFIPW	Water fluid-in-place at surface conditions
SGAS	Gas saturation
SGASMAX	Maximum value of gas saturation that the cell has experienced thus far in the simulation
SGTRAP	Trapped gas saturation
SGTRAPD	Dynamic trapped gas saturation
SOIL	Oil saturation
SOILMAX	Maximum value of oil saturation that the cell has experienced thus far in the simulation
SOILMIN	Minimum value of oil saturation that the cell has experienced thus far in the simulation
STATE	Cell state
STEN	The surface tension between the liquid and vapor phases in compositional simulations
STENDP	derivative of surface tension w.r.t. pressure
SWAT	Water saturation
SWATMIN	The lowest value of water saturation experienced so far in each cell
TEMP	Static cell temperature
TOTCOMP	Total fluid compressibility in compositional runs
TRANMOD	Multiplier applied to the transmissibility from rock compaction
TRANS	Transmissibility TRANX, TRANY, TRANZ
VGAS	The viscosity of the gas phase
VISC	Viscosity for oil, water and gas
VMF	The vapor mole fraction ( $\beta$ ) in compositional runs
VOIL	Oil viscosity
VWAT	Water viscosity
WATPOT	Water phase potential (depth corrected reservoir Water pressure)
WMF	Water mole fraction ( $\beta_a$ )

XMF	Liquid composition
YMF	Vapor composition
ZMF	Total composition

**Example**

The following example could be used in the SCHEDULE section of a compositional model to report the molar densities and compositions of the liquid and vapor phases, as well as the viscosity of all phases.

```
RPTRST  
BASIC=1 BOIL BGAS XMF YMF VISC /
```



## 2.348 RPTSCHED

### Description

The keyword **RPTSCHED** governs the verbosity for the SCHEDULE section in the PRT file. It is followed by a series of mnemonics and integers and terminated with a slash (/).

### Record format

#### 1. **WELLS:** Verbosity for wells.

A production and injection report is logged for wells. Both current and cumulative values are shown.

**Type:** String

**Minimum:** 1

**Maximum:** 1

#### 2. **FIP:** Verbosity for the fluid in place.

When set to 1, the report encompasses fluids in place for the entire field under reservoir and surface conditions.

When set to 2, in addition, each defined fluid in place region using the FIPNUM keyword provides a report on fluid in place for both surface and reservoir conditions.

Dynamic pore volume, average pressure and saturations are reported too.

**Type:** String

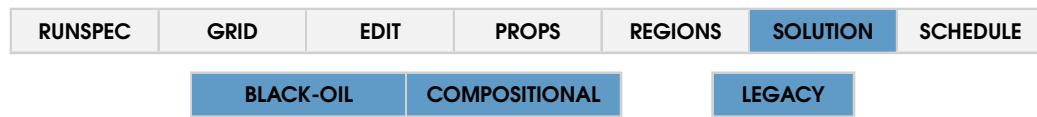
**Minimum:** 1

**Maximum:** 2

### Example

Control settings WELLS and FIP are used to generate extra logging in the PRT file.

```
RPTSCHED  
WELLS=1 FIP=2 /
```



## 2.349 RPTSOL

### Description

The RPTSOL keyword is used to control the report output to the PRT file.

However, currently only one option is supported under this keyword. This option controls which dynamic property values should be written out for 3D visualization.

It is followed by a single record with a slash character at the end,

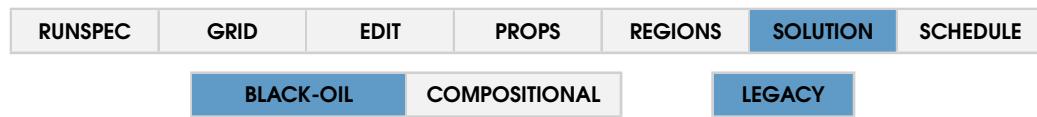
### Record format

Name	Description
RESTART	Controls the 3D output to be written to the UNRST file, by assing an integer number to RESTART option as follows If RESTART is set to a number bigger than 0, pressure and saturations for each phase is reported to UNRST file. If RESTART is set to a number bigger than 3, fluid in place for each phase is reported to UNRST file.

### Example

The following example could be used in the **SOLUTION** section in order to ensure all dynamic states (pressure and saturations) as well as fluid in places are reported in the 3D output for visualization.

```
RPTSOL
RESTART=4 /
```



## 2.350 RS

### Description

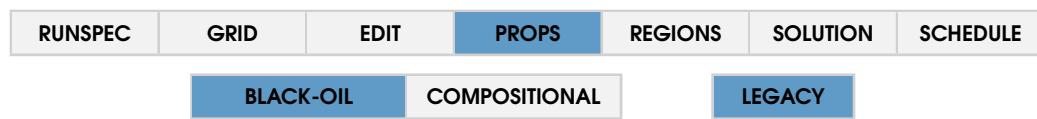
The [RS](#) keyword is used to specify the initial solution gas-oil ratio,  $R_s$  of each cell in the reservoir when using an enumerated initial state rather than hydrostatic equilibrium. The keyword should be followed by a single record containing  $NX \times NY \times NZ$  values, i.e. one  $R_s$  value for every cell in the reservoir. Similarly, data for [PRESSURE](#), [SWAT](#) and [SGAS](#) should be given. For extended black-oil models with vaporized oil, [RV](#) should also be provided. For compositional simulations, see also [XMY](#), [YMF](#), [ZMF](#), and [ZI](#) for providing the initial composition of the reservoir fluids as well as [TEMPI](#) or [RTEMP](#) for providing the initial temperature.

**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

### Example

For a  $10 \times 12 \times 3$  reservoir with a uniform gas-oil ratio of 2.05 Mscf/stb in field units:

```
SOLUTION  
RS  
360*2.05 /
```



## 2.351 RSCONST

### Description

The `RSCONST` keyword is used to provide a constant value for the solution gas-oil ratio,  $R_s$  for simulations containing only water and dead oil, i.e. without free gas. If `RSCONST` is used, it is assumed that  $R_s$  is uniform throughout the reservoir, time-invariant throughout the simulation and it marks the oil wellstream. It is then possible to effectively use VFP tables (see `VFPPROD` keyword) where a gas-liquid fraction (e.g. oil GOR) is used as an independent variable.

The user may also supply a bubble point pressure,  $P_b$ . If any converged cell pressure goes below the supplied  $P_b$ , this means that the dead-oil assumption was invalid. Rather than proceeding to produce unphysical results, the simulation is terminated. The keyword is followed by a single slash-terminated record containing two floating point numbers corresponding to the constant  $R_s$  value and  $P_b$ , respectively. If a model has more than one PVT region and the user wishes to supply different  $R_s$  and/or  $P_b$  values for each region, the `RSCONSTT` keyword may be used instead.

### Record format

1. **RS:** Constant solution gas-oil ratio.  
**Type:** Float  
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Minimum:** 0
2. **PBUB:** Bubble-point pressure. If any converged cell pressure falls below the bubble point pressure in any timestep, then the dead-oil assumption is invalid, and the simulation will terminate.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)

### Example

The following specifies an  $R_s$  value of 1.5 Mscf/stb and a  $P_b$  of 2418 psi.

```
RSCONST
1.5 2418.0 /
```



## 2.352 RSCONSTT

### Description

The `RSCONSTT` keyword is used to provide a constant value for each PVT region for the solution gas-oil ratio,  $R_s$  for simulations containing only water and dead oil, i.e. without free gas. It is a more flexible version of `RSCONST`, which allows only a single value for the entire reservoir. If `RSCONSTT` is used, it is assumed that  $R_s$  is uniform throughout each PVT region and time-invariant throughout the simulation. `PVTNUM` based  $R_s$  also marks wellstreams, giving the possibility to effectively use VFP tables (see `VFPProd` keyword) where a gas-liquid fraction (e.g. oil GOR) is used as an independent variable.

The user may also supply a bubble point pressure,  $P_b$ . If any converged cell pressure goes below the supplied  $P_b$ , this means that the dead-oil assumption was invalid. Rather than proceeding to produce unphysical results, the simulation is terminated. The keyword is followed by a slash-terminated record for each PVT region. Each record should contain two floating point numbers corresponding to the constant  $R_s$  value and  $P_b$ , respectively.

Note that if multiple values for  $R_s$  are provided with this keyword, there should be no oil flow between PVT regions.

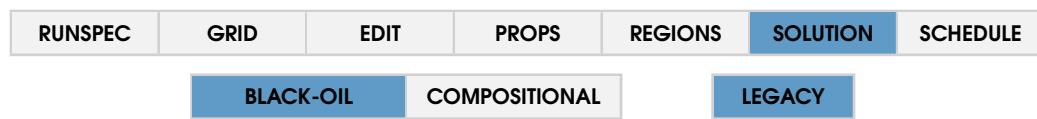
### Record format

1. **RS:** Constant solution gas-oil ratio.  
**Type:** Float  
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Minimum:** 0
2. **PBUB:** Bubble-point pressure. If any converged cell pressure falls below the bubble point pressure in any timestep, then the dead-oil assumption is invalid, and the simulation will terminate.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)

### Example

The following specifies constant  $R_s$  and  $P_b$  values for a model with two PVT regions:

```
RSCONSTT
1.5 2418.0 /
1.46 2519.0 /
```



## 2.353 RSVD

### Description

This keyword is used to tabulate the value of  $R_s$  versus depth for use in vertical equilibration with the [EQUIL](#) keyword. Alternatively, the data can be specified by giving the bubble point pressure ( $P_b$ ) vs. depth with the [PBVD](#) keyword.

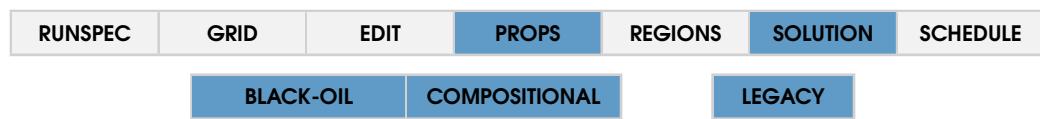
The data consists of two columns. The first gives the depth measured in feet ([FIELD](#)) or meters ([METRIC](#)). The second column is the solution gas-oil ratio ( $R_s$ ) given in Mscf/stb ([FIELD](#)) or sm<sup>3</sup>/sm<sup>3</sup> ([METRIC](#)). A separate slash-terminated table record should be provided for each equilibration region. The number of regions is specified in the first field of [EQLDIMS](#).

### Table columns

#### Example

For a model with two non-communicating equilibration regions and constant composition vs. depth:

```
RSVD
-- Depth (m)  Rs (sm3/sm3)
 2000      88.0
 2400      88.0
/
 1800      79.3
 2300      79.3
/
```



## 2.354 RTEMP

### Description

The [RTEMP](#) keyword can be used to specify a constant and spatially uniform value for temperature in each equation-of-state (EOS) region. The keyword should be followed by  $N$  slash-terminated records, where  $N$  is the number of EOS regions specified in the [TABDIMS](#) keyword. Each record should contain a single value representing the reservoir temperature for the corresponding region. The temperature can also be set with the [TEMPVD](#) keyword for models with vertical equilibration or with [TEMPI](#) for enumerated initial conditions.

For black-oil models with thermal degradation of injected polymers, [RTEMP](#) can also be used to specify a single temperature for the whole run in the PROPS section. In this case, only a single record is expected.

### Record format

#### 1. TEMPERATURE:

Type: Float

Units: Fahrenheit (FIELD), Celsius (METRIC)

### Example

For a model with 3 EOS regions:

```
SOLUTION  
  
RTEMP  
423.0 /  
441.0 /  
419.0 /
```



## 2.355 RTEMPVD

### Description

This keyword is used to tabulate the value of temperature versus depth for use in vertical equilibration with the [EQUIL](#) keyword. The keyword is an alias of the keyword [TEMPVD](#).

### Example

For constant temperature vs. depth:

```
RTEMPVD
-- Depth (m)  Temperature (C)
 2000        123.0
 2400        123.0
 /
```



## 2.356 RUNSUM

### Description

The **RUNSUM** keyword enables the output of summary vector time series in a comma-separated values (CSV) format, in addition to the binary SMSPEC/UNSMRY format file. This format can be easily imported into spreadsheet applications for customized post-processing and plotting. This keyword has no associated data records.

### Example

```
SUMMARY  
-- Turn on CSV output  
RUNSUM
```



## 2.357 RV

### Description

The [RV](#) keyword is used to specify the initial vaporized oil-gas ratio,  $R_v$ , of each cell in the reservoir when using an enumerated initial state rather than hydrostatic equilibrium. The keyword should be followed by a single record containing  $NX \times NY \times NZ$  values, i.e. one  $R_v$  value for every cell in the reservoir. Similarly, data for [PRESSURE](#), [SWAT](#), [SGAS](#) and [RS](#) should be given. For compositional simulations, see also [XMF](#), [YMF](#), [ZMF](#), and [ZI](#) for providing the initial composition of the reservoir fluids as well as [TEMPI](#) or [RTEMP](#) for providing the initial temperature.

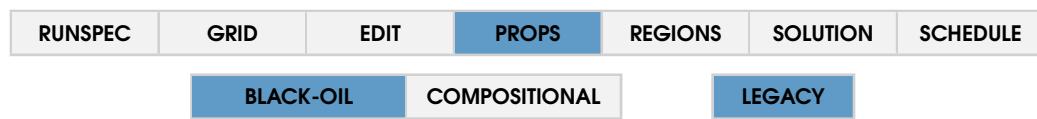
**Units:** stb/Mscf (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

### Example

For a  $16 \times 10 \times 4$  reservoir with a uniform gas-oil ratio of 0.89 stb/Mscf in field units:

```
SOLUTION
```

```
RS  
640*0.89 /
```



## 2.358 RVCONST

### Description

The `RVCONST` keyword is used to provide a constant value for the vaporized oil-gas ratio,  $R_v$ , for simulations containing only water and gas, i.e. without liquid oil. If `RVCONST` is used, it is assumed that  $R_v$  is uniform throughout the reservoir, time-invariant throughout the simulation, and it marks the gas wellstream. It is then possible to effectively use VFP tables (see `VFPPROD` keyword) where a gas-liquid fraction (e.g. gas OGR) is used as an independent variable.

The user may also supply a dew-point pressure,  $P_d$ . If any converged cell pressure goes below the supplied  $P_d$ , this means that the assumption of no liquid oil dropout was invalid. Rather than proceeding to produce unphysical results, the simulation is terminated. The keyword is followed by a single slash-terminated record containing two floating point numbers corresponding to the constant  $R_v$  value and  $P_d$ , respectively. If a model has more than one PVT region and the user wishes to supply different  $R_v$  and/or  $P_d$  values for each region, the `RVCONSTT` keyword may be used instead.

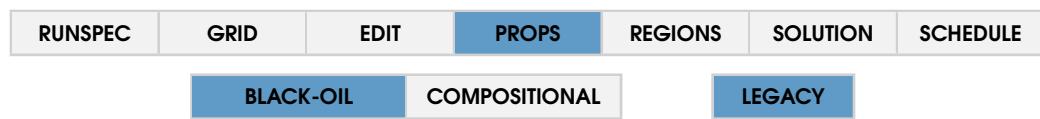
### Record format

1. **RV:** Constant vaporized oil-gas ratio.  
**Type:** Float  
**Units:** stb/Mscf (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Minimum:** 0
2. **PDEW:** Dew-point pressure. If any converged cell pressure falls below the dew-point pressure in any timestep, then the assumption of no condensate dropout is invalid, and the simulation will terminate.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Minimum:** 0

### Example

The following specifies an  $R_v$  value of 0.12 stb/Mscf and a  $P_d$  of 2943 psi.

```
RVCONST
0.12 2943.0 /
```



## 2.359 RVCONSTT

### Description

The `RVCONSTT` keyword is used to provide a constant value for each PVT region for the vaporized oil-gas ratio,  $R_v$ , for simulations containing only water and gas, i.e. without liquid oil. It is a more flexible version of `RVCONST`, which allows only a single value for the entire reservoir. If `RVCONSTT` is used, it is assumed that  $R_v$  is uniform throughout each PVT region and time-invariant throughout the simulation. `PVTNUM` based  $R_s$  also mark wellstreams, giving the possibility to effectively use VFP tables (see `VFPPROD` keyword) where a gas-liquid fraction (e.g. OGR) is used as an independent variable.

The user may also supply a dew-point pressure,  $P_d$ . If any converged cell pressure goes below the supplied  $P_d$ , this means that the assumption of no liquid oil was invalid. Rather than proceeding to produce unphysical results, the simulation is terminated. The keyword is followed by a slash-terminated record for each PVT region. Each record should contain two floating point numbers corresponding to the constant  $R_v$  value and  $P_d$ , respectively.

Note that if multiple values for  $R_d$  are provided with this keyword, there should be no oil flow between PVT regions.

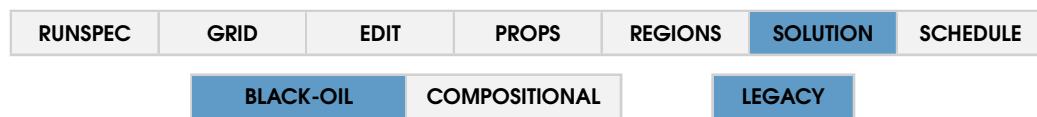
### Record format

1. **RV:** Constant vaporized oil-gas ratio.  
**Type:** Float  
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Minimum:** 0
2. **PDEW:** Dew-point pressure. If any converged cell pressure falls below the dew-point pressure in any timestep, then the assumption of no condensate dropout is invalid, and the simulation will terminate.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Minimum:** 0

### Example

The following specifies constant  $R_v$  and  $P_d$  values for a model with two PVT regions:

```
RVCONSTT
0.111  2518.0 /
0.104  2313.0 /
```



## 2.360 RVVD

### Description

This keyword is used to tabulate the value of the vaporized oil-gas ratio,  $R_v$ , versus depth for use in vertical equilibration with the [EQUIL](#) keyword. Alternatively, the data can be specified by giving the dew-point pressure ( $P_d$ ) vs. depth with the [PDVD](#) keyword.

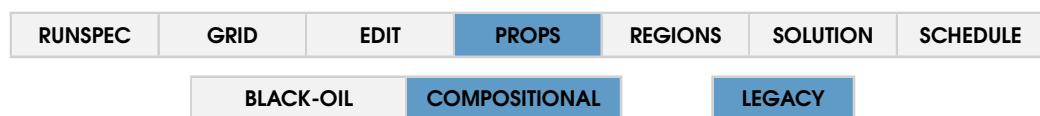
The data consists of two columns. The first gives the depth measured in feet ([FIELD](#)) or meters ([METRIC](#)). The second column is the solution gas-oil ratio ( $R_v$ ) given in stb/Mscf ([FIELD](#)) or  $\text{sm}^3/\text{sm}^3$  ([METRIC](#)). A separate slash-terminated table record should be provided for each equilibration region. The number of regions is specified in the first field of [EQLDIMS](#).

### Table columns

#### Example

For a model with two non-communicating equilibration regions and constant composition vs. depth in metric units:

```
RVVD
-- Depth (m)  Rs (sm3/sm3)
  2000        0.0081
  2400        0.0081
/
  1800        0.0087
  2300        0.0087
/
```



## 2.361 SALINITR

### Description

This keyword is used to specify the water salinity in each equation of state region. The specified value is used for equilibrium calculations in the Soreide and Whitson equation of state. Moreover, it is used by default for the computation of aqueous properties (i.e. density and viscosity) if internal analytical correlations are adopted, that is to say whenever the user does not specify either [PVTW](#) or [PVTWSALT](#) keywords.

The keyword is followed by NEOSR ([TABDIMS](#) ninth field) record.

### Record format

1. **Salinity Value:** Water salinity

**Type:** Float

**Default value:** BO: , COMP: 0

**Allowed values:**

2. **Salinity Options:** Option to specify if salinity should be considered for equilibrium only or also for aqueous phase properties computation.

**Type:** String

**Default value:** BO: , COMP: YES

**Allowed values:**

Name	Value Type	Description
YES	String	Use salinity in the computation of aqueous phase properties. This holds if internal analytical correlations are adopted for water properties computation, i.e. <a href="#">PVTW</a> and <a href="#">PVTWSALT</a> are not entered by the user.
NO	String	Do not use salinity in the computation of aqueous phase properties but only for equilibrium. This holds if internal analytical correlations are adopted for water properties computation, i.e. <a href="#">PVTW</a> and <a href="#">PVTWSALT</a> are not entered by the user.

### Example 1

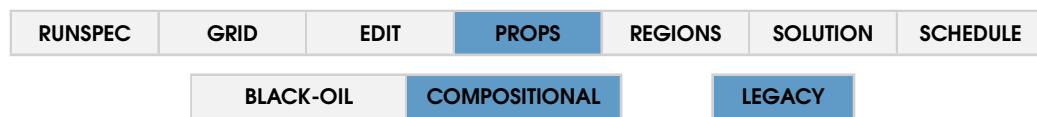
This example specifies salinity for three equation of state regions, to be used for equilibrium and aqueous properties computation.

```
SALINITY
0.5 YES /
0.2 YES /
0.8 YES /
```

### Example 2

This example specifies salinity for three equation of state regions, to be used for equilibrium computation only.

```
SALINITY
0.5 NO /
0.2 NO /
0.8 NO /
```



## 2.362 SALINITY

### Description

This keyword is used to specify the water salinity. The specified value is used for equilibrium calculations in the Soreide and Whitson equation of state. Moreover, it is used by default for the computation of aqueous properties (i.e. density and viscosity) if internal analytical correlations are adopted, that is to say whenever the user does not specify either [PVTW](#) or [PVTWSALT](#) keywords.

### Record format

1. **Salinity Value:** Water salinity

**Type:** Float

**Default value:** BO: , COMP: 0

**Allowed values:**

2. **Salinity Options:** Option to specify if salinity should be considered for equilibrium only or also for aqueous phase properties computation.

**Type:** String

**Default value:** BO: , COMP: YES

**Allowed values:**

Name	Value Type	Description
YES	String	Use salinity in the computation of aqueous phase properties. This holds if internal analytical correlations are adopted for water properties computation, i.e. <a href="#">PVTW</a> and <a href="#">PVTWSALT</a> are not entered by the user.
NO	String	Do not use salinity in the computation of aqueous phase properties but only for equilibrium. This holds if internal analytical correlations are adopted for water properties computation, i.e. <a href="#">PVTW</a> and <a href="#">PVTWSALT</a> are not entered by the user.

### Example 1

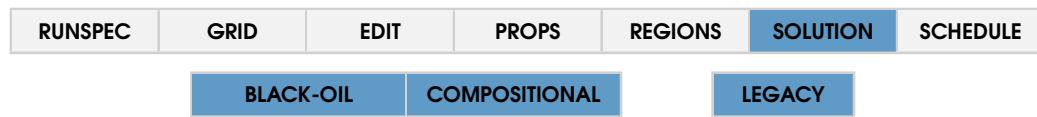
This example specifies salinity for all the reservoir, to be used for equilibrium and aqueous properties computation.

```
SALINITY
0.5 YES /
```

### Example 2

This example specifies salinity for all the reservoir, to be used for equilibrium computation only.

```
SALINITY
0.5 NO /
```



## 2.363 SALT

### Description

The keyword defines salt concentrations of the reservoir as a 3D array, which means one value for each cell. It should only be used if the Brine Tracking Model is activated using the keyword [BRINE](#). The keyword must be terminated with a trailing slash. SALT keyword should be used when the model is initialized by enumeration.

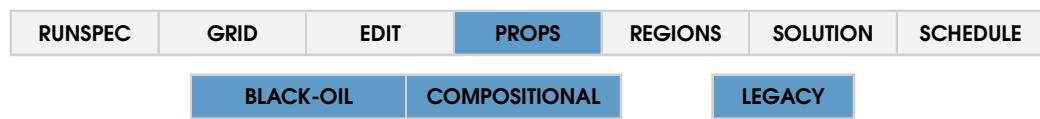
The [SALTVD](#) should be used instead of [SALT](#) when the initial state of fluids is characterized using equilibration (see [EQUIL](#) for details).

**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

### Example

This SALT keyword sets concentration in a grid of 15 cells.

```
SALT  
5*0.2 5*0.3 0.0 4*0.4 /
```



## 2.364 SALTNODE

### Description

This keyword specifies the brine concentrations to compute the water phase viscosity multiplier. The data should be entered as a one-column table for NTPVT (second field in TABDIMS record) regions with at least two rows.

SALTNODE should be used in conjunction with the keywords POLYMER, BRINE, and PLYVISCS. The keyword may contain up to NPPVT number of records in a table, each table must be terminated with a slash (/).

### Record format

1. **CONCENTRATION:** The brine concentration.

Values in the table must strictly increase down the column and correspond to the number of entries in PLYVISCS

**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

### Example

The keyword specifies NTPVT = 2 tables and is compatible with the PLYVISCS example.

```
SALTNODE
-- first region has 4 SALTNODE entries
0.0
0.33
0.66
1.0
/
-- second region has 2 SALTNODE entries
0.0
1.0
/
```



## 2.365 SALTVD

### Description

This keyword allows specifying the concentration of salt as a function of depth for each equilibration region. The number of entered tables cannot exceed NTEQUL and every table must have at least two entries (4 values) but not exceed NDNOES (the third field of the [EQLDIMS](#) keyword). Every region table must be terminated with a slash (/).

SALTVD should be used in conjunction with the keywords [BRINE](#) and [EQUIL](#).

### Record format

#### 1. DEPTH:

Depth  
The values should increase monotonically down the column.

**Units:** ft (FIELD), m (METRIC)

#### 2. SALT\_CONC:

Salt concentration.

**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

**Minimum:** 0

### Example

This example specifies salt concentration tables for NTEQUL=2 equilibration regions (see [EQLDIMS](#))

```
SALTVD
5000    0.0
8000    0.5    /
6000    0.0
7000    1.0    /
```



## 2.366 SATNUM

### Description

This keyword is used to indicate which saturation function region every grid block belongs to. It is followed by one integer value - saturation function region number - for each grid cell in the input box, which by default is the entire grid, following natural ordering with index along I running faster, then along J and last along K. Repeat counts may be used for repeated values. A slash (/) should be terminating the record. Integer values in the record should range from 1 to NTSFUN (first field in TABDIMS record).

### Example

This example shows how 4 saturation function regions can be defined for a 30 x 30 x 3 reservoir grid.

```
SATNUM  
600*1 300*2  
600*3 300*2  
600*4 300*2 /
```



## 2.367 SATOPTS

### Description

The [SATOPTS](#) keyword is used, through the HYSTER mnemonic, to activate the relative permeability and capillary pressure hysteresis option in ECHELON (see [Section 10.5](#) in the Technical Description).

Details of the hysteresis model can be selected through the [EHYSTR](#) (and possibly the [EHYSTRR](#)) keyword in the PROPS section.

### Record format

Name	Description
HYSTER	Activates the relative permeability hysteresis option

### Example

```
SATOPTS  
HYSTER /
```



## 2.368 SAVE

### Description

This keyword is a component of the ECHELON restart facility, documented in detail in [Chapter 13](#) of ECHELON Technical Description.

The SAVE keyword can be used in the RUNSPEC and the SCHEDULE section. No matter where its is used, it instructs the simulator to write the state of the simulation for the report step just before the keyword (if in RUNSPEC or at the beginning of the schedule this means the initial state of the model at the date defined by [START](#)). The frequency of the next update of the SAVE file with new reservoir states is given by the [RPTRST](#) keyword, more specifically the BASIC field in the [RESTART](#) record.

The SAVE file can be used independently to restart a simulation in a flexible way (see [RESTART](#) keyword) or in a fast mode (see [LOAD](#) keyword).

Note that to save the state of an ECHELON Reservoir Coupling run the previous statements are valid and necessary to be implemented in all the coupled DATA files, while the Master DATA file does not require edits.

See also [Chapter 13](#) in the Technical Description and keywords [SAVENOW](#), [LOAD](#), [RESTART](#) and [SKIPREST](#) keywords.

### Example 1

Save the report at the start date of the simulation. Other reports are saved according to the RPTRST keyword.

```
RUNSPEC
SAVE
```

### Example 2

Save report on 01-Jan-2000. Other reports are saved according to the RPTRST keyword.

```
SCHEDULE
DATES
01 JAN 2000 /
/
SAVE
DATES
01 JUN 2001 /
/
DATES
01 JAN 2002 /
/
```

**Example 3**

Save report at the start date of the simulation and with a frequency determined by the RPTRST keyword, in this case, the first report step of every year. So the second report will be saved on 01-Jan-2001, then 01-Jan-2002 and so on.

```
RUNSPEC  
SAVE  
  
..  
  
SCHEDULE  
RPTRST  
BASIC=4 FREQ=1 /  
  
DATES  
01 JAN 2000 /  
  
DATES  
01 JUN 2001 /  
  
DATES  
01 JAN 2002 /  
/
```

**Example 4**

Save report at 01-Jan-2000 and with a frequency determined by the RPTRST, in this case the first report step of every year. So the second report will be saved on 01-Jan-2002.

```
SCHEDULE  
RPTRST  
BASIC=4 FREQ=1 /  
DATES  
01 JAN 2000 /  
  
SAVE  
DATES  
01 JUN 2001 /  
  
DATES  
01 JAN 2002 /  
/
```



## 2.369 SAVENOW

### Description

This keyword is a component of the ECHELON restart facility, documented in detail in [Chapter 13](#) of ECHELON Technical Description.

The SAVENOW keyword can be used only in the SCHEDULE section to write the current reservoir condition in the SAVE file ([Chapter 13](#) of Echelon Technical Description). More specifically, ECHELON writes the state of the simulation in the SAVE file for the last simulation report just before the keyword position in the SCHEDULE section. The SAVE file can be used independently to restart a simulation in a flexible way (see RESTART keyword) or in a fast mode (see LOAD keyword).

The SAVENOW keyword is not followed by any record.

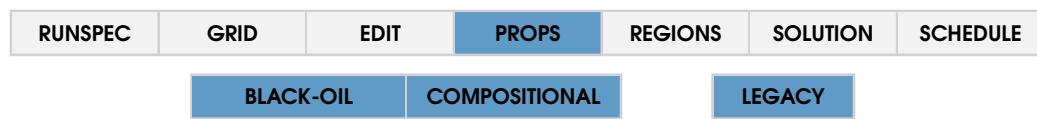
Note that to save the current state of an ECHELON Reservoir Coupling run the previous statements are valid and necessary to be implemented in all the coupled DATA files, while the Master DATA file does not require edits.

See also [Chapter 13](#) in the Technical Description and keywords [SAVE](#), [LOAD](#), [RESTART](#) and [SKIPREST](#) keywords.

### Example

Save report on 01-Jan-2000 and 01-Mar-2000, RPTRST doesn't affect report frequency.

```
SCHEDULE  
DATES  
01 JAN 2000 /  
/  
SAVENOW  
DATES  
01 FEB 2000 /  
/  
DATES  
01 MAR 2000 /  
/  
SAVENOW
```



## 2.370 SCALECRS

### Description

This keyword can be used to control the end-point scaling method in simulation where this functionality is active (see keyword [ENDSCALE](#), [Section 10.3](#) and [Section 10.4](#) in the Technical Description).

The keyword has a simple record with only one field, which may take either YES or NO, with NO as default value. YES instructs the simulation to use the three-point scaling method, while NO means using the two-point method.

### Example

```
SCALECRS  
YES /
```



## 2.371 SEPCOND

### Description

The keyword sets or modifies conditions for a stage of a named separator, see [Chapter 14](#) in ECHELON Technical Description. Each slash terminated record of SEPCOND keyword specifies the temperature and pressure of a stage. Multiple records can be used to define a multi-stage separator.

The keyword is terminated with an empty record (slash). Many records can be used to define a multi-stage separator.

The named separator can then be used in the [WSEPCOND](#) keyword to assign it to (a) specific well(s).

The separation process is usually associated with an equation of state which is used for all calculations. It is also possible to use a gas plant table simplified model (see [Section 14.2](#) in the ECHELON Technical Description) and gas density is computed using Agamat's law if both 11<sup>th</sup> and 12<sup>th</sup> are not defaulted.

### Record format

1. **NAME:** Separator name  
**Type:** String
2. **GROUP\_NAME:** The name of the group over which the defined separator stages applies. If a well in the group has a different separator set by [WSEPCOND](#), then the override takes precedence.  
Wildcards can be used in GROUP\_NAME to assign the state to more than one group.  
If GROUP\_NAME is defaulted (1\*) or is a blank string (''), then the stage is not assigned to any group.  
**Type:** String
3. **STAGE\_ID:** Separator stage index  
**Type:** Integer  
**Default value:** 1
4. **TEMPERATURE:** Separator stage temperature  
**Type:** Float  
**Units:** Fahrenheit (FIELD), Celsius (METRIC)  
**Default value:** BO: (FIELD), (METRIC)  
COMP: 60 (FIELD), 15.56 (METRIC)
5. **PRESSURE:** Separator stage pressure  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 14.6959 (FIELD), 1.01325 (METRIC)
6. **LIQUID\_DEST:** Destination of the liquid output from this stage. By default, taken as the next stage unless STAGE\_ID is the last.  
**Type:** Integer  
**Default value:** 0
7. **VAPOR\_DEST:** Destination of the vapor output from this stage. By default (0), taken as standard output (i.e., vapor is accumulated over all stages to constitute the standard surface gas volume).  
**Type:** Integer  
**Default value:** 0
8. *Reserved*

9. **GAS\_PLANT\_ID:** Gas plant table number, used instead of the equation of state for the separation process. Zero is the default value (the equation of state is used).  
**Type:** Integer  
**Default value:** 0
10. **EOS\_NUM:** The surface equation of state number is needed if more than one equation of state is defined (see [TABDIMS](#) field 10).  
**Type:** Integer  
**Default value:** 0
11. **T\_NGL:** Temperature for NGL density evaluation.  
**Type:** Float  
**Units:** Fahrenheit (FIELD), Celsius (METRIC)
12. **P\_NGL:** Pressure for NGL density evaluation.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)

### Example 1

SC is a two-stage separator that is not associated with any group. The last stage is at standard conditions (unity system i [FIELD])

```
SEPCOND
SC   '   1 80 65   /
SC   '   2 60 14.7 /
/
```

### Example 2

SEPPLANT is a four-stage separator train. Stage 1 oil is routed to Stage 2, Stage 2 oil is routed to Stage 4, Stage 1 and Stage 2 gas is routed to Stage 3, Stage 3 gas is converted to surface conditions and Stage 4 oil is flashed at stock tank conditions.

```
SEPCOND
SEPPLANT  1      60      125      2      3   /
SEPPLANT  2      60      80       4      3   /
SEPPLANT  3      5       70       0      0   /
SEPPLANT  4      25      35       0      0   /
/
```



## 2.372 SGAS

### Description

The [SGAS](#) keyword is used to specify the initial gas saturation of each cell in the reservoir when using an enumerated initial state rather than hydrostatic equilibrium. The keyword should be followed by a single record containing  $NX \times NY \times NZ$  values, i.e. one saturation for every cell in the reservoir. Similarly, values for [PRESSURE](#) should be given, as well as [SWAT](#). For compositional simulations, see also [XMF](#), [YMF](#), [ZMF](#), and [ZI](#) for providing the initial composition of the reservoir fluids as well as [TEMPI](#) or [RTEMP](#) for providing the initial temperature.

### Example

For a  $12 \times 10 \times 3$  reservoir with uniform gas saturation of 0.2:

```
SOLUTION  
SGAS  
360*0.2 /
```



## 2.373 SGCR

### Description

The SGCR keyword allows the user to rescale the horizontal saturation axis for gas-oil relative permeability tables (*e.g.* SGOF tables assigned by SATNUM). The saturation axis is rescaled to a modified critical gas saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical gas saturation is the largest gas saturation for which gas relative permeability is zero in the relative permeability table. Relative permeability is zero at this saturation. SGCR can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling.

Section 10.3 of the Technical Description describes consistency requirements such as  $SGL \leq SGCR$ .

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

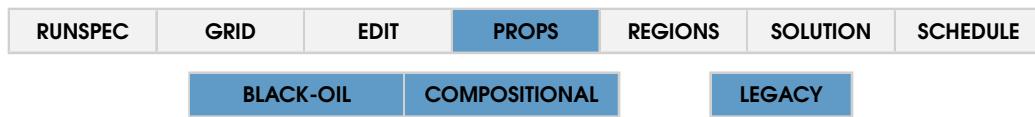
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.42

### Example

SGCR is used here in a dual media case to assign critical gas saturation for flow in the matrix (top reservoir half) and fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
SGCR
9000*0.05 9000*0.01 /
```



## 2.374 SGFN

### Description

The **SGFN** keyword is used to specify tables for interpolating the gas relative permeability and capillary pressure as a function of gas saturation. Each table consists of three columns for  $S_g$ ,  $k_{rg}$ , and  $p_{cgo}$ , respectively, with strictly monotonically increasing gas saturation. Each table should be terminated with a slash (/) character. It is possible to use repeated counts in the second and third column of the table: in such lines missing  $k_{rg}$  and/or  $p_{cgo}$  values are defined by interpolation.

SGFN tables are used together **SWFN** and **SOF3** keyword (split input type of keyword, see [Chapter 10](#) in the Technical Description).

The total number of tables should be the same as the number of saturation regions (NTSFUN) specified in the **TABDIMS** keyword (first field). It is possible to default an entire table, provided it is not the first. A copy of the previous table is used in this case.

The simulator uses SGFN tables to define the critical gas saturation  $S_{gcr}$ , which is the maximum table gas saturation with a zero gas relative permeability (see [Section 10.2](#) in the Technical Description). For this purpose any relative permeability value below a threshold of  $10^{-6}$  is set to zero. The threshold value, which can be modified using **TOLCRIT** keyword, may impact the definition of  $S_{gcr}$ .

### Table columns

1. **SGAS:** Gas saturation  
Subsequent values in this column must strictly increase
2. **KRG:** Gas relative permeability  
Subsequent values in this column must increase or remain constant
3. **PCGO:** Oil-gas capillary pressure  
Subsequent values in this column must increase or remain constant  
**Units:** psi (FIELD), bar (METRIC)

### Example

SGFN is used here to define gas relative permeability and gas-oil capillary pressure. ECHELON selects 0.06 as  $S_{gcr}$  because 0.00000007 is less than  $10^{-6}$ , while capillary pressure for  $S_g$  equals 0.1 and 0.2 are interpolated.

```
SGFN
0      0          0
0.06   0.00000007  0.01
0.1    0.001       1*
0.2    0.1         1*
0.4    0.5         0.05
0.6    0.7         0.1
0.8    0.9         0.3
/
```



## 2.375 SGL

### Description

The SGL keyword allows the user to rescale the horizontal saturation axis for gas-oil relative permeability tables (*e.g.* SGOF tables assigned by SATNUM). The saturation axis is rescaled to a modified lowest gas saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Lowest (gas saturation) is the smallest gas saturation in the relative permeability table. Relative permeability is zero at this saturation. SGL can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes consistency requirements such as  $SGL \leq SGCR$ . SGL is commonly set to zero (connate gas saturation is meaningless).

Section 10.3 of the Technical Description describes consistency requirements such as  $SGL \leq SGCR$ .

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

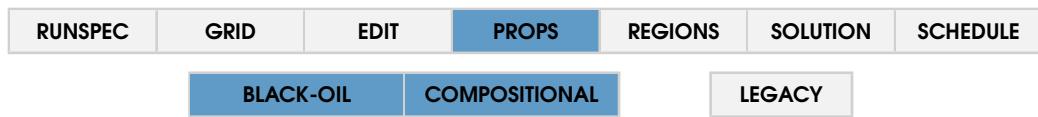
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.43

### Example

SGL is used here in a dual media case to assign lowest gas saturation for flow in the matrix (top reservoir half) and fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
SGL
 9000*0.0  9000*0.0 /
```



## 2.376 SGOCOREY

### Description

This keyword can be used to define Corey saturation functions for oil-gas. For a more detailed description of his keyword refer to Technical Documentation [Chapter 10](#).

The oil-gas Corey relative permeability and capillary pressure functions (see [Section 10.2](#) in the Technical Description) are expressed as follows:

$$k_{rog}(s_g) = \begin{cases} k_{rorg} + (k_{rolg} - k_{rorg}) \frac{s_{gcr} - s_g}{s_{gcr} - s_{gl}} & s_{gl} \leq s_g < s_{gcr} \\ k_{rorg} \left(1 - \frac{s_g - s_{gcr}}{1 - s_{gcr} - s_{ogcr} - s_{wl}}\right)^{Noil} & s_{gcr} \leq s_g \leq 1 - s_{ogcr} - s_{wl} \\ 0 & 1 - s_{ogcr} - s_{wl} < s_g \leq s_{gu} \end{cases}$$

$$k_{rg}(s_g) = \begin{cases} 0 & s_{gl} \leq s_g < s_{gcr} \\ k_{rgr} \left(\frac{s_g - s_{gcr}}{1 - s_{gcr} - s_{ogcr} - s_{wl}}\right)^{Ngas} & s_{gcr} \leq s_g \leq 1 - s_{ogcr} - s_{wl} \\ k_{rgu} - (k_{rgu} - k_{rgr}) \frac{s_{gu} - s_g}{s_{ogcr} + s_{gu} + s_{wl} - 1} & 1 - s_{ogcr} - s_{wl} < s_g \leq s_{gu} \end{cases}$$

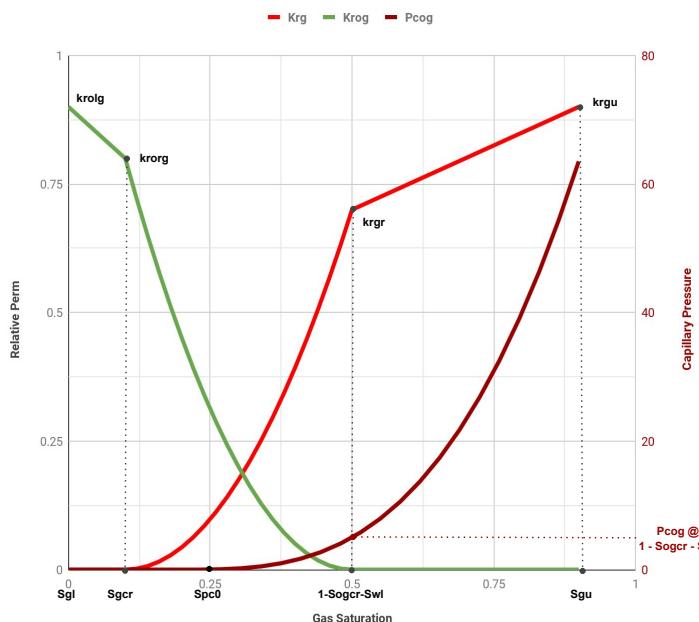
$$P_{cog}(s_g) = \begin{cases} 0 & s_{gl} \leq s_g \leq s_{pc0} \\ p_{cog} \left(1 - s_{ogcr} - s_{wl}\right) \left(\frac{s_g - s_{pc0}}{1 - s_{pc0} - s_{ogcr} - s_{wl}}\right)^{Np} & s_{pc0} < s_g \leq s_{gu} \end{cases}$$

Note that if there is a J-function defined on gas (or both phases), the following correlation is used instead of aforementioned capillary pressure,

$$J_{og}(s_g) = \begin{cases} 0 & s_{wl} \leq s_g \leq s_{pc0} \\ \left(\frac{s_g - s_{pc0}}{P_{cog}}\right)^{1/Np} & s_{pc0} < s_g \leq s_{gu} \end{cases}$$

It is assumed that the exponent is chosen to be a positive value ( $Np > 0$ ).

The number of records in `SGOCOREY` should match the number of saturation functions that is defined in `TABDIMS`. The keyword is terminated with an empty record (/).



**Figure 2.3:** Example plot of relative perm and capillary pressure curves using SGOCOREY.

### Record format

1. **SGL:** Minimum gas saturation  
**Type:** Float  
**Default value:** 0.0
2. **SGCR:** Critical gas saturation  
**Type:** Float  
**Default value:** equal to SGL
3. **SOGCR:** Residual oil saturation  
**Type:** Float  
**Default value:** 0.0
4. **SGU:** Maximum gas saturation  
**Type:** Float  
**Default value:** 1.0
5. **KROLG:** Maximum oil-gas relative perm at SGL  
**Type:** Float  
**Default value:** 1.0
6. **KRORG:** Maximum oil-gas relative permeability at SGCR  
**Type:** Float  
**Default value:** equal to KROLW
7. **KRGR:** Maximum water relative perm at  $1 - \text{SOGCR} - \text{SWL}$ , where SWL is the minimum water saturation  
**Type:** Float  
**Default value:** equal to KRGU
8. **KRGU:** Maximum water relative perm at SGU  
**Type:** Float  
**Default value:** 1.0

9. **PCOG:** Oil-gas capillary pressure at 1 - SOGCR - SWL, where SWL is the minimum water saturation  
**Type:** Float  
**Default value:** 0.0
10. **SPC0:** Gas saturation where capillary pressure starts from zero  
**Type:** Float  
**Default value:** equal to SWU
11. **Noil:** Polynomial degree for oil-gas relative perm curve  
**Type:** Float  
**Default value:** 1.0
12. **Ngas:** Polynomial degree for gas relative perm curve  
**Type:** Float  
**Default value:** 1.0
13. **Np:** Polynomial degree for oil-gas capillary pressure curve  
**Type:** Float  
**Default value:** 1.0

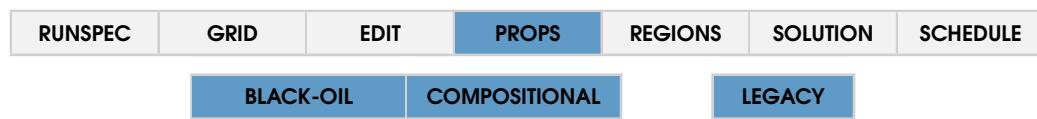
**Example 1**

```
SGOCOREY
--sgl sgcr sogcr sgu krolg krorg krgrg krgu P cog spc0 No Ng Np
 0.0 0.1 0.4 0.9 1.0 0.8 0.7 0.9 5.0 0.2 2.0 2.5 3.0 /
/
```

**Example 2**

If all the parameters in **SGOCOREY** are defaulted, Corey function will generate linear saturation functions between 0.0 and 1.0 for relative permeabilities with zero capillary pressure.

```
SGOCOREY
-- Default all the inputs
13* /
/
```



## 2.377 SGOF

### Description

The SGOF keyword is used to specify tables for interpolating the relative permeability of gas and oil along with capillary pressure between the phases as a function of gas saturation. If the water phase is present in the system, SWOF must also be used. Data is provided in tabular form in four columns with monotonically increasing gas saturation. Each table should be terminated with a slash (/).

The total number of tables should be the same as the number of saturation regions (NTSFUN) specified in the TABDIMS keyword (first field). It is possible to default an entire table provided it is not the first. A copy of the previous table is used in this case.

In the second, third and fourth columns it is possible to use default values (1\*). When the table is read by the simulator, these values will be replaced by a linear interpolation based on adjacent non-defaulted values.

The critical saturations (see [Section 10.2](#) in the Technical Description) for each relative permeability, namely  $s_{gcr}/s_{ogcr}$ , are defined according to the highest/lowest saturation value where the relative permeability at hand is lower than  $10^{-6}$ . This value can be modified using [TOLCRIT](#).

### Table columns

1. **SGAS:** Gas saturation  
**Minimum:** 0.0  
**Maximum:** 1.0
2. **KRG:** Gas relative permeability  
**Minimum:** 0.0  
**Maximum:** 1.0
3. **KRO:** Oil relative permeability  
**Minimum:** 0.0  
**Maximum:** 1.0
4. **PCGO:** Oil-gas capillary pressure  
**Units:** psi (FIELD), bar (METRIC)  
**Minimum:** -inf  
**Maximum:** inf

**Example**

For a model with a single saturation region:

```
SGOF
 0.000  0.00000  0.938   0.000
 0.020  0.00000  0.739   0.417
 0.058  0.02678  0.456   0.450
 0.096  0.05872  0.270   0.479
 0.134  0.09582  0.151   0.506
 0.172  0.13808  0.079   0.536
 0.210  0.18550  0.038   0.568
 0.248  0.23808  0.016   0.603
 0.286  0.29582  0.006   0.644
 0.324  0.35872  0.002   0.691
 0.362  0.42678  0.000   0.747
 0.400  0.50000  0.000   0.814
 0.450  0.60420  0.000   1*
 0.500  0.71734  0.000   1*
 0.550  0.83942  0.000   1.295
 0.600  0.97042  0.000   1.626
/
```

$S_{gcr}$  is 0.06 while  $S_{ogcr}$  is 0.6 - 0.362. Capillary pressure values for  $S_g$  equal to 0.45 and 0.50 are interpolated



## 2.378 SGU

### Description

The SGU keyword allows the user to rescale the horizontal saturation axis for gas-oil relative permeability tables (*e.g.* SGOF tables assigned by SATNUM). The saturation axis is rescaled to a modified highest possible gas saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest gas saturation is the maximum gas saturation in the relative permeability table. Gas relative permeability should be greater than zero at this saturation. SGU can be used for cases without hysteresis or for drainage tables with hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes end-point consistency requirements. SGU is commonly set to a value of 1.0-SWL.

Section 10.3 of the Technical Description describes consistency requirements such as  $SGL \leq SGCR$ .

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

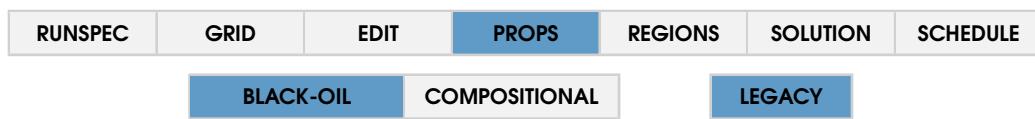
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.44

### Example

SGU is used here to assign highest gas saturation for gas-oil relative permeability. This model has 10000 cells.

```
SGU
10000*0.85 /
```



## 2.379 SGWFN

### Description

The SGWFN keyword is used in two-phase gas-water simulations (without oil) to specify tables for interpolating the gas and water relative permeabilities ( $k_{rg}$  and  $k_{rw}$ ) along with the capillary pressure between the two phases ( $p_{cgw}$ ) as a function of gas saturation ( $S_g$ ). Data is provided in tabular form in four columns (see Table columns description below). Each table should be terminated with a slash (/).

In the second, third and fourth columns it is possible to use default values (1\*). When the table is read by the simulator, these values will be replaced by a linear interpolation based on adjacent non-defaulted values.

The total number of tables should be the same as the number of saturation regions (NTSFUN) specified in the TABDIMS keyword (first field). It is possible to default an entire table, provided it is not the first. A copy of the previous table is used in this case.

The simulator uses SGWFN tables to define the critical gas saturation ( $S_{gcr}$ ) which is the maximum table gas saturation with a zero gas relative permeability, and  $1 - S_{wcr}$ , which is the minimum table gas saturation where water relative permeability is zero (see [Section 10.2](#) in the Technical Description). For this purpose any relative permeability value below a threshold of  $10^{-6}$  is set to zero. This threshold value can be modified using [TOLCRIT](#).

### Table columns

1. **SGAS:** Gas saturation (strictly increasing)
2. **KRG:** Gas relative permeability (increasing)
3. **KRW:** Water relative permeability (decreasing)
4. **PCGW:** Water-gas capillary pressure (increasing)

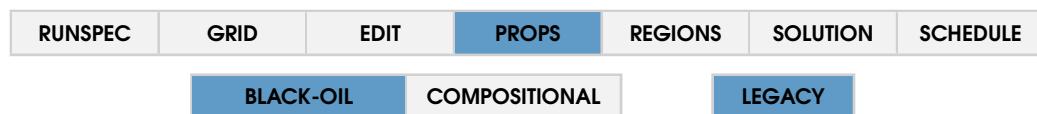
**Units:** psi (FIELD), bar (METRIC)

### Example

For a model with two saturation regions:

SGWFN			
0.000	0.000	0.900	0.000
0.030	0.000	0.876	0.01
0.144	0.042	0.407	0.02
0.201	0.071	0.176	1*
0.315	0.141	0.093	1*
0.372	0.184	0.067	1*
0.486	0.282	0.033	0.7
0.543	0.339	0.023	1.2
0.650	0.457	0.011	2.0
0.750	0.583	0.000	15.0 /

$S_{gcr}$  is 0.030 while  $S_{wcr}$  is  $1 - 0.750$ .



## 2.380 SHRATE

### Description

This keyword specifies a parameter for the polymer solution viscosity calculations.

SHRATE should be used in conjunction with the keyword [POLYMER](#). It must be paired with the keyword [PLYSHLG](#). See [Chapter 17](#) section in ECHELON Technical Description.

The keyword may contain up to [NPPVT](#) entries, each entry must be terminated with a slash (/).

### Record format

#### 1. SHEAR\_RATE\_CONST: Shear rate constant

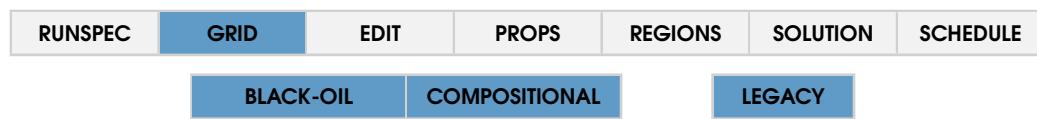
This value can be defaulted and must be a non-zero positive value.

**Default value:** BO: 4.8, COMP: 4.8

### Example

The keyword specifies data for [NTPVT](#) = 2 regions

```
SHRATE  
4.8 /  
5.0 /
```



## 2.381 SIGMA

### Description

The SIGMA ( $\sigma$ ) value represents the  $A/(L \cdot V)$  term in the fracture-matrix transmissibility calculation. The use of this keyword implies a constant value in all grid cells. The SIGMAV keyword allows different values for each grid cell.  $A$  is the total fracture-matrix surface area in the grid cell,  $L$  is the characteristic length (distance) from the fracture faces to the matrix block center and  $V$  represents the volume of the grid block. Thus the units of  $\sigma$  are  $1/ft^2$  in FIELD units and  $1/m^2$  in metric units. For uniform fracture spacing in the x, y and z-directions ( $L_x, L_y, L_z$ ),  $\sigma$  has been shown to be equal to  $4(1/L_x^2 + 1/L_y^2 + 1/L_z^2)$ . Alternatively, some literature has proposed that the value of 4 in the equation be replaced with  $\pi^2$ .

**Units:**  $1/ft^2$  in FIELD units and  $1/m^2$  in METRIC units.

### Example

```
SIGMA  
0.2/
```



## 2.382 SIGMAV

### Description

The SIGMAV ( $\sigma_v$ ) value represents the  $A/(L \cdot V)$  term in the fracture-matrix transmissibility calculation. The SIGMAV keyword allows different values for each grid cell as opposed to the use of the SIGMA keyword which implies a constant value in all grid cells.  $A$  is the total fracture-matrix surface area in the grid cell,  $L$  is the characteristic length (distance) from the fracture faces to the matrix block center, and  $V$  represents the volume of the grid block. For uniform fracture spacing in the x, y and z-directions ( $L_x, L_y, L_z$ ),  $\sigma$  has been shown to be equal to  $4(1/L_x^2 + 1/L_y^2 + 1/L_z^2)$ . Alternatively, some literature has proposed that the value of 4 in the equation be replaced with  $\pi^2$ .

SIGMAV input is per natural grid ordering for the current input box and is required only for grid blocks in the first NZRES/2 dual-media layers.

**Units:**  $1/ft^2$  in FIELD units and  $1/m^2$  in METRIC units.

### Example

Define values for the input box of 1000 cells. SIGMAV input is required only for the top one-half of dual-media layers.

```
SIGMAV  
100*0.2 100*0.2 100*0.5 500*0.3 100*0.7 100*0.7/
```



## 2.383 SKIPREST

### Description

This keyword is a component of the ECHELON restart facility, documented in detail in [Chapter 13](#) of ECHELON Technical Description.

Preparing a simulation model to run as a restart from a previous simulation may require some clean-up of the SCHEDULE section until the restart date: the SKIPREST keyword gives the possibility to leave this job to the simulator itself.

The best place for this keyword is as close as possible to the beginning of the SCHEDULE section. If the model is simulated using an equilibrium type initialization, see [EQUIL](#) and other keywords in the SOLUTION section, then the keyword at hand is simply ignored by ECHELON. If the simulation is a restart (no matter if flexible or fast) then keywords provided until the restart position are skipped, with some exceptions. It is important to note that the presence of SKIPREST in the SCHEDULE section requires providing the necessary instruction to progress the simulation from the start date of the simulation (see the [START](#) in RUNSPEC section) till the report point where the simulation restarts. At that report point it is necessary to set [DATES](#) keyword with a record date equals to the restart date. The restart report point can also be defined using [TIME](#) keyword, while the use of [TSTEP](#) is discouraged.

It is important to note that some SCHEDULE section keywords are not skipped because the information they convey is not saved in the restart file file. The list of keywords read even if they are after SKIPREST and before the restart [DATES/TIME](#) keyword includes:

- [VFPPROD](#),
- [VFPINJ](#),
- [FBHPDEF](#),
- [FNS\\_INCLUDE](#),
- [FNS\\_WELLINFO](#),
- [WRFTPLT](#),
- [RPTRST](#).

ECHELON reads also any keyword which can be used in the SCHEDULE section to update cell transmissibility values, e.g. [MULTX/MULTY/MULTZ](#) applied along the simulation usually to simulate hydraulic fracturing, and the [MAXTRANS](#) keyword. These keywords are not stored in the SAVE file and then it is necessary to read them to guarantee a restarted simulation to be consistent with the base one.

See also [Chapter 13](#) in the Technical Description and keywords [SAVE](#), [SAVENOW](#), [LOAD](#), [RESTART](#)

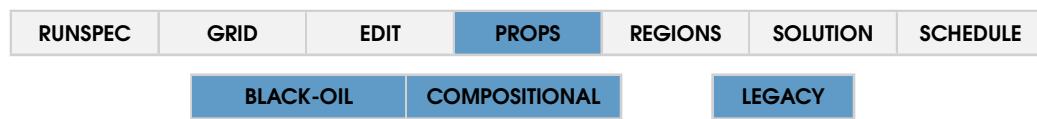
### Example

The best place for SKIPREST is as close as possible to SCHEDULE.

```
-- Content of a .DATA file
.

.

-- SCHEDULE section --
SCHEDULE
SKIPREST
```



## 2.384 SLGOF

### Description

The SLGOF keyword is used to specify tables for interpolating the relative permeability of gas and oil along with capillary pressure between the phases as a function of liquid (oil + water) saturation. If the water phase is present in the system [SWOF](#) must also be used. Data is provided in tabular form in four columns with monotonically increasing liquid saturation, which smallest value equals the sum of connate water and residual oil saturations. Each table should be terminated with a slash (/).

The total number of tables should be the same as the number of saturation regions (NTSFUN) specified in the [TABDIMS](#) keyword (first field). It is possible to default an entire table, provided it is not the first. A copy of the previous table is used in this case.

The simulator uses SLGOF tables to define the critical gas saturation ( $S_{gcr}$ ), which corresponds to  $1 - S_{lacr}$ , being  $S_{lacr}$  the minimum table liquid saturation with a zero gas relative permeability, and the critical oil saturation in the gas-oil system ( $s_{ogcr}$ , which is defined by the last table liquid saturation with  $k_{rog} = 0$ , see [Section 10.2](#) in the Technical Description. For this purpose any relative permeability value below a threshold of  $10^{-6}$  is set to zero. This threshold value can be modified using [TOLCRIT](#).

### Table columns

1. **SLIQ:** Liquid saturation.  
**Minimum:** 0.0  
**Maximum:** 1.0
2. **KRG:** Gas relative permeability (last value must be zero)  
**Minimum:** 0.0  
**Maximum:** 1.0
3. **KRO:** Oil relative permeability  
**Minimum:** 0.0  
**Maximum:** 1.0
4. **PCGO:** Oil-gas capillary pressure  
**Units:** psi (FIELD), bar (METRIC)  
**Minimum:** -inf  
**Maximum:** inf

### Example

For a model with a single saturation region:

```

SLGOF
 0.154  0.938  0.00000  0.000
 0.172  0.079  0.13808  0.536
 0.210  0.038  0.18550  0.568
 0.248  0.016  0.23808  0.603
 0.286  0.006  0.29582  0.644
 0.324  0.002  0.35872  0.691
 0.362  0.000  0.42678  0.747
 0.400  0.000  0.50000  0.814
 0.450  0.000  0.60420  0.925
 0.500  0.000  0.71734  1.077
 0.550  0.000  0.83942  1.295
 0.600  0.000  0.97042  1.626
/
  
```

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SCHEDULE
		BLACK-OIL			COMPOSITIONAL	
					LEGACY	

## 2.385 SOF2

### Description

The SOF2 keyword is used to specify tables for interpolating the relative permeability of oil in two-phase oil-water systems. SOF2 is not intended to be used in three-phase systems: use [SOF3](#) instead. Data is provided in tabular form in two columns with monotonically increasing oil saturation. Each table should be terminated with a slash (/).

The total number of tables should be the same as the number of saturation regions (NTSFUN) specified in the [TABDIMS](#) keyword (first field). It is possible to default an entire table, provided it is not the first. A copy of the previous table is used in this case.

The simulator uses SOF2 tables to define the critical oil saturation in an oil-water system,  $S_{owcr}$ , as the largest saturation table with  $k_{row} = 0.$ , see [Section 10.2](#) in the Technical Description. For this purpose any relative permeability value below a threshold of  $10^{-6}$  is set to zero. This threshold value can be modified using [TOLCRIT](#).

### Table columns

#### Example

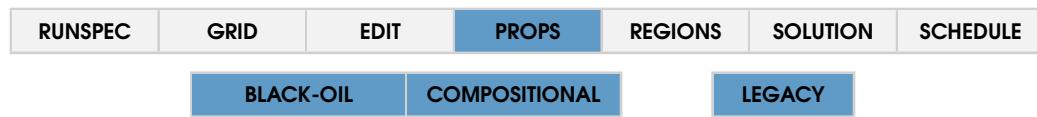
For a model with four saturation regions:

```

SOF2
.4000  .0000
.8500  1.0000
/
/
.3000  .0000
.7500  1.0000
/
/

```

Note: tables for the second and fourth regions are copied from the first and second region tables, respectively.



## 2.386 SOF3

### Description

The SOF3 keyword is used to specify tables for interpolating the relative permeability of oil in three-phase systems. Data are provided in tabular form in three columns with monotonically increasing oil saturation. Each table should be terminated with a slash (/).

The total number of tables should be the same as the number of saturation regions (NTSFUN) specified in the TABDIMS keyword (first field). It is possible to default an entire table, provided it is not the first. A copy of the previous table is used in this case.

In the second and third columns it is possible to use default values (1\*). When the table is read by the simulator, these values will be replaced by a linear interpolation based on adjacent non-defaulted values.

The critical saturations for each relative permeability, namely  $s_{owcr}/s_{ogcr}$ , are defined according to the highest/lowest table saturation value where the relative permeability at hand is less than  $10^{-6}$ , see Section 10.2 in the Technical Description. This value can be modified using TOLCRIT.

### Table columns

1. **SOIL:** Oil saturation

**Minimum:** 0.0

**Maximum:** 1.0

2. **KROW:** Oil relative permeability in the oil-water system

**Minimum:** 0.0

**Maximum:** 1.0

3. **KROG:** Oil relative permeability in the oil-gas system with connate water.

**Minimum:** 0.0

**Maximum:** 1.0

### Example

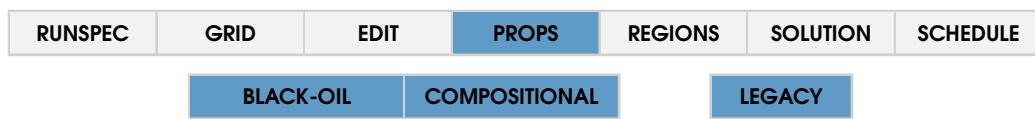
SOF3 is used to set oil relative permeability for oil-ware and gas-oil systems; oil relative permeability in the oil-fas system is linear, hence all values for oil saturation between 0 and 0.90 are defaulted:

```

SOF3
0.00  0.00  0.00
0.10  0.00  1*
0.20  0.05  1*
0.40  0.10  1*
0.60  0.40  1*
0.80  0.60  1*
0.90  0.70  0.70
/

```

Note that  $s_{owcr} = 0.10$  and  $s_{ogcr} = 0.0$



## 2.387 SOGCR

### Description

The SOGCR keyword allows the user to rescale the horizontal saturation axis for gas-oil relative permeability tables (*e.g.* SGOF tables assigned by SATNUM). The saturation axis is rescaled to a modified critical(residual) oil-in-gas saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical(residual) oil-in-gas saturation is the largest oil saturation for which oil relative permeability is zero in the gas-oil relative permeability table. Oil relative permeability is zero at this saturation. SOGCR can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables.

The end-point scaling option, is discussed in [Section 10.3](#) and in [Section 10.4](#) inside the Technical Description.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.45

### Example

SOGCR is used here in a dual media case to assign critical oil-in-gas saturation for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
SOGCR
 9000*0.25  9000*0.05  /
```



## 2.388 SOLVER

### Description

The [SOLVER](#) keyword can be used to adjust parameters for the linear and nonlinear solver algorithms. It is followed by a single slash-terminated record containing an arbitrary number of key-value pairs for the form NAME=value. The valid mnemonics for NAME, their associated possible and default values together with a brief description are enumerated in the table below.

Insights on the various parameters and how they are connected can be found in [Chapter 3](#). Note that all SOLVER parameters are reported in the solver.log file, first at the beginning of the simulation and then any time they are updated using the keyword at hand.

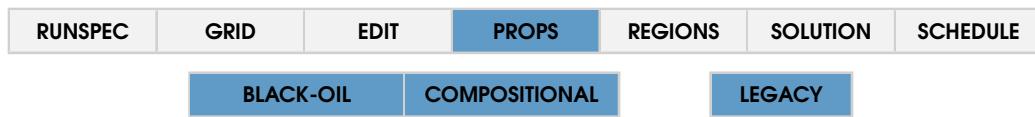
Default linear and non-linear solver settings have been carefully selected by simulator developers and any modification may lead to unexpected results, most often increasing the simulation time or making the model largely unstable. We recommend modifying SOLVER default values carefully.

### Record format

Name	Value Type	Default	Description
ABSTOL	Float	0.0	Absolute linear solver tolerance
CNVTOL	Float	BO: 0.001 COMP: N/A	Nonlinear convergence tolerance for black-oil models
CPR_STAGE2	String	Automatically selected based on model parameters	Second stage of CPR preconditioner: ANISO, DILU, GS, or ILU0
FIRST_NEWTON_NORM	Integer	BO: 1 COMP: 0	In deciding when the linear solve has converged, setting this flag to one measure the relative tolerance relative to the norm of the first Newton iteration, rather than the present Newton iteration.
FIRST_NEWTON_NORM_GUARD	Integer	1	When using the FIRST_NEWTON_NORM option, ensure that the linear residual is reduced by at least this factor when determining whether the linear solve has converged.
FULL_SETUP_NEWTONS	Integer		Number of Newtons for which to reconstruct the full AMG hierarchy (see <a href="#">Section 3.8</a> in the Technical Description).
GAMPACK_MAX_ITER	None	1	Maximum number of GMRES iterations to use in the AMG stage of the CPR preconditioner.
GAMPACK_REL_TOL	None	0.0	Target relative tolerance for the first stage (AMG) of the CPR preconditioner.
GMRES_VECS	Float	20	Number of GMRES history vectors
ILUK_PASSES	Integer	3 for ANISO, 1 otherwise	Number of passes of the second stage preconditioner

LIMIT_NEXT_TIMESTEP	Float	BO: 365 COMP: 50	The maximum size permitted on the timestep following this SOLVER keyword (units are days)
MAX_CNVTOL	Float	BO: 0.01 COMP: N / A	The maximum acceptable nonlinear convergence error after all of Newton iterations have been expended.
MAX_HCPHASE_INTRODUCTION	Integer	BO: N/A COMP: 5	Maximum number of times to introduce a new hydrocarbon phase due to flash. Setting this to a smaller value may allow timesteps to converge that would otherwise oscillate between having one and two hydrocarbon phases.
MAX_ITERS	Integer		The maximum number of linear iterations per Newton iteration
MAX_MBETOL	Float	1e-6	The maximum acceptable material balance error after all Newton iterations have been expended.
MAX_NEWTONS	Integer	12	The maximum number of Newton iterations per timestep
MAX_TIMESTEP	Float	BO: 365 COMP: 50	The maximum timestep length
MBETOL	Float	BO: 1e-7 COMP: 1e-6	Tolerance of the material balance error
MIN_ITERS	Integer	1	Minimum linear iterations per Newton
MIN_NEWTONS	Integer	1	Minimum Newton iterations per timestep
PRES_CHOP	Float	1500 psi	The maximum cell pressure update allowed in a Newton iteration. Any update with a magnitude greater than this value will be clamped.
PRES_CHOP_WELL	Float	0.15 psi	The maximum pressure update allowed for each grid cell containing a connection to a well in a Newton iteration. If the grid cell pressure change exceeds the well BHP limit plus a hydrostatic correction by this amount, it is clamped so that the connection will continue to flow. If in the subsequent non-linear iteration the pressure change is in the same direction, the chop is no longer applied.
RELTOL	Float	0.001	Relative linear tolerance
SAT_CHOP	Float	0.2	Maximum cell saturation update in a Newton iteration. Larger values will be clamped to this value.
SCALE_ADAPTIVE	Integer	0	If nonzero, this will enable adaptive scaling of the nonlinear update
SCALE_AFTER_NEWTON	Float	0	If nonzero, apply a newton damping factor starting after the N <sup>th</sup> newton iteration of each timestep, where N is the number provided

UPDATE_SCALE	Float	0.9	Nonlinear update scaling factor to be applied if SCALE_AFTER_NEWTON is set
WELL_STAGE1	String	exact	If “exact”, active well constraints are included directly in the CPR pressure matrix. If set to “approx”, wells will be treated in the first CPR stage through an approximate Schur complement.
WELL_STAGE2	None	no	Defaults to “no”, meaning wells are not included in the second stage preconditioner. If set to “approx”, wells will be treated in the second CPR stage through an approximate Schur complement.
WELL_VAR_NUM	Integer	1	If set to 3 in black-oil models, this will use three primary variables for each well, rather than the default of a single primary variable (the well BHP).



## 2.389 SOWCR

### Description

The SOWCR keyword allows the user to rescale the horizontal saturation axis for water-oil relative permeability tables (*e.g.* SWOF tables assigned by SATNUM). The saturation axis is rescaled to a modified critical(residual) oil-in-water saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical(residual) oil-in-water saturation is the largest oil saturation for which oil relative permeability is zero in the water-oil relative permeability table. Oil relative permeability is zero at this saturation. SOWCR can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables.

The end-point scaling option, including consistency requirements such as  $\text{SWCR} + \text{SOWCR} \leq 1$ , is discussed in [Section 10.3](#) and in [Section 10.4](#) inside the Technical Description.

The technical manual describes the details for end-point scaling.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.46

### Example

SOWCR is used here in a dual media case to assign critical oil-in-water saturation for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
SOGCR
9000*0.20  9000*0.05  /
```



## 2.390 SPOLY

### Description

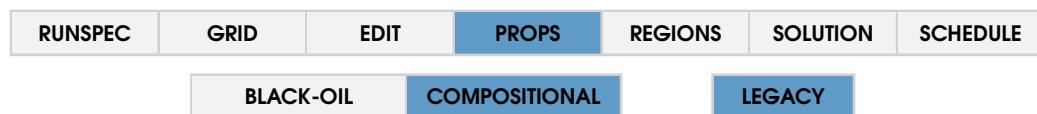
The keyword defines the polymer concentration of the reservoir as a 3D array, which means one value for each cell. The keyword should only be used if the Polymer Flood Model is activated using the keyword [POLYMER](#). The keyword must be terminated with a trailing slash.

**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)

### Example

This [SPOLY](#) keyword sets concentration in a grid of 15 cells.

```
SPOLY  
5*0.2 5*0.3 0.0 4*0.4 /
```



## 2.391 SSHIFT

### Description

This keyword specifies the volume shift parameters of the hydrocarbon components in a compositional simulation. The number of volume shift parameters should be equal to the number of components in the simulation. If multiple equations of state are used, values must be specified for each of them. See [Section 7.4](#) of the Technical Description for further details about equation-of-state parameters.

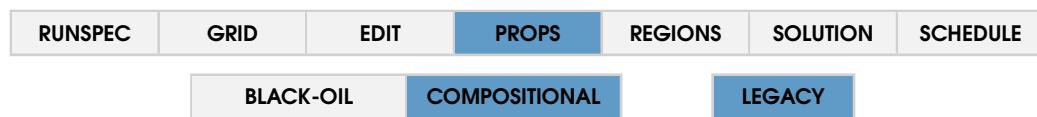
### Record format

1. **VOL\_SHIFT:** (repeated NCOMP times)  
Component volume shift parameters.  
The default value used by the simulator is 0 for each component, so no shift is applied.  
**Type:** Float

### Example

This example specifies the volume shift parameters for a compositional simulation with five components

```
SSSHIFT  
-0.102 -0.042 -0.288 -0.103 -0.077 -0.056 /
```



## 2.392 SSHIFTS

### Description

This keyword specifies the volume shift parameters of the hydrocarbon components for the surface equation of state in a compositional simulation. The number of volume shift parameters should be equal to the number of components in the simulation. If multiple surface equations of state are used, values must be specified for each of them. See [Section 7.4](#) of the Technical Description for further details about equation-of-state parameters.

### Record format

1. **VOL\_SHIFTS:** Component volume shift parameters

The default value used by the simulator is 0 for each component, so no shift is applied.

**Type:** Float

### Example

This example specifies the volume shift parameters for the surface equation of state in a compositional simulation with five components

```
SSHIFTS  
-0.102 -0.042 -0.288 -0.103 -0.077 -0.056 /
```



## 2.393 START

### Description

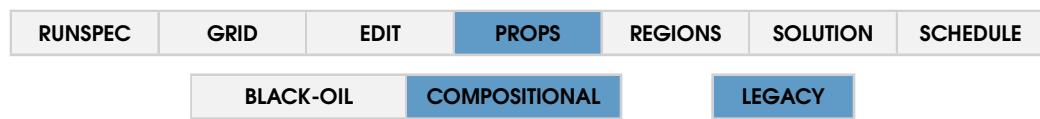
The **START** keyword is used to specify the day and time in which the simulation begins. The keyword should be followed by a single slash-terminated record in the format given below. If not provided, the start defaults to 1 JAN 1990 at 00:00.

### Record format

Field	Name	Type	Description
1	DAY	Integer	Day of the month (1-31)
2	MONTH	String	One of JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, or DEC. JLY is also accepted for July.
3	YEAR	Integer	Four-digit year
4	TIME	String	Time of day in the format HH:MM:SS.SSSS, where HH is [0-23].

### Example

```
RUNSPEC  
START  
19 APR 2013 /
```



## 2.394 STCOND

### Description

This keyword specifies the values of standard temperature and pressure used in a compositional run. If no other separators are defined using the [SEPCOND](#), [WSEPCOND](#) or [FIELDSEP](#) keyword, a flash to the conditions specified in the STCOND keyword is used to compute surface volumes.

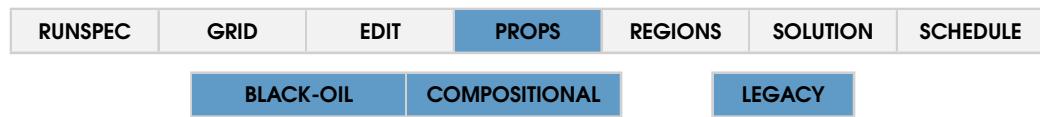
### Record format

1. **ST\_TEMP:** Standard Temperature Value  
**Type:** Float  
**Units:** Fahrenheit (FIELD), Celsius (METRIC)  
**Default value:** 60 (FIELD), 15.56 (METRIC)
2. **ST\_PRESS:** Standard Pressure Value  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 14.6959 (FIELD), 1.01325 (METRIC)

### Example

This example specifies the standard conditions to be used in a compositional run.

```
STCOND
15 1 /
```



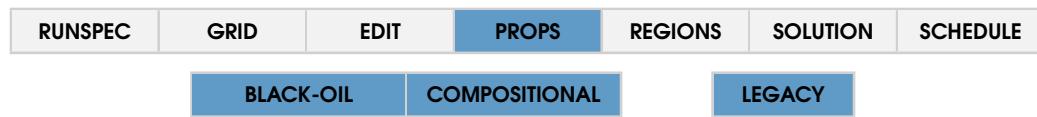
## 2.395 STONE

### Description

This keyword, without records, is an alias for the [STONE2](#) keyword. By default, ECHELON uses a simplified Baker model. See [Chapter 10](#) for more details.

### Example

```
STONE
```



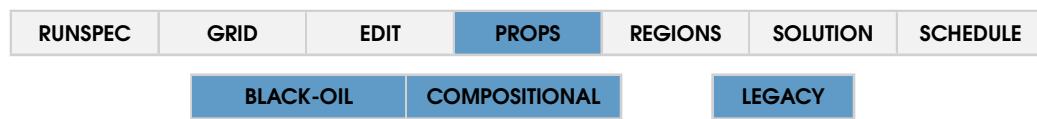
## 2.396 STONE1

### Description

This keyword instructs ECHELON to use the first Stone method for three-phase oil relative permeability interpolation. By default, ECHELON uses a simplified Baker model. See [Chapter 10](#) for more details.

### Example

```
STONE1
```



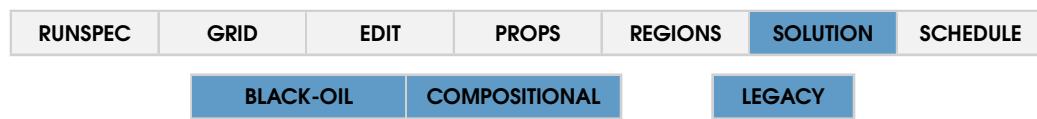
## 2.397 STONE2

### Description

This keyword instructs ECHELON to use the second Stone method for three-phase oil relative permeability interpolation. By default, ECHELON uses a simplified Baker model. See [Chapter 10](#) for more details.

### Example

```
STONE2
```



## 2.398 SWAT

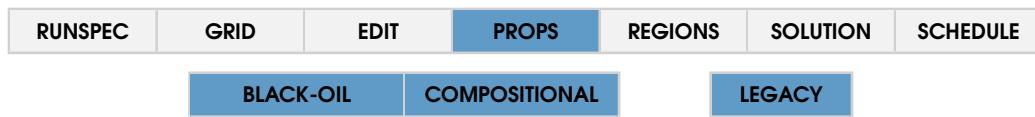
### Description

The [SWAT](#) keyword is used to specify the initial water saturation of each cell in the reservoir when using an enumerated initial state rather than hydrostatic equilibrium. The keyword should be followed by a single record containing  $NX \times NY \times NZ$  values, i.e. one saturation for every cell in the reservoir. Similarly, values for [PRESSURE](#) should be given, as well as [SGAS](#) for simulations containing gas. For compositional simulations, see also [XMY](#), [YMF](#), [ZMF](#), and [ZI](#) for providing the initial composition of the reservoir fluids as well as [TEMPI](#) or [RTEMP](#) for providing the initial temperature.

### Example

For a  $20 \times 10 \times 1$  reservoir with uniform water saturation of 0.31:

```
SOLUTION  
SWAT  
200*0.31 /
```



## 2.399 SWATINIT

### Description

The SWATINIT keyword is used in the [PROPS](#) section to “force” a specified equilibrium initial water saturation of each cell in the reservoir rather than using standard hydrostatic equilibrium based on user-defined capillary pressures and fluid densities. This method , outlined in [Section 10.4](#) in the Technical Description, is based on end-point scaling using calculated [PCW](#) end-point values. The keyword should be followed by a single record with one water saturation per cell. Values must be provided using natural I, J, K ordering and the entire grid should be assigned a SWATINIT value.

The use of SWATINIT requires input capillary pressure curves to be defined for the cells. Note that the water-oil capillary pressure functions must have at least one positive value. In each cell, the [PCW](#) endpoint is calculated so that the water saturation obtained by capillary equilibrium equals the desired saturation.

In the regions of the model where the J-function model is active, or where user-input [PCW](#) values exist, these are disregarded, and priority is given to matching the desired water saturation. The modified capillary pressure curves affect the simulation beyond the initialization phase and thus extremely large and nonphysical capillary pressures may lead to undesired results. It is possible to define an upper bound in the [PCW](#) value using the [PPCWMAX](#) keyword. In this case, capillary pressure is bound by the [PPCWMAX](#) threshold and SWATINIT values are decreased in the appropriate cells. If SWATINIT values are less than the capillary pressure defined connate saturation, then settings on the [PPCWMAX](#) keyword can be used to determine which connate value is to be honored.

### Example

This sets initial water saturation for a 5-layer model with 1000 cells per layer

```
SWATINIT
 1000*0.20
 1000*0.25
 1000*0.32
 1000*0.41
 1000*0.55 /
```



## 2.400 SWCR

### Description

The SWCR keyword allows the user to rescale the horizontal saturation axis for water-oil relative permeability tables (*e.g.* SWOF tables assigned by SATNUM). The saturation axis is rescaled to a modified critical water saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Critical water saturation is the largest water saturation for which water relative permeability is zero in the relative permeability table. Relative permeability is zero at this saturation. SWCR can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables.

The end-point scaling option, including consistency requirements such as SWL $\leq$ SWCR, is discussed in Section 10.3 and in Section 10.4 inside the Technical Description.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.47

### Example

SWCR is used here in a dual media case to assign critical water saturation for flow in the matrix (top reservoir half) and fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
SWCR
 9000*0.26  9000*0.03 /
```



## 2.401 SWFN

### Description

The SWFN keyword provides a tabulation of the water relative permeability and water-oil capillary pressure as a function of water saturation. The table consists of three columns for  $S_w$ ,  $k_{rw}$ , and  $p_{cow}$ , respectively, and it is terminated by a slash (/).

The first saturation value provide defines the connate water saturation,  $S_{wco}$ . Then, the largest table water saturation with zero  $k_{rw}$  defines the critical water saturation  $S_{wcr}$ . For this purpose, any relative permeability value below a threshold of  $10^{-6}$  is set to zero. This threshold value can be modified using [TOLCRIT](#).

In the second and third columns, it is possible to use default values (1\*). When the table is read by the simulator, these values will be replaced by a linear interpolation based on adjacent non-defaulted values.

NTSFUN (see [TABDIMS](#) keyword) tables should be provided after the keyword. Any table other than the first can consist of an empty record. In this case, the table for that saturation region will be defaulted to the previous table. See [Chapter 10](#) of the ECHELON Technical Description for more information.

### Table columns

1. **SW:** Water saturation (strictly increasing)
  2. **KRW:** Water relative permeability (increasing)
  3. **PCOW:** oil-water capillary pressure (decreasing)
- Units:** psi (FIELD), bar (METRIC)

### Example

Water relative permeability and oil-water capillary pressure provided using SWFN for a model with NTSFUN=3

```

SWFN
-- SW      KRW      PCOW
 0.2      0        10
 0.3      0.05     2.0
 0.4      0.2      0.5
 0.5      0.4      1*
 0.6      0.6      1*
 0.8      0.8      0.1
 1.0      1.0      0.07
/
 0.4      0        10
 0.45     0.05     5.0
 0.50     0.2      0.5
 0.55     0.4      1*
 0.6      0.6      1*
 0.8      0.8      0.1
 1.0      1.0      0.07
/
/

```



## 2.402 SWL

### Description

The SWL keyword allows the user to rescale the horizontal saturation axis for water-oil relative permeability tables (*e.g.* SWOF tables assigned by SATNUM). The saturation axis is rescaled to a modified lowest (connate) water saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Lowest (connate) water saturation is the smallest water saturation in the relative permeability table. Relative permeability is zero at this saturation. SWL can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables.

The end-point scaling option, including consistency requirements such as  $\text{SWL} \leq \text{SWCR}$ , is discussed in Section 10.3 and in Section 10.4 inside the Technical Description.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

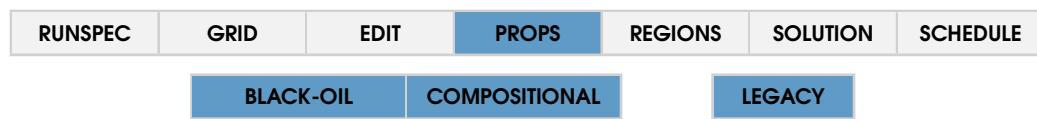
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.48

### Example

SWL is used here in a dual media case to assign lowest (connate) water saturation for flow in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fractures cells.

```
SWL
 9000*0.24  9000*0.02 /
```



## 2.403 SWLPC

### Description

The SWLPC keyword allows the user to rescale the horizontal saturation axis for water-oil capillary pressure (*e.g.* SWOF tables assigned by SATNUM). The saturation axis is rescaled to a modified lowest (connate) water saturation value for water-oil capillary pressure on a cell-by-cell basis. Water-oil relative permeability tables are not impacted by this keyword. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Lowest (connate) water saturation is the smallest water saturation in the water-oil capillary pressure table. Capillary pressure is a maximum at this saturation. SWLPC can be used for cases without hysteresis or cases with drainage tables with hysteresis (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables or by SWL values input for water-oil relative permeability.

The end-point scaling option, including consistency requirements such as  $\text{SWL} \leq \text{SWCR}$ , is discussed in [Section 10.3](#) and in [Section 10.4](#) inside the Technical Description.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

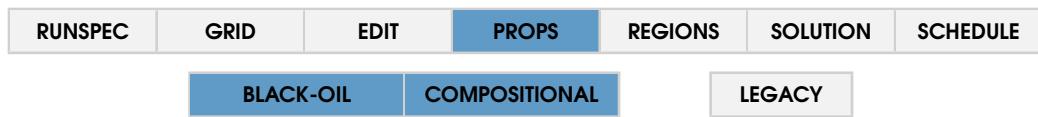
Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.49

### Example

SWLPC is used here in a dual media case to assign lowest (connate) water saturation for water-oil capillary pressure in the matrix (top reservoir half) and for the fractures (bottom reservoir half). This model has 9000 matrix cells and 9000 fracture cells.

```
SWLPC
 9000*0.22  9000*0.0 /
```



## 2.404 SWOCOREY

### Description

This keyword can be used to define Corey saturation function for oil-water. For a more detailed description of this keyword refer to Technical Documentation [Chapter 10](#).

The oil-water Corey saturation and capillary pressure functions are expressed as follows.

$$k_{row}(s_w) = \begin{cases} k_{rorw} + (k_{rolw} - k_{rorw}) \frac{s_{wcr} - s_w}{s_{wcr} - s_{wl}} & s_{wl} \leq s_w < s_{wcr} \\ k_{rorw} \left(1 - \frac{s_w - s_{wcr}}{1 - s_{wcr} - s_{owcr} - s_{gl}}\right)^{Noil} & s_{wcr} \leq s_w \leq 1 - s_{owcr} - s_{gl} \\ 0 & 1 - s_{owcr} - s_{gl} < s_w \leq s_{wu} \end{cases}$$

$$k_{rw}(s_w) = \begin{cases} 0 & s_{wl} \leq s_w < s_{wcr} \\ k_{rwr} \left(\frac{s_w - s_{wcr}}{1 - s_{wcr} - s_{owcr} - s_{gl}}\right)^{Nwat} & s_{wcr} \leq s_w \leq 1 - s_{owcr} - s_{gl} \\ k_{rwu} - (k_{rwu} - k_{rwr}) \frac{s_{wu} - s_w}{s_{owcr} + s_{wu} + s_{gl} - 1} & 1 - s_{owcr} - s_{gl} < s_w \leq s_{wu} \end{cases}$$

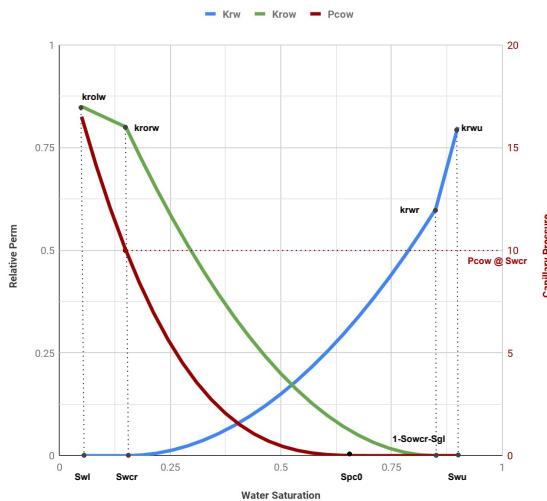
$$P_{cow}(s_w) = \begin{cases} p_{swcr} \left(\frac{s_{pc0} - s_w}{s_{pc0} - s_{wcr}}\right)^{Np} & s_{wl} \leq s_w \leq s_{pc0} \\ 0 & s_{pc0} < s_w \leq s_{wu} \end{cases}$$

Note that if there is a J-function defined on water (or both phases), the following correlation is used instead of aforementioned capillary pressure,

$$J_{ow}(s_w) = \begin{cases} (0.001)^{1/Np} & s_{wl} \leq s_w \leq s_{pc0} \\ \left(\frac{s_w - s_{pc0}}{p_{swcr}}\right)^{1/Np} & s_{pc0} < s_w \leq s_{wu} \end{cases}$$

It is assumed that the exponent is chosen to be a negative value ( $Np < 0$ ), which means the second equation is discontinuous for  $s_w$  equal to  $s_{pc0}$  and goes to infinity. In order to avoid this problem, the correlation value is bounded to  $(0.001)^{1/Np}$  for  $s_{wl} \leq s_w \leq s_{pc0}$  as defined.

The number of records in [SWOCOREY](#) should match the number of saturation functions that is defined in [TABDIMS](#). The keyword is terminated with an empty record (/).



**Figure 2.4: Example plot of relative perm and capillary pressure curves using SWOCOREY.**

### Record format

1. **SWL:** Minimum water saturation  
**Type:** Float  
**Default value:** 0.0
2. **SWCR:** Critical water saturation  
**Type:** Float  
**Default value:** equal to SWL
3. **SOWCR:** Residual oil saturation  
**Type:** Float  
**Default value:** 0.0
4. **SWU:** Maximum water saturation  
**Type:** Float  
**Default value:** 1.0
5. **KROLW:** Maximum oil-water relative perm at SWL  
**Type:** Float  
**Default value:** 1.0
6. **KRORW:** Maximum oil-water relative permeability at SWCR  
**Type:** Float  
**Default value:** equal to KROLW
7. **KRWR:** Maximum water relative perm at 1 - SWOR - SGL, where SGL is the minimum gas saturation  
**Type:** Float  
**Default value:** equal to KRWU
8. **KRWU:** Maximum water relative perm at SWU  
**Type:** Float  
**Default value:** 1.0
9. **PSWCR:** Oil-water capillary pressure at SWCR  
**Type:** Float  
**Default value:** 0.0
10. **SPC0:** Water saturation where capillary pressure becomes zero

**Type:** Float

**Default value:** equal to SWU

11. **Noil:** Polynomial degree for oil-water relative perm curve

**Type:** Float

**Default value:** 1.0

12. **Nwat:** Polynomial degree for water relative perm curve

**Type:** Float

**Default value:** 1.0

13. **Np:** Polynomial degree for oil-water capillary pressure curve

**Type:** Float

**Default value:** 1.0

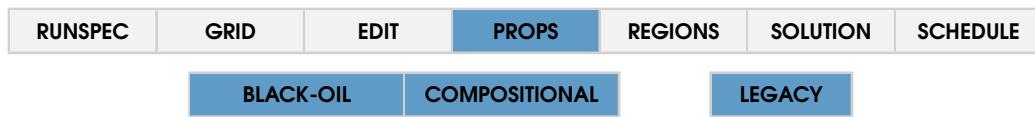
#### Example 1

```
SWOCOREY
-- swl swcr sowcr swu krolw krrow krwr krwu Pswcr spc0 No Nw Np
  0.1 0.15 0.15 0.9 0.9    0.8   0.6 0.8   10.0 0.7 2.5 2.0 3.0 /
/
```

#### Example 2

If all the parameters in **SWOCOREY** are defaulted, Corey function will generate linear saturation functions between 0.0 and 1.0 for relative permeabilities with zero capillary pressure.

```
SWOCOREY
-- Default all the inputs
13* /
/
```



## 2.405 SWOF

### Description

The SWOF keyword is used to specify tables for interpolating the relative permeability of water and oil along with capillary pressure between the phases as a function of water saturation. If the gas phase is present in the system, [SGOF](#) or [SLGOF](#) must also be used. Data is provided in tabular form in four columns with monotonically increasing water saturation. Each table should be terminated with a slash (/).

In the second, third and fourth columns it is possible to use default values (1\*). When the table is read by the simulator, these values will be replaced by a linear interpolation based on adjacent non-defaulted values.

The critical saturations for each relative permeability, namely  $s_{wcr}$  and  $s_{owcr}$ , are defined using the largest table water saturation with zero  $k_{rw}$  and the lowest table water saturation where  $k_{rwo}$  is zero. For this purpose any relative permeability value below a threshold of  $10^{-6}$  is set to zero. This threshold value can be modified using [TOLCRIT](#). See [Chapter 10](#) of the Technical Description for more information.

NTSFUN (see [TABDIMS](#) keyword) tables should be provided after the keyword. Any table other than the first can consist of an empty record. In this case, the table for that saturation region will be defaulted to the previous table.

### Table columns

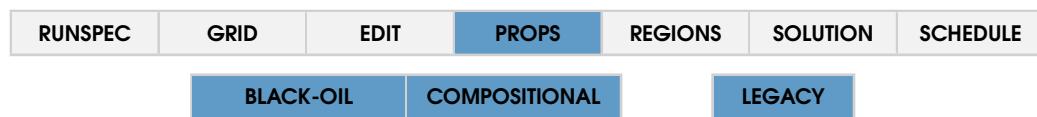
1. **SWAT:** Water saturation (strictly increasing). The first value is connate water saturation and the last value should be 1.0  
**Minimum:** 0.0  
**Maximum:** 1.0
2. **KRW:** Water relative permeability (increasing). The first value should be zero.  
**Minimum:** 0.0  
**Maximum:** 1.0
3. **KRO:** Oil relative permeability (decreasing).  
**Minimum:** 0.0  
**Maximum:** 1.0
4. **PCWO:** Oil-water capillary pressure (decreasing)  
**Units:** psi (FIELD), bar (METRIC)  
**Minimum:** -inf  
**Maximum:** inf

### Example

For a model with a single saturation region:

SWOF			
--Sw	Krw	Krow	Pcwo
0.2	0.0	0.9	10.0
0.25	0.1	0.8	1.0
0.35	0.2	0.5	1*
0.55	0.4	0.3	1*
0.75	0.6	0.0	0.5
1.0	1.0	0.0	0.4

In this case  $S_{wcr} = 0.2$  and  $S_{owcr} = 1.0 - 0.6 = 0.4$



## 2.406 SWU

### Description

The SWU keyword allows the user to rescale the horizontal saturation axis for water-oil relative permeability tables (*e.g.* SWOF tables assigned by SATNUM). The saturation axis is rescaled to a modified highest possible water saturation value on a cell-by-cell basis. Values are expected for each cell in the current input BOX following the natural I, J, K grid ordering. Highest water saturation is the maximum water saturation in the relative permeability table. Water relative permeability should be greater than zero at this saturation. SWU can be used for cases without hysteresis or for drainage tables with hysteresis cases (see SATOPTS). Any endpoints not rescaled will use those defined by the corresponding input tables. The technical manual describes the details for end-point scaling. The manual also describes end-point consistency requirements. SWU is commonly set to a value of 1.0.

The end-point scaling option, including consistency requirements such as SWL $\leq$ SWCR, is discussed in Section 10.3 and in Section 10.4 inside the Technical Description.

Additional endpoint arrays are allowed for capillary pressures (*e.g.* PCW), relative permeability (*e.g.* KRW) and low-salinity flooding (*e.g.* LSWL). Following are the possible endpoint saturation arrays.

Array	Description
SWL	Drainage lowest water saturation
ISWL	Imbibition lowest water saturation
SWLPC	Drainage lowest water saturation for capillary pressure
ISWLPC	Imbibition lowest water saturation for capillary pressure
SWCR	Drainage critical water saturation
ISWCR	Imbibition critical water saturation
SWU	Drainage upper (maximum) water saturation
ISWU	Imbibition upper (maximum) water saturation
SOWCR	Drainage critical oil saturation in water-oil tables
ISOWCR	Imbibition critical oil saturation in water-oil tables
SOGCR	Drainage critical oil saturation in gas-oil tables
ISOGCR	Imbibition critical oil saturation in gas-oil tables
SGL	Drainage lowest gas saturation
ISGL	Imbibition lowest gas saturation
SGCR	Drainage critical gas saturation
ISGCR	Imbibition critical gas saturation

Table 2.50

### Example

SWU is used here to assign highest water saturation for water-oil relative permeability. This model has 10000 cells.

```
SWU
 10000*0.99 /
```



## 2.407 TABDIMS

### Description

This keyword is used to set the size of various tables, including PVT and relative permeability tables. It is followed by a single slash terminated record with some fields reserved for future usage.

### Record format

1. **NTSFUN:** Number of saturation functions used in the PROPS sections using, for instance, [SWOF/SGOF](#) keywords.  
**Type:** Integer  
**Default value:** 1
2. **NTPVT:** Number of PVT tables (e.g. [PVT0](#) tables) in the PROPS section  
**Type:** Integer  
**Default value:** 1
3. *Reserved*
4. *Reserved*
5. **NTFIP:** Maximum number of fluid in place regions defined using [FIPNUM](#)  
**Type:** Integer  
**Default value:** 1
6. *Reserved*
7. *Reserved*
8. *Reserved*
9. **NEOSR:** Number of EOS regions for reservoir conditions  
**Type:** Integer  
**Default value:** 1
10. **NEOSS:** Number of EOS regions for surface conditions  
**Type:** Integer  
**Default value:** NEOSR
11. **NFLUX:** Maximum Number of flux regions defined using [FLUXNUM](#). **NFLUX** can also be set using [REGDIMS](#) keyword and , if it is set using both [REGDIMS](#) and [TABDIMS](#) the largest value is taken.  
**Type:** Boolean  
**Default value:** 1
12. *Reserved*
13. **NTABROCK:** Number of rock compaction tables (see, e.g. [ROCK](#) or [ROCKTAB](#))  
**Type:** Integer
14. **NPMANNUM:** The maximum number of pressure maintenance regions (see [PMANUM](#) keyword).  
**Type:** Integer  
**Default value:** 0

**Example**

To set three saturation tables and four PVT tables in a black-oil model:

```
TABDIMS  
3 4 /
```



## 2.408 TBLK

### Description

The keyword defines tracer concentrations of the reservoir as a 3D array, which means one value for each cell. The keyword must be terminated with a trailing slash.

The keyword should be appended by additional characters according to the formulation of the model (black-oil or compositional).

Black-oil formulation:

- Character 5. The letter 'F' should be used for a tracer existing only in the free phase. Water and non-vaporizing oil tracers are typical examples. When the tracer can be partitioned between free and solution phases, TVDP should be initialized twice using letters 'F' and 'S'. Oil and gas tracers with the ability of a phase to vaporize or dissolve are the typical examples (see [VAPOIL](#) and [DISGAS](#)).
- Characters 6-8. The tracer name from [TRACER](#) (up to 3 characters).

Compositional formulation:

- Characters 5-8. The tracer name from [TRACER](#) (up to 4 characters).

**Units** are based on TRACER\_UNITS as defined using [TRACER](#) keyword (e.g. kg):

- [METRIC](#) TRACER\_UNITS/sm<sup>3</sup>
- [FIELD](#) TRACER\_UNITS/stb for tracers in liquid phases, and TRACER\_UNITS/Mscf for gas phase tracers.

### Example 1

This example specifies tracer 'TRA' concentration values for a 100-cell model. The host oil phase can vaporize (see [VAPOIL](#)).

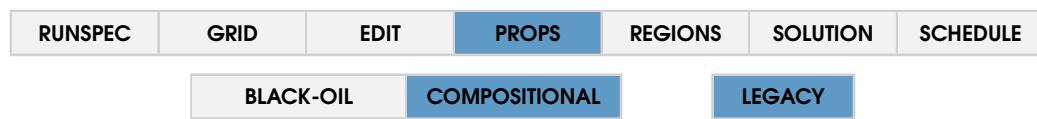
```
-- free phase
TBLKFTRA
100*0.0 /

-- solution phase
TBLKSTRA
100*1.0 /
```

### Example 2

This example specifies compositional tracer 'TRAB' concentration values for a 500 cells model.

```
TBLKTRAB
250*0.0 250*1.0 /
```



## 2.409 TCRIT

### Description

This keyword specifies the critical temperatures of the hydrocarbon components in a compositional simulation. It is followed by NEOSR slash terminated records, one for each reservoir equation of state region, each of them providing  $n_c$  critical temperature, one for each component.

NEOSR is defined using the ninth field in [TABDIMS](#) keyword.

### Record format

1. **T\_CRIT:** (repeated NCOMP times)

$n_c$  Component critical temperatures

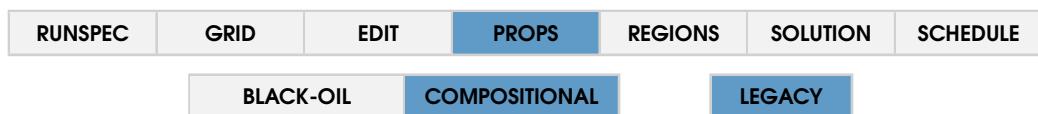
**Type:** Float

**Units:** Rankine (FIELD), Kelvin (METRIC)

### Example

This example specifies the critical temperatures for a compositional simulation with five components

```
TCRIT  
548.46 227.16 343.08 549.77 665.64 /
```



## 2.410 TCRITS

### Description

This keyword specifies the critical temperatures of the hydrocarbon components for the surface equation of state computations in a compositional simulation. It is followed by NEOSS slash terminated records, one for each surface equation of state region, each of them providing  $n_c$  critical temperature, one for each component.

If the keyword is not provided the values specified in [TCRIT](#) are used.

NEOSS is defined using the tenth field in [TABDIMS](#) keyword.

### Record format

1. **T\_CRITS:** Component critical temperatures

**Type:** Float

**Units:** Rankine (FIELD), Kelvin (METRIC)

### Example

This example specifies the critical temperatures for the surface equation of state in a compositional simulation with five components

```
TCRITS  
548.46 227.16 343.08 549.77 665.64 /
```



## 2.411 TEMPI

### Description

The [TEMPI](#) keyword is used to specify the initial temperature of each cell in a compositional reservoir model when using an enumerated initial state rather than hydrostatic equilibrium. The keyword should be followed by a single record containing  $NX \times NY \times NZ$  values, i.e. one temperature for every cell in the reservoir. Similarly, values for [SWAT](#) should be given, as well as [SGAS](#) for simulations containing gas. For compositional simulations, see also [XMF](#), [YMF](#), [ZMF](#), and [ZI](#) for providing the initial composition of the reservoir fluids. For models with vertical equilibration, see [RTEMP](#) and [TEMPVD](#) for providing constant temperature or temperature varying with depth, respectively. If this keyword is specified for only part of the grid, the initial temperature for the remainder of the grid will be set using [RTEMP](#) or [TEMPVD](#), or if neither is specified, the default reservoir temperature of 100 °C.

**Units:** Fahrenheit (FIELD), Celsius (METRIC)

### Example

For a  $10 \times 20 \times 3$  reservoir with uniform temperature of 250 degrees:

```
SOLUTION  
TEMPI  
600*250.0 /
```



## 2.412 TEMPVD

### Description

This keyword is used to tabulate the value of temperature versus depth for use in vertical equilibration with the [EQUIL](#) keyword in compositional models.

The data consists of two columns in each record. The first gives the depth measured in feet ([FIELD](#)) or meters ([METRIC](#)). The second column is the temperature given in degree Fahrenheit ([FIELD](#)) or Celsius ([METRIC](#)). A slash-terminated table record should be provided for each equilibration region. The number of regions is specified in the first field of [EQLDIMS](#).

### Table columns

1. **DEPTH:** Depth  
**Units:** ft ([FIELD](#)), m ([METRIC](#))
2. **TEMP:** Temperature  
**Units:** Fahrenheit ([FIELD](#)), Celsius ([METRIC](#))

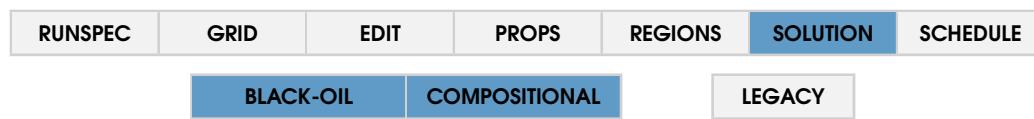
### Notes

This keyword has limited support for a special polymer degradation model (see [PLYDEGT](#)) for the black-oil formulation.

### Example

For constant temperature vs. depth:

```
TEMPVD
-- Depth (m)  Temperature (C)
 2000        123.0
 2400        123.0
/
```



## 2.413 THPRES

### Description

This keyword defines the threshold pressure between different equilibration regions. This threshold defines the potential difference between two regions before flow can occur between those regions. An equilibration region can be defined by using [EQLNUM](#) in [REGIONS](#) section. Threshold pressure option is turned on using [EQLOPTS](#) keyword in [RUNSPEC](#). The simulator uses a threshold pressure  $\Delta p$  to evaluate fluxes between each pair of equilibration regions set in the first two fields of each record. More specifically, if IRREVERS is selected in [EQLOPTS](#), then two  $\Delta p$  values are set at equilibration regions interfaces, one for each direction.

The keyword is followed by an arbitrary number of slash terminated records, with Record format described below, with an empty, slash terminated record to close keyword input. The maximum equilibration region number, [NTEQUL](#) is set in [EQLDIMS](#).

### Record format

1. **EQLNUM1:**  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NTEQUL
2. **EQLNUM2:**  
**Type:** Integer  
**Minimum:** 1  
**Maximum:** NTEQUL
3. **DELTAP:**  $\Delta p$  threshold for fluxes from EQLNUM1 to EQLNUM2 (and vice versa if IRREVRS is not set in [EQLOPTS](#)). A zero  $\Delta p$  forces the simulator to compute a threshold based on potentials for the various phases found at initialization.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Minimum:** 0  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)

### Example

In this example, the threshold pressure is defined between regions one/two, one/three and two/three. If [NTEQUL](#) is set to a value higher than three in [EQLDIMS](#), the threshold pressure for those regions will be zero.

```
THPRES
-- From To Threshold
  1     2    10.0  /
  2     1    12.0  /
  1     3    15.0  /
  3     1    15.0  /
  2     3    1*   /
/
```

Note that defining different values for flow from 1 to 2 and flow from 2 to 1 makes sense only if [EQLOPTS](#) turns on the IRREVERS feature. Threshold  $\Delta p$  between region 2 and 3 is computed by the simulator



## 2.414 THPRESFT

### Description

This keyword defines the threshold pressure across a fault already defined in the [FAULTS](#) keyword. To use this keyword, the option THPRES should be set in the equilibration option keyword [EQLOPTS](#) in [RUNSPEC](#). This keyword prevents flow across a fault while the potential difference does not exceed the defined threshold value. It can be used in conjunction with [THPRES](#), then, for a fault interface which is also an equilibration region interface the largest pressure threshold is used.

### Record format

1. **FAULT\_NAME:** Fault name as defined in [FAULTS](#). It is possible to use wildcards to set the option for many faults together.

**Type:** String

2. **DELTAP:** Threshold pressure.

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Minimum:** 0

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

### Example

In this example, the threshold pressure is defined across two faults

```
THPRESFT
-- Fault      Threshold
'FLT1'      10.0  /
'FLT2'      15.0  /
/
```



## 2.415 TIME

### Description

The `TIME` keyword is used to advance the simulation to specified absolute times since the beginning of the simulation specified in `START`. The keyword is followed by a single slash-terminated record containing an arbitrary number of times, expressed in days since the `START` date. The times should increase monotonically to avoid backward timestepping.

### Record format

1. **TIME:** (repeated \* times)

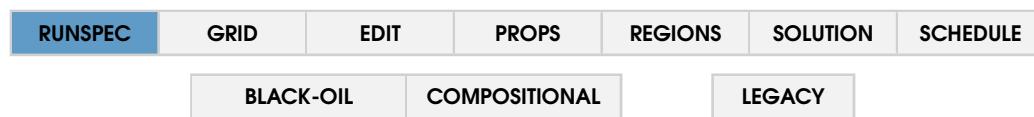
Time of report steps.

**Type:** Float

**Units:** Day (FIELD), Day (METRIC)

### Example

```
TIME
31 59 89 119 150 180 211 242 273 303 334 365 /
```



## 2.416 TIMEOUT

### Description

The **TIMEOUT** keyword allows the user to specify a maximum wall time limit for a simulation. If the wall time exceeds the specified limit, the simulator will terminate. This can be particularly useful in the case of multi-realization runs, since some combinations of parameters can result in unphysical situations that can lead to excessive timestep chopping and run time.

### Record format

1. **TIME:** Time limit

**Type:** Integer

2. **UNIT:** Time unit

**Type:** String

**Allowed values:**

Name	Description
S	Seconds
M	Minutes
H	Hours

#### Example 1

The default time unit is seconds, so the follow specifies a maximum run time of one hour.

```
TIMEOUT  
3600 /
```

#### Example 2

The following specifies a time limit of 145 minutes.

```
TIMEOUT  
145 M /
```



## 2.417 TITLE

### Description

The `TITLE` keyword is used to document the name of the case specified in the current input file. It has a unique format in that the line following the keyword is read as the title and the data is not terminated by a slash or other character.

#### Example

```
RUNSPEC  
TITLE  
Model from the SPE Third Comparative Solution Project
```

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SCHEDULE
		BLACK-OIL			COMPOSITIONAL	
					LEGACY	

## 2.418 TNUM

### Description

This keyword allows to initialize the concentration of a tracer in each grid block and link cells to tables of initial tracer concentration based on depth [TVDP](#). The keyword name is composed of three segments, with the first segment always being 'TNUM'. The keyword is followed by an integer value for each grid block which is the region number used to define initial tracer concentration for this region.

Black-oil formulation:

- Character 5. The letter 'F' should be used for a tracer existing only in the free phase. Water and non-vaporizing oil tracers are typical examples.
- Characters 6-8. The tracer name from [TRACER](#) (up to 3 characters).

Compositional formulation:

- Characters 5-8. The tracer name from [TRACER](#) (up to 4 characters).

### Example 1

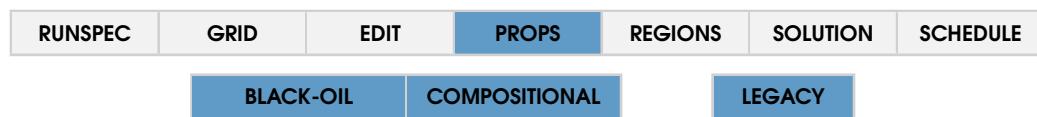
In this example the tracer BO exiting in free and solution states is defined for a model containing 200 grid blocks. First 100 grid blocks use the second TVDPFBO table.

```
TNUMFB0
100*2 100*1 /
TNUMSBO
100*1 100*1 /
```

### Example 2

In this example the tracer C1 is defined for a model containing 200 grid blocks. First 100 grid blocks use the second TVDPC1 table.

```
TNUMC1
100*2 100*1 /
```



## 2.419 TOLCRIT

### Description

The phase critical saturation is determined from the relative permeability table as the saturation for which the relative permeability becomes nonzero. Since the relative permeability is interpolated linearly, the saturation will become nonzero at the last node in the saturation table for which the relative permeability is zero. The **TOLCRIT** keyword sets the value of relative permeability below which it is considered zero to determine the critical saturation. It is followed by a single slash-terminated record containing a single value. This tolerance defaults to  $10^{-6}$ .

### Record format

1. **TOLCRIT:** Tolerance below which relative permeability is considered zero for determining the critical saturation.

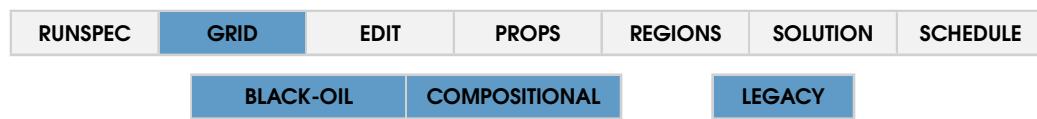
**Type:** Float

**Default value:**  $1.0e-6$

### Example

Set the tolerance for determining the critical saturation to  $10^{-4}$ .

```
TOLCRIT  
1.0e-4 /
```



## 2.420 TOPS

### Description

This keyword sets the depth of the top surface for the cells in the current input box, by default the entire grid, for a block-centered geometry. The simulator then needs one value for all the cells in the reservoir grid, but it is possible to define **TOPS** values for the first layer only: values for cells in the deeper layers will be computed using the thickness of the cells defined using **DZ** or **DZVAR** keywords.

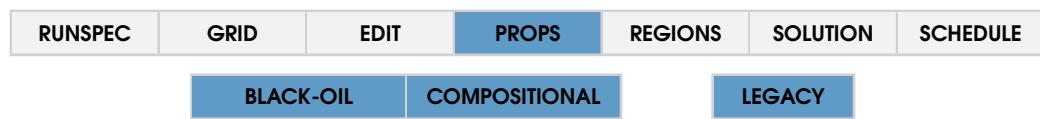
Values are provided following a natural ordering, with the I-index cycling faster, then J and eventually K, while repeat counts may be used for repeated values.

**Units:** ft (FIELD), m (METRIC)

### Example

**TOPS** is set for a first layer in a 10 x 10 x 3 grid, while values for the second and third layers are defined using thickness **DZ** provided in the first and second layers, respectively:

```
EQUALS
DZ 20 1 10 1 10 1 1 1 /
DZ 70 1 10 1 10 2 2 2 /
DZ 10 1 10 1 10 3 3 3 /
TOPS 6500 1 10 1 10 1 1 1 /
/
```



## 2.421 TRACER

### Description

This keyword allows specifying the number of passive tracers.

A tracer should be associated with a phase or a component for the black-oil and compositional formulations respectively.

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

See [Chapter 16](#) of the Technical Description for more information on tracers.

### Record format

1. **TRACER\_NAME:** The tracer name.  
Up to 3 characters for black-oil and 4 characters for compositional formulations.
2. **TRACER\_FLUID:** The associated fluid or component names.  
The fluid names can be set to OIL, WAT, GAS (black-oil formulation)  
Hydrocarbon component names should be taken from [CNAMES](#) and water component name is WATER (compositional formulation).
3. **TRACER\_UNITS:** The tracer units.  
The units are arbitrary, but should be consistent with [TBLK](#) and [TVDP](#).

### Example

This example sets specifies 2 tracers.

```
-- black-oil (max 3 symbols)
TRACER
'TR1' 'OIL' /
'TR2' 'GAS' /
/

-- compositional (max 4 symbols)
TRACER
'TR11' 'WATER' /
'TR22' 'C4' /
/
```



## 2.422 TRACK

### Description

This keyword allows tracking recovered hydrocarbon surface volumes from specified parts of the reservoir. The keyword may contain up to 4 values and should be terminated with a slash (/).

### Record format

1. **DIVISION\_METHOD:** The division method.

The following words should be used to specify the method:

- GOC - gas-oil contact
- DEPTH - user-defined depth (see item 2)
- REGONLY - user-defined regions (see [TRACKREG](#))

**Default value:** GOC

2. **DEPTH:** The division depth.

**Units:** ft (FIELD), m (METRIC)

**Minimum:** 0

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

3. *Reserved*

4. **COMPONENTS:** The list of hydrocarbon components.

The component names should be consistent with [CNAMES](#). The word ALL activates the tracking of all hydrocarbon components.

**Default value:** ALL

### Example 1

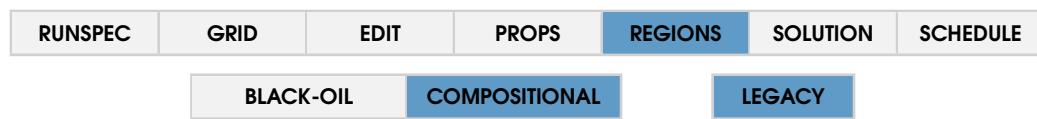
This example specifies tracking of all components using the default GOC division method.

```
TRACK
3* ALL /
```

### Example 2

This example specifies tracking of the 'C4' component.

```
TRACK
DEPTH    5000 1* C4 /
```



## 2.423 TRACKREG

### Description

This keyword specifies the region numbers used to initialize the concentration of a tracer in each grid block with the purpose to track the original fluid.

The first field in the Tracer Tracking option [TRACK](#) needs to be set to REGONLY for this keyword to take effect. The keyword defines a 3D array, with one value for each grid cell for a total of  $NX \times NY \times NZ$  integers. [TRACKREG](#) values are provided following a natural ordering with I indices running faster followed by J and then K, with the possibility to use repeated counts.

### Example

The following example sets the first 200 and remaining 100 cells to tracer tracking regions 1 and 2 correspondingly.

```
TRACKREG
 200*1
 100*2 /
```



## 2.424 TRANX

### Description

The keyword defines the transmissibility along the X- (I-) direction of the reservoir as a 3D array, which means one non-negative number for each cell. This overrides any previous computation of transmissibility along the I-direction, with the possibility to define a connection between cells that have no face overlap (e.g. because of a fault throw).

Cell **TRANX** values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). Then, **TRANX** value for cell (i,j,k) sets transmissibility with cell (i+1,j,k).

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

### Example

This **TRANX** keyword sets transmissibility in a grid of 15 cells:

```
TRANX  
15*0.5 /
```



## 2.425 TRANY

### Description

The keyword defines the transmissibility along the Y- (J-) direction of the reservoir as a 3D array, which means one non-negative number for each cell. This overrides any previous computation of transmissibility along the I-direction, with the possibility to define a connection between cells that have no face overlap (e.g. because of a fault throw).

Cell **TRANY** values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). Then, **TRANY** value for cell (i,j,k) sets transmissibility with cell (i,j+1,k).

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

### Example

This **TRANY** keyword sets transmissibility in a grid of 15 cells:

```
TRANY  
15*0.5 /
```



## 2.426 TRANZ

### Description

The keyword defines the transmissibility along Z (K) direction of the reservoir as a 3D array, which means one non-negative number for each cell. This overrides any previous computation of transmissibility along the I-direction, with the possibility to define a connection between cells that has no face overlap (e.g. because of a fault throw).

Cell `TRANZ` values are defined following a natural order where I index (for the x-direction) cycles faster, then followed by J (for Y) and K (for Z). Then, `TRANZ` value for cell (i,j,k) sets transmissibility with cell (i,j,k+1)

**Units:** cP·rb/(day·psi) (FIELD), cP·rm<sup>3</sup>/(day·bar) (METRIC)

### Example

This `TRANZ` keyword sets transmissibility in a grid of 15 cells:

```
TRANZ  
15*0.5 /
```



## 2.427 TSTEP

### Description

The **TSTEP** keyword is used to advance the simulation time by a set of time increments. It is followed by a single record containing an arbitrary number of numbers specifying the number of days to advance. The keyword is terminated by a slash (/). The simulator may elect to progress by shorter timesteps to achieve the progression indicated in this keyword, but it will ensure that the time increments indicated by this keyword are reached. For example, if a TSTEP of 30 days, the simulator may first take a step of 15 days, followed by two timesteps of 7.5 days to ensure that the 30-day increment is reached precisely. The repeat syntax can be employed to facilitate the specification of a sequence of equal-length steps (e.g. 12\*30.0).

### Record format

#### 1. TIMESTEP:

Type: Float

Units: Day (FIELD), Day (METRIC)

### Example

```
TSTEP  
10*1.0 5*2.0 20*15.0 /
```



## 2.428 TSTEPCRIT

### Description

ECHELON utilizes an adaptive timestep selection algorithm that attempts to maximize simulator performance while maintaining accuracy by controlling time discretization errors. The **TSTEPCRIT** keyword can be used to tune the parameters governing this adaptive timestep selection. The keyword is followed by a single record containing an arbitrary number of key-value pairs with the syntax “key=value”. The allowed keys are described in the table below.

### Record format

Name	Value Type	Default	Description
SCC_TARGET_SAT	None		Target saturation change
SCC_TARGET_PRESSURE	None		Target pressure change
MIF_AFTER_CHOP	None	1.5	Maximum increase factor after a chopped timestep
MIN_ALLOWABLE_TIMESTEP	None	$10^{-5}$	Smallest timestep that can be taken (days)
TTE_TARGET_SAT	None	BO: 0.2 COMP: None	Target saturation time truncation error
TTE_TARGET_MOLES	None	BO: None COMP: 0.2	Target molar time truncation error
TARGET_NEWTONS	None	BO: 8 COMP: 11	Target Newton iterations per timestep
TARGET_LINEARS	None		Target linear iterations per timestep
MAX_ALLOWABLE_FAILURES	None		Maximum convergence failures before stopping simulation
REVERRT_DTMIN_AFTER_CHOP	None	0	
USE_SQRT_TTE	None	1	If 1, then a square root is included in computing the TTE

### Example

The following increases the maximum increase factor to 2.0 and decreases the target number of Newton iterations to 6.

```
TSTEPCRIT
MIF_AFTER_CHOP=2.0 TARGET_NEWTONS=6 /
```



## 2.429 TUNING

### Description

The TUNING keyword allows the modification of timestepping controls, linear and nonlinear convergence criteria, and other parameters governing the linear and nonlinear solver criteria. It consists of three records, each terminated by a slash (/). The first record controls timestep selection parameters. The second record controls convergence criteria. The final record is reserved for future use.

#### Record 1 format

Field	Name	Type	Default	Description
1	TSINIT	Integer	1 day	Maximum initial timestep
2	MAX_TIMESTEP	Float	BO: 365.0 days COMP: 50 days	Maximum length for subsequent timesteps
3	TSMINZ	Float	BO: 0.1 day COMP: 0.02 day	Minimum timestep
4				<i>Reserved</i>
5	TSFMAX	Float	BO: 3.0 COMP: 2	Timestep increase factor
6	TSFMIN	Float	0.3	Minimum cutback factor
7	TSFCNV	Float	0.1	Chop factor for un converged timesteps

#### Record 2 format

Field	Name	Default	Description
1			<i>Reserved</i>
2	CNVTOL	0.001	Black-oil local nonlinear convergence threshold
3	MBETOL	BO: 1e-07 COMP: 1e-06	Global material balance error for timestep convergence
4	TRGLCV	0.001	Linear solver relative tolerance
5			<i>Reserved</i>
6	XXXCNV	0.01	Black-oil local nonlinear convergence threshold at the last Newton iteration
7	XXXMBE	1e-06	Maximum nonlinear convergence error

#### Record 3 format

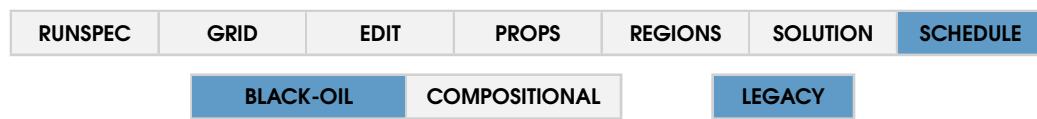
Field	Name	Description

**Example**

This example limits the next timestep to 5 days.

```
TUNING  
5 /  
/  
/
```

Timesteps after the first timestep are limited to the default value.



## 2.430 TUNINGDP

### Description

The [TUNINGDP](#) keyword can be used to adjust linear and nonlinear convergence parameters. In particular, it can adjust the relative convergence tolerances for the linear solver as well as set parameters for the solution-change criteria in black-oil models. If the pressure and saturation solution change criteria are set with this keyword, then a timestep can be considered converged if the maximum material balance error criterion (MBETOL in [TUNING](#) second record and [SOLVER](#) key) is satisfied *and* one of the following conditions are satisfied:

1. the nonlinear convergence criteria based on TRGCNV and MAXCNV (see [TUNING](#) keyword second record and [Section 3.5](#));
2. the maximum solution change for both pressure and saturation (specified in fields 3 and 4 of this keyword, respectively).

### Record format

1. **RELTOL:** Relative linear solver tolerance.  
**Default value:** 0.001
2. *Reserved*
3. **TRGDDP:** Maximum change in cell pressure during a Newton iteration for the timestep to be considered converged. Note that without TUNINGDP this value is  $10^{20}$ .  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 1.5 (FIELD), 0.1034 (METRIC)
4. **TRGDDS:** Maximum change in cell saturation during a Newton iteration for the timestep to be considered converged. Note that without TUNINGDP this value is  $10^{20}$ .

### Example

In a model with FIELD units, the following sets the maximum pressure and saturation changes experienced during a Newton iteration to 10 psi and 0.02, respectively.

```
TUNINGDP
2* 10.0 0.02 /
```



## 2.431 TVDP

### Description

This keyword allows specifying the concentration of a tracer as a function of depth for each equilibration region. The number of entered tables cannot exceed [NTTRVD](#) and every table must have at least two entries (4 values) but not exceed [NSTRVD](#) (see [EQLDIMS](#) for details). Every region table must be terminated with a slash (/).

The keyword should be appended by additional characters.

black-oil formulation:

- Character 5. The letter 'F' should be used for a tracer existing only in the free phase. Water and non-vaporizing oil tracers are the typical examples. When the tracer can be partitioned between free and solution phases, TVDP should be initialized twice using letters 'F' and 'S'. Oil and gas tracers with the ability of a phase to vaporize or dissolve are the typical examples (see [VAPOIL](#) and [DISGAS](#)).
- Characters 6-8. The tracer name from [TRACER](#) (up to 3 characters).

Compositional formulation:

- Characters 5-8. The tracer name from [TRACER](#) (up to 4 characters).

**Units** are based on [TRACER\\_UNITS](#) as defined using [TRACER](#) keyword (e.g. kg):

- [METRIC](#) [TRACER\\_UNITS](#)/sm<sup>3</sup>
- [FIELD](#) [TRACER\\_UNITS](#)/stb for tracers in liquid phases, and [TRACER\\_UNITS](#)/Mscf for gas phase tracers.

### Record format

1. **DEPTH:** Depth  
The values should increase monotonically down the column.  
**Units:** ft (FIELD), m (METRIC)
2. **TRACER\_CONCENTRATION:** The tracer concentration.  
**Minimum:** 0

#### Example 1

This example specifies tracer 'TRA' concentration tables for [NTTRVD](#) = 1. The host oil phase can vaporize (see [VAPOIL](#)).

```
-- free phase
TVDPFTRA
5000    0.0
8000    0.0    /
-- solution phase
TVDPSTRA
5000    1.0
8000    1.0    /
```

**Example 2**

This example specifies compositional tracer 'TRAB' concentration tables for [NTTRVD](#) = 2.

```
TVDPTRAB
5000    0.0
8000    0.0    /
5000    1.0
8000    1.0    /
```



## 2.432 UDQ

### Description

The UDQ keyword is used to define user-defined quantities that can be expressed as mathematical functions of constants, pre-defined SUMMARY quantities and other UDQs. The name of the UDQ always starts with 'F', 'G', 'W', 'R' or 'C', representing field, group, well, region or connection UDQs, respectively. The second character is always 'U'.

A thorough description of the UDQ logic, including available operators, can be found in [Chapter 25](#) of the Technical Description.

### Record format

#### 1. OPERATION: UDQ operations

**Type:** String

**Allowed values:**

Name	Value Type	Description
ASSIGN	String	ASSIGN
DEFINE	String	DEFING
UNITS	String	UNITS
UPDATE	String	UPDATE

#### 2. UNAME: Name of the UDQ quantity. The second char must be "U"

**Type:** String

#### 3. DATA: Expression for this UDQ operation

**Type:** String

### Example 1

```
UDQ
ASSIGN FU_ONE 1.0 /
ASSIGN FU_STEP FU_ONE + 1 /
/
```

### Example 2

```
UDQ
ASSIGN FU_OR1 21000 /
ASSIGN FU_OR2 22000 /
DEFINE FU_MIN MIN(GOPR) /
DEFINE FU_MAX MAX(GOPR) /
DEFINE FU_SUM SUM(GOPR)/2 /
DEFINE FU_AVEA AVEA(GOPR) /
/
```



## 2.433 UDQDIMS

### Description

The keyword is used to indicate whether a new seed will be used for restart run in RRNDN and RRNDU function calls that appear in [UDQ](#) definitions. It is defaulted to 'N', meaning the restart simulation will use the same seed as the base simulation.

### Record format

Field	Name	Description
1 - 10		<i>Reserved</i>
11	RESET_RND	'Y' to generate a new seed for a restarted run, otherwise 'N'

### Example

```
UDQDIMS  
10* Y /
```



## 2.434 UDQPARAM

### Description

UDQPARAM controls some of the parameters related to the [UDQ](#) keyword.

### Record format

1. Seed value for RANDN and RANDU random number functions in UDQs. Default is 1.  
**Type:** Integer  
**Default value:** 1
2. The permitted value range (+/-) of the UDQs. The default is 1.0E+20.  
**Type:** Float  
**Default value:** 1.0E+20
3. Value given to undefined elements for output.  
**Type:** Float  
**Default value:** 0.0
4. The fractional equality tolerance used in the ==, !=, <= and >= functions. Defaulted to 1.0E-4.  
**Type:** Float  
**Default value:** 1.0E-4

### Example

```
UDQPARAM
10 1.0E20 0.0 1.0E-4 /
```



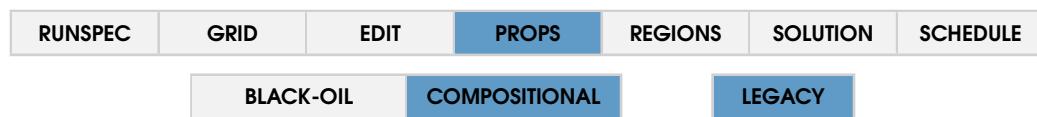
## 2.435 VAPOIL

### Description

Specifies that, in black-oil runs, stock-tank oil is allowed to vaporize in the gas phase at reservoir conditions. This activates the wet-gas option.

### Example

```
RUNSPEC  
VAPOIL
```



## 2.436 VCRIT

### Description

This keyword specifies the critical volumes of the hydrocarbon components in a compositional simulation. It is followed by NEOSR slash terminated records, one for each reservoir equation of state region, each of them providing  $n_c$  critical volumes, one for each component.

NEOSR is defined using the ninth field in [TABDIMS](#) keyword.

### Record format

1. **V\_CRIT:** Component critical volumes

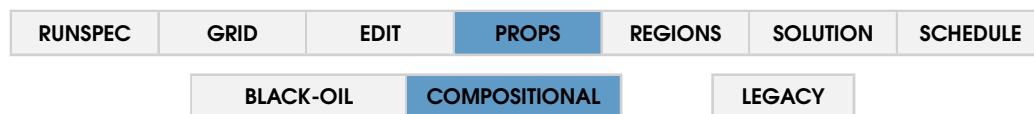
**Type:** Float

**Units:** ft<sup>3</sup>/lb-moles (FIELD), m<sup>3</sup>/kg-moles (METRIC)

### Example

This example specifies the critical volumes for a compositional simulation with five components

```
VCRIT  
1.6 2.0 1.6 3.6 6.0 /
```



## 2.437 VCRITLI

### Description

This keyword specifies the critical volumes of the equation of state components to be used for calculation of hydrocarbon phases critical temperatures using Li correlation. It is followed by NEOSR slash terminated records, one for each reservoir equation of state region, each of them providing  $n_c$  critical volumes, one for each component.

If this keyword or [ZCRITLI](#) is not provided the values specified in [ZCRIT](#) or [VCRIT](#) are used for the hydrocarbon components.

In runs with livewater option ([GASWAT](#), [OILWAT](#) or [LIVEWAT](#) keywords), and in the absence of this keyword or [ZCRITLI](#), a value of 0 is used for  $H_2O$ . In other words, by default, the amount of water component in the liquid or vapor phases does not impact the Li critical temperature

NEOSR is defined using the ninth field in [TABDIMS](#) keyword.

### Record format

1. **V\_CRIT\_LI:** Component critical volumes for hydrocarbon-phase critical temperature calculation with Li correlation

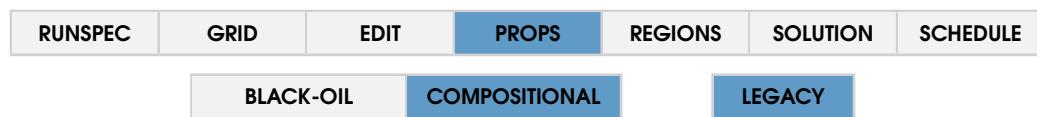
**Type:** Float

**Units:** ft<sup>3</sup>/lb-moles (FIELD), m<sup>3</sup>/kg-moles (METRIC)

### Example

This example specifies the critical volumes for Li critical temperature calculations in a compositional simulation with live water and five hydrocarbon components plus water

```
VCRITLI  
1.6 2.0 1.6 3.6 6.0 1.12 /
```



## 2.438 VCRITS

### Description

This keyword specifies the critical volumes of the hydrocarbon components for the surface equation of state computations in a compositional simulation. It is followed by NEOSS slash terminated records, one for each surface equation of state region, each of them providing  $n_c$  critical volumes, one for each component.

If the keyword is not provided the values specified in [VCRIT](#) are used.

NEOSS is defined using the tenth field in [TABDIMS](#) keyword.

### Record format

1. **V\_CRITS:** Component critical volumes

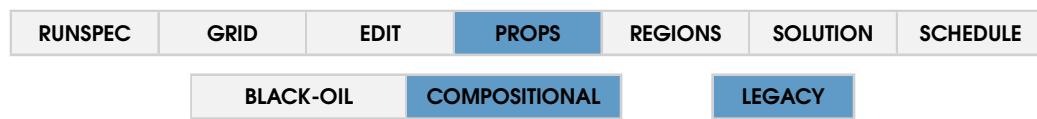
**Type:** Float

**Units:** ft<sup>3</sup>/lb-moles (FIELD), m<sup>3</sup>/kg-moles (METRIC)

### Example

This example specifies the critical volumes for the surface equation of state in a compositional simulation with five components

```
VCRITS  
1.6 2.0 1.6 3.6 6.0 /
```



## 2.439 VCRITVIS

### Description

This keyword specifies the critical volumes of the hydrocarbon components to be used for viscosity computation only in a compositional simulation. It is followed by NEOSR slash terminated records, one for each reservoir equation of state region, each of them providing  $n_c$  critical volumes, one for each component.

If this keyword or [ZCRITVIS](#) is not provided the values specified in [ZCRIT](#) or [VCRIT](#) are used.

NEOSR is defined using the ninth field in [TABDIMS](#) keyword.

### Record format

1. **V\_CRIT\_VIS:** Component critical volumes for viscosity calculations

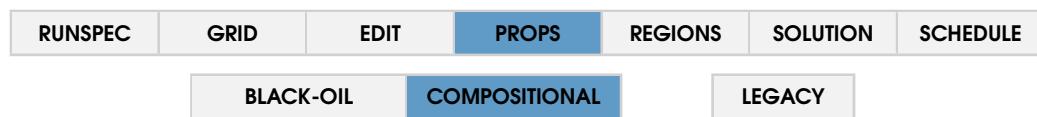
**Type:** Float

**Units:** ft<sup>3</sup>/lb-moles (FIELD), m<sup>3</sup>/kg-moles (METRIC)

### Example

This example specifies the critical volumes for viscosity calculations in a compositional simulation with five components

```
VCRITVIS  
1.6 2.0 1.6 3.6 6.0 /
```



## 2.440 VDKRGC

### Description

This keyword allows to set the parameters of the velocity-dependent relative permeability model by saturation region (see [Section 10.10](#)). The number of records should be the same as NTSFUN specified in the [TABDIMS](#) keyword, each of them terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **EXP:** The exponent  $n$  used in the definition of the scaling parameter  $f$  of the velocity-dependent relative permeability model.  
**Type:** Float  
**Default value:** 0.65
2. **ALPHAC0:** Coefficient used in the definition of the scaling parameter  $f$  of the velocity-dependent relative permeability model.  
**Type:** Float  
**Default value:** 10000

### Example

```
VDKRGC
--exp alphac0
0.8 1e5 /
```



## 2.441 VELDEP

### Description

This keyword activates the velocity-dependent relative permeability model. The relative permeability scaling can be activated for the gas phase only or for both the gas and oil phases. If the Generalized Pseudo-Pressure model is used and the appropriate flag in [PICOND](#) or [WPICOND](#) keywords is set to YES, velocity effects are included also in GPP calculations. The model depends on two parameters which have their default values, but these values can be modified using the keyword [VDKRGC](#) in [PROPS](#) section.

### Record format

1. *Reserved*
2. *Reserved*
3. *Reserved*
4. *Reserved*
5. **CN\_ALT:** This item specifies whether the velocity-dependent relative permeability model applies to the gas phase only or to both the gas and the oil phase. The model is activated for gas only if this item is set to 1, or to gas and oil phases if it is set to 2. If this item is set to 0, the model is inactive.

**Type:** Integer

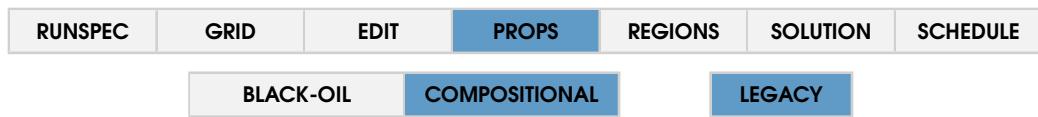
**Minimum:** 0

**Maximum:** 2

**Default value:** 0

### Example

```
VELDEP  
4* 2 /
```



## 2.442 VISCAQA

### Description

This keyword specifies the coefficients to be used in the Ezrokhi's formula for the computation of aqueous phase viscosity in **GASWAT** cases. Three coefficients should be entered for each component. If the keyword is not specified zero coefficients are assumed. The keyword is followed by NEOSR (**TABDIMS** ninth field) record, one for each equation of state.

The aqueous phase viscosity is then computed as:

$$\log(\mu_w) = \log(\mu_{w,pure}) + \sum_{n=1}^{N_c-1} C_n(T) w_n$$

where

$w_n$  is the weight fraction of the component  $n$  excluding water,  $\mu_{w,pure}$  is the viscosity of pure water and

$$C_n(T) = c_{1,n} + c_{2,n}T + c_{3,n}T^2$$

The  $c_{i,n}$  are the coefficients specified in this keyword.

### Record format

1. **Ezrokhi's coefficients:** coefficients to be used in the Ezrokhi formula, three for each component

**Type:** Float

### Example

This example specifies Ezrokhi coefficients for density modification in a case with three components

```
VISCAQA
2.0e-07 1.28e-10 2.0e-09
2.0e-07 2.28e-10 2.37e-09
2.0e-07 2.28e-10 2.37e-09 /
```



## 2.443 WADVANCE

### Description

This keyword creates an additional gas source connected to a producing well. A gas consumer utilizes available gas from the ADVANCE source and then subtracts produced gas to satisfy the re-injection volumes. The ADVANCE source cannot be used for contractual obligations (see [GRUPFUEL](#) and [GRUPSALE](#)).

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

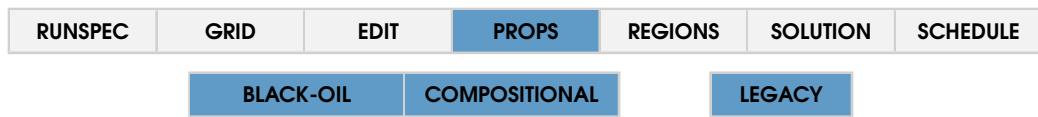
### Record format

1. **WELL\_NAME:** Name of well, template, or well list (see [WLIST](#)).
2. **STREAM\_NAME:** The stream name.  
The name links the ADVANCE source composition to the composition defined by the keyword [WELLSTRE](#).
3. **AVAILABLE\_RATE:** The maximum available gas rate.  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

### Example

In this example, the keyword specifies an additionally available gas linked to the producer P. The additional source has a limited available rate of 1000 Mscf/Day and has a fixed composition from STR1.

```
WADVANCE
P STR1 1000 /
/
```



## 2.444 WAGHYSTR

### Description

The **WAGHYSTR** keyword is used in models with relative permeability hysteresis to override the two-phase gas-oil model with a three-phase gas hysteresis model. A record per saturation region is required.

### Record format

1. **LAND\_PARAMETER:** Land parameter (C)  
**Type:** Float  
**Default value:** NONE  
**Allowed values:**
2. **DRAINAGE\_REDUCTION\_FACTOR:** Drainage reduction factor  
**Type:** Float  
**Default value:** 1  
**Allowed values:**
3. **KRG\_FLAG:** Flag to activate the three-phase gas hysteresis model (YES or NO)  
**Type:** String  
**Default value:** YES  
**Allowed values:**
4. **SORM\_FLAG:** Flag to activate the residual oil saturation reduction due to trapped gas in the presence of STONE I three-phase mixing model (YES or NO)  
**Type:** String  
**Default value:** YES
5. **RESERVED:** Reserved. Must be explicitly set to NO.  
**Type:** String  
**Default value:** YES
6. **LINEAR\_FRAC:** Fraction of the gas saturation range between Sgmax and Sgcrt where the relationship between flowing gas saturation and gas saturation is linearized (as opposed to coming from the original Carlson model).  
**Type:** Integer  
**Default value:** 0.1
7. **EPS\_TOL:** Small value used as tolerance to (a) check if the water saturation is above connate to activate three-phase hysteresis, and (b) to detect drainage reversal.  
**Type:** Integer  
**Default value:** 0.001
8. **SORM\_RED\_FACT:** Residual oil saturation parameter when the corresponding flag is active.  
**Type:** Integer  
**Default value:** 1

**Example**

Example with 2 saturation regions.

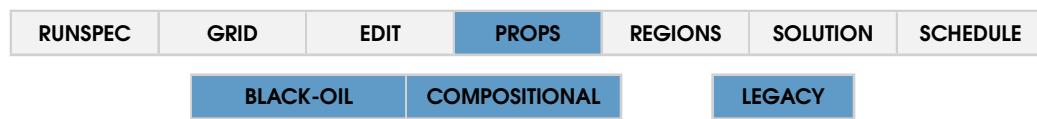
```
WAGHYSTR
2  0.0  YES  NO  NO  /
3  0.2  YES  NO  NO  /
```



## 2.445 WATER

### Description

This keyword shows that the simulation contains an active water phase: the saturation of this water phase can vary.



## 2.446 WATERTAB

### Description

The [WATERTAB](#) keyword is used to provide a table of water formation volume factor and viscosity vs. pressure.

The keyword is followed by a number of tables equal to the number of PVT regions specified in the [TABDIMS](#) keyword. Each table consists of three columns, as described below, and is terminated by a slash (/).

### Table columns

1. **PRESSURE:** Pressure of the water phase  
Subsequent values in this column must strictly increase  
**Units:** psi (FIELD), bar (METRIC)
2. **FVF:** Water formation volume factor  
Subsequent values in this column must decrease or remain constant  
**Units:** rb/stb (FIELD), rm<sup>3</sup>/sm<sup>3</sup> (METRIC)
3. **VISCOSITY:** Water viscosity  
Subsequent values in this column must increase or remain constant  
**Units:** cPoise (FIELD), cPoise (METRIC)

### Example

```
WATERTAB
 2000      1.02      0.50
 2500      1.01      0.51
 3000      1.00      0.52 /
```



## 2.447 WAVAILIM

### Description

The WAVAILIM keyword is optionally used by the Gas Accounting to request available gas for injection.

Gas production and available gas for injection should be understood as gas produced by wells and gas available for field operations. Generally, they have different values, since gas can be also consumed for contractual obligations (see [GRUPFUEL](#) and [GRUPSALE](#)) and supplemented by additional gas sources such as [GADVANCE](#), [WADVANCE](#), and makeup gas.

When gas is re-injected from a well or a group of wells and injecting amount is greater than available gas the extra gas is taken from the makeup source. If the makeup source is not specified and injecting gas exceeds available gas then WAVAILIM limits the injecting target. Without specifying WAVAILIM more than available gas is injected and the production/injection balance is not honored. The available gas is computed by accounting [GRUPFUEL](#), [GRUPSALE](#), [GADVANCE](#), [WADVANCE](#), and [WTAKEGAS](#) keywords.

The following steps are taken to honor WAVAILIM:

- The Rate Balancing algorithm is executed based on user-defined settings prior to accounting for injection stream properties. As a result, every injecting well is assigned an estimated gas injection rate.
- A specific order (see [WTAKEGAS](#)) is taken into account. In cases when fuel or sale has higher priority, gas is extracted from corresponding sources and apportioned between dependent wells. The advance gas cannot be used for fuel and sales and added after apportioning.
- The allocated injection rates are compared with the available gas using stream settings. If the allocated rates exceed available gas, WAVAILIM reduces rates proportionally, cutting values based on current rates

Additional rate balancing iterations may be required because the injection composition is rate dependent.

### Example

```
SCHEDULE  
-- Require gas availability  
WAVAILIM
```



## 2.448 WCONHIST

### Description

This keyword is used for a producing well or a list of producing wells that are being history matched (instead of keyword [WCONPROD](#)). During History Matching some observed data, e.g. oil/gas and water rates at STC, are available and the purpose of the keyword is to constraint production using observed data.

[WCONHIST](#) provides a limited number of control modes in comparison to [WCONPROD](#) and constraints are managed differently. More specifically, the following rate controls are available:

- **ORAT**: well produces the observed surface oil rate
- **WRAT**: well produces the observed surface water rate
- **GRAT**: well produces the observed surface gas rate
- **LRAT**: well produces the sum of the observed surface oil and water rate
- **NGL**: well produces the NGL observed rate
- **WGRA**: well produces the wet gas observed rate
- **RESV**: ECHELON uses the reservoir pressure available at the beginning of the timestep to convert observed surface oil, water and gas rates into a daily reservoir volume and use that volume as well control

If a rate control is set for a well, the only pressure constraint is a minimum bottom hole pressure of 1 atm, regardless of any observed bottom hole pressure value provided in the record. This bound can be changed using the keyword [FBHPDEF](#) for all wells or with the keyword [WELLTARG](#) for a specific well. In addition to rate controls, a BHP control mode is also available constraining the well to operate at the observed bottom hole pressure. In this case, observed surface rates are not used as constraints (i.e., the well does not switch to rate control if any of the observed rates is violated).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELLNAME**: This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** ‘\*’

2. **STATUS**: Well status

**Type:** String

**Default value:** OPEN

**Allowed values:**

Name	Description
OPEN	The well is open for surface production and crossflow may occur in the subsurface, if enabled
STOP	The well is shutin for surface production, but crossflow may occur in the subsurface. If crossflow is disabled this is equivalent to SHUT condition
SHUT	The well is shutin at the surface and downhole

3. **MODE**: Well control mode

**Type:** String

**Allowed values:**

Name	Description
ORAT	The well is controlled by the observed oil surface rate defined in item 4
WRAT	The well is controlled by the observed water surface rate defined in item 5
GRAT	The well is controlled by the observed gas surface rate defined in item 6
LRAT	The well is controlled by the observed liquid surface rate (water+oil)
RESV	The well is controlled by the volumetric reservoir rate computed from the observed rate of oil, gas and water
BHP	The well is controlled by the observed bottom hole pressure defined in item 10
WGRA	The well is controlled by the observed wet gas rate defined in item 11
NGL	The well is controlled by the observed NGL rate defined in item 12

4. **ORAT:** Observed oil surface rate

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

5. **WRAT:** Observed water surface rate

**Type:** Float

**Units:** rb/day (FIELD), rm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

6. **GRAT:** Observed gas surface rate

**Type:** Float

**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

7. **VFP:** VFP table number for the well (see keyword [VFPPROD](#))

**Type:** Integer

**Default value:** 0

8. **ALQ:** Artificial lift quantity for the associated VFP table. Units depend on the associated quantity selected in the keyword [VFPPROD](#).

**Type:** Float

**Default value:** 0.0

9. **THP:** Observed THP. This item is used for reporting only.

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

10. **BHP:** Observed BHP

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** 14.6959 (FIELD), 1.01315 (METRIC)

11. **WGRA:** Observed wet gas rate

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

12. **NGL:** Observed NGL rate

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

**Example**

In this example, well P1 is controlled by the observed oil surface rate with a target of 100 and all wells with prefix PR are controlled by the observed gas surface rate with a target of 50.

```
WCONHIST
--well status ctrl  orat   wrat   grat   vfp    alq    THP    BHP
'P1'    OPEN    ORAT   100.0  5.0    25.5   1*    1*    1*    125.0  /
'PR*'   OPEN    GRAT   50.0   1*     50.0   /
```



## 2.449 WCONINJE

### Description

The WCONINJE keyword provides a set of operating limits for the control of injecting wells. Each record starts with a well name, a named well list, or a pattern for matching well names. This is followed by the specification of an injector type and a default control. Each of the remaining fields (except item 9, which gives the VFP table ID), gives an upper or lower constraint on a particular quantity. The user may provide a value for any number of these fields or leave the quantity defaulted, which implies no constraint for most quantities (see below for exceptions). During simulation, each limit is checked and the most constraining limit becomes the active constraint for the present timestep. The active constraint will thus change automatically depending on the operating conditions.

In compositional run, the well solution is determined by internally converting surface volume rates to molar rates. For the WATER injector, a constant molar density is assumed and it is determined from the mass density specified with the keyword [DENSITY](#) or [GRAVITY](#) and the water molecular weight. For the GAS injector, the gas molar density is computed from the ideal gas law. For the HCGAS injector, the gas molar density is determined from a flash at standard conditions (see keyword [STCOND](#)).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

- WELLNAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** ‘\*’

- TYPE:** Well injector type

**Type:** String

**Allowed values:**

Name	Description
WATER	Water injector
GAS	Gas injector. In a compositional run, the type of injected gas must be specified with keyword <a href="#">WINJGAS</a> , unless the well is under group control and the group injection fluid have been defined
OIL	Oil injector. This is supported for black-oil runs only
HCGAS	Gas injector. In a compositional run, the nature of the injected gas must be specified with the keyword <a href="#">WINJGAS</a> , unless the well is under group control and the group injection fluid has been defined.

- STATUS:** Well status

**Type:** String

**Default value:** OPEN

**Allowed values:**

Name	Description
OPEN	The well is open for surface injection and crossflow may occur in the subsurface, if enabled
STOP	The well is shutin for surface injection, but crossflow may occur in the subsurface. If crossflow is disabled this is equivalent to SHUT condition
SHUT	The well is shutin at the surface and downhole

#### 4. MODE: Well control mode

**Type:** String

**Allowed values:**

Name	Description
RATE	Well is controlled by the surface rate target defined in item 5
RESV	Well is controlled by the reservoir rate target defined in item 6
BHP	Well is controlled by the BHP target defined in item 7
THP	Well is controlled by the THP target defined in item 8
GRUP	Well is under group control and injects its share of the group's target as defined with <a href="#">GCONINJE</a> keyword

#### 5. RATE: Surface injection rate target or upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

#### 6. RESV: Reservoir volumetric injection rate target or upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** rb/day (FIELD), rm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

#### 7. BHP: BHP target or upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** BO: 1E5 (FIELD), 6895 (METRIC)

COMP: 14695.9 (FIELD), 1013.15 (METRIC)

#### 8. THP: THP target or upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

#### 9. VFP: Well VFP table number (see [VFPINJ](#))

**Type:** Integer

**Default value:** 0

#### Example

In this example, well INJ1 is controlled by water rate with a target of 100, Additionally, a BHP limit of 1000 is specified. If the BHP goes above this value during the run, the well will automatically switch from rate control to BHP control. Well INJ2 is under group control. Individual limits on gas rate, BHP and THP are also specified.

```
WCONINJE
--well type status ctrl      rate    resv    BHP    THP    vfp id
INJ1   WATER OPEN    RATE    100.0  1*     1000  1*    1*      /
INJ2   GAS   OPEN    GRUP    50.0   1*     1000  800   14   /
/
```



## 2.450 WCONINJH

### Description

This keyword is used for an injecting well or a list of injecting wells that are being history matched (instead of keyword [WCONINJE](#)). During History Matching some observed data, e.g. gas or water injection rates at STC, are available and the purpose of the keyword is to constraint injection using observed data.

[WCONINJH](#) provides a limited number of control modes in comparison to [WCONINJE](#) and constraints are managed differently. More specifically, the set of control mode for a well is restricted to RATE and BHP. If a well is under RATE control, the BHP limit is internally set to a large value regardless of any observed bottom hole pressure value entered in the record. This bound can be changed using the keyword [FBHPDEF](#) for all wells or with the keyword [WELLTARG](#) for a specific well. If a well is controlled by its bottom hole pressure, the target corresponds to the observed BHP. In this case, the observed injection rate is not used as a constraint (i.e., the well does not switch to rate control if the injection rate is violated).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELLNAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** '\*'

2. **TYPE:** Well injector type

**Type:** String

**Allowed values:**

Name	Description
WATER	Water injector
GAS	Gas injector. In a compositional run the type of injected gas must be specified with keyword <a href="#">WINJGAS</a> , unless the well is under group control and the group injection fluid have been defined
OIL	Oil injector. This is supported for black-oil runs only

3. **STATUS:** Well status

**Type:** Enum

**Default value:** OPEN

**Allowed values:**

Name	Description
OPEN	The well is open for surface injection and crossflow may occur in the subsurface, if enabled
STOP	The well is shutin for surface injection, but crossflow may occur in the subsurface. If crossflow is disabled this is equivalent to the SHUT condition
SHUT	The well is shutin at the surface and downhole

4. **RATE:** Observed surface injection rate

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** No limit (FIELD), No limit (METRIC)

5. **BHP:** Observed BHP

**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** BO: 1E5 (FIELD), 6895 (METRIC)  
COMP: 14695.9 (FIELD), 1013.25 (METRIC)

6. **THP:** Observed THP. This item is used for reporting only

**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)

7. **VFP:** Well VFP table number

**Type:** Integer  
**Default value:** 0

8. *Reserved*

9. *Reserved*

10. *Reserved*

11. *Reserved*

12. **MODE:** Well control mode

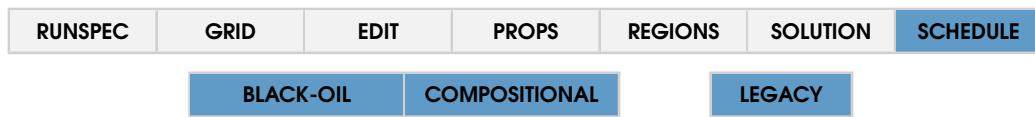
**Type:** String  
**Default value:** RATE  
**Allowed values:**

Name	Description
RATE	Well is controlled by a surface injection rate
BHP	Well is controlled by bottom hole pressure

### Example

In this example, well INJ1 is controlled by a water surface injection rate of 100 and all wells with the prefix RF are controlled by a gas surface injection rate of 50.

```
WCONINJH
--well type status rate obs BHP
'INJ1' WATER OPEN 100.0 1000 /
'RF*' GAS OPEN 50.0 1000 /
/
```



## 2.451 WCONPROD

### Description

The WCONPROD keyword provides a set of operating limits for the control of production wells. Each record starts with a well name, a named well list, or a pattern for matching well names. This is followed by a default control. The remaining fields (except field 11, which gives the VFP table ID), each give an upper or lower constraint on a particular production property. The user may provide a value for any number of these fields or leave the quantity defaulted, which implies no constraint for most quantities (see below for exceptions). During simulation, each limit is checked and the most constraining limit becomes the active constraint for the present timestep. The active constraint will thus change automatically depending on the operating conditions. For example, the active control may change from a rate constraint to a pressure constraint as the reservoir pressure depletes.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELLNAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** '\*'

2. **STATUS:** Well status

**Type:** String

**Default value:** OPEN

**Allowed values:**

Name	Description
OPEN	Well is open for surface flow and crossflow may occur in the subsurface, if enabled
SHUT	Well is shutin: no surface flow and crossflow is allowed
STOP	Well is shutin for surface flow, but crossflow may occur in the subsurface, if enabled. If crossflow is disabled in the WELSPECS keyword and the well is set to STOP, this is equivalent to SHUT.

3. **CONTROL:** Well control

**Type:** String

**Default value:** Undefined

**Allowed values:**

Name	Description
ORAT	Well is controlled by the oil surface rate defined in item 4
WRAT	Well is controlled by the water surface rate defined in item 5
GRAT	Well is controlled by the gas surface rate defined in item 6
LRAT	Well is controlled by the total liquid (oil+water) surface rate defined in item 7
RESV	Well is controlled by the reservoir volume rate defined in item 8
BHP	Well is controlled by the bottom hole pressure defined in item 9
THP	Well is controlled by the tubing head pressure defined in item 10
WGRA	Well is controlled by the wet gas rate defined in item 13
TMRA	Well is controlled by the total molar rate defined in item 14
NGL	Well is controlled by the natural gas rate defined in item 20

4. **ORAT:** Oil surface rate upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

5. **WRAT:** Water surface rate upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

6. **GRAT:** Gas surface rate upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

7. **LRAT:** Liquid surface rate upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

8. **RESV:** Reservoir volumetric rate upper limit.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** rb/day (FIELD), rm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

9. **BHP:** The lower limit for the bottom hole pressure.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** BO: 14.6959 (FIELD), 1.01315 (METRIC)

COMP: 1469.59 (FIELD), 101.315 (METRIC)

10. **THP:** The lower limit for the tubing head pressure.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

11. **VFP:** VFP table number for the well

**Type:** Integer

**Default value:** 0

12. **ALQ:** Quantify representing artificial lift for the associated VFP table.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Default value:** 0.0

13. **WGRA:** The upper limit for surface wet gas rate.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Integer

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

14. **TMRA:** The upper limit for total molar production rate.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Integer

**Units:** lb-moles/day (FIELD), kg-moles/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

15. *Reserved*

16. *Reserved*

17. *Reserved*

18. *Reserved*

19. *Reserved*

20. **NGL:** The upper limit for natural gas liquids rate.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Integer

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** No limit (FIELD), No limit (METRIC)

### Example

In this example, well PRD1 is controlled by oil rate with a target of 100. Additionally, an upper gas rate limit of 500, a minimum BHP limit of 250 and a minimum THP of 150 are specified. Well PRD2 is controlled by bottom hole pressure with a target of 150. All wells matching the prefix R are under group control with individual limits on BHP and THP. If any limit is violated during the run, the well will automatically switch to the most constraining limit.

```
WCONPROD
--well status ctrl orat wrat grat lrat resv BHP THP VFP
'PRD1' OPEN ORAT 100.0 1* 500.0 1* 1* 250 150 1 /
'PRD2' OPEN BHP 1* 1* 1* 1* 150
'R*' OPEN GRUP 5*
/

```

RUNSPEC	GRID	EDIT	PROPS	REGIONS	SOLUTION	SCHEDULE
		BLACK-OIL			COMPOSITIONAL	
					LEGACY	

## 2.452 WCUTBACK

### Description

WCUTBACK sets cutback limits for producers and injectors wells. The keyword may contain an arbitrary number of slash-terminated records. Each record consists of 15 fields and the format is described in section below. The keyword itself is terminated with a trailing slash.

The logic of the keyword is as follows:

- if the well exceeds one of the limits defined in items 2-5, 8 and 15, then it will be set to operate at a reduced rate of the phase specified in item 7 (if it is not already under that control). The new target rate of the control phase will be set equal to the well current flow rate times the cutback factor defined in item 6.
- If the well does not exceed one of the cutback reversal limits specified with items 9-13, and if the well's operating limit is the rate of the control phase given in field 7, then it will be set to operate at an increased rate of that phase equal to the current flow rate divided by the cutback factor specified in item 6.

Note that the well target rate of the phase specified in item 7 is reset every time a cutback is applied and any initially user-defined target rate is “lost”. Thus a series of cutback reversals may increase the target rate of the control phase beyond its initial limit. This can be avoided by selecting in item 7 a phase for which no user-defined limit are specified.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** ‘\*’

2. **WCT:** Water cut upper bound to trigger a cutback of a production well rate target. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** stb/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

3. **GOR:** Gas-oil ratio upper bound to trigger a cutback of a production well rate target. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

4. **GLR:** Gas-liquid ratio upper bound to trigger a cutback of a production well rate target. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

5. **WGR:** Water-gas ratio upper bound to trigger a cutback of a production well rate target. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** stb/Mscf (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

6. **FACTOR:** Whenever the well violates one of the limits specified in items 2 to 5 and 8, its production target rate is reset to the well's current flow rate of the phase specified in item 7 multiplied by this factor.

**Type:** Float

**Minimum:** 0

**Maximum:** 1.0

**Default value:** 1.0

7. **PHASE:** The phase to which the cutback rate applies

**Type:** String

**Default value:** None

**Allowed values:**

Name	Description
OIL	Oil rate
WAT	Water rate
GAS	Gas rate
LIQ	Liquid rate
RESV	Reservoir volume rate
WGAS	Wet gas rate
NGL	Natural gas rate

8. **WBP\_LIMIT:** Minimum grid block pressure for producer or maximum grid block pressure for injectors to trigger a rate cutback. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

9. **WBP\_REVERSE:** Maximum grid block pressure for producers or minimum grid block pressure for injectors for reversing the cutback. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

10. **WCT\_REVERSE:** Minimum water cut for reversing producer cutback. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** stb/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

11. **GOR\_REVERSE:** Minimum gas-oil ratio for reversing producer cutback. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

12. **GLR\_REVERSE:** Minimum gas-liquid ratio for reversing producer cutback. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

13. **WGR\_REVERSE:** Minimum water-gas ratio for reversing producer cutback. The default value (= 0.0 ) turns off this limit.

**Type:** Integer

**Units:** stb/Mscf (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

14. **WORK\_OVER:** Flag to keep or remove rate cutbacks when the well is worked over

**Type:** String

**Default value:** NO

**Allowed values:**

Name	Description
YES	When set to YES, if a workover is performed due to the violation of an economic limit (e.g. through <a href="#">WECON</a> ), cutbacks which were applied on the control phase specified in field 7 are eliminated by removing the rate limits on that phase
NO	Any rate cutback applied to the phase specified with item 7 is kept

15. **GLR\_BH:** Maximum bottom hole gas-liquid ratio for producer rate cutback. This limit is ignored in a compositional run. The default value (= 0.0 ) turns off this limit.

**Type:** Float

**Units:** rb/rb (FIELD), rm<sup>3</sup>/rm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

### Example

In this example, two cutback limits are set for all wells with prefix P: an upper limit on the water cut of 0.7 and an upper limit on the gas-oil ratio of 3.0. If any of these limits is violated, the well will set to operate at a reduced oil production rate with a target given by the current oil flow rate multiplied by 0.8.

```
WCUTBACK
'P*' 0.7 3.0 2* 0.8 OIL /
/
```



## 2.453 WCYCLE

### Description

This keyword enables automatic cycling of wells between OPEN and SHUT status at predetermined intervals. If a well is shut for reasons other than cycling, such as manual closure or by automatic workovers (economic limits), it remains shut until it is reopened. Upon reopening, it resumes cycling as before.

In order to avoid convergence issues while opening a well with high production rate, it may help to gradually open the well. This option is available by defining a startup time, which will be accounted for in the form of reduced efficiency factor.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

`WCYCLE` can be used for both producers and injectors. In the latter case, it can for instance be used to model WAG (Water Alternating Gas) injection by having a water and a gas injectors overlaying each other and switching on and off with an offset. A similar result could be achieved with the `WELLWAG` keyword.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by `WLIST`) or template. If this item is defaulted, this keyword applies to all wells already defined in the `SCHEDULE` section  
**Type:** String  
**Default value:** '\*'
2. **ON\_PERIOD:** How long the well should stay OPEN for  
**Type:** Float  
**Units:** Day (FIELD), Day (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
3. **OFF\_PERIOD:** How long the well should stay SHUT for  
**Type:** Float  
**Units:** Day (FIELD), Day (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
4. **STARTUP\_TIME:** The efficiency factor of the well is ramped up regularly over this time when it is turned on by automatic cycling. 0.0 means instantaneous ramp up.  
**Type:** Float  
**Units:** Day (FIELD), Day (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
5. *Reserved*
6. **SYNC\_TIMESTEP:** If set to 'YES', this option will introduce intermediate timesteps to align precisely with the on/off cycling times of the cycling well  
**Type:** String  
**Default value:** NO

**Example**

In this example, **WCYCLE** keyword is used in simulating a water alternating gas (WAG) process, separated water injector and gas injector wells represent the injection process. The water is injected for 30 days before cycling off and gas injector comes online for 20 days. The injectors are cycled on and off alternatively.

```
WCYCLE
'WAT_INJ' 30.0 20.0 1* 1* 'YES' /
'GAS_INJ' 20.0 30.0 1* 1* 'YES' /
/
```

In order to start the WAG process, the water injector is opened whereas the gas injector is shut.

```
WEOPEN
'WAT_INJ' 'OPEN' /
'GAS_INJ' 'SHUT' /
/
```

After 30 days, the water injector will be shut automatically. In order for the gas injector to come online and start alternating with the water injector, the gas injector should be opened.

```
TSTEP
30.0 /
WOPEN
'GAS_INJ' 'OPEN' /
/
```



## 2.454 WDFAC

### Description

This keyword defines the well's D-factor (flow-dependent skin for gas). The connection D-factor is evaluated from the well's D-factor as

$$D_j = D_{well} \frac{\sum_j T_j}{T_j}$$

where  $T_j$  is transmissibility factor at connection  $j$  and the sum is over the currently open connections.

Note that the connection D-factors are computed according to the number of open connections at the time **WDFAC** is entered in the **SCHEDULE**. If subsequently one or more connections are closed or any **WPIMULT** is specified, the well D-factor changes but the connection D-factors are not affected and retain their original values.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field can be a specific Well name, a list of wells (as defined by **WLIST**) or a template (=a quote delimited string with '\*' as wild card). The keyword applies to wells already defined in the SCHEDULE section and, if defaulted, it applies to all wells.

**Type:** String

**Default value:** '\*'

2. **WDFAC:** The well's D-factor

**Type:** Integer

**Units:** day/Mscf (FIELD), day/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

### Example

```
WDFAC
'P*' 1E-3 /
P2    1E-4 /
/
```



## 2.455 WDFACCOR

### Description

This keyword defines the connection D-factor based on an inertial resistance correlation, usually known as  $\beta$ , in Forchheimer's flow equation.

The connection D-factor is computed as follows:

$$D = A \cdot K_e^B \cdot \phi^C \frac{K_e}{h} \cdot \frac{1}{r_w} \cdot \frac{\gamma_g}{\mu_g}$$

where coefficients A, B, C are supplied with this keyword,  $K_e$  is the effective permeability of the grid block containing the connection,  $\phi$  is the porosity of grid block containing the connection,  $h$  is the length of the connection,  $r_w$  is the wellbore radius,  $\gamma_g$  is the relative density of gas at surface conditions with respect to the air at standard conditions and  $\mu_g$  is the gas viscosity at BHP conditions.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.  
**Type:** String  
**Default value:** '\*'
2. **COEFF\_A:** Coefficient A in the D-factor correlation  
**Type:** Float  
**Units:** cP·day·ft<sup>2</sup>/(mD·Mscf) (FIELD), cP·day·m<sup>2</sup>/(mD·sm<sup>3</sup>) (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
3. **COEFF\_B:** Coefficient B in the D-factor correlation  
**Type:** Float  
**Default value:** 0.0
4. **COEFF\_C:** Coefficient C in the D-factor correlation  
**Type:** Float  
**Default value:** 0.0

### Example

```

WDFACCOR
--well A      B      C
PROD1  1.2E-5 -1.012 0   /
/

```



## 2.456 WDRILPRI

### Description

This keyword sets the well drilling priority values for the wells in drilling queue. The values in this keyword override the calculated drilling priority based on [DRILPRI](#) keyword. The wells in a drilling queue will be opened in descending order of priority in order to maintain a group rate target, see [GCONPROD](#) and [GCONINJE](#). An alternative to the priority queue is the sequential queue where the wells are opened in the order they were input, see [QDRILL](#). Note that only one kind of drilling queue can be active in a run. The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** Well name, list (as defined by [WLIST](#)) or template  
**Type:** String
2. **DRILL\_PRI:** Drilling priority value. If the value is positive, the priority is fixed at this value. If the value is zero, the well will be removed from the queue and if the value is negative the priority formula from [DRILPRI](#) is used for calculating the priority.  
**Type:** Float  
**Default value:** negative

### Example

```
WDRILPRI
'P1' -1   / -- priority is calculated based on formula
'P2' 10.0 / -- priority is set to 10.0
/
```



## 2.457 WDRILTIM

### Description

This keyword defines the rate at which new wells can be opened in a drilling queue. A non-zero drilling time implies that a drilling rig is required. A rig is assigned to a group with the [GRUPRIG](#) keyword.

In the event that a rig is not accessible in the current group or any higher-level groups, drilling will be delayed until a rig becomes available.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELLNAME:** well name, well template, or well list  
**Type:** String
2. **DRILLTIME:** Time required to drill the well.  
**Type:** Float  
**Units:** Day (FIELD), Day (METRIC)  
**Default value:** 0.0
3. **EFF\_DURING\_DRILL:** Option to treat the well as shut while it is being drilled or worked over by setting the well efficiency factor to zero.  
**Type:** String  
**Default value:** 'NO'

#### Allowed values:

Name	Description
YES	The well is treated as shut
NO	The well flow is accounted for at the beginning of the drilling or during the workover

### Example

In this example, the drilling time for well 'W1' is set to 30 DAYS.

```
WDRILTIM
-- well_name    drill_time
  'W1'          30.0      /
/
```



## 2.458 WECON

### Description

This keyword defines economic limits for production wells.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.  
**Type:** String  
**Default value:** '\*'
2. **OIL:** The lower economic limit for the oil rate. In case of violation, the well will be SHUT or STOP depending on item 9 of the keyword [WELSPECS](#). A value of 0.0 switches off this limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
3. **GAS:** The lower economic limit for gas rate. In case of violation, the well will be SHUT or STOP depending on item 9 of the keyword [WELSPECS](#). A value of 0.0 switches off this limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
4. **WCUT:** The upper economic limit for water cut. A value of 0.0 switches off this limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
5. **GOR:** The upper economic limit for the gas-oil ratio. If set to a negative value, the well is allowed to have a higher water cut if it is a gas producer, that is the well is not shut or worked over in violation of the water cut limit (item 4) if its gas-liquid ratio is higher than the (positive) value entered with this item. A value of 0.0 switches off this limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
6. **WGR:** The upper economic limit for the water-gas ratio. A value of 0.0 switches off this limit. This value can be specified using a user-defined argument ([UDA](#)).  
**Type:** Float  
**Units:** stb/Mscf (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)
7. **WORKOVER:** Workover action if water cut, gas-oil ratio, water-gas ration or gas-liquid ratio is violated  
**Type:** String  
**Default value:** NONE

**Allowed values:**

Name	Description
NONE	Do nothing
CON	Shutin the worst offending completion
+CON	Shutin the worst offending completion and all below
WELL	Shutin or stop the well depending on item 9 of keyword <a href="#">WELSPCS</a>

8. **ENDRUN:** Flag to continue or stop the simulation

**Type:** Boolean

**Default value:** NO

**Allowed values:**

Name	Description
NO	The simulation continues
YES	The simulation will be stopped at the next report step in case the well is shut or stopped for any limit violation

9. **FOLLOW\_ON\_WELLS:** The name of the well that will be open if the well specified in the item 1 is shut due to a violation of any limit. The follow on the well must be previously defined as a SHUT producer or injector. Note that a manual closure of the well defined in item 1, will not cause this well to be opened.

**Type:** String

**Default value:** Undefined

10. **RATE\_OR\_POT:** Quantity to which minimum economic limits (defined with items 2, 3, 14 and 16) apply

**Type:** Integer

**Default value:** RATE

**Allowed values:**

Name	Description
RATE	The limits are applied to the well production rates
POTN	The limits are applied to the well production potentials

11. *Reserved*

12. *Reserved*

13. **GLR:** Upper economic limit for gas-liquid ratio. A value of 0.0 switches off this limit

**Type:** Float

**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

14. **LRAT:** Lower economic limit for liquid rate. In case of violation, the well will be SHUT or STOP depending on the item 9 of the keyword [WELSPCS](#). A value of 0.0 switches off this limit.

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

15. *Reserved*

16. **RESV:** Lower economic limit for reservoir volume rate. In case of violation, the well will be SHUT or STOP depending on item 9 of the keyword [WELSPCS](#). A value of 0.0 switches off this limit

**Type:** Float

**Units:** rb/day (FIELD), rm<sup>3</sup>/day (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

**Example**

This example sets limits for 2 wells. Well P1 has a minimum oil rate of 100 and a maximum possible water cut of 0.95. If the oil rate falls below 100, the well will be SHUT or STOP depending on item 9 of the [WELSPECs](#) keyword. If water cut rises above 0.95, the worst offending connection will be closed. Well P2 has a maximum possible gas-oil ratio of 0.8. If this limit is exceeded, the well will be shut and the simulation will be stopped at the next report step.

```
WECON
P1 100 1* 0.95 2* CON /
P2 3* 0.8 1* WELL YES /
/
```



## 2.459 WEFAC

### Description

This keyword sets the well efficiency factor, that is the time fraction during which the well is operated. Note that well pressures and flow rates are computed at their full flowing conditions, that is without the efficiency factor being applied, to represent the actual flowing conditions in the field. The effective rates are calculated by applying the efficiency factor when summing individual well rates to give group flow rates or well's cumulative rates, and when connection flows are applied as source terms into the reservoir material balance equations. This is equivalent to arbitrarily shutting in the wells for a certain period of time during a timestep, as opposed to all wells going down concurrently.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.  
**Type:** String
2. **WEFAC:** The well efficiency factor. The value should be positive  
**Type:** Float  
**Minimum:** 0.0  
**Default value:** 1.0
3. *Reserved*

### Example

```
WEFAC
'P*' 0.9 /
P2    0.85 /
/
```



## 2.460 WELDRAW

### Description

This keyword defines the maximum drawdown allowed for production wells.

At Newton iteration (within the [NUPCOL](#) value), the maximum drawdown is converted into a maximum rate limit for the phase input in item 3, using the latest value of the phase's mobility in each connection:

$$Q_{max} = D_{max} \sum_j T_j M_j,$$

where  $Q_{max}$  is the max production rate of the phase entered with item 3,  $D_{max}$  is the maximum allowed drawdown entered with item 2,  $T_j$  is the transmissibility of connection  $j$ ,  $M_j$  is the phase mobility in the cell connected to connection  $j$ , and the sum is performed over all open connections.

If the PI-weighted average of the drawdown in the cells to which the well has open connections is selected, then the drawdown is computed as:

$$D = p_{avg} - BHP,$$

where  $p_{avg}$  is the PI-weighted average of the pressure  $p$  in the cells with open-connections to the well, i.e.

$$p_{avg} = \frac{\sum_j T_j M_j (p_j - H_{w,j})}{\sum_j T_j M_j},$$

where  $p_j$  is the pressure at connected cell  $j$  and  $H_{w,j}$  is the hydrostatic head between connection  $j$  and well bottom hole reference depth.

If instead the maximum drawdown is selected, the minimal allowed bottom hole pressure is computed as

$$BHP_{min} = \max_j (p_j - H_{w,j} - D_{max})$$

and the maximum production rate is evaluated as

$$Q_{max} = \sum_j T_j M_j (p_j - H_{w,j} - BHP_{min})$$

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** This field sets the wells to which the keyword applies. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** Integer

2. **DRAWDOWN:** Maximum drawdown for the well.

This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

3. **PHASE:** Phase to which the limit applies.

**Type:** String

**Default value:** LIQ

**Allowed values:**

Name	Description
LIQ	Liquid if well produces oil
GAS	Gas if the well produces gas

4. **POT:** Flag to include the maximum drawdown limit in potential calculations.

**Type:** Boolean

**Default value:** NO

**Allowed values:**

Name	Description
YES	The well potentials depend on BHP, THP and drawdown limits
NO	The well potentials depend only on BHP and THP limits

5. **AVG\_OR\_MAX:** Whether to limit the PI-weighted average of the drawdowns within the cells with open connections to the well, or the maximum drawdown within this same set of cells.

**Type:** String

**Default value:** AVG

**Allowed values:**

Name	Description
AVG	Limit the PI-weighted average drawdown
MAX	Limit the maximum drawdown

**Example**

```
WELDRAW
P1 200 LIQ YES MAX /
P2 100 GAS 2*  /
/
```



## 2.461 WELLGROUP

### Description

This keyword assigns wells to a group. The well should have been previously defined with keyword [WELSPECS](#). The group name entered with keyword [WELSPECS](#) will be overwritten by this keyword.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template. If this item is defaulted, this keyword applies to all wells already defined in the [SCHEDULE](#) section  
**Type:** String
2. **GROUP\_NAME:** The name of the group  
**Type:** String

### Example

In this example, well PR1 is assigned to group GPRD1. Wells INJ1 and INJ2 are both assigned to group GINJ1.

```
WELLGROUP
PR1 GPRD1 /
INJ1 GINJ1 /
INJ2 GINJ1 /
/
```



## 2.462 WELLSTRE

### Description

This keyword sets the composition of the injection stream in compositional run. If the mole fractions do not sum to 1.0, an internal renormalization is performed. Once the stream is defined, it can be used in the [WINJGAS](#) or [GINJGAS](#) keyword to specify the injection composition of wells or groups.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** The name of the injection stream

**Type:** String

2. **MOLE\_FRACTIONS:** (repeated  $N_c$  times)

$N_c$  mole fractions, where  $N_c$  is the number of components in the run. These values can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

**Default value:** 0.0

### Example

In this example, two injection streams are defined for  $N_c = 7$

```
WELLSTRE
STR1 0.0 1.0 0.0 0.0 0.0 0.0 0.0 /
STR2 0.0 0.0 1.0 0.0 0.0 0.0 0.0 /
/
```



## 2.463 WELLWAG

### Description

The purpose of this keyword is to define a water alternative gas (WAG) injection mode for a well. To establish the injection fluids, targets, and limits, a [WCONINJE](#) keyword must have been entered beforehand. The initial injection mode can be either water or gas, but the [WELLWAG](#) mode supersedes it. The other phase injection rate can be defined using [WELTARG](#).

If [WCONINJE](#) keyword is used after [WELLWAG](#) to specify the injection rates, the well will be reverted to single phase injection. However, if [WELTARG](#) is used to modify the rates, the wag process still continues with the new modifications.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

Using [WELLWAG](#) yields similar results as using [WCYCLE](#) with a gas and water injectors overlaying each other and switching on and off with an offset.

### Record format

- WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template. If this item is defaulted, this keyword applies to all wells already defined in the [SCHEDULE](#) section  
**Type:** String  
**Default value:** '\*'
- TIME\_PERIOD\_TYPE:** A character specifying the time period type  
**Type:** String  
**Default value:** T  
**Allowed values:**

Name	Description
T	Injection period is in days
M	Injection period is in months
Y	Injection period is in years

- 1ST\_INJ\_PHASE:** First injection phase

**Type:** String

**Allowed values:**

Name	Description
W	Water
G	Gas

- 1ST\_INJ\_PERIOD:** Injection period for the first phase defined in item 3

**Type:** Float

**Units:** Day (FIELD), Day (METRIC)

- 2ND\_INJ\_PHASE:** Second injection phase

**Type:** String

**Default value:** W if item 3 is G, or vice versa.

**Allowed values:**

Name	Description
W	Water
G	Gas

6. **2ND\_INJ\_PERIOD:** Injection period for the second phase defined in item 5

**Type:** Float  
**Units:** Day (FIELD), Day (METRIC)

7. **1ST\_INJ\_VFP:** Injection VFP table number for the first phase

**Type:** Integer

8. **2ND\_INJ\_VFP:** Injection VFP table number for the second phase

**Type:** Integer

9. **1ST\_INJ\_CONTROL\_MODE:** Control mode for the first phase

**Type:** String

**Default value:** RATE

**Allowed values:**

Name	Description
RATE	Controlled by surface flow rate defined in <a href="#">WCONINJE</a> or <a href="#">WELTARG</a>
BHP	Controlled by BHP limit
THP	Controlled by THP limit

10. **2ND\_INJ\_CONTROL\_MODE:** Control mode for the second phase

**Type:** String  
**Default value:** RATE  
**Allowed values:**

Name	Description
RATE	Controlled by surface flow rate defined in <a href="#">WCONINJE</a> or <a href="#">WELTARG</a>
BHP	Controlled by BHP limit
THP	Controlled by THP limit

11. **BHP\_Target\_1:** BHP target for the first injection phase

**Type:** Integer  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** BHP target previously defined in [[WCONINJE]] or [[WELTARG]]

12. **BHP\_Target\_2:** BHP target for the second injection phase

**Type:** Integer  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** BHP target previously defined in [[WCONINJE]] or [[WELTARG]]

13. **THP\_Target\_1:** THP target for the first injection phase

**Type:** Integer  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** THP target previously defined in [[WCONINJE]] or [[WELTARG]]

14. **THP\_Target\_2:** THP target for the second injection phase

**Type:** Integer  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:** THP target previously defined in [[WCONINJE]] or [[WELTARG]]

15. **SYNC\_TIMESTEP:** If set to 'YES', this option enforces the timesteps to have the same on-off cycling times of this well

**Type:** String  
**Default value:** NO

**Example**

In this example, [WELLWAG](#) keyword is used in simulating a water alternating gas (WAG) process. There are two wag injectors.

In the first one, water (first phase) is injected for 60 days before switching to gas (second phase) injection for another 60 days. The injection process will continue to alternate till the well is shut (manually or due to physical reasons) or the well wag stops by defining [WCONINJE](#) again.

The second injector alternate between gas and water with cycles of 3 month for each phase.

```
WELLWAG
'INJ1' T W 60.0 G 60.0 /
'INJ2' M G 3.0 W 3.0 /
/
```



## 2.464 WELL\_FRACTURE

### Description

This keyword assigns a planar fracture template to a well that has been defined through [WELL\\_TRAJECTORY](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Well name. This item cannot be defaulted  
**Type:** String
2. **TEMPLATE\_NAME:** Template name to be assigned to the well  
**Type:** String

### Example

In this example, planar fracture template 'HORIZ\_X\_TEMP' is assigned to well P1 and 'HORIZ\_Y\_TEMP' to well P2, provided that these two templates have already been defined using [PLANAR\\_FRACTURE\\_TEMPLATE](#) keyword.

```
WELL_FRACTURE
--wname    tempalte_name
  P1      'HORIZ_X_TEMP' /
  P2      'HORIZ_Y_TEMP' /
/
```



## 2.465 WELL\_TRAJECTORY

### Description

This keyword is used to input the well trajectory, which can be used to define connected cells and connection factors by using the keyword [COMPDATMD](#). The well trajectory is given as a list of x, y, z coordinates (consistent with grid coordinates) versus measured depths. The trajectory is taken as a linear segment between two successive coordinate entries. Completions are then defined along the trajectory via upper and lower measured depth for each completed interval.

Each record of this keyword consists of a well name followed by a list of coordinates versus measured depth. The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template. If this item is defaulted, this keyword applies to all wells already defined in the [SCHEDULE](#) section  
**Type:** String  
**Default value:** '\*'
2. **MD:** Measured depth of this trajectory point  
**Type:** Float
3. **X\_COORD:** X-coordinate of this trajectory point  
**Type:** Float
4. **Y\_COORD:** Y-coordinate of this trajectory point  
**Type:** Float
5. **Z\_COORD:** Z-coordinate of this trajectory point  
**Type:** Float

### Example

In this example, the trajectory of well W1 is specified using 10 points

```

WELL_TRAJECTORY
W1
0. 250. -1754.05 0.
1741.0 250. -1754.05 -1741.
1820.8 329. -1754.05 -1744.
1940.5 449. -1754.05 -1744.
2060.2 569. -1754.05 -1742.
2199.9 710. -1754.05 -1741.
2519.1 1030. -1754.05 -1738.
2539.0 1050. -1754.05 -1739.
2618.9 1130. -1754.05 -1740.
2638.8 1150. -1754.05 -1740. /

```



## 2.466 WEOPEN

### Description

This keyword shuts or reopens wells or connections. To shut or open a well, default items from 3 to 7. To change the current status of a connection or a list of connections defined with [COMPLUMP](#) keyword specify its coordinate with fields 3 to 5 or the range with fields 6 and 7. If any of the fields between the first and the seventh are not defaulted, then the connections matching the items are selected and opened/shut according to the second field. A value less or equal to zero selects all the available connections.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.
2. **STATUS:** Well or connection status  
**Default value:** OPEN  
**Allowed values:**

Name	Description
OPEN	Well or connection is open to flow
SHUT	Well or connection is shutin
STOP	Well is surface shutin, but crossflow may occur in the subsurface if enabled. If it applies to a connection, it is equivalent to SHUT

3. **I:** I-location of the connection  
**Default value:** Negative
4. **J:** J-location of the connection  
**Default value:** Negative
5. **K:** K-location of the connection  
**Default value:** Negative
6. **FIRST\_COMPLETION:** Number of the first completion in the range (completions are specified via [COMPLUMP](#))  
**Default value:** Negative
7. **LAST\_COMPLETION:** Number of the last completion in the range (completions are specified via [COMPLUMP](#))  
**Default value:** Negative

**Example**

This example opens well PROD1, shuts well PROD2, opens well INJ1 in layer 3 and SHUT all connections in completions 5, 6 and 7 of well INJ2

```
WEOPEN
--well status I J K first last
PROD1 OPEN           /
PROD2 SHUT          /
INJ1  OPEN   0 0 3    /
INJ2  SHUT   3*      5     7 /
/
```



## 2.467 WEOPENL

### Description

This keyword shuts or reopens wells or connections in a local grid. To shut or open a well, default items from 3 to 7. To change the current status of a connection or a list of connections defined with [COMPLUMP](#) keyword specify its coordinate with fields 3 to 5 or the range with fields 6 and 7. If any of the fields between the first and the seventh is not defaulted, then the connections matching the items are selected and opened/shut according to the second field. A value less or equal to zero selects all the available connections.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash. DOUBLECHECK WITH CLIPSE - WE HAVE DEFECTS

### Record format

1. **NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.
2. **LGRNAME:** Name of the local grid that contains the well connection. If this item is defaulted, the local grid name will be set equal to the well's local grid name entered in [WELSPECL](#) keyword

**Default value:** None

3. **STATUS:** Well or connection status

**Default value:** OPEN

**Allowed values:**

Name	Description
OPEN	Well or connection is open to flow
SHUT	Well or connection is shutin
STOP	Well is surface shutin, but crossflow may occur in the subsurface if enabled. If it applies to a connection, it is equivalent to SHUT.

4. **I:** I-location of the connection

**Default value:** Negative

5. **J:** J-location of the connection

**Default value:** Negative

6. **K:** K-location of the connection

**Default value:** Negative

7. **FIRST\_COMP:** The number of the first completion in the range (completions are specified via [COMPLMPL](#))

**Default value:** Negative

8. **LAST\_COMP:** The number of the last completion in the range (completions are specified via [COMPLMPL](#))

**Default value:** Negative

**Example**

This example opens all wells whose name begin with P, shuts well PROD2, opens well PROD3 in layer 3 of LGR1 grid and SHUT all connections in completions 5, 6 and 7 of well INJ2

```
WEOPEN
--well lgr  status  I  J  K  first last
'P*'
PROD2  SHUT
PROD3  LGR1  OPEN    0  0  3      /
INJ2   1*    SHUT    3*      5      7  /
/
```



## 2.468 WELPI

### Description

This keyword is used to specify the productivity or injectivity index for the wells. Well connections should be specified using the keyword [COMPDAT](#). Connection transmissibility factors are calculated so that the productivity or injectivity index matches that specified with this keyword.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword input is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.  
**Type:** String  
**Default value:** '\*'  
2. **PI:** Well productivity or injectivity index  
**Type:** Float  
**Units:** stb/day/psi (FIELD), sm<sup>3</sup>/day/bar (METRIC)  
**Default value:** None (FIELD), None (METRIC)

### Example

```
WELPI
PRD1 10.2 /
INJ3 8.04 /
/
```



## 2.469 WELPRI

### Description

This keyword sets the well priority values or a scaling factor for the inputted priority value or the calculated priority through priority formula, see [PRIORITY](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.  
**Type:** String  
**PRI1:** If positive, this number overrides any value computed by the first priority formula (see [PRIORITY](#)). Zero throws an error.  
**Type:** Float  
**Default value:** negative
2. **SCALE1:** Scaling factor for the well first priority value, no matter if is set by the first priority formula or by PRI1 in this keyword.  
**Type:** Float  
**Default value:** 1.0
3. **PRI2:** If positive, this number overrides any value computed by the second priority formula (see [PRIORITY](#)). Zero throws an error.  
**Type:** Float  
**Default value:** negative
4. **SCALE2:** Scaling factor for the well second priority value, no matter if set by the second priority formula or PRI2 in this keyword.  
**Type:** Float  
**Default value:** 1.0

### Example

```
WELPRI
'P1' 10.0 /
'P2' 1* 2.0 /
'P3' 1* 1* 5.0 /
/
```



## 2.470 WELSPECL

### Description

This keyword should be used instead of [WELSPECS](#) to define new wells and well properties in local grids. In this case the keyword [COMPDATL](#) should be used to define the connection data instead of the keyword [COMPDAT](#). [WELSPECL](#) must be entered in the [SCHEDULE](#) section before any other well specification keyword that refers to this well.

The keyword may contain an arbitrary number of records, each record is terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** The well name. This item can not be defaulted  
**Type:** String  
**Default value:** None
2. **GROUP\_NAME:** The name of the group that contains the well  
**Type:** String  
**Default value:** FIELD
3. **LGR\_NAME:** The name of the local grid to which the well is assigned (see keyword [CARFIN](#))  
**Type:** String
4. **HEAD\_I:** I-location of the wellhead in the coordinate of the local grid  
**Type:** Integer
5. **HEAD\_J:** J-location of the wellhead in the coordinate of the local grid  
**Type:** Integer
6. **REF\_DEPTH:** The reference depth for reporting the bottom hole pressure of the well.  
The reference depth should be located in the vicinity of the perforations. It is recommended to use the center depth of the topmost perforation of the well.  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)  
**Default value:** Center depth of the shallowest connection (FIELD), Center depth of the shallowest connection (METRIC)
7. **PHASE:** The preferred phase for the well. It is used to determine:
  - the phase used to calculate the well productivity or injectivity index,
  - the worst offending well or connection to close when a group's production constraint, as defined in keyword [GCONPROD](#) or [GCONPRI](#), has been violated.

**Type:** String

#### Allowed values:

Name	Description
OIL	Oil is the preferred phase
GAS	Gas is the preferred phase
WAT	Water is the preferred phase
LIQ	The liquid (oil+water) phase is the preferred phase

8. **DR:** The well drainage radius used for the calculation of productivity or injectivity index. If defaulted or set to zero, then the simulator will use the pressure equivalent radius of the grid blocks that contain well's connections.

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

9. **INFLOW\_EQ:** Phase mobility model to be used for computing gas and oil flow rates between completed cells and well completions. The Russell-Goodrich and dry gas-pseudo pressure models are supported for black-oil runs only. The generalized pseudo-pressure model is supported for compositional runs only.

**Type:** Integer

**Default value:** STD

**Allowed values:**

Name	Description
STD	Standard inflow equation
NO	Equivalent to STD
R-G	Russell-Goodrich inflow equation
P-P	Dry-gas pseudo-pressure equation
GPP	Generalized pseudo-pressure equation

10. **SHUTIN:** Automatic action to be taken when economic limits of the well or of its group are violated.

**Type:** String

**Default value:** SHUT

**Allowed values:**

Name	Description
SHUT	The well is shutin at the surface and downhole
STOP	The well is shutin for surface flow, but crossflow may occur in the subsurface, if enabled.

11. **XFLOW:** Flag to disable crossflow

**Type:** String

**Default value:** YES

**Allowed values:**

Name	Description
YES	Crossflow is allowed in the well
NO	Crossflow is disabled. A STOP well with crossflow disabled behaves as a SHUT well

12. **PVTNUM:** PVT table number used in the calculation of the wellbore fluid properties that define the relationship between reservoir and surface volume rates. Only the default value is currently supported.

- **BO:** If it set to zero or defaulted, the PVT number is set to be the same as the PVT region number of the deepest connection in the well
- **COMP:** if it is set to zero or defaulted, the PVT number is set to be the same as the PVT region number of the first well connection

**Type:** Integer

**Default value:** 0

13. **DENSITY:** Type of density calculation used in calculating the wellbore hydrostatic head

**Type:** String

**Default value:** SEG

**Allowed values:**

Name	Description
AVG	The mixture density is considered uniform in the wellbore and is dependent on each phase total inflow rate and on the bottom hole pressure.
SEG	The mixture density is computed between each pair of neighboring well connections using the flowing phase volumes from the connections. This is generally more accurate if the fluid properties flowing from the well connections are variable.

14. **FIPNUM:** The number of the FIP region to be used for computing the well's reservoir volume rate:

- If it is set to zero or defaulted, the average properties for the field will be used
- If it is set to a negative value, the **FIPNUM** region of the deepest connection in the well will be used
- If it is set to a positive value, the **FIPNUM** identified by this value will be used

**Type:** Integer

**Default value:** 0

### Example

```
WELSPECL
--name group LGR I J depth phase dr inflow head FIP
P1 G1 LGR1 10 35 1200.0 1* 1* GPP /
P2 G2 LGR2 20 42 1700.0 1* 1* 4* AVG -1 /
/
```



## 2.471 WELSPECS

### Description

This keyword defines a new well and its properties, such as the well name, location of the wellhead, the well reference depth and other properties. It must be entered in the **SCHEDULE** section before any other well specification keyword that refers to this well.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELLNAME:** The well name. This item can not be defaulted

**Type:** String

**Default value:** None

2. **GROUPNAME:** The name of the group that contains the well

**Type:** String

**Default value:** FIELD

3. **HEAD\_I:** I-location of the wellhead or heel

**Type:** Integer

**Minimum:** 1

**Maximum:** NX

**Default value:** None

4. **HEAD\_J:** J-location of the wellhead or heel

**Type:** Integer

**Minimum:** 1

**Maximum:** NY

**Default value:** None

5. **REF\_DEPTH:** The reference depth for reporting the bottom hole pressure of the well.

The reference depth should be located in the vicinity of the perforations. It is recommended to use the center depth of the topmost perforation of the well.

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** Center depth of the shallowest connection (FIELD), Center depth of the shallowest connection (METRIC)

6. **PHASE:** The preferred phase for the well.

It is used to determine:

- the phase used to calculate the well productivity or injectivity index,
- the worst offending well or connection to close when a group's production constraint, as defined in keyword **GCONPROD** or **GCONPRI**, has been violated.

**Type:** String

**Default value:** None

**Allowed values:**

Name	Description
OIL	Oil is the preferred phase
GAS	Gas is the preferred phase
WAT	Water is the preferred phase
LIQ	The liquid (oil+water) phase is the preferred phase

7. **DR:** The well drainage radius for productivity or injectivity index calculation. If defaulted or set to zero, then the simulator will use the pressure equivalent radius of the grid blocks that contain well's connections.

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

8. **INFLOW\_EQ:** Phase mobility model to be used for computing gas and oil flow rates between completed cells and well completions. The Russell-Goodrich and dry gas-pseudo pressure models are supported for black-oil runs only. The generalized pseudo-pressure model is supported for compositional runs only.

**Type:** String

**Default value:** STD

**Allowed values:**

Name	Description
STD	Standard inflow equation
NO	Equivalent to STD
R-G	Russell-Goodrich inflow equation
P-P	Dry-gas pseudo-pressure equation
GPP	Generalized pseudo-pressure equation

9. **SHUTIN:** Automatic action to be taken if the well or group's economic limits are violated.

**Type:** String

**Default value:** SHUT

**Allowed values:**

Name	Description
SHUT	The well is shutin at the surface and downhole
STOP	Well is shutin for surface flow, but crossflow may occur in the subsurface, if enabled.

10. **XFLOW:** Flag to disable crossflow

**Type:** String

**Default value:** YES

**Allowed values:**

Name	Description
YES	Crossflow is allowed in the well
NO	Crossflow is disabled. A STOP well with crossflow disabled behaves as a SHUT well

11. **PVTNUM:** PVT table number is used in the calculation of the wellbore fluid properties that define the relationship between reservoir and surface volume rates. Only the default value is currently supported.

- **BO:** If it is set to zero or defaulted, the PVT number is set to be the same as the PVT region number of the deepest connection in the well
- **COMP:** if it is set to zero or defaulted, the PVT number is set to be the same as the PVT region number of the first well connection

**Type:** Integer

**Minimum:** 0

**Maximum:** 0

**Default value:** 0

12. **DENSITY:** The type of density calculation used in calculating the wellbore hydrostatic head

**Type:** String

**Default value:** SEG

**Allowed values:**

Name	Description
AVG	The mixture density is considered uniform in the wellbore and is dependent on each phase total inflow rate and on the bottom hole pressure.
SEG	The mixture density is computed between each pair of neighboring well connections using the flowing phase volumes from the connections. This is generally more accurate if the fluid properties flowing from the well connections are variable.

13. **FIPNUM:** The number of the FIP region to be used for computing the well's reservoir volume rate:

- If it is set to zero or defaulted, the average properties for the field will be used
- If it is set to a negative value, the **FIPNUM** region of the deepest connection in the well will be used
- If it is set to a positive value, the **FIPNUM** identified by this value will be used

**Type:** Integer

**Default value:** 0

### Example

In this example, two wells are defined. Well P1 belongs to group G1, its wellhead is located at I=10 and J=35, its reference depth is set to 1200, and GPP inflow model is used. Well P2 belongs to group G2, its wellhead is located at I=20 and J=42, the reference depth is 1700, the average density option is selected for wellbore density calculation and the **FIPNUM** of the deepest connection is used for reservoir rate calculation.

```
WELSPECS
--name group I   J   depth  phase dr   inflow  head   FIP
  P1    G1    10  35  1200.0 1*    1*   GPP      / 
  P2    G2    20  42  1700.0 1*    1*   4*       AVG     -1  /
/
```



## 2.472 WELTARG

### Description

This keyword resets the value of well control or target, defined by [WCONPROD](#) or [WCONINJE](#) keywords or by [WCONHIST](#) and [WCONINJH](#) keywords if the well is being history matched. Depending on whether the well is operating on history or non-history mode, the following rules apply with [WELTARG](#):

- If BHP limit is specified in item 2, [WELTARG](#) always resets the BHP limit for both history and non-history operated wells
- If history mode is on and the well is on rate control, [WELTARG](#) resets the limit only if the limit specified in item 2 matches the control mode set using [WCONHIST](#) or [WCONINJH](#) keywords. If the control modes do not match and item 2 is not BHP, the original history value is reset with the target value specified in item 3 for the corresponding phase (but not the limit).
- If history mode is on and the well is under BHP control, [WELTARG](#) resets the observed history values for the specified phase rate. However, the historical BHP does not get changed (only the limit does).
- If history mode is off, [WELTARG](#) simply resets the target for the specified control mode

Additionally, [WELTARG](#) can be used to reset the VFP table number, the artificial lift quantity or guide rate (for wells under group control).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template. If this item is defaulted, this keyword applies to all wells already defined in the [SCHEDULE](#) section

**Type:** String

**Default value:** '\*'

2. **MODE:** Control or quantity to be changed

**Type:** String

**Allowed values:**

Name	Description
ORAT	Oil surface rate. The target can be specified using a user-defined argument ( <a href="#">UDA</a> )
WRAT	Water surface rate. The target can be specified using a <a href="#">UDA</a>
GRAT	Gas surface rate. The target can be specified using a <a href="#">UDA</a>
LRAT	Liquid surface rate. The target can be specified using a <a href="#">UDA</a>
BHP	Bottom hole pressure. The target can be specified using a <a href="#">UDA</a>
THP	Tubing head pressure. The target can be specified using a <a href="#">UDA</a>
VFP	VFP table number
LIFT	Artificial lift quantity. The target can be specified using a <a href="#">UDA</a>
GUID	Guide rate. The target can be specified using a <a href="#">UDA</a>

3. **TARGET:** The new value for the quantity selected in item 2.

**Type:** Float

**Example**

```
WELTARG
PR1 BHP 100 /
INJ1 WRAT 1000 /
/
```



## 2.473 WFLUIDSPLIT

### Description

This keyword enables the association of wells with the [FLUIDSPLIT](#) tables. It can contain an arbitrary number of records, each terminated by a slash (/), with a trailing slash marking the end.

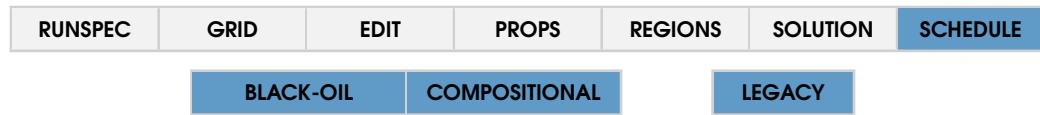
### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the [SCHEDULE](#) section.
2. **FLUID\_SPLIT\_TABLE:** The corresponding [FLUIDSPLIT](#) table name.  
For the provided table name, a well is linked to a user-named table, **FLUID\_SPLIT\_TABLE**.  
For the missing table name, a well is dynamically linked to [FLUIDSPLIT](#) tables using PVT/EOS regions associated with the well.

### Example

In this example, we consider the producing wells “PROD\*” and two injecting wells IG1, IG2. All producing wells matching the “PROD\*” pattern are linked to the FLUID-SPLIT table named SPLIT1. The gas injector IG1 is defaulted, and the [FLUIDSPLIT](#) will be dynamically assigned based on the EOS/PVT region number associated with a well. The well IG2 has no WFLUIDSPLIT properties and will behave similarly to well IG1.

```
WFLUIDSPLIT
'PROD*' SPLIT1 /
'IG1' /
/
```



## 2.474 WGRUPCON

### Description

This keyword defines well guide rate for group control.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** '\*'

2. **GROUP\_CTRL:** Is this well available for group control?

**Type:** Boolean

**Default value:** YES

**Allowed values:**

Name	Description
YES	The well is under group control if a rate target is set for its group or on a connecting higher level group as well as the FIELD group.
NO	The well is NOT under group control. It operates with its own limits

3. **GUIDE\_RATE:** A well guide rate is a dimensionless number specifying the well's share of the group target rate. The target well rates are set proportionally to its guide rate. If a zero or negative number is specified, then at the beginning of each timestep the guide rate is set according to the formula specified with the keyword [GUIDERAT](#). If no formula is specified or if the well is an injector, the well guide rate is set proportionally to its production or injection potentials.

**Type:** Float

**Default value:** Negative

4. **PHASE:** The phase to which the guide rate applies

**Type:** String

**Allowed values:**

Name	Description
OIL	Oil phase
WAT	Water phase
GAS	Gas phase
LIQ	Liquid (oil+water) phase
WGA	Wet gas rate
RES	Reservoir volume rate

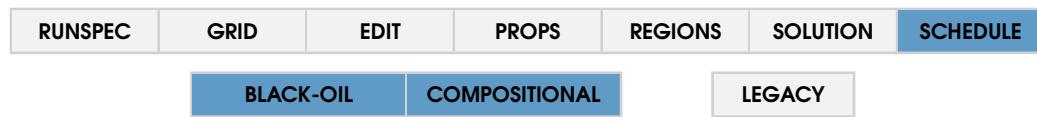
5. **SCALE:** Scaling factor to multiply the well guide rate

**Type:** Float

**Default value:** 1.0

**Example**

```
WGRUPCON
PR YES 1000 OIL /
PR2 NO /
/
```



## 2.475 WHHDFACT

### Description

The `WHHDFACT` keyword adjusts the damping factor applied to the update of well hydrostatic heads from timestep to timestep. The keyword should be followed by any number of slash-terminated records. Each record should consist of a well name or pattern followed by a floating-point damping factor. A damping factor of 0 results in no damping, while a factor of 1 will result in a constant, time-independent head. The keyword is terminated by a line containing only a slash.

### Record format

Field	Name	Type	Description
1	WELLNAME	String	Well name or pattern
2	DAMPFACT	Float	Damping factor

#### Example 1

To set the head damping factor for well P3A to 0.25:

```
WHHDFACT
  'P3A' 0.25 /
/
```

#### Example 2

Adjust the damping factor for all wells that have been defined up to this point in the SCHEDULE to 0.4.

```
WHHDFACT
  '*' 0.4 /
/
```



## 2.476 WHISTCTL

### Description

This keyword allows for a quick change of the control mode of all history matching production wells without having to work through all the `WCONHIST` keywords. It overwrites the control mode specified in all subsequent `WCONHIST` and `WCONINJH` keyword with the control mode specified in item 1. Note that this keyword does not affect previously defined `WCONHIST` keywords.

The keyword contains a single record, terminated with a slash (/).

### Record format

1. **MODE:** Control mode used to override the control mode specified in all subsequent `WCONHIST`

**Type:** String

**Default value:** NONE

**Allowed values:**

Name	Description
BHP	Observed bottom hole pressure
GRAT	Observed gas rate
LRAT	Observed liquid (oil+water) rate
NGL	Observed natural gas rate
NONE	No override is applied. The control mode specified in the subsequent <code>WCONHIST</code> keywords will be used
ORAT	Observed oil rate
RESV	Observed reservoir volume rate
WGRAT	Observed wet gas rate
WRAT	Observed water rate

2. *Reserved*

### Example

```
WHISTCTL
ORAT /
```



## 2.477 WINJGAS

### Description

The `WINJGAS` keyword can be used to control how the composition of injected gas is determined for a well. If the superior group has gas injection controls for which the nature of the injected gas has been specified using the keyword `GINJGAS`, the injection stream will be that defined for the group if well injection stream is not specified using this keyword. The `GINJGASOPTS` keyword also enables the user to select a specific group of `GINJGAS` properties to be used for a well.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

- WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by `WLIST` keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the `SCHEDULE` section.

**Type:** String

- GAS\_NATURE:** The nature of the injected gas

**Type:** String

**Default value:** GRUP

**Allowed values:**

Name	Description
GAS	The gas composition corresponds to the field separator gas composition
STREAM	The gas composition is defined with the keyword <code>WELLSTRE</code> . The stream name must be entered in item 3 of this keyword
MIX	The gas composition mixture is defined with the keywords <code>WINJORD</code> , <code>WINJMIX</code> , and <code>WINJSUM</code> . The mixture name must be entered in item 3 of this keyword
GV	The gas composition corresponds to the gas composition produced by a specified group. The group name of the group must be entered in item 3 of this keyword
WV	The gas composition corresponds to the gas composition produced by a specified well. The well name (or group name) must be entered in item 3 of this keyword
GRUP	The gas composition is that defined for a superior group

- SOURCE\_NAME:** The name of the stream, mixture, group or well depending on the value specified in item 2

**Type:** String

- MAKE\_UP\_GAS:** Name of a well stream to be used as makeup gas, in case there is not enough gas for injection from the source specified with item 2 and 3. The makeup gas composition must be defined with the keyword `WELLSTRE`

**Type:** String

- SEPARATOR\_STAGE:** The stage separator number which defines the fluid composition for injection. The gas from any stage may be used for injection.

**Type:** Integer

**Default value:** 0

**Example**

In this example, the nature of the injected gas of well PR1 is set to a stream whose name is CO2-STREAM. The gas composition should have been previously defined with keyword WELLSTRE

```
WINJGAS
'PR1' STREAM 'CO2-STREAM'
/
```



## 2.478 WINJMX

### Description

This keyword creates injection streams by blending different sources, where each source contribution is computed using a requested fraction and an available volumetric rate. The resulting mixture has the specified source contributions (fractions).

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash. Each record defines a source for an injection stream.

When `WINJMX` is utilized in conjunction with `WAVAILIM`, the gas available for injection is constrained by the total gas output of all producing items. By default, the gas availability does not extend to items within the mixture, and an item's availability may exceed the gas it produces. The participation of each item is calculated based on the gas available from all items and user-defined fractions. Effectively, `WINJMX` can provide a mixture composition independent of the injection rate.

Using `EXTEND_WINJMX_AVAILABILITY=YES` in `DEFAULTS` allows for the consideration of individual item availabilities in the mixture and overrides the default keyword behavior.

### Record format

1. **MIXTURE\_NAME:** Name of the injecting stream.
2. **CONTRIBUTION\_INDEX:** The contribution index of this fluid in the injecting mixture.
3. **FRACTION:** The fraction of this fluid in the resulting injecting mixture.
4. **SOURCE\_TYPE:** The fluid source type.

#### Allowed values:

Name	Description
GAS	The same as GV
STREAM	The injected composition of the mixture is defined using <code>WELLSTRE</code> from the item 5.
GV	The injected composition is inherited from a producing group given in item 5.
WV	The injected composition is inherited from a producing well given in item 5.

5. **SOURCE\_NAME:** The fluid source name. This option is available with STREAM, GV, and WV. GAS is internally converted into GV and utilizes gas from the FIELD level.
6. **SEPARATOR\_STAGE:** The separator stage used for injection. The default value is zero and allows to injected gas form a head of a separator.

### Example 1

In this example, the keyword specifies the injecting mixture MX consuming gas from the well PRD1 and the fixed stream STR1.

```
WINJMX
MX 1 0.4 WV PRD1 /
MX 2 0.6 ST STR1 /
/
```

**Example 2**

In this example the mixture defined by WINJMIX is limited in its availability by [WAVAILIM](#) and only 17 millions of scf/day can be injected.

```
WAVAILIM  
  
WINJMIX  
  MX 1 0.5 GV G1 /  
  MX 2 0.5 GV G2 /  
/  
  
GCONPROD  
  FIELD GRAT 2* 25000 /  
  G1 GRAT 2* 9000 /  
  G2 GRAT 2* 8000 /  
/  
  
GCONINJE  
  FIELD GAS REIN 1* 1* 1.0 4* FIELD /  
/  
  
GINJGAS  
  FIELD MIX MX /  
/
```



## 2.479 WINJORD

### Description

This keyword creates an ordered stream and allows specifying the composition of an injected gas. This stream ranks sources and performs mixing by adding sources according to their contribution indices. It requires a list of sources and a list of contribution indices.

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

### Record format

1. **MIXTURE\_NAME:** Name of the injecting stream.
2. **CONTRIBUTION\_INDEX:** The contribution index of this fluid in the injecting mixture.
3. **SOURCE\_TYPE:** The fluid source type.

#### Allowed values:

Name	Description
GAS	The same as GV
STREAM	The injected composition of the mixture is defined using <a href="#">WELLSTRE</a> from the item 4.
GV	The injected composition is inherited from a producing group given in item 4.
WV	The injected composition is inherited from a producing well given in item 4.

4. **SOURCE\_NAME:** The fluid source name. This option is available with STREAM, GV, and WV. GAS is internally converted into GV and utilizes gas from the FIELD level.
5. **SEPARATOR\_STAGE:** The separator stage used for injection. The default value is zero and allows to injected gas form a head of a separator.

### Example

In this example, the keyword specifies the injecting mixture MX consuming gas from the well PRD1 and the fixed stream STR1.

```
WINJORD
MX 1 WV PRD1 /
MX 2 ST STR1 /
/
```



## 2.480 WINJSUM

### Description

This keyword creates a weighted stream and allows specifying the composition of an injected gas. This stream forms a mixture from a list of sources, where each source contribution is computed using its fraction. The resulting mixture is obtained by directly adding weighted volumetric rates from each source. The keyword has a similar input format as [WINJMIX](#) but produces a different composition. It requires a list of sources and a list of contribution indices.

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

### Record format

1. **MIXTURE\_NAME:** Name of the injecting stream.
2. **CONTRIBUTION\_INDEX:** The contribution index of this fluid in the injecting mixture.
3. **FRACTION:** The volumetric contribution of this fluid to the injecting mixture.
4. **SOURCE\_TYPE:** The fluid source type.

#### Allowed values:

Name	Description
GAS	The same as GV
STREAM	The injected composition of the mixture is defined using <a href="#">WELLSTRE</a> from the item 5.
GV	The injected composition is inherited from a producing group given in item 5.
WV	The injected composition is inherited from a producing well given in item 5.

5. **SOURCE\_NAME:** The fluid source name. This option is available with STREAM, GV, and WV. GAS is internally converted into GV and utilizes gas from the FIELD level.
6. **SEPARATOR\_STAGE:** The separator stage used for injection. The default value is zero and allows to injected gas form a head of a separator.

### Example

In this example, the keyword specifies the injecting mixture MX consuming gas from the well PRD1 and the group GRP1.

```
WINJSUM
MX 1 0.5 WV PRD1  /
MX 2 0.5 GV GRP1  /
/
```



## 2.481 WLIFT

### Description

This keyword can be used to modify how artificial lift works. More specifically, it may alter the value of the artificial lift quantity used in THP computations or well efficiency factor whenever one of the following conditions is met:

- Well's production rate falls below the value specified in item 2
- Well's water cut exceeds the value specified in item 7
- Well's gas-liquid ratio exceeds the value specified in item 9

`WLIFT` operations will only be carried out for open producers. In particular, a closed producer will not be opened if `WLIFT` conditions are met.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

Note: This keyword is unrelated to the gas lift optimization facility managed with the `LIFTOPT`, `WLIFTOPT` and `GLIFTOPT` keywords.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by `WLIST` keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** ‘\*’

2. **RATE:** Well production rate, below which the lift switching operation is performed. A zero or negative value implies that the switching operation is not triggered by a low production rate

**Type:** Float

**Units:** stb/day (FIELD), sm<sup>3</sup>/day (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

3. **RATE\_NAME:** Phase to which the production rate limit specified in item 2 applies

**Type:** String

**Default value:** OIL

**Allowed values:**

Name	Description
OIL	Rate production limit applies to the oil phase
LIQUID	Rate production limit applies to the liquid (oil+water) phase
GAS	Rate production limit applies to the gas phase

4. *Reserved*

5. **LIFT:** New artificial lift quantity to be used to interpolate the VFP table. This value replaces any previously specified value entered with keywords `WCONPROD` or `WELTARG`. The lift switching is performed can be performed in stages using the incremental value specified in item 10

**Type:** Float

**Default value:** 0.0

6. **WEFAC:** New well efficiency factor after lift switching. This value replaces any number previously specified with the keyword `WEFAC`. A zero or negative value left the original efficiency factor unchanged

**Type:** Float

**Default value:** 0.0

7. **WCUT:** Well water cut limit, above which the lift switching operation is performed. A zero or negative value implies that the switching operation is not triggered in case of high water cut

**Type:** Float

**Units:** stb/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

8. *Reserved*

9. **WGLR:** Well gas-liquid volume ratio, above which the lift switching operation is performed. A zero or negative value implies that the switching operation is not triggered in case of high gas-liquid volume ratio

**Type:** Float

**Units:** Mscf/stb (FIELD), sm<sup>3</sup>/sm<sup>3</sup> (METRIC)

**Default value:** 0.0 (FIELD), 0.0 (METRIC)

10. **INCREMENT:** Increment value to be added to (or subtracted from) the well's ALQ value at each lift switching in order to reach the final ALQ value (specified in item 5).

**Type:** Float

#### Example

```
WLIFT  
'PROD' 40 OIL 1* 5 /  
/
```



## 2.482 WLIFTOPT

### Description

This keyword specifies for which wells the gas lift rate should be controlled by the gas lift optimization option, previously activated with [LIFTOPT](#). For each well, the user can set minimum and maximum rates and options for preferential allocation and gradients computation.

The keyword contains one record per well. Each record is terminated with a slash (/). The keyword is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Name of the well.  
**Type:** String
2. **IS\_LIFT\_OPTIMIZED:** This item specifies whether the gas lift should be optimized for this well.  
**Type:** String  
**Allowed values:**

Name	Value Type	Description
YES	String	The lift rate assigned to this well is calculated through the gas lift optimization option.
NO	String	The lift rate assigned to this well is fixed and equal to the value set in Item 3.

3. **MAXIMUM\_LIFT:** The maximum gas lift rate that can be assigned to the well. If Item 2 is set to NO, this corresponds to the fixed gas lift rate that is assigned to the well. Setting a maximum gas lift rate for gas lift optimization higher than the largest gas lift rate in the VFP table might lead to convergence issues. If this item is defaulted, ECHELON uses the largest gas lift value of the corresponding VFP table.

**Type:** Float  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

4. **WEIGHT\_FACTOR:** The weight factor used in the computation of the weighted incremental gradient. When the maximum gas lift rate of a group ([GLIFTOPT](#), Item 2) is exceeded by the sum of the minimum gas lift rates of the children wells (Item 5), this value is used to prioritize the allocation of the minimum gas lift rates. If this value is larger than 1, the well will always flow with a gas lift rate larger than the minimum value (Item 5) even if the group target could be achieved with a lower rate.

**Type:** Float  
**Default value:** 1.0

5. **MINIMUM\_LIFT:** The minimum gas lift rate that can be assigned to the well. If a negative value is used, the well will be assigned at least enough gas lift to keep it flowing, unless the well cannot flow with the maximum lift rate set in Item 3. If a positive value is used, the well will be assigned a gas lift rate larger than the limit, unless one of following conditions holds: (a) a rate target of the well could be achieved with a lower level of gas lift; (b) a target of any group up in the hierarchy could be achieved with a lower level of gas lift and the weight factor (item 4) is lower than 1. If the gas lift rate available is not sufficient to satisfy the minimum requirements of all the wells, this minimum bounds are respected in decreasing order of weight factor (item 4).

**Type:** Float  
**Units:** Mscf/day (FIELD), sm<sup>3</sup>/day (METRIC)

6. **GAS\_WEIGHT\_FACTOR:** The gas gas weight factor used in the computatation of the incremental gradient. Values larger than 0 can be used to discourage enhanced gas production due to gas lift.

**Type:** Float

**Default value:** 0

### Example

In this example, the weight factor of WELL1 is larger than 1 so that the well is always allocated at least 2000 MScf/d of lift gas even if group targets could be achieved with a lower value. Furthermore, a value of gas weight different from 0 is set to discourage enhanced production of gas due to lift gas allocation. WELL2 is not optimized and its gas lift rate is set to 1000 MScf/d. Finally, the gas lift rate of WELL3 is controlled in such a way to keep it flowing, unless it cannot flow at its maximum value of 3000 MScf/d.

```
WLIFTOPT
-- Well Opt?      Max     Weight   Min     Gas
-- Name           Lift     Lift    Weight
  WELL1    YES      2000     1.01    1*      0.1   /
  WELL2    NO       1000
  WELL3    YES      3000     1*      -1
/

```



## 2.483 WLIST

### Description

This keyword is used to specify and maintain well lists, that are lists of well names. Well list names can be used to replace well names in every well keyword in the [SCHEDULE](#) section that requires a well root name to be specified, as well as in every well [SUMMARY](#) keyword.

In order to use well list in a well keyword, well list name should be prepended with “\*”.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **LIST\_NAME:** The well list name  
**Type:** String
2. **OPERATION:** Operation to be performed on this list of well names  
**Type:** String

#### Allowed values:

Name	Description
NEW	Well names specified in item 3 are added to a new list whose name is specified in item 1
ADD	Add well names specified in item 3 to the list specified in item 1
MOVE	Move well names specified in item 3 to the list specified in item 1
DEL	Remove well names specified in item 3 from the list specified in item 1

3. **WELL\_NAMES:** List of well names. Note that wells should have been previously defined with keyword [WELSPCS](#). If this item is defaulted, all wells already defined in the [SCHEDULE](#) section are added to the list

**Type:** String

**Default value:** ‘\*’

### Example

In this example, a new list L1 is created and wells PR1 and PR2 are added to the list. Well PR3 is added to list L2. List L1 is used to update oil rate target for all wells in the list.

```

WLIST
L1 NEW PR1 PR2 /
L2 ADD PR3 /
/

WELTARG
*L1 ORAT 1500 /
/

```



## 2.484 WORK

### Description

The `WORK` keywords are used to specify temporary double-precision values for each cell. The keyword name is followed immediately by an integer indicating the array, number, e.g. “`WORK1`”, “`WORK2`”, etc. These array values are not directly utilized in themselves, but are used as intermediate storage in computing complex expressions for other cell-based input. `WORK` can be the source or target array for other keywords such as `OPERATE`, `OPERATER`, `ADD`, `EQUALS`, `MINVALUE`, `MAXVALUE`, `MULTIPLY`, `MULTIREG`, etc. `WORK` values are not carried over between sections.

The maximum number of work arrays is specified in the 8<sup>th</sup> field of the `REGDIMS` keyword. See also `IWORK` for storing temporary integer arrays.

### Example

The following is used to set permeability as a function of porosity. Note that this example has little physical meaning, but could be used to implement the following equation:

$$\text{PERMX} = \frac{1}{\sqrt{1 + \text{PORO}^2}}.$$

```

EQUALS
  WORK1 1.0 /
  WORK2 0.0 /
/

OPERATE
  -- compute WORK1 = 1 + PORO^2
  WORK1 6* POLY PORO 1.0 2.0 /

  -- compute WORK2 = sqrt(WORK1)
  WORK2 6* POLY WORK1 1.0 2.0 /

  -- compute PERMX = 1.0 / WORK2
  PERMX 6* INV WORK2 /
/

```



## 2.485 WORKLIM

### Description

The keyword defines the time taken by a workover rig to accomplish any workover. A non-zero workover time implies that a workover rig is required. A workover rig is assigned to a group with the [GRUPRIG](#) keyword. In the event that a rig is not accessible in the current group or any higher-level groups, workover will be delayed until a rig becomes available.

Currently, only workover related to [WECON](#) will use the time defined in this keyword.

Note that a well efficiency factor will be set to zero during workover if the option is set in item 3 of [WDRILTIME](#) keyword.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WORK\_OVER\_TIME:** Time needed to do a workover

**Type:** Float

**Units:** Day (FIELD), Day (METRIC)

**Default value:** 0.0

### Example

In this example, the workover time for all the wells is set to 30 days.

```
WORKLIM
-- workover_time
  30.0      /
/
```



## 2.486 WPAVEC

### Description

The keyword [WPAVEC](#) (or [WWPAVEC](#) for individual wells) controls the method of computation for reporting the average pressure near wells. See the technical manual for more details. These keywords are allowed in the [SCHEDULE](#) section. The [WPAVEC](#) keywords applies to all wells defined in the [SCHEDULE](#) section following the date where the keyword is first activated. The parameters can be provided in any order on the keyword.

The average pressure reported by ECHELON for a well is an average of completion connection factor weighting and pore volume weighting according to  $p_w = f \cdot p_{w,CT} + (1-f) \cdot p_{w,PV}$  where  $p_{w,CT}$  is connection transmissibility weighted average and  $p_{w,PV}$  is pore volume weighted average.  $f$  is the weighting factor between  $p_{w,CT}$  and  $p_{w,PV}$ , with  $0 \leq f \leq 1$ .

Well specific controls can be provided by using keyword [WWPAVEC](#) in which case the WELL\_NAMES parameter is required to define a well name, well list or well name pattern. If a WELL\_NAMES parameter is not provided, the settings are applied to all the wells (as with [WPAVEC](#)). Wells must be previously defined before assigning them in [WWPAVEC](#). If no [WPAVEC](#) / [WWPAVEC](#) is present, then default values as noted below are used when computing the average pressure for reporting.

The keywords can be present more than once, with values from newer entries overriding the values from previous entries.

The cells which contribute to the average pressure calculation can be assigned via this keyword. If there are no neighbors to be included, only the perforated grid blocks are used in the average pressure computation (level 0), otherwise a larger stencil is used (levels 1 to 4). ECHELON currently supports neighbors which are at most 4 layers away from a perforated cell. The search for neighbors is done in an unstructured framework solely based on the grid transmissibility graph. This means that if a well is perforated in cell (i,j,k), then cell (i,j+1,k) can only contribute to the stencil if [TRANY](#) in cell (i,j,k) is not zero. On the other hand, if cell (i,j,k) is connected through a non-neighbor connection to a cell whose logical indexes are not necessarily neighbors, then it will participate in the pressure stencil.

The averaging process can be tuned to 1) combine connection transmissibility and pore volume weighting, 2) correct cell pressure with respect to a defined depth, 3) assign weights for the levels, and 4) use all perforated cells or only the open perforated cells as level zero.

Well average pressure can be reported by using the summary vectors mnemonic WBPC\_n in the [SUMMARY](#) section (where n is the level, as an integer from 1 to 5). As with other well related summary vectors, WBPC\_n can be for a specific well, a list of wells or a well pattern.

### Record format

1. **TRANS\_WT\_FACTOR:** Transmissibility weighting factor in well average pressure calculation
 

**Type:** Float  
**Minimum:** 0  
**Maximum:** 1  
**Default value:** 0.0
2. **APPLY\_PORE\_VOLUME:** Apply pore volume weighting to cell pressures prior to transmissibility weighting (YES/NO)
 

**Type:** String  
**Default value:** NO
3. **WELL\_CONN\_FLAG:** Controls which connections are considering in weighting (OPEN/ALL)

**Type:** String

**Default value:** ALL

4. **REFERENCE\_DEPTH:** Assign a reference depth for pressures (default is well bottom hole reference depth)

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Minimum:** -inf

**Maximum:** inf

5. **DEPTH\_CORRECTION:** Density for cell pressure correction. Options are: the average fluid density in the well (WELL), the average fluid density in the participating cells (RES), which is the average of the phase saturation weighted phase densities in each cell which are then volume weighted across cells, or no correction

**Type:** String

**Default value:** RES

6. **HOP\_WT\_N:** Weighting factor for well connected cells ( $1 \leq N \leq 5$ ). 1 means well connected cells only (level=0), or 2-5 includes connected cell levels (1 to 4)

**Type:** Float

**Minimum:** 1

**Maximum:** 5

**Default value:** 1

### Example

Control settings are assigned for all the wells, requesting equal weighting between transmissibility-weighted average (TRANS\_WT\_FACTOR = 0.5) and pore-volume weighted average ( $f = 0.5$ ). Additionally, the transmissibility-based average is weighted by pore volume (APPLY\_PORE\_VOLUME =YES) and the default depth correction method uses the average fluid density in the relevant cells (DEPTH\_CORRECTION =RES). Depth correction is made to the bottom hole reference depth as no new reference depth is provided (no REFERENCE\_DEPTH). First neighbor level cells (HOP\_WT\_2) have a weighting of 0.005, thus reducing their weight compared to the default weight of 1.0 for contributions from connected cells.

```
WPAVEC
TRANS_WT_FACTOR =0.5
APPLY_PORE_VOLUME =YES
DEPTH_CORRECTION =RES
HOP_WT_2 =0.005
/
```



## 2.487 WPAVEDEP

### Description

This keyword can be used to modify the reference depth for calculating the well block pressure reported using [WBP](#) summary vector. By default, the well bottom hole depth (see [WELLSPECS](#) keyword) is used as a reference for calculating the block pressure. The grid block pressure is adjusted by the hydrostatic pressure with respect to reference depth point.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **NAME:** Well name, list (as defined by [WLIST](#)) or template  
**Type:** String
2. **REF\_DEPTH:** Reference depth (defaults to well's bottom hole depth)  
**Type:** Float  
**Units:** ft (FIELD), m (METRIC)

### Example

In this example the reference depth for calculating of well 'P1' block average pressure is set to 2100.

```
WPAVEDEP
P1    2100.0 /
/
```



## 2.488 WPICOND

### Description

The keyword controls the individual well options of the Generalized Pseudo-Pressure(GPP) model that is used for modeling the gas mobility reduction due to condensate drop-out in the near wellbore region (see [Section 15.7](#) in the Technical Documentation). Alternatively, GPP options for all wells can be specified using the keyword [PICOND](#). If neither [PICOND](#) nor [WPICOND](#) are provided the default options specified below apply.

The GPP model may be enabled on a well-by-well basis in a number of ways:

- Setting field 8 of a [WELSPECS](#) record to “GPP”
- Setting field 9 of a [WELSPECL](#) record to “GPP”
- Setting field 2 of a [WPICOND](#) record to “YES”

Alternatively, the GPP model can be activated for all wells using the keyword [PSEUPRES](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** ‘\*’

2. **FLAG:** Select or deselect the GPP model to be applied to the wells defined in item 1

**Type:** String

**Default value:** YES

**Allowed values:**

Name	Description
YES	Activate the GPP model for this well
NO	Deactivate the GPP model for this well

3. **MAX\_DP\_BELOW:** Maximum interval between pressure points below the saturation pressure

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:**  $4 \times P_{atm}$  (FIELD),  $4 \times P_{atm}$  (METRIC)

4. **MAX\_DP\_ABOVE:** Maximum interval between pressure points above the saturation pressure

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:**  $10 \times P_{atm}$  (FIELD),  $10 \times P_{atm}$  (METRIC)

5. **DAMP:** Blocking factor damping coefficient,  $D$ . This coefficient must be between 0.0 and 1.0 and allows damping the blocking factor,  $BF$ , by averaging it with its value computed from the previous timestep according to  $BF = D \times BF_{current} + (1.0 - D) \times BF_{previous}$

**Type:** Float

**Minimum:** 0.0

**Maximum:** 1.0

- Default value:** 1.0
6. **VDRP:** Include velocity-dependent relative permeability in GPP calculations. Either YES or NO.  
**Type:** String  
**Default value:** NO
  7. **F\_LOW:** Multiplicative factor,  $f_{low}$ , which determines the lower pressure bound,  $p_{low}$ , to be used in the construction of the GPP table. This is expressed as a multiplier to the current pressure,  $p_{conn}$ , of the grid block containing the connection,  $p_{low} = f_{low} \times p_{conn}$   
**Type:** Float  
**Minimum:** 0.0  
**Maximum:** 0.95  
**Default value:** 0.0
  8. **F\_UP:** Multiplicative factor,  $f_{up}$ , which determines the upper pressure bound,  $p_{up}$ , to be used in the construction of the GPP table. This is expressed as a multiplier to the current pressure,  $p_{conn}$ , of the grid block containing the connection,  $p_{up} = f_{up} \times p_{conn}$   
**Type:** Float  
**Minimum:** 1.05  
**Maximum:** 2.0  
**Default value:** 1.1
  9. **MAX\_DS:** Maximum change in water saturation of the grid block containing the connection which triggers a recalculation of the GPP table. This change is treated as the absolute difference between the current water saturation value and the value when the table was last updated. If a negative value is specified, this control is disabled.  
**Type:** Float  
**Default value:** 0.01
  10. **MAX\_DP:** Maximum change in pressure of the grid block containing the connection which triggers a recalculation of the GPP table. This change is treated as the absolute difference between the current pressure value and the value when the table was last updated. If a negative value is specified, this control is disabled.  
**Type:** Float  
**Units:** psi (FIELD), bar (METRIC)  
**Default value:**  $1 \times P_{atm}$  (FIELD),  $1 \times P_{atm}$  (METRIC)
  11. **MAX\_DCOMP:** Maximum change in the composition of any component of the grid block containing the connection which triggers a recalculation of the GPP table. This change is treated as the relative difference between the current composition and the composition when the table was last updated. If a negative value is specified, this control is disabled.  
**Type:** Float  
**Default value:** 0.01
  12. **MAX\_TIME:** Maximum simulation time change which triggers a recalculation of the GPP table. This change is treated as the absolute difference between the current simulation time value and the value when the table was last updated. If a negative value is specified, this control is disabled.  
**Type:** Float  
**Units:** Day (FIELD), Day (METRIC)  
**Default value:** -1
  13. **ADAPTIVE:** A positive value indicates that the interval between the pressure points in the vicinity of the saturation pressure should be further reduced to better capture non-linearity. The number of additional pressure points and their spacing is determined automatically depending on the minimum pressure step specified in item 14. A negative value deactivates the adaptive ordinate control  
**Type:** Float  
**Default value:** -1
  14. **MIN\_DP:** Minimum pressure spacing for adaptive ordinate control.

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:**  $0.1 \times P_{atm}$  (FIELD),  $0.1 \times P_{atm}$  (METRIC)

### Example

In this example, the GPP model is activated for well P1 and deactivated for well P2. For well P1, a blocking factor damping coefficient of 0.5 is specified, the adaptive ordinate control is switched on with a minimum pressure spacing of 0.1 and it is requested to include the velocity-dependent effects in GPP calculations.

```
WPICOND
--well  flag      damp   vdrp     adaptive mindp
      P1    YES    2*  0.5    YES   6*    1      0.1 /
      P2    NO   /
/
```



## 2.489 WPIMULT

### Description

This keyword is used to multiply well connection transmissibility factors by a given value. If items 3-7 are defaulted, ECHELON will automatically multiply the transmissibility factors of **all** connections of the well. Alternatively, items 3-5 or/and items 6-7 can be used to either identify a subset of connections through their I, J, K locations or through their completion number as specified with keyword **COMPLUMP**, or through both. The following rules are used when applying the well multipliers:

- If a **COMPDAT** keyword contains data inducing a transmissibility factor recalculation, any previously defined well multipliers entered with this keyword will be reset to 1.0
  - If **WPIMULT** is specified several times for the same set of connections of a given well, its effect is always cumulative - that is the multiplier is applied every time the keyword is entered - with a single exception. If **all** of the following conditions are met:
    - it is a black-oil run, and
    - **WPIMULT** is specified to **all** connections of the well (items 3-7 defaulted), and
    - keyword specifications are entered within the same timestep (hence, there is no **TIME**, **TSTEP**, or **DATES** between them), and
    - keyword specifications come from the same context - either from **SCHEDULE** directly, or from the same **ACTIONX** body,
- then only the last specification will be accounted for. In all other cases, every multiplier will be applied.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by **WLIST** keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the **SCHEDULE** section.

**Type:** String

**Default value:** ‘\*’

2. **MULTIPLIER:** Connection transmissibility factor multiplier. This value can be specified using a user-defined argument (**UDA**).

**Type:** Float

**Minimum:** 1.0E-10

**Default value:** 1.0

3. **I\_LOC:** I-location of connecting grid block. If a negative value is specified or the item is defaulted, any I-location is allowed

**Type:** Integer

**Default value:** Negative

4. **J\_LOC:** J-location of connecting grid block. If a negative value is specified or the item is defaulted, any J-location is allowed

**Type:** Integer

**Default value:** Negative

5. **Z\_LOC:** Z-location of connecting grid block. If a negative value is specified or the item is defaulted, any Z-location is allowed

**Type:** Integer

**Default value:** Negative

6. **FIRST\_COMP:** Number of the first completion the multiplier applies to. If a negative value is specified or the item is defaulted, all completions up to item 7 (if set) are allowed

**Type:** Integer

**Default value:** Negative

7. **LAST\_COMP:** Number of the last completion the multiplier applies to. If a negative value is specified or the item is defaulted, all completions from item 6 (if set) are allowed

**Type:** Integer

**Default value:** Negative

### Example 1

In this example, several multipliers are applied to all connections of well P1 at a given time. In black-oil runs, only the last one is applied (0.9), while in compositional runs all of them are applied ( $1.2 \times 0.6 \times 0.9$ ).

```
WPIMULT
P1 1.2 /
P1 0.6 /
P1 0.9 /
/
```

### Example 2

In this example, the connection factor of the completed cell [5 5 1] of well P1 is doubled. For well P2, only those connections with I-location equal to 1 are doubled.

```
WPIMULT
P1 2.0 5 5 1 /
P2 2.0 1 /
/
```

**Example 3**

Finally, let's consider another example with the ACTIONX keyword involved. Assume a black-oil simulation starting in 1999, and a well P1 is already defined. ACTIONX is introduced to trigger up to 2 times if the simulation year is equal to 2000. We take a timestep of 366 days, and action triggers for the first time. Since two WPIMULT keywords are specified in the same context (body of "MULT\_A1" action), and items 3-7 are defaulted, only the last multiplier of 1.5 is taken into account. In addition, at the same timestep another two WPIMULT keywords are entered in SCHEDULE for the same well. Similarly, only the last multiplier of 2 is taken into account. Finally, multipliers from different contexts are accumulated, hence well productivity is multiplied by  $1.5 \times 2 = 3$ . After 30 days, "MULT\_A1" action is triggered for the second and final time, multiplying productivity factor of well P1 further by 1.5 times.

```
ACTIONX
MULT_A1 2 1* /
YEAR = 2000 /
/

WPIMULT
P1 2 /
/

WPIMULT
P1 1.5 /
/

ENDACTIO

TSTEP
366
/

WPIMULT
P1 4 /
/

WPIMULT
P1 2 /
/

TSTEP
30
/
```



## 2.490 WPIMULTL

### Description

This keyword is used to multiply connection transmissibility factors of wells completed in the local grid by a given value. If items 4-8 are defaulted, ECHELON automatically multiplies the transmissibility factors of **all** connections of the well. Alternatively, items 4-6 or/and items 7-8 can be used to either identify a subset of connections through their I, J, K locations or through their completion number as specified with keyword **COMPLUMP**, or through both. The following rules are used when applying the well multipliers:

- If a **COMPDAT** keyword contains data inducing a transmissibility factor recalculation, any previously defined well multipliers entered with this keyword will be reset to 1.0 If **WPIMULTL** is specified several times for the same set of connections of a given well, its effect is always cumulative - that is the multiplier is applied every time the keyword is entered - with a single exception. If **all** of the following conditions are met:
    - it is a black-oil run, and
    - **WPIMULTL** is specified to **all** connections of the well (items 3-7 defaulted), and
    - keyword specifications are entered within the same timestep (hence, there is no **TIME**, **TSTEP**, or **DATES** between them), and
    - keyword specifications come from the same context - either from SCHEDULE directly, or from the same **ACTIONX** body,
- then only the last specification will be accounted for. In all other cases, every multiplier will be applied.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by **WLIST** keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.  
**Type:** String  
**Default value:** '\*'
2. **MULTIPLIER:** Connection transmissibility factor multiplier. This value can be specified using a user-defined argument (**UDA**).  
**Type:** Float  
**Minimum:** 1.0E-10  
**Default value:** 1.0
3. **LGR\_NAME:** Name of the local grid in which the connections specified with items 4-6 are located. If defaulted, the local grid name of the well (entered with keyword **WELSPEC1**) will be used  
**Type:** String  
**Default value:** None
4. **I\_LOC:** I-location of connecting grid block in the local grid. If a negative value is specified or the item is defaulted, any I-location is allowed  
**Type:** Integer
5. **J\_LOC:** J-location of connecting grid block in the local grid. If a negative value is specified or the item is defaulted, any J-location is allowed  
**Type:** Integer

6. **K\_LOC:** Z-location of connecting grid block in the local grid. If a negative value is specified or the item is defaulted, any Z-location is allowed  
**Type:** Integer
7. **FIRST\_COMP:** Number of the first completion in range. If a negative value is specified or the item is defaulted, any completion number up to item 8 (if set) is allowed  
**Type:** Integer
8. **LAST\_COMP:** Number of the last completion in range. If a negative value is specified or the item is defaulted, any completion number from item 7 (if set) is allowed  
**Type:** Integer

**Example**

In this example, three multipliers are specified: the first applies to all connections of well PRD1, the second applies to all connections of well PRD2 located in the local grid LGR1, and the third applies to all connections of well PRD3 in layer 3 of the local grid LGR2.

```
WPIMULTL
PRD1 1.3 /
PRD2 0.75 LGR1 /
PRD3 0.5 LGR2 2* 3 /
/
```



## 2.491 WPOLYMER

### Description

This keyword allows specifying the concentration of polymer and salt for water phase injecting wells. The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

`WPOLYMER` should be used in conjunction with the keyword `POLYMER` and optional keyword `BRINE`. The injection polymer and salt concentrations are set to zero when the keyword is missing in the `SCHEDULE` and `POLYMER` is specified.

The salt injection settings are ignored when the `BRINE` keyword is not activated. `WSALT` can be used to define the injection salt concentration for the Brine Tracking Model with no polymers.

### Record format

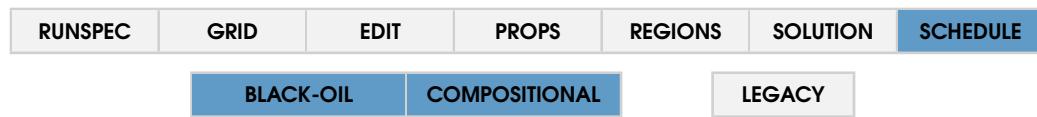
1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by `WLIST` keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the `SCHEDULE` section.
2. **POLY\_CONC:** The injected polymer concentration.  
This value can be specified using a user-defined argument (`UDA`).  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)  
**Minimum:** 0  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
3. **SALT\_CONC:** The injected salt concentration.  
This value can be specified using a user-defined argument (`UDA`).  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)  
**Minimum:** 0  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
4. **POLY\_GROUP:** The polymer source group name.  
This option allows using the provided group name as a polymer source. If the group name is specified the injected concentration is assumed to be equal to the produced polymer concentration. The item 2 concentration is used otherwise.
5. **SALT\_GROUP:** The salt source group name.  
This option is analogous to item 4. It allows using the specified group salt production or salt concentration from item 3.

**Example**

This example sets polymer and salt concentrations to 1 for the well M1 and prescribes injecting polymer only to wells with the prefix P1.

The well M1 uses the polymer concentration from the producing group PGRP and the salt concentration from SGRP, and injecting wells with the prefix P2 use the polymer concentration from PGRP and fixed salt concentration equal to 1.0 from item 3.

```
WPOLYMER
'M1'    1.0    1.0    /
'P1*'   1.0    0.0    /
'M2'    2* PGRP SGRP  /
'P2*'   1* 1.0 PGRP  /
/
```



## 2.492 WREVIVE

### Description

By default, when a well dies due to being unable to flow during a time-step, ECHELON attempts up to 3 well revivals. The [WREVIVE](#) keyword can be used to modify this behavior.

Two parameters can be changed on a well basis. First, whether the revival threshold X should be CUMULATIVE (default behavior, i.e., attempt X revivals), the more stringent SUCCESSIVE\_NEWTON (i.e., X revivals in a row), or the less stringent SPECIFIED\_NEWTON (attempt revival only in the first X Newtons).

Second, the threshold value X itself. A different value can be specified for wells opened manually, or for wells just reopened from well testing.

### Record format

Name	Value Type	Default	Description
NAME	String		Well name (wild cards are allowed)
STRATEGY	String		Any of CUMULATIVE (default), SUCCESSIVE_NEWTON or SPECIFIED_NEWTON
THRESHOLD	Integer		Threshold (default=3)
THRESHOLD_WELLTEST	Integer		Threshold for wells that have reopened from well testing in the current time-step (default=Threshold)

### Example

Only attempt well revivals for the first 3 Newton iterations of each time-step, for all wells defined so far.

```
WREVIVE
NAME='*' STRATEGY=SPECIFIED_NEWTON THRESHOLD=3 /
/
```



## 2.493 WRFTPLT

### Description

This keyword controls the well output data to be written to RFT file. The well must have been previously defined in the [SCHEDULE](#) section. There are two categories of data that can be written to RFT file:

- RFT data: depth, pressure, water and gas saturation for each connected grid block
- PLT data: depth, pressure, oil, water and gas flow rates, tubing flows at each connection (total upstream flow rates at surface and wellbore conditions), connection transmissibility factor and connection  $K_h$

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the [SCHEDULE](#) section.

**Type:** String

**Default value:** `'*'`

2. **RFT\_DATA:** Control outputs of RFT data

**Type:** String

**Default value:** NO

**Allowed values:**

Name	Description
YES	Output current RFT data at this time
REPT	Output current RFT data at this time and all subsequent report times
TIMESTEP	Output current RFT data at this time and all subsequent time steps
FOPN	Output current RFT data at this time if the well is open. If the well is not yet open, the output will be written to the RFT file when the well is first opened
NO	Do not output RFT data

3. **PLT\_DATA:** Control outputs of PLT data

**Type:** Integer

**Default value:** NO

**Allowed values:**

Name	Description
YES	Output PLT data at this time
REPT	Output PLT data at this time and all subsequent report times
TIMESTEP	Output PLT data at this time and all subsequent timesteps
NO	Do not output PLT data

**Example**

```
WRFTPLT
'*'      FOPN /
PROD1   REPT REPT /
/
```



## 2.494 WSALT

### Description

This keyword allows specifying the concentration of salt for water phase injecting wells. The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

Note that to use this keyword, brine tracking should be enabled in the [RUNSPEC](#) section using keyword [BRINE](#). The keyword cannot be used with the Polymer Flood Model (see [POLYMER](#)) and the keyword [WPOLYMER](#) should be used to define the injection salt concentrations.

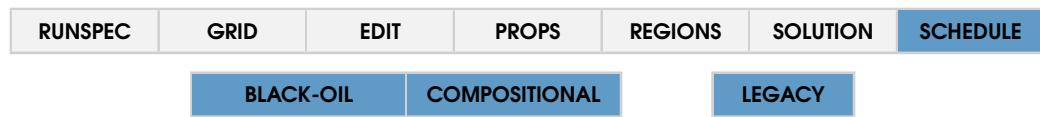
### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the [SCHEDULE](#) section.
2. **SALT\_CONC:** The injected salt concentration.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Units:** lb/stb (FIELD), kg/sm<sup>3</sup> (METRIC)  
**Minimum:** 0  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)
3. **SALT\_GROUP:** The salt source group name.  
This option allows using the provided group name as a salt source. If the group name is specified the injected concentration is assumed to be equal to the produced salt concentration. The item 2 concentration is used otherwise.  
**Minimum:** 0  
**Default value:** 0.0 (FIELD), 0.0 (METRIC)

### Example

This example sets salt concentrations to 1 for the well M1 and prescribes to inject salt with a concentration equal to 0.5 to wells with the prefix S1. All other wells with the prefix S2 utilize salt from the producing group SGRP.

```
WSALT
'M1'    1.0    /
'S1*'   0.5    /
'S2*'   1*    SGRP    /
/
```



## 2.495 WSEPCOND

### Description

This keyword assigns separators to wells. The separator name should have been previously defined with keyword [SEPCOND](#). If the well separator is not defined, the group separator as defined by the keyword [SEPCOND](#) will be used to compute the well's surface volume rates. If the group separator is not specified, then the field separator (defined by keyword [FIELDSEP](#)) will be used. If the field separator is also undefined, well surface volumes are computed by a single flash at standard conditions given by [STCOND](#) keyword.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

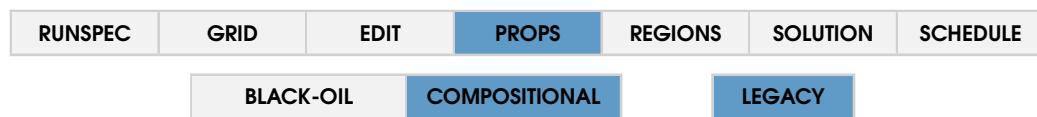
**Default value:** '\*'

2. **SEP\_NAME:** Name of the separator associated with this well

**Type:** String

### Example

```
WSEPCOND
W1 SEP1 /
W12 SEP2 /
W3 /
/
```



## 2.496 WSF

### Description

The WSF keyword provides a tabulation of the water relative permeability as a function of water saturation. The table consists of two columns for  $S_w$  and  $k_{rw}$ , respectively, and it is terminated by a slash (/). It is similar to the [SWFN](#) keyword except for the absence of capillary pressure column.

The keyword is only available for models using the [GASWAT](#) option, and should be complemented by the [GSF](#) keyword.

The first saturation value provide defines the connate water saturation,  $S_{wco}$ . Then, the largest table water saturation with zero  $k_{rw}$  defines the critical water saturation  $S_{wcr}$ . For this purpose, any relative permeability value below a threshold of  $10^{-6}$  is set to zero. This threshold value can be modified using [TOLCRIT](#).

In second column, it is possible to use default values (1\*). When the table is read by the simulator, these values will be replaced by a linear interpolation based on adjacent non-defaulted values.

NTSFUN (see [TABDIMS](#) keyword) tables should be provided after the keyword. Any table other than the first can consist of an empty record. In this case, the table for that saturation region will be defaulted to the previous table. See [Chapter 10](#) of the ECHELON Technical Description for more information.

### Table columns

1. **SW:** Water saturation (strictly increasing)
2. **KRW:** Water relative permeability (increasing)

### Example

Water relative permeability provided using SWFN for a model with NTSFUN=3, in the presence of GASWAT option.

```

SWFN
-- SW      KRW
 0.2      0
 0.3      0.05
 0.4      0.2
 0.5      0.4
 0.6      0.6
 0.8      0.8
 1.0      1.0
/
 0.4      0
 0.45     0.05
 0.50     0.2
 0.55     0.4
 0.6      0.6
 0.8      0.8
 1.0      1.0
/
/

```



## 2.497 WTADD

### Description

This keyword can be used to modify a well control target or limit by adding (or subtracting) a specific amount.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** Well name, list (as defined by [WLIST](#)) or template. If this item is defaulted, this keyword applies to all wells already defined in the [SCHEDULE](#) section

**Type:** String

**Default value:** '\*'

2. **CONTROL:** Quantity to be changed

**Type:** String

**Allowed values:**

Name	Description
ORAT	Oil rate
WRAT	Water rate
GRAT	Gas rate
LRAT	Liquid (oil+water) rate
RESV	Reservoir volume rate
BHP	Bottom hole pressure
THP	Tubing head pressure
LIFT	Artificial lift quantity
GUID	Guide rate
NGL	Natural gas rate

3. **VALUE:** Value to be added to the quantity specified in item 2. Negative values are allowed. This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

4. *Reserved*

### Example

```
WTADD
PRD1 ORAT -100 /
PRD2 GRAT 500 /
/
```



## 2.498 WTAKEGAS

### Description

This keyword specifies the order in which FUEL (F), SALE (S) and REINJECTION (R) gas are taken from production sources.

WTAKEGAS should be used in conjunction with the keywords GRUPFUEL, GRUPSALE, WINJGAS, and GINJGAS.

The keyword contains one record and must be terminated with a slash (/).

Note: there are no limitations for WTAKEGAS, it can be used either in black-oil and compositional reservoir models.

### Example

This example sets gas usage order as SFR (SALE, FUEL, REINJECTION).

```
WTAKEGAS
SFR
/
```



## 2.499 WTEST

### Description

This keyword sets instructions for periodic testing of closed wells. It may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the [SCHEDULE](#) section.

**Type:** String

**Default value:** '\*'

2. **INTERVAL:** Well test time lag (must be a positive number). When a well that is subject to periodic well testing is closed, then a test to re-open the well is performed when the period specified here is passed. If the test is unsuccessful, subsequent tests will be performed every INTERVAL days until the well opens, well testing is turned off or the simulation stops.

**Type:** Float

**Units:** Day (FIELD), Day (METRIC)

3. **REASONS:** Closure reason(s) that will trigger a well test. It should be a string of up to 3 characters. Defaulting this item switches off the automatic testing for this well. The tables show the possible values for the characters

**Type:** String

**Default value:** ' ' (empty string)

#### Allowed values:

Name	Description
P	Well test will be attempted if the closure reason was a physical one, e.g., a pressure limits violation with a failure in THP solution or inability to inject at given pressure conditions, or violation of BHP or THP limits.
E	Well test will be attempted if the closure reason was economic (see keyword <a href="#">WECON</a> ). If there is at least one connection open and if the economic limits are satisfied by the potential rate, the the well is reopen. Notably, if all connections are closed because a sequence of workovers motivated by <a href="#">WECON</a> or <a href="#">CECON</a> , then they are tested and the well is reopened if at least one connection allows flowing within limits.
G	Test is performed on wells closed because of GROUP or FIELD limit violation (see keywords <a href="#">GECON</a> , <a href="#">GCONPROD</a> and <a href="#">GCONPRI</a> ). The well is reopened unconditionally because it can not be tested by itself. If then it causes a new violation economic violation (group or field limit, or possibly any other violation), the well will be closed again at the end of the timestep.

4. **REPEATS:** Maximum number of times the well can be tested, until the counter is reset with a new [WTEST](#) keyword in the [SCHEDULE](#) section. If this item is defaulted or set to a null or negative number, the well can be tested an unlimited number of times.

**Type:** Integer

**Default value:** Negative

5. **STARTUP:** Ramp-up time. When allowed to reopen, the well efficiency factor is progressively increased from zero to its value given in [WEFAC](#), possibly over several timesteps, according to  $\frac{T-T_0}{\text{startup-time}}$ , where  $T$  is the current time and  $T_0$  is the time the well was reopened. This may possibly improve convergence by smoothing out sudden changes in reservoir withdrawal rates.

**Type:** Float

**Units:** Day (FIELD), Day (METRIC)

**Default value:** 0.0

**Example**

All wells beginning with PRDA are tested every 30 days for all possible reasons, well PRD2 is tested up to 10 times every 60 days, only if it has been closed for physical reasons with a start-up time of 30 days.

```
WTEST
'PRDA*' 30 PEG /
PRD2 60 P 10 30 /
/
```



## 2.500 WTMULT

### Description

This keyword multiplies a well control target or limit by a specific factor.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** '\*'

2. **CONTROL:** Quantity to be changed

**Type:** String

**Allowed values:**

Name	Description
ORAT	Oil rate
WRAT	Water rate
GRAT	Gas rate
LRAT	Liquid (oil+water) rate
RESV	Reservoir volume rate
BHP	Bottom hole pressure
THP	Tubing head pressure
LIFT	Artificial lift quantity
GUID	Guide rate
NGL	Natural gas rate

3. **VALUE:** Multiplication factor for the quantity specified in item 2. This value can be specified using a user-defined argument ([UDA](#)).

**Type:** Float

4. *Reserved*

### Example

```
WTMULT
PRD1 ORAT 2.0 /
PRD2 GRAT 0.5 /
/
```



## 2.501 WTRACER

### Description

This keyword allows specifying the concentration of a tracer for injecting wells.

[WTRACER](#) should be used in conjunction with the keyword [TRACER](#).

The keyword may contain an arbitrary number of records, each terminated with a slash (/) and is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.
2. **TRACER\_NAME:** The injected tracer name.  
Up to 3 characters for black-oil and 4 characters for compositional formulations. The names must be consistent with [TRACER](#).
3. **TRACER\_CONC:** The injected tracer concentration.  
This value can be specified using a user-defined argument ([UDA](#)).  
**Minimum:** 0
4. *Reserved*
5. **TRACER\_GROUP:** The tracer source group name.  
This option allows using the provided group name as a tracer source. If the group name is specified the injected concentration is assumed to be equal to the produced tracer concentration. The item 3 concentration is used otherwise.

### Example

This example sets tracer T1 concentrations to 1 for the well M1 and prescribes to inject the tracer T2 with a concentration equal to 0.5 to wells with the prefix S1. All other wells with the prefix S2 utilize the tracer T3 from the producing group TGRP.

```
WTRACER
'M1'    'T1'  1.0   /
'S1*'  'T2'  0.5   /
'S2*'  'T3'  2*    'TGRP'   /
/
```



## 2.502 WVFPDP

### Description

This keyword can be used to adjust the BHP obtained by interpolating the well VFP table. Note that the simulator automatically adjusts the interpolated BHP to account for the hydrostatic head using the density of the wellbore fluid and the difference between a well's BHP reference depth (item 5 or 5 of keywords [WELSPECS](#) and [WELSPECL](#)), and the VFP reference depth (item 2 of keywords [VFPPPROD](#) or [VFPINJ](#)). Thus, this keyword applies an additional adjustment to match a well's flow rate to a given tubing head pressure, by adjusting the BHP.

It is also possible to specify a tubing pressure loss scaling factor,  $F_s$ , with item 3. The well's BHP obtained from the interpolation of the VFP table is adjusted by the simulator by multiplying the tubing pressure loss (BHP - THP) by this factor, i.e. the well BHP will be adjusted according to

$$\text{BHP} = \text{THP} + F_s(\text{BHP}_{\text{tab}} - \text{THP})$$

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash.

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** '\*'

2. **DELTA\_P:** Pressure value to be added to the well BHP

**Type:** Float

**Units:** psi (FIELD), bar (METRIC)

**Default value:** 0.0

3. **FACTOR:** Tubing pressure loss scaling factor,  $F_s$

**Type:** Float

**Default value:** 1.0

### Example

```

WVFPDP
PRD1  15.0 /
PRD2  -25.0 /
PRD3  1* 1.2 /
/

```



## 2.503 WVFPEXP

### Description

This keyword defines several optional settings for wells under THP control. In particular, it can be used to define:

- specific interpolation or extrapolation rules of the VFP tables,
- actions to be taken if a well is found to operate on the stabilized part of its VFP table,
- actions to be taken to avoid mode hunting.

The keyword may contain an arbitrary number of records, each terminated with a slash (/). The keyword itself is terminated with a trailing slash (an empty record).

### Record format

1. **WELL\_NAME:** This field sets the wells the keyword applies to. It consists of a string which can be the name of a single well, a well list set by [WLIST](#) keyword or a template where wildcards are used to match a variety of wells. If the user defaults this field, then the keyword applies to all wells already defined in the SCHEDULE section.

**Type:** String

**Default value:** ‘\*’

2. **FRAC\_TYPE:** Interpolation rule for flow fractions

**Type:** String

**Default value:** IMP

**Allowed values:**

Name	Description
IMP	Implicit (latest) values of water and gas flowing fractions are used for VFP interpolation
EXP	Water and gas flowing fractions computed at the previous timestep are used to evaluate VFP tables along Newton's iteration.
IMPEXP	VFP table is interpolated using the implicit values of water and gas flowing fractions. However, if at any given time the THP solver fails at least once, explicit flow fractions will be used for all subsequent newton iterations of the current timestep. Implicit flow fractions will be used again from the next timestep.

3. **STAB\_OPT:** Action to be taken if the well is found to operate on the stabilized part of the VFP curve

**Type:** String

**Default value:** NO

**Allowed values:**

Name	Description
YES	If the well is under THP control and it is operating on the stabilized part of its VFP, then it is closed. The check is performed at the end of every timestep.
NO	No check is performed

4. **HUNTING:** Action to be taken if the well changes from rate control to THP control when it operates on the unstable part of the VFP curve. Note that in compositional runs, the switch to THP control is always suppressed if switching would result in oscillating between rate and THP controls.

**Type:** String

**Default value:** NO

**Allowed values:**

Name	Description
NO	In black-oil runs, changes from rate to THP control are not prevented. If a double violation occurs - that is the THP control violates the most constraining limit among all the others and the most constraining control violates the THP limit - then the well will be closed.
YES1	The well is prevented to switch to THP control if it is constrained by a rate limit to operate on the unstable part of its VFP. The well will continue to operate under rate control, while its THP may decrease below its minimum limit.

5. **EXTRAP\_VFP:** Control how values that fall outside of the bounding values of the VFP table are extrapolated

**Type:** String

**Default value:** WG

**Allowed values:**

Name	Description
WG	Water and gas fractions are extrapolated at a constant value, while linear interpolation is used for ALQ
WGA	Water fraction, gas fractions and ALQ extrapolated at a constant value
NONE	Water fraction, gas fractions and ALQ are extrapolated linearly

### Example

Here we set interpolation and extrapolation logics for all wells beginning with 'P\_ ', using a well template. Water and gas fractions are evaluated explicitly, wells are shut if they are under THP control at the end of the timestep and the solution is unstable and, the well is not switched to THP control if it is constrained by a rate limit to operate on the unstable part of its VFP and ga/water fractions together with artificial lift quantities will be set constant outside table ranges.

```
WVFPEXP
'P_*' EXP YES YES1 WGA/
/
```



## 2.504 WWPAVEC

### Description

The keyword [WWPAVEC](#) controls the method of computation for reporting the average pressure near specific wells (see [WPAVEC](#) for application to all wells). See the technical manual for more details. These keywords are allowed in the [SCHEDULE](#) section. A WELL\_NAMES parameter is required to define a well name, well list or well name pattern to which the average pressure computation is applied. If a WELL\_NAMES parameter is not provided, the settings are applied to all the wells (as with [WPAVEC](#)). Wells must be previously defined before assigning them in [WWPAVEC](#). If no [WPAVEC](#) / [WWPAVEC](#) is present, then default values, as noted below, are used when computing the average pressure for reporting.

The [WWPAVEC](#) keywords apply to the specified wells defined in the [SCHEDULE](#) section following the date where the keyword is first activated. The parameters can be provided in any order on the keyword.

The average pressure reported by ECHELON for a well is an average of completion connection factor weighting and pore volume weighting according to  $p_w = f \cdot p_{w,CT} + (1 - f) \cdot p_{w,PV}$  where  $p_{w,CT}$  is connection transmissibility weighted average and  $p_{w,PV}$  is pore volume weighted average.  $f$  is the weighting factor between  $p_{w,CT}$  and  $p_{w,PV}$ , with  $0 \leq f \leq 1$ .

The keywords can be present more than once, with values from newer entries overriding the values from the previous entries.

The cells which contribute to the average pressure calculation can be assigned via this keyword. If there are no neighbors to be included, only the perforated grid blocks are used in the average pressure computation (level 0), otherwise a larger stencil is used (levels 1 to 4). ECHELON currently supports neighbors which are at most 4 layers away from a perforated cell. The search for neighbors is done in an unstructured framework solely based on the grid transmissibility graph. This means that if a well is perforated in cell (i,j,k), then cell (i,j+1,k) can only contribute to the stencil if [TRANY](#) in cell (i,j,k) is not zero. On the other hand, if cell (i,j,k) is connected through a non-neighbor connection to a cell whose logical indexes are not necessarily neighbors, then it will participate in the pressure stencil.

The averaging process can be tuned to 1)combine connection transmissibility and pore volume weighting, 2)correct cell pressure with respect to a defined depth, 3)assign weights for the levels, and 4)use all perforated cells or only the open perforated cells as level zero.

Well average pressure can be reported by using the summary vectors mnemonic WBPC\_n in the [SUMMARY](#) section (where n is the level, as an integer from 1 to 5). As with other well related summary vectors, WBPC\_n can be for a specific well, a list of wells or a well pattern.

### Record format

1. **TRANS\_WT\_FACTOR:** Transmissibility weighting factor in well average pressure calculation
 

**Type:** Float  
**Minimum:** 0  
**Maximum:** 1  
**Default value:** 0.0
2. **APPLY\_PORE\_VOLUME:** Apply pore volume weighting to cell pressures prior to transmissibility weighting (YES/NO)
 

**Type:** String  
**Default value:** NO
3. **WELL\_CONN\_FLAG:** Controls which connections are considering in weighting (OPEN/ALL)

**Type:** String

**Default value:** ALL

4. **REFERENCE\_DEPTH:** Assign a reference depth for pressures (default is the well bottom hole reference depth)

**Type:** Float

**Units:** ft (FIELD), m (METRIC)

**Minimum:** -inf

**Maximum:** inf

5. **DEPTH\_CORRECTION:** Density for cell pressure correction. Options are: the average fluid density in the well (WELL), the average fluid density in the participating cells (RES), which is the average of the phase saturation weighted phase densities in each cell which is then volume weighted across cells, or no correction

**Type:** String

**Default value:** RES

6. **HOP\_WT\_N:** Weighting factor for well-connected cells ( $1 \leq N \leq 5$ ). 1 means well connected cells only (level=0), or 2-5 includes connected cell levels (1 to 4)

**Type:** Float

**Minimum:** 1

**Maximum:** 5

**Default value:** 1

7. **WELL\_NAMES:** List of well names, well list and or well-name pattern

**Type:** String

### Example

Control settings are to be used for three specific wells ('Inj-1', 'Inj-2', 'Prod-3'). Transmissibility weighted average is to be considered (TRANS\_WT\_FACTOR = 1). Only cells that have 'open' connections (WELL\_CONN\_FLAG = OPEN) and their neighboring cells (if chosen) are associated with these 'open' cells contribute to the computation. The cell pressures are corrected using a user-provided reference depth of 5000 (REFERENCE\_DEPTH = 5000) and the average density of the fluid in the well (DEPTH\_CORRECTION = WELL). The contribution from the well cells is reduced in value via a weighting factor of 0.001 compared to the default value of 1 (HOP\_WT\_1 = 0.001). These settings are used for computing average pressure only for the given three wells.

```
WWPAVEC
WELL_NAMES ='Inj -1', 'Inj -2', 'Prod -3'
TRANS_WT_FACTOR =1
WELL_CONN_FLAG = OPEN
REFERENCE_DEPTH =5000
DEPTH_CORRECTION = WELL
HOP_WT_1 =0.001 /
```

/



## 2.505 XMF

### Description

The [XMF](#) keyword is used to provide the initial composition of the liquid phase in each cell when using enumerated initial conditions. For equilibrated initial conditions, see [COMPVD](#), [ZMFVD](#), [ZI](#), or [XMFVP](#).

The keyword is followed by a record consisting of  $N_x \times N_y \times N_z \times N_c$  values, where  $N_x$ ,  $N_y$ , and  $N_z$  are the number of cells in the  $X$ ,  $Y$ , and  $Z$  directions (specified in the [DIMENS](#) keyword), respectively and  $N_c$  is the number of components (specified in the [COMPS](#) keyword). The data is ordered such that the  $X$  index progresses fastest, while the component index increases slowest. Since the data represent the component mole fraction for a phase, the component data for each cell should sum to 1.0.

### Example

For a reservoir of dimensions  $5 \times 5 \times 3$  with six components:

```
SOLUTION  
  
XMF  
-- Component 1  
75*0.573  
-- Component 2  
75*0.174  
-- Component 3  
75*0.121  
-- Component 4  
75*0.038  
-- Component 5  
75*0.053  
-- Component 6  
75*0.041  
/
```



## 2.506 XMFVP

### Description

For compositional models that specify equilibrated initial conditions with the [EQUIL](#) keyword, the [XMFVP](#) keyword is used to provide a table of liquid composition vs. pressure. After the initial pressure is determined for each cell, the liquid composition,  $x_i$  will be interpolated from this table using the cell pressure. Similarly, a table of the vapor composition vs. depth can be provided with the [YMFVP](#) keyword.

The table consists of one record for each equilibration region. The number of equilibration regions is specified in the [EQLDIMS](#) keyword. Each record consists of NCOMP+1 columns of numbers, where NCOMP is the number of components in the equation-of-state (specified by the [COMPS](#) keyword). The first column is the pressure and the remaining NCOMP columns define the liquid composition. The composition at each pressure should sum to 1.

### Example

For a compositional model with six components in FIELD units:

XMFVP						
-- Pres.	x_1	x_2	x_3	x_4	x_5	x_6
4000	0.177	0.435	0.232	0.083	0.051	0.022
4500	0.183	0.415	0.231	0.079	0.049	0.021 /



## 2.507 YMF

### Description

The [YMF](#) keyword is used to provide the initial composition of the vapor phase in each cell when using enumerated initial conditions. For equilibrated initial conditions, see [COMPVD](#), [ZMFVD](#), [ZI](#), or [YMFVP](#).

The keyword is followed by a record consisting of  $N_x \times N_y \times N_z \times N_c$  values, where  $N_x$ ,  $N_y$ , and  $N_z$  are the number of cells in the  $X$ ,  $Y$ , and  $Z$  directions (specified in the [DIMENS](#) keyword), respectively and  $N_c$  is the number of components (specified in the [COMPS](#) keyword). The data is ordered such that the  $X$  index progresses fastest, while the component index increases slowest. Since the data represent the component mole fraction for a phase, the component data for each cell should sum to 1.0.

### Example

For a reservoir of dimensions  $5 \times 5 \times 3$  with six components:

```
SOLUTION  
  
YMF  
-- Component 1  
75*0.573  
-- Component 2  
75*0.174  
-- Component 3  
75*0.121  
-- Component 4  
75*0.038  
-- Component 5  
75*0.053  
-- Component 6  
75*0.041  
/
```



## 2.508 YMFVP

### Description

For compositional models that specify equilibrated initial conditions with the [EQUIL](#) keyword, the [YMFVP](#) keyword is used to provide a table of vapor composition vs. pressure. After the initial pressure is determined for each cell, the vapor composition,  $x_i$  will be interpolated from this table using the cell pressure. Similarly, a table of the liquid composition vs. depth can be provided with the [XMFVP](#) keyword.

The table consists of one record for each equilibration region. The number of equilibration regions is specified in the [EQLDIMS](#) keyword. Each record consists of NCOMP+1 columns of numbers, where NCOMP is the number of components in the equation-of-state (specified by the [COMPS](#) keyword). The first column is the pressure and the remaining NCOMP columns define the liquid composition. The composition at each pressure should sum to 1.

### Example

For a compositional model with six components in FIELD units:

```

YMFVP
-- Pres.    y_1      y_2      y_3      y_4      y_5      y_6
  4000    0.793   0.147   0.048   0.009   0.002   0.001
  4500    0.791   0.145   0.048   0.011   0.0035  0.0015
/

```



## 2.509 ZCORN

### Description

This keyword is used to independently define the depth of each corner for every grid block inside the current input box. If the box at hand consists of  $NX \times NY \times NZ$  cells it is necessary to provide  $2 \times NX \times 2 \times NY \times 2 \times NZ$  floating point numbers in a single record terminated by a slash character. Notably, if the current input box is the reservoir grid, then a total of  $2 \times NXRES \times 2 \times NYRES \times 2 \times NZRES$  floating point values are needed. If **ZCORN** is used inside a **CARFIN /ENDFIN**, or inside a **REFINE/ENDFIN** block, it is necessary to provide  $2 \times NXREF \times 2 \times NYREF \times 2 \times NZREF$  values.

The ordering of the data in the record is based on the local ordering of the cell corners. If  $l$  labels a generic grid cell, its eight **ZCORN** can be ordered such that the first four, namely  $z_{1,l}, \dots, z_{4,l}$ , are for the top face corners while the second four, namely  $z_{5,l}, \dots, z_{8,l}$  are for the bottom face corners. Then,  $z_{1,l}$  is the depth of the near left corner,  $z_{2,l}$  is the depth of the near right corner,  $z_{3,l}$  is the depth of the far left corner and  $z_{4,l}$  is the depth of the far right corner. Depth values  $z_{5,l}, \dots, z_{8,l}$  are ordered similarly.

Having described the local ordering, it is possible to explain how the values in the **ZCORN** record are given one plane after the other according to the following steps:

1. For the first  $NX$  cells in the current grid:
  - the depth of the near left and near right corners are provided according to the following order

$z_{1,1}, z_{2,1}, z_{1,2}, z_{2,2}, \dots, z_{1,l}, z_{2,l}, \dots, z_{1,NX}, z_{2,NX},$

- followed by the far left and near right corners provided in a similar manner

$z_{3,1}, z_{4,1}, z_{4,2}, z_{3,2}, \dots, z_{3,l}, z_{4,l}, \dots, z_{3,NX}, z_{4,NX},$

2. Step 1 is repeated for the remaining  $NY-1$  rows of  $NX$  cells in the first layer,
3. Steps 1 to 2 are repeated for the remaining  $2NZ-1$  planes in the current grid.

See [Figure 4.1](#) of the Technical Description.

**Units:** ft (FIELD), m (METRIC)

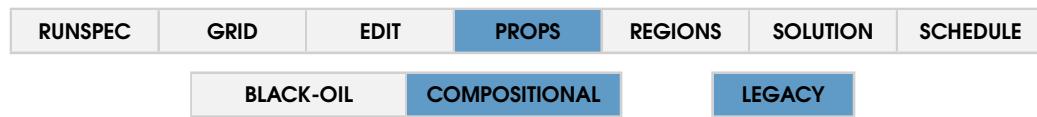
### Example

This example demonstrates how depths of grid block corners can be defined for a simple  $4 \times 5 \times 3$  reservoir with perfectly horizontal layers and docked cells:

```

ZCORN
80*2010
80*2020
80*2020
80*2030
80*2030
80*2040 /

```



## 2.510 ZCRIT

### Description

This keyword specifies the critical compressibility factor of the hydrocarbon components in a compositional simulation. It is followed by NEOSR slash terminated records, one for each reservoir equation of state region, each of them providing  $n_c$  critical volumes, one for each component.

NEOSR is defined using the ninth field in [TABDIMS](#) keyword.

### Record format

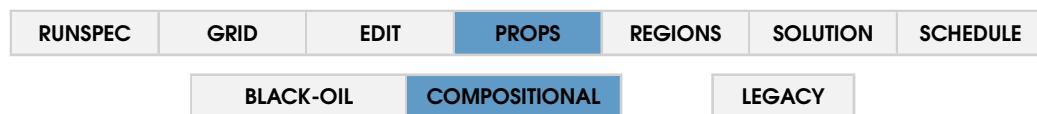
1. **Z\_CRIT:** Component critical compressibilities

Type: Float

#### Example

This example specifies the critical compressibilities for a compositional simulation with five components

```
ZCRIT  
0.2871 0.2819 0.2838 0.2773 0.2767 0.2838 /
```



## 2.511 ZCRITLI

### Description

This keyword specifies the critical compressibility factor of the hydrocarbon components to be used for calculation of hydrocarbon phases critical temperatures using Li correlation. It is followed by NEOSR slash terminated records, one for each reservoir equation of state region, each of them providing  $n_c$  critical compressibilities, one for each component.

If this keyword or [ZCRITVIS](#) is not provided the values specified in [ZCRIT](#) or [VCRIT](#) are used for the hydrocarbon components.

In runs with livewater option ([GASWAT](#), [OILWAT](#) or [LIVEWAT](#) keywords), and in the absence of this keyword or [VCRITLI](#), a value of 0 is used for  $H_2O$ . In other words, by default, the amount of water component in the liquid or vapor phases does not impact the Li critical temperature.

NEOSR is defined using the ninth field in [TABDIMS](#) keyword.

### Record format

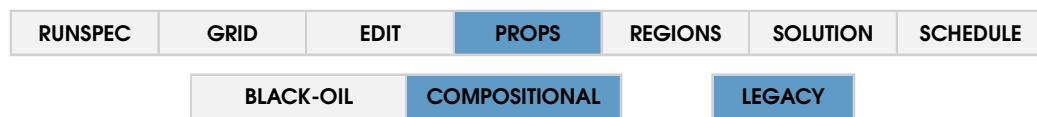
1. **Z\_CRIT\_LI:** Component critical compressibilities for hydrocarbon-phase critical temperature calculation with Li correlation

**Type:** Float

#### Example

This example specifies the critical compressibilities for viscosity calculations in a compositional simulation with five components plus water

```
ZCRITLI  
0.2871 0.2819 0.2838 0.2773 0.2767 0.2838 0.229 /
```



## 2.512 ZCRITS

### Description

This keyword specifies the critical compressibility factor of the hydrocarbon components for the surface equation of state computations in a compositional simulation. It is followed by NEOSS slash terminated records, one for each surface equation of state region, each of them providing  $n_c$  critical compressibilities, one for each component.

If the keyword is not provided the values specified in [ZCRIT](#) are used.

NEOSS is defined using the tenth field in [TABDIMS](#) keyword.

### Record format

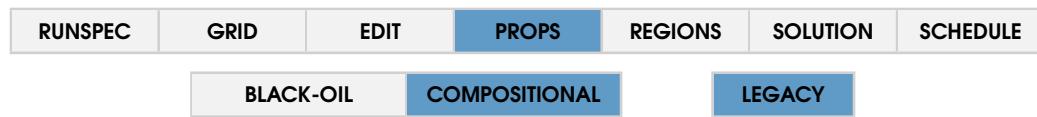
1. **Z\_CRITS:** Component critical compressibilities

**Type:** Float

### Example

This example specifies the critical compressibilities for the surface equation of state in a compositional simulation with five components

```
ZCRITS  
0.2871 0.2819 0.2838 0.2773 0.2767 0.2838 /
```



## 2.513 ZCRITVIS

### Description

This keyword specifies the critical compressibility factor of the hydrocarbon components to be used for viscosity computation only in a compositional simulation. It is followed by NEOSR slash terminated records, one for each reservoir equation of state region, each of them providing  $n_c$  critical compressibilities, one for each component.

If this keyword or [ZCRITVIS](#) is not provided the values specified in [ZCRIT](#) or [VCRIT](#) are used.

NEOSR is defined using the ninth field in [TABDIMS](#) keyword.

### Record format

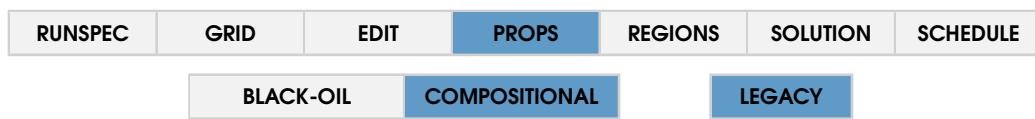
1. **Z\_CRIT\_VIS:** Component critical compressibilities for viscosity calculations

**Type:** Float

#### Example

This example specifies the critical compressibilities for viscosity calculations in a compositional simulation with five components

```
ZCRITVIS  
0.2871 0.2819 0.2838 0.2773 0.2767 0.2838 /
```



## 2.514 ZI

### Description

The **ZI** keyword is used to specify an initial uniform composition for all cells in each equation-of-state (EOS) region. The keyword should be followed by NMEOSR records, where NMEOSR is the number of EOS regions specified in the **TABDIMS** keyword. Each record should specify a single composition with  $n_c$  values, where  $n_c$  is the number of components specified in the **COMPS** keyword. Since it specifies a component mole fraction, each record should sum to one.

### Example

For a model with two EOS regions and five components:

```
ZI
0.238 0.431 0.043 0.185 0.103 /
0.229 0.441 0.046 0.183 0.101 /
```



## 2.515 ZMF

### Description

The [ZMF](#) keyword is used to provide the initial composition of the liquid and vapor phases in each cell when using enumerated initial conditions. For equilibrated initial conditions, see [COMPVD](#), [ZMFVD](#), or [ZI](#).

The keyword is followed by a record consisting of  $N_x \times N_y \times N_z \times N_c$  values, where  $N_x$ ,  $N_y$ , and  $N_z$  are the number of cells in the  $X$ ,  $Y$ , and  $Z$  directions (specified in the [DIMENS](#) keyword), respectively and  $N_c$  is the number of components (specified in the [COMPS](#) keyword). The data is ordered such that the  $X$  index progresses fastest, while the component index increases slowest. Since the data represent the component mole fraction for a phase, the component data for each cell should sum to 1.0.

### Example

For a reservoir of dimensions  $5 \times 5 \times 3$  with six components:

```
SOLUTION  
  
ZMF  
-- Component 1  
75*0.573  
-- Component 2  
75*0.174  
-- Component 3  
75*0.121  
-- Component 4  
75*0.038  
-- Component 5  
75*0.053  
-- Component 6  
75*0.041  
/
```



## 2.516 ZMFVD

### Description

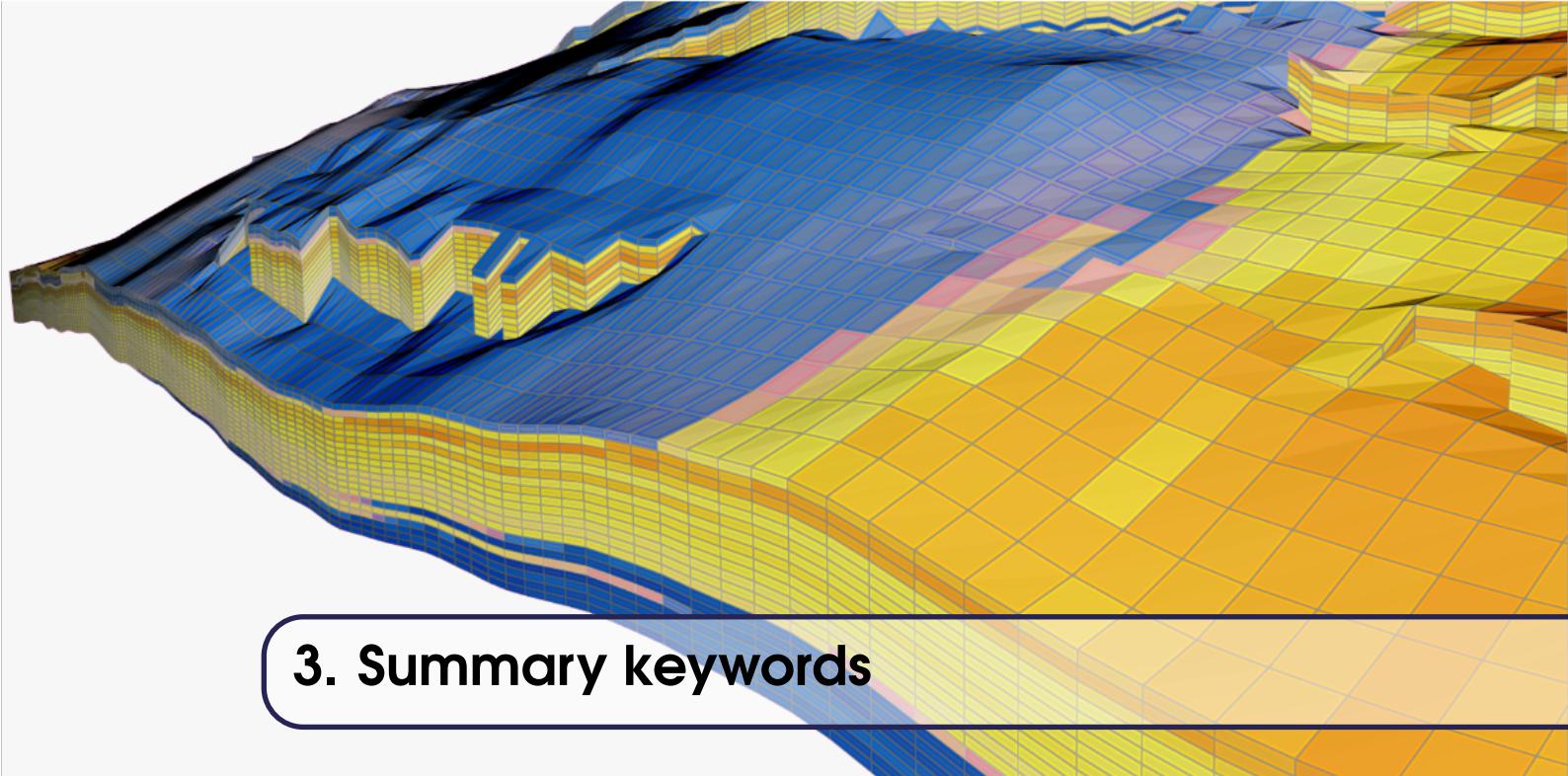
For compositional models that specify equilibrated initial conditions with the [EQUIL](#) keyword, the [ZMFVD](#) keyword is used to provide a table of total composition vs. depth. The total composition of each cell,  $z_i$  will be interpolated from this table using the cell's depth.

The table consists of one record for each equilibration region. The number of equilibration regions is specified in the [EQLDIMS](#) keyword. Each record consists of NCOMP+1 columns of numbers, where NCOMP is the number of components in the equation-of-state (specified by the [COMPS](#) keyword). The first column is the depth and the remaining NCOMP columns define the total fluid composition. The composition at each depth should sum to 1.

### Example

For a compositional model with six components in FIELD units:

ZMFVD	-- Depth	x_1	x_2	x_3	x_4	x_5	x_6	
	3000	0.183	0.415	0.231	0.079	0.049	0.021	
	3500	0.177	0.435	0.232	0.083	0.051	0.022	/



## 3. Summary keywords

The **SUMMARY** section of the input file is used to specify what quantities should be output in the time series output files for later plotting and analysis. Each quantity is requested by inclusion of a keyword in this section. Since hundreds of quantities are available, we do not provide a dedicated page for each quantity, but rather provide tabulated lists organized by type.

### 3.1 Basic structure of reporting keywords

Many keywords, including those specifying cumulative or average quantities over the entire field, require no data following the keyword. Other keywords, such as those reporting well, completion, group, cell, or region properties, are followed by data records which specify the wells, groups, cells, or regions of interest.

### 3.2 Aquifer items

Reporting various quantities for aquifers may be accomplished with the keywords below. Each keyword is followed by a single record with the numerical indices of the desire aquifers. For example, the following will report the pressure for analytics aquifers 1 and 4:

```
AAQP  
1 4 /
```

Any items which require a component index (indicated by the presence of 'C' in the Indices column) have a slightly different structure. These keywords expect a sequence of 1 or more records, each containing a pair of integers corresponding to the aquifer and component index, respectively. The keyword is terminated by an extra trailing '/'. For example, the following would report the molar influx into aquifer 2 for components 1 and 2 and well as the influx into aquifer 4 for component 5.

```
AAQMR  
2 1 /  
2 2 /  
4 5 /  
/
```

Name	BO	CMP	Field Units	Metric Units	Indices	Description
AAQMR	X	X	stb/d	sm <sup>3</sup> /d		analytic aquifer molar influx rate
AAQMT	X	X	stb	sm <sup>3</sup>		analytic aquifer molar influx total
AAQP	X	X	psi	bar		analytic aquifer pressure
AAQPD	X	X				Carter-Tracy aquifer dimensionless pressure
AAQR	X	X	stb/d	sm <sup>3</sup> /d		analytic aquifer influx rate
AAQRG	X	X	Mscf/d	sm <sup>3</sup> /d		analytic aquifer gas influx rate
AAQT	X	X	stb	sm <sup>3</sup>		analytic aquifer influx total
AAQTD	X	X				Carter-Tracy aquifer dimensionless time
AAQTG	X	X	Mscf	sm <sup>3</sup> /d		analytic aquifer gas influx total
ALQMR	X	X	stb/d	sm <sup>3</sup> /d		analytic aquifer list molar influx rate
ALQMT	X	X	stb	sm <sup>3</sup>		analytic aquifer list molar influx total
ALQR	X	X	stb/d	sm <sup>3</sup> /d		analytic aquifer list influx rate
ALQRG	X	X	Mscf/d	sm <sup>3</sup> /d		analytic aquifer list gas influx rate
ALQT	X	X	stb	sm <sup>3</sup>		analytic aquifer list influx total
ALQTG	X	X	Mscf	sm <sup>3</sup> /d		analytic aquifer list gas influx total
ANQP	X	X	psi	bar		numerical aquifer pressure
ANQR	X	X	stb/d	sm <sup>3</sup> /d		numerical aquifer influx rate
ANQT	X	X	stb	sm <sup>3</sup>		numerical aquifer influx total
FAQR	X	X	stb/d	sm <sup>3</sup> /d		field analytic aquifer influx rate
FAQRG	X	X	Mscf/d	sm <sup>3</sup> /d		field analytic aquifer gas influx rate
FAQTG	X	X	Mscf	sm <sup>3</sup> /d		field analytic aquifer gas influx total

### 3.3 Cell block items

Block summary items are used to report quantities for individual cells. Cells are identified by their (I,J,K) coordinates, which are provided as a sequence of records containing triplets of integers. The keyword is terminated by a trailing '/'.

For example, the block pressure in cells (8,12,3) and (3,7,1) can be reported by

```
BPR
 8 12 3 /
 3 7 1 /
/
```

The Tracer Tracking option keywords must be combined with the corresponding tracer name. For instance, if the concentration of a tracer TR1 is required, the keyword BTRCN should be used, complemented by the tracer name as BTCNTR1.

Name	BO	CMP	Field Units	Metric Units	Indices	Description
BAMF		X				aqueous mole fraction
BCAD	X	X	lb/stb	kg/sm <sup>3</sup>		Polymer adsorbed concentration
BCCN	X	X	lb/stb	kg/sm <sup>3</sup>		Polymer concentration
BCIP	X	X	lb	kg		Polymer in place
BDENG	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		gas density
BDENO	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		oil density
BDENW	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		water density
BEWV_SAL	X	X	cPoise	cPoise		water viscosity
BGIP	X	X	Mscf	sm <sup>3</sup> /d		gas in place
BGIPG	X	X	Mscf	sm <sup>3</sup> /d		gas-phase gas in place
BGIPL	X	X	Mscf	sm <sup>3</sup> /d		liquid-phase gas in place
BGKR	X	X				gas relative permeability

BGPC	X	X				gas-oil capillary pressure
BGSAT	X	X				gas saturation
BGTPD	X	X				dynamic trapped gas saturation
BGTRP	X	X				trapped gas saturation
BGVIS	X	X	cPoise	cPoise		gas viscosity
BKRG	X	X				gas relative permeability
BKRO	X	X				oil relative permeability
BKROG	X	X				oil-gas relative permeability
BKROW	X	X				oil-water relative permeability
BKRW	X	X				water relative permeability
BOIP	X	X	stb	sm <sup>3</sup>		oil in place
BOIPG	X	X	stb	sm <sup>3</sup>		liquid-phase oil in place
BOIPL	X	X	stb	sm <sup>3</sup>		gas-phase oil in place
BOKR	X	X				oil relative permeability
BOSAT	X	X				oil saturation
BOVIS	X	X	cPoise	cPoise		oil viscosity
BPMIN	X	X	psi	bar		minimum historical pressure
BPORVMOD	X	X				dynamic pore volume multiplier
BPPG	X	X	psi	bar		gas phase potential
BPPO	X	X	psi	bar		oil phase potential
BPPW	X	X	psi	bar		water phase potential
BPR	X	X	psi	bar		oil pressure
BRK	X	X				water relative permeability reduction
BRS	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		gas fraction
BRV	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		liquid gas ratio
BSCN	X	X	lb/stb	kg/sm <sup>3</sup>		Salt concentration
BSGAS	X	X				gas saturation
BSGASMAX	X	X				maximum historical gas saturation
BSIP	X	X	lb	kg		Salt in place
BSOIL	X	X				oil saturation
BSOILMAX	X	X				maximum historical oil saturation
BSOILMIN	X	X				minimum historical oil saturation
BSTATE	X	X				cell phase
BSTEN	X	X				surface tension
BSWAT	X	X				water saturation
BSWATMIN	X	X				minimum historical water saturation
BTCN	X	X				tracer concentration (total)
BTCAF	X	X				tracer concentration (free)
BT CNS	X	X				tracer concentration (solution)
BTIPF	X	X				tracer in place (free)
BTIPS	X	X				tracer in place (solution)
BTIPT	X	X				tracer in place (total)
BVGAS	X	X	cPoise	cPoise		gas viscosity
BVOIL	X	X	cPoise	cPoise		oil viscosity
BWWAT	X	X	cPoise	cPoise		water viscosity
BWFVF	X	X	rb/stb	rm <sup>3</sup> /sm <sup>3</sup>		water formation volume factor
BWIP	X	X	stb	sm <sup>3</sup>		water in place
BWKR	X	X				water relative permeability
BWPC	X	X				oil-water capillary pressure
BWSAT	X	X				water saturation
BWVIS	X	X	cPoise	cPoise	C	water viscosity
BXMF		X			C	liquid mole fraction
BYMF		X			C	vapor mole fraction

### 3.4 Completion items

Connection summary items are used to report quantities for individual connections between the wellbore and reservoir cells. The keyword is followed by a sequence of records, each of which contains a well name followed by the (I,J,K) coordinates of the connected cell. Either or both of the well name and indices may be defaulted. If the (I,J,K) coordinates are defaulted (or left blank), the quantity will be reported for all connections of the specified well. If the well is also defaulted, it will be reported all connections of all wells.

For example, the following will report the gas flow rate in a single connection of well PD1:

```
CGFR
'PD1' 3 17 44 /
/
```

The following will report the cumulative water injected into each connection of wells WI14 and WI23:

```
CWIT
'WI14' /
'WI23' /
/
```

Name	BO	CMP	Field Units	Metric Units	Indices	Description
CAPI	X	X				completion api
CDBF	X	X				blocking factor
CDFAC	X	X				D factor
CGFR	X	X	Mscf/d	sm <sup>3</sup> /d		gas flow rate
CGFRF	X	X	Mscf/d	sm <sup>3</sup> /d		free gas flow rate
CGFRS	X	X	Mscf/d	sm <sup>3</sup> /d		solution gas flow rate
CGFRU	X	X	Mscf/d	sm <sup>3</sup> /d		upstream gas flow rate
CGIR	X	X	Mscf/d	sm <sup>3</sup> /d		gas injection rate
CGIT	X	X	Mscf	sm <sup>3</sup> /d		gas injection total
CGITF	X	X	Mscf	sm <sup>3</sup> /d		free-gas injection total
CGITS	X	X	Mscf	sm <sup>3</sup> /d		solution-gas injection total
CGLR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		gas-liquid ratio
CGOR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		gas-oil ratio
CGPTN	X	X				gpp table update counter
CGPTS	X	X				gpp table update status
CGPR	X	X	Mscf/d	sm <sup>3</sup> /d		gas production rate
CGPRF	X	X	Mscf/d	sm <sup>3</sup> /d		free-gas production rate
CGPRS	X	X	Mscf/d	sm <sup>3</sup> /d		solution-gas production rate
CGPT	X	X	Mscf	sm <sup>3</sup> /d		gas production total
CGPTF	X	X	Mscf	sm <sup>3</sup> /d		gas free-production total
CGPTS	X	X	Mscf	sm <sup>3</sup> /d		gas solution-production total
CHMR		X	lb-moles/d	kg-moles/d		molar flow rate
CKFR	X	X	lb-moles/d	kg-moles/d		molar flow rate
COFR	X	X	stb/d	sm <sup>3</sup> /d		oil flow rate
COFRF	X	X	stb/d	sm <sup>3</sup> /d		free oil flow rate
COFRS	X	X	stb/d	sm <sup>3</sup> /d		vaporized oil flow rate
COFRU	X	X	stb/d	sm <sup>3</sup> /d		upstream oil flow rate
COGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		oil-gas ratio
COIR	X	X	stb/d	sm <sup>3</sup> /d		oil injection rate
COIT	X	X	stb	sm <sup>3</sup>		oil injection total
COITF	X	X	stb	sm <sup>3</sup>		free-oil injection total
COITS	X	X	stb	sm <sup>3</sup>		vaporized-oil injection total
COPR	X	X	stb/d	sm <sup>3</sup> /d		oil production rate
COPRF	X	X	stb/d	sm <sup>3</sup> /d		free-oil production rate

COPRS	X	X	stb/d	sm <sup>3</sup> /d		vaporized-oil production rate
COPT	X	X	stb	sm <sup>3</sup>		oil production total
COPTF	X	X	stb	sm <sup>3</sup>		free-oil production total
COPTS	X	X	stb	sm <sup>3</sup>		vaporized-oil production total
CPR	X	X	psi	bar		pressure
CSFR	X	X				salt flow rate
CSIC	X	X	lb/stb	kg/sm <sup>3</sup>		salt injection concentration
CSIR	X	X	lb/d	kg/d		salt injection rate
CSIT	X	X	lb	kg		salt injection total
CSPC	X	X	lb/stb	kg/sm <sup>3</sup>		salt production concentration
CSPR	X	X	lb/d	kg/d		salt production rate
CSPT	X	X	lb	kg		salt production total
CTFAC	X	X	cP·rb/(d·psi)	cP·rm <sup>3</sup> /(d·bar)		transmissibility factor
CTFR	X	X				tracer flow rate
CTIC	X	X				tracer injection concentration
CTIR	X	X	Mscf/d	sm <sup>3</sup> /d		tracer injection rate
CTIT	X	X	Mscf	sm <sup>3</sup> /d		tracer injection total
CTPC	X	X				tracer production concentration
CTPR	X	X	Mscf/d	sm <sup>3</sup> /d		tracer production rate
CTPT	X	X	Mscf	sm <sup>3</sup> /d		tracer production total
CWCT	X	X				water cut
CWFR	X	X	stb/d	sm <sup>3</sup> /d		water flow rate
CWFRRU	X	X	stb/d	sm <sup>3</sup> /d		upstream water flow rate
CWGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		water-gas ratio
CWIR	X	X	stb/d	sm <sup>3</sup> /d		water injection rate
CWIT	X	X	stb	sm <sup>3</sup>		water injection total
CWPR	X	X	stb/d	sm <sup>3</sup> /d		water production rate
CWPT	X	X	stb	sm <sup>3</sup>		water production total
CZMF	X	X				total mole fraction

## 3.5 Field region items

Field summary items are used to report quantities taken cumulatively across the entire field. Most of these keywords expect no data records following the keywords. However, the keywords with a 'C' in the Indices column require a single record with the indices of the components to report terminated by a '/'. If the record is empty or defaulted, the quantity will be reported for all components.

For example, the following will report the average vapor composition for the field for all components:

```
FXMF
/
```

Name	BO	CMP	Field Units	Metric Units	Indices	Description
FAGIP	X	X	Mscf	sm <sup>3</sup> /d		field aqueous-phase gas in place
FAPI	X	X				field API
FAQMR	X	X	stb/d	sm <sup>3</sup> /d		field analytic aquifer molar influx rate
FAQMT	X	X	stb	sm <sup>3</sup>		field analytic aquifer molar influx total
FAQT	X	X	stb	sm <sup>3</sup>		field analytic aquifer influx total
FCMIP	X	X			C	component molar mass in place
FFGR	X	X	Mscf/d	sm <sup>3</sup> /d		field fuel gas rate
FFGT	X	X	Mscf	sm <sup>3</sup> /d		cumulative field fuel gas
FGDN	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		gas surface density
FGIP	X	X	Mscf	sm <sup>3</sup> /d		field gas in place
FGIPG	X	X	Mscf	sm <sup>3</sup> /d		field gas-phase gas in place
FGIPL	X	X	Mscf	sm <sup>3</sup> /d		field liquid-phase gas in place
FGIR	X	X	Mscf/d	sm <sup>3</sup> /d		field gas injection rate

FGIRH	X	X	Mscf/d	sm <sup>3</sup> /d		field gas injection rate history
FGIT	X	X	Mscf	sm <sup>3</sup> /d		field gas injection total
FGITH	X	X	Mscf	sm <sup>3</sup> /d		field gas injection total history
FGLIR	X	X	Mscf/d	sm <sup>3</sup> /d		field gas lift injection rate
FGLR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		field gas-liquid ratio
FGLRH	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		field gas-liquid ratio history
FGOR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		field gas-oil ratio
FGORH	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		field gas-oil ratio history
FGPI	X	X	Mscf/d	sm <sup>3</sup> /d		field gas injection potential
FGPI2	X	X	Mscf/d	sm <sup>3</sup> /d		field gas injection potential
FGPP	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production potential
FGPP2	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production potential all
FGPR	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production rate
FGPR1	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production rate above GOC
FGPR2	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production rate below GOC
FGPRA	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production rate above GOC
FGPRB	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production rate below GOC
FGPRF	X	X	Mscf/d	sm <sup>3</sup> /d		field free-gas production rate
FGPRH	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production rate history
FGPRS	X	X	Mscf/d	sm <sup>3</sup> /d		field solution-gas production rate
FGPRT	X	X	Mscf/d	sm <sup>3</sup> /d		field gas production rate limit
FGPT	X	X	Mscf	sm <sup>3</sup> /d		field gas production total
FGPT1	X	X	Mscf/d	sm <sup>3</sup> /d		total field gas production above GOC
FGPT2	X	X	Mscf/d	sm <sup>3</sup> /d		total field gas production below GOC
FGPTA	X	X	Mscf/d	sm <sup>3</sup> /d		total field gas production above GOC
FGPTB	X	X	Mscf/d	sm <sup>3</sup> /d		total field gas production below GOC
FGPTF	X	X	Mscf	sm <sup>3</sup> /d		field free-gas production total
FGPTH	X	X	Mscf	sm <sup>3</sup> /d		field gas production total history
FGPTS	X	X	Mscf	sm <sup>3</sup> /d		field solution-gas production total
FGPV	X	X	rb	rm <sup>3</sup>		field dynamic pore volume containing gas
FGSAT	X	X				field gas saturation
FHPV	X	X	rb	rm <sup>3</sup>		field dynamic pore volume containing hydrocarbons
FLPR	X	X	stb/d	sm <sup>3</sup> /d		field liquid production rate
FLPRH	X	X	stb/d	sm <sup>3</sup> /d		field liquid production rate history
FLPT	X	X	stb	sm <sup>3</sup>		field liquid production total
FLPTH	X	X	stb	sm <sup>3</sup>		field liquid production total history
FMBEA		X			C	material balance error absolute
FMBEC		X			C	material balance error normalized to moles-in-place
FMBEN		X			C	material balance error normalized to total moles-in-place
FMWDR	X	X				number of drilling events during timestep
FMWDT	X	X				number of drilling events total
FMWIA	X	X				number of abandoned injector wells
FMWIG	X	X				number of injector wells in group control
FMWIN	X	X				number of flowing injector wells
FMWIP	X	X				number of injector wells operating in pressure control
FMWIS	X	X				number of injector wells operating in own surface rate control
FMWIT	X	X				number of injector wells
FMWIU	X	X				number of unused injector wells
FMWIV	X	X				number of injector wells operating in own reservoir rate limit

FMWPA	X	X				number of abandoned producer wells
FMWPG	X	X				number of producer wells in group control
FMWPL	X	X				number of producer wells using artificial lift
FMWPO	X	X				number of producer wells in own oil rate control
FMWPP	X	X				number of producer wells operating in pressure control
FMWPR	X	X				number of flowing producer wells
FMWPS	X	X				number of producer wells operating in own surface rate control
FMWPT	X	X				number of producer wells
FMWPU	X	X				number of unused producer wells
FMWPV	X	X				number of producer wells operating in own reservoir rate limit
FNLIP	X	X	stb	sm <sup>3</sup>		field ngl in place
FNLPR	X	X	stb/d	sm <sup>3</sup> /d		field NGL production rate
FNLPRH	X	X	stb/d	sm <sup>3</sup> /d		field NGL production rate history
FNLPT	X	X	stb	sm <sup>3</sup>		field NGL production total
FNLPTH	X	X	stb	sm <sup>3</sup>		field NGL production total history
FNQR	X	X	stb/d	sm <sup>3</sup> /d		field numerical aquifer influx rate
FNQT	X	X	stb	sm <sup>3</sup>		field numerical aquifer influx total
FODN	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		oil surface density
FOE	X	X				field oil recovery efficiency w.r.t initial OIP
FOEW	X	X				field oil production efficiency w.r.t initial OIP
FOGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		field oil-gas ratio
FOGRH	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		field oil-gas ratio history
FOIP	X	X	stb	sm <sup>3</sup>		field oil in place
FOIPG	X	X	stb	sm <sup>3</sup>		field gas-phase oil in place
FOIPL	X	X	stb	sm <sup>3</sup>		field liquid-phase oil in place
FOIR	X	X	stb/d	sm <sup>3</sup> /d		field oil injection rate
FOIRH	X	X	stb/d	sm <sup>3</sup> /d		field oil injection rate history
FOIT	X	X	stb	sm <sup>3</sup>		field oil injection total
FOITH	X	X	stb	sm <sup>3</sup>		field oil injection total history
FOPI	X	X	stb/d	sm <sup>3</sup> /d		field oil injection potential
FOPI2	X	X	stb/d	sm <sup>3</sup> /d		field oil injection potential
FOPP	X	X	stb/d	sm <sup>3</sup> /d		field oil production potential
FOPP2	X	X	stb/d	sm <sup>3</sup> /d		field oil production potential all
FOPR	X	X	stb/d	sm <sup>3</sup> /d		field oil production rate
FOPR1	X	X	stb/d	sm <sup>3</sup> /d		field oil production rate above GOC
FOPR2	X	X	stb/d	sm <sup>3</sup> /d		field oil production rate below GOC
FOPRA	X	X	stb/d	sm <sup>3</sup> /d		field oil production rate above GOC
FOPRB	X	X	stb/d	sm <sup>3</sup> /d		field oil production rate below GOC
FOPRF	X	X	stb/d	sm <sup>3</sup> /d		field free-oil production rate
FOPRH	X	X	stb/d	sm <sup>3</sup> /d		field oil production rate history
FOPRS	X	X	stb/d	sm <sup>3</sup> /d		field vaporized-oil production rate
FOPRT	X	X	stb/d	sm <sup>3</sup> /d		field oil production rate limit
FOPT	X	X	stb	sm <sup>3</sup>		field oil production total
FOPT1	X	X	stb	sm <sup>3</sup>		total field oil production above GOC
FOPT2	X	X	stb	sm <sup>3</sup>		total field oil production below GOC
FOPTA	X	X	stb	sm <sup>3</sup>		total field oil production above GOC
FOPTB	X	X	stb	sm <sup>3</sup>		total field oil production below GOC
FOPTF	X	X	stb	sm <sup>3</sup>		field free-oil production total
FOPTH	X	X	stb	sm <sup>3</sup>		field oil production total history
FOPTS	X	X	stb	sm <sup>3</sup>		field vaporized-oil production total

<b>FOPV</b>	X	X	rb	rm <sup>3</sup>		field dynamic pore volume containing oil
<b>FOSAT</b>	X	X				field oil saturation
<b>FO_PR</b>	X	X	stb/d	sm <sup>3</sup> /d		field stage oil production rate
<b>FPPG</b>	X	X	psi	bar		field gas potential (gas pressure corrected to a datum depth)
<b>FPPO</b>	X	X	psi	bar		field oil potential (oil pressure corrected to a datum depth)
<b>FPPW</b>	X	X	psi	bar		field water potential (water pressure corrected to a datum depth)
<b>FPR</b>	X	X	psi	bar		field oil pressure
<b>FPRH</b>	X	X	psi	bar		field oil pressure
<b>FPRP</b>	X	X	psi	bar		average field oil pressure weighted by pore volumn
<b>FRPV</b>	X	X	rb	rm <sup>3</sup>		field dynamic pore volume
<b>FRS</b>	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		field gas liquid ratio
<b>FRV</b>	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		field liquid gas ratio
<b>FSALT</b>	X	X				field salt concentration
<b>FSGR</b>	X	X	Mscf/d	sm <sup>3</sup> /d		field sale gas rate
<b>FSGT</b>	X	X	Mscf	sm <sup>3</sup> /d		cumulative field sale gas
<b>FSIR</b>	X	X	lb/d	kg/d		Salt injection rate
<b>FSIT</b>	X	X	lb	kg		Salt injection total
<b>FSPC</b>	X	X	lb/stb	kg/sm <sup>3</sup>		Salt production concentration
<b>FSPR</b>	X	X	lb/d	kg/d		Salt production rate
<b>FSPT</b>	X	X	lb	kg		Salt production total
<b>FTCM</b>	X	X	lb-moles/d	kg-moles/d		field tracer carrier molar rate
<b>FTIC</b>	X	X				field tracer injection concentration
<b>FTIPF</b>	X	X				field tracer in place (free)
<b>FTIPS</b>	X	X				field tracer in place (solution)
<b>FTIPT</b>	X	X				field tracer in place
<b>FTIR</b>	X	X	Mscf/d	sm <sup>3</sup> /d		field tracer injection rate
<b>FTIT</b>	X	X	Mscf	sm <sup>3</sup> /d		field tracer injection total
<b>FTLM</b>	X	X	lb	kg		field traced liquid mass total rate
<b>FTML</b>	X	X	lb/d	kg/d		field traced liquid mass rate
<b>FTMR</b>	X	X	lb/d	kg/d		field traced mass rate
<b>FTMT</b>	X	X	lb	kg		field traced mass total
<b>FTMV</b>	X	X	lb/d	kg/d		fiels traced vapor mass rate
<b>FTPC</b>	X	X				field tracer production concentration
<b>FTPR</b>	X	X	Mscf/d	sm <sup>3</sup> /d		field tracer production rate
<b>FTPT</b>	X	X	Mscf	sm <sup>3</sup> /d		field tracer production total
<b>FTQR</b>	X	X	lb-moles/d	kg-moles/d		field traced molar rate
<b>FTTL</b>	X	X	stb	sm <sup>3</sup>		field traced liquid volume total rate
<b>FTTV</b>	X	X	Mscf	sm <sup>3</sup> /d		fiels traced vapor volume total rate
<b>FTVL</b>	X	X	stb/d	sm <sup>3</sup> /d		field traced liquid volume rate
<b>FTVM</b>	X	X	lb	kg		fiels traced vapor mass total rate
<b>FTVV</b>	X	X	Mscf/d	sm <sup>3</sup> /d		fiels traced vapor volume rate
<b>FVIR</b>	X	X	rb/d	rm <sup>3</sup> /d		field reservoir volume injection rate
<b>FVIT</b>	X	X	rb	rm <sup>3</sup>		field reservoir volume injection total
<b>FVPR</b>	X	X	rb/d	rm <sup>3</sup> /d		field reservoir volume production rate
<b>FVPT</b>	X	X	rb	rm <sup>3</sup>		field reservoir volume production total
<b>FWCT</b>	X	X				field water cut
<b>FWCTH</b>	X	X				field water cut history
<b>FWDN</b>	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		water surface density
<b>FWGIR</b>	X	X	Mscf/d	sm <sup>3</sup> /d		field wet gas injection rate
<b>FWGIT</b>	X	X	Mscf	sm <sup>3</sup> /d		field wet gas injection total
<b>FWGPR</b>	X	X	Mscf/d	sm <sup>3</sup> /d		field wet gas production rate
<b>FWGPT</b>	X	X	Mscf	sm <sup>3</sup> /d		field wet gas production total
<b>FWGR</b>	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		field water-gas ratio

FWGRH	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		field water-gas ratio history
FWIP	X	X	stb	sm <sup>3</sup>		field water in place
FWIR	X	X	stb/d	sm <sup>3</sup> /d		field water injection rate
FWIRH	X	X	stb/d	sm <sup>3</sup> /d		field water injection rate history
FWIT	X	X	stb	sm <sup>3</sup>		field water injection total
FWITH	X	X	stb	sm <sup>3</sup>		field water injection total history
FWMIR	X	X	lb-moles/d	kg-moles/d		field molar water injection rate
FWMIT	X	X	lb-moles	kg-moles		field molar water injection total
FWMPR	X	X	lb-moles/d	kg-moles/d		field molar water production rate
FWMPT	X	X	lb-moles	kg-moles		field molar water production total
FWPI	X	X	stb/d	sm <sup>3</sup> /d		field water injection potential
FWPI2	X	X	stb/d	sm <sup>3</sup> /d		field water injection potential
FWPP	X	X	stb/d	sm <sup>3</sup> /d		field water production potential
FWPP2	X	X	stb/d	sm <sup>3</sup> /d		field water production potential all
FWPR	X	X	stb/d	sm <sup>3</sup> /d		field water production rate
FWPRH	X	X	stb/d	sm <sup>3</sup> /d		field water production rate history
FWPRT	X	X	stb/d	sm <sup>3</sup> /d		field water production rate limit
FWPT	X	X	stb	sm <sup>3</sup>		field water production total
FWPTH	X	X	stb	sm <sup>3</sup>		field water production total history
FWPV	X	X	rb	rm <sup>3</sup>		field dynamic pore volume containing water
FWSAT	X	X				field water saturation
FXMF	X	X			C	liquid mole fraction
FXMF_	X	X			C	liquid mole fraction for separator stages
FYMF	X	X			C	vapor mole fraction
FYMF_	X	X			C	vapor mole fraction for separator stages
FZMF	X	X			C	total mole fraction

## 3.6 Well group items

Group summary items are used to report quantities related to well groups within the hierarchical structure specified by `GRUPTREE`. Most keywords accept a single slash-terminated record with a list of the groups for which the quantity report is desired.

However, any keyword with a 'C' in the Indices column is used to report a quantity for specified components and an alternative syntax is required. In these cases, any number of slash-terminated records may be specified, each of which contains a group name followed by a component index. If the component index is defaulted or unspecified, the quantity will be reported for all components.

For example, the following requests the total mole fraction for group FPSO1 for component 2 and all components for group PRD3:

```
GZMF
'FPSO1' 2 /
'PRD3'   /
/
```

Name	BO	CMP	Field Units	Metric Units	Indices	Description
FCGMR	X	X	lb-moles/d	kg-moles/d	C	vapor component molar rate
FCIC	X	X	lb/stb	kg/sm <sup>3</sup>		Polymer injection concentration
FCIR	X	X	lb/d	kg/d		Polymer injection rate
FCIT	X	X	lb	kg		Polymer injection total
FCMIR	X	X	lb-moles/d	kg-moles/d	C	component molar injection rate
FCMIT	X	X			C	component molar injection total
FCMPR	X	X	lb-moles/d	kg-moles/d	C	component molar production rate

FCMPT	X	X			C	component molar production total
FCNMR	X	X	lb-moles/d	kg-moles/d	C	ngl component molar rate
FCOMR	X	X	lb-moles/d	kg-moles/d	C	liquid component molar rate
FCPC	X	X	lb/stb	kg/sm <sup>3</sup>		Polymer production concentration
FCPR	X	X	lb/d	kg/d		Polymer production rate
FCPT	X	X	lb	kg		Polymer production total
FG_PR	X	X	stb/d	sm <sup>3</sup> /d		field stage gas production rate
FSIC	X	X	lb/stb	kg/sm <sup>3</sup>		Salt injection concentration
GAPI	X					group api
GCGMR		X	lb-moles/d	kg-moles/d	C	vapor component molar rate
GCIC	X	X	lb/stb	kg/sm <sup>3</sup>		Polymer injection concentration
GCIR	X	X	lb/d	kg/d		Polymer injection rate
GCIT	X	X	lb	kg		Polymer injection total
GCMIR		X	lb-moles/d	kg-moles/d	C	component molar injection rate
GCMIT		X			C	component molar injection total
GCMPR		X	lb-moles/d	kg-moles/d	C	component molar rate
GCMPT		X			C	component molar rate
GCNMR		X	lb-moles/d	kg-moles/d	C	ngl component molar rate
GCOMR		X	lb-moles/d	kg-moles/d	C	liquid component molar rate
GCPC	X	X	lb/stb	kg/sm <sup>3</sup>		Polymer production concentration
GCPR	X	X	lb/d	kg/d		Polymer production rate
GCPT	X	X	lb	kg		Polymer production total
GEFF	X	X				group efficiency factor
GFGR	X	X	Mscf/d	sm <sup>3</sup> /d		group fuel gas rate
GFGT	X	X	Mscf	sm <sup>3</sup> /d		cumulative group fuel gas rate
GGDN	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		gas surface density
GGIR	X	X	Mscf/d	sm <sup>3</sup> /d		group gas injection rate
GGIRH	X	X	Mscf/d	sm <sup>3</sup> /d		group gas injection rate history
GGIT	X	X	Mscf	sm <sup>3</sup> /d		group gas injection total
GGITH	X	X	Mscf	sm <sup>3</sup> /d		group gas injection total history
GGLIR	X	X	Mscf/d	sm <sup>3</sup> /d		group gas lift injection rate
GGLR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		group gas-liquid ratio
GGLRH	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		group gas-liquid ratio history
GGOR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		group gas-oil ratio
GGORH	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		group gas-oil ratio history
GGPGR	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production guide rate
GGPI	X	X	Mscf/d	sm <sup>3</sup> /d		group gas injection potential
GGPI2	X	X	Mscf/d	sm <sup>3</sup> /d		group gas injection potential
GGPP	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production potential
GGPP2	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production potential all
GGPR	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production rate
GGPR1	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production rate above GOC
GGPR2	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production rate below GOC
GGPRA	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production rate above GOC
GGPRB	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production rate below GOC
GGPRF	X	X	Mscf/d	sm <sup>3</sup> /d		group free-gas production rate
GGPRH	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production rate history
GGPRL	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production rate limit
GGPRS	X	X	Mscf/d	sm <sup>3</sup> /d		group solution-gas production rate
GGPRT	X	X	Mscf/d	sm <sup>3</sup> /d		group gas production rate limit
GGPT	X	X	Mscf	sm <sup>3</sup> /d		group gas production total
GGPT1	X	X	Mscf	sm <sup>3</sup> /d		total group gas production above GOC
GGPT2	X	X	Mscf	sm <sup>3</sup> /d		total group gas production below GOC
GGPTA	X	X	Mscf	sm <sup>3</sup> /d		total group gas production above GOC
GGPTB	X	X	Mscf	sm <sup>3</sup> /d		total group gas production below GOC
GGPTF	X	X	Mscf	sm <sup>3</sup> /d		group free-gas production total
GGPTH	X	X	Mscf	sm <sup>3</sup> /d		group gas production total history
GGPTS	X	X	Mscf	sm <sup>3</sup> /d		group solution-gas production total

GG_PR	X	X	Mscf/d	sm <sup>3</sup> /d	group stage gas production rate
GLPR	X	X	stb/d	sm <sup>3</sup> /d	group liquid production rate
GLPRH	X	X	stb/d	sm <sup>3</sup> /d	group liquid production rate history
GLPRL	X	X	stb/d	sm <sup>3</sup> /d	group liquid production rate limit
GLPRT	X	X	stb/d	sm <sup>3</sup> /d	group liquid production rate limit
GLPT	X	X	stb	sm <sup>3</sup>	group liquid production total
GLPTH	X	X	stb	sm <sup>3</sup>	group liquid production total history
GMWDR	X	X			number of drilling events during timestep
GMWDT	X	X			number of drilling events total
GMWIA	X	X			number of abandoned injector wells
GMWIG	X	X			number of injector wells in group control
GMWIN	X	X			number of flowing injector wells
GMWIP	X	X			number of injector wells operating in pressure control
GMWIS	X	X			number of injector wells operating in own surface rate control
GMWIT	X	X			number of injector wells
GMWIU	X	X			number of unused injector wells
GMWIV	X	X			number of injector wells operating in own reservoir rate limit
GMWPA	X	X			number of abandoned producer wells
GMWPG	X	X			number of producer wells in group control
GMWPL	X	X			number of producer wells using artificial lift
GMWPO	X	X			number of producer wells in own oil rate control
GMWPP	X	X			number of producer wells operating in pressure control
GMWPR	X	X			number of flowing producer wells
GMWPS	X	X			number of producer wells operating in own surface rate control
GMWPT	X	X			number of producer wells
GMWPU	X	X			number of unused producer wells
GMWPV	X	X			number of producer wells operating in own reservoir rate limit
GNLPR	X	X	stb/d	sm <sup>3</sup> /d	group NGL production rate
GNLPRH	X	X	stb/d	sm <sup>3</sup> /d	group NGL production rate history
GNLPT	X	X	stb	sm <sup>3</sup>	group NGL production total
GNLPTH	X	X	stb	sm <sup>3</sup>	group NGL production total history
GODN	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>	oil surface density
GOGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>	group oil-gas ratio
GOGRH	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>	group oil-gas ratio history
GOIR	X	X	stb/d	sm <sup>3</sup> /d	group oil injection rate
GOIRH	X	X	stb/d	sm <sup>3</sup> /d	group oil injection rate history
GOIT	X	X	stb	sm <sup>3</sup>	group oil injection total
GOITH	X	X	stb	sm <sup>3</sup>	group oil injection total history
GOPGR	X	X	stb/d	sm <sup>3</sup> /d	group oil production guide rate
GOPI	X	X	stb/d	sm <sup>3</sup> /d	group oil injection potential
GOPI2	X	X	stb/d	sm <sup>3</sup> /d	group oil injection potential
GOPP	X	X	stb/d	sm <sup>3</sup> /d	group oil production potential
GOPP2	X	X	stb/d	sm <sup>3</sup> /d	group oil production potential all
GOPR	X	X	stb/d	sm <sup>3</sup> /d	group oil production rate
GOPR1	X	X	stb/d	sm <sup>3</sup> /d	group oil production rate above GOC
GOPR2	X	X	stb/d	sm <sup>3</sup> /d	group oil production rate below GOC
GOPRA	X	X	stb/d	sm <sup>3</sup> /d	group oil production rate above GOC

GOPRB	X	X	stb/d	sm <sup>3</sup> /d		group oil production rate below GOC
GOPRF	X	X	stb/d	sm <sup>3</sup> /d		group free-oil production rate
GOPRH	X	X	stb/d	sm <sup>3</sup> /d		group oil production rate history
GOPRL	X	X	stb/d	sm <sup>3</sup> /d		group oil production rate limit
GOPRS	X	X	stb/d	sm <sup>3</sup> /d		group vaporized-oil production rate
GOPRT	X	X	stb/d	sm <sup>3</sup> /d		group oil production rate limit
GOPT	X	X	stb	sm <sup>3</sup>		group oil production total
GOPT1	X	X	stb	sm <sup>3</sup>		total group oil production above GOC
GOPT2	X	X	stb	sm <sup>3</sup>		total group oil production below GOC
GOPTA	X	X	stb	sm <sup>3</sup>		total group oil production above GOC
GOPTB	X	X	stb	sm <sup>3</sup>		total group oil production below GOC
GOPTF	X	X	stb	sm <sup>3</sup>		group free-oil production total
GOPTH	X	X	stb	sm <sup>3</sup>		group oil production total history
GOPTS	X	X	stb	sm <sup>3</sup>		group vaporized-oil production total
GO_PR	X	X	stb/d	sm <sup>3</sup> /d		group stage oil production rate
GPR	X	X	psi	bar		group node pressure
GSGR	X	X	Mscf/d	sm <sup>3</sup> /d		group sale gas rate
GSGT	X	X	Mscf	sm <sup>3</sup> /d		cumulative group sale gas rate
GSIC	X	X	lb/stb	kg/sm <sup>3</sup>		Salt injection concentration
GSIR	X	X	lb/d	kg/d		Salt injection rate
GSIT	X	X	lb	kg		Salt injection total
GSPC	X	X	lb/stb	kg/sm <sup>3</sup>		Salt production concentration
GSPR	X	X	lb	kg		Salt production rate
GSPT	X	X	lb/d	kg/d		Salt production total
GTCM	X	X	lb-moles/d	kg-moles/d		group tracer carrier molar rate
GTIC	X	X				group tracer injection concentration
GTIR	X	X	Mscf/d	sm <sup>3</sup> /d		group tracer injection rate
GTIT	X	X	Mscf	sm <sup>3</sup> /d		group tracer injection total
GTLM	X	X	lb	kg		group traced liquid mass total rate
GTML	X	X	lb/d	kg/d		group traced liquid mass rate
GTMR	X	X	lb/d	kg/d		group traced mass rate
GTMT	X	X	lb	kg		group traced mass total
GTMV	X	X	lb/d	kg/d		group traced vapor mass rate
GTPC	X	X				group tracer production concentration
GTPR	X	X	Mscf/d	sm <sup>3</sup> /d		group tracer production rate
GTPT	X	X	Mscf	sm <sup>3</sup> /d		group tracer production total
GTQR	X	X	lb-moles/d	kg-moles/d		group traced molar rate
GTTL	X	X	stb	sm <sup>3</sup>		group traced liquid volume total rate
GTTV	X	X	Mscf	sm <sup>3</sup> /d		group traced vapor volume total rate
GTVL	X	X	stb/d	sm <sup>3</sup> /d		group traced liquid volume rate
GTVM	X	X	lb	kg		group traced vapor mass total rate
GTVV	X	X	Mscf/d	sm <sup>3</sup> /d		group traced vapor volume rate
GVIR	X	X	rb/d	rm <sup>3</sup> /d		group reservoir volume injection rate
GVIT	X	X	rb	rm <sup>3</sup>		group reservoir volume injection total
GVPR	X	X	rb/d	rm <sup>3</sup> /d		group reservoir volume production rate
GVPT	X	X	rb	rm <sup>3</sup>		group reservoir volume production total
GWCT	X	X				group water cut
GWCTH	X	X				group water cut history
GWDN	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		water surface density
GWGIR	X	X	Mscf/d	sm <sup>3</sup> /d		group wet gas injection rate
GWGIT	X	X	Mscf/d	sm <sup>3</sup> /d		group wet gas injection total
GWGPR	X	X	Mscf/d	sm <sup>3</sup> /d		group wet gas production rate
GWGPT	X	X	Mscf	sm <sup>3</sup> /d		group wet gas production total
GWGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		group water-gas ratio
GWGRH	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		group water-gas ratio history
GWIR	X	X	stb/d	sm <sup>3</sup> /d		group water injection rate
GWIRH	X	X	stb/d	sm <sup>3</sup> /d		group water injection rate history

GWIT	X	X	stb	sm <sup>3</sup>		group water injection total
GWITH	X	X	stb	sm <sup>3</sup>		group water injection total history
GWMIR	X	X	lb-moles/d	kg-moles/d		group molar water injection rate
GWMIT	X	X	lb-moles	kg-moles		group molar water injection total
GWMPR	X	X	lb-moles/d	kg-moles/d		group molar water production rate
GWMPT	X	X	lb-moles	kg-moles		group molar water production total
GPWGR	X	X	stb/d	sm <sup>3</sup> /d		group water production guide rate
GWPI	X	X	stb/d	sm <sup>3</sup> /d		group water injection potential
GWPI2	X	X	stb/d	sm <sup>3</sup> /d		group water injection potential
GWPP	X	X	stb/d	sm <sup>3</sup> /d		group water production potential
GWPP2	X	X	stb/d	sm <sup>3</sup> /d		group water production potential all
GWPR	X	X	stb/d	sm <sup>3</sup> /d		group water production rate
GWPRH	X	X	stb/d	sm <sup>3</sup> /d		group water production rate history
GWPRL	X	X	stb/d	sm <sup>3</sup> /d		group water production rate limit
GWPRT	X	X	stb/d	sm <sup>3</sup> /d		group water production rate limit
GWPT	X	X	stb	sm <sup>3</sup>		group water production total
GWPTH	X	X	stb	sm <sup>3</sup>		group water production total history
GXMF		X			C	liquid mole fraction
GXMF_		X			C	liquid mole fraction for separator stages
GYMF		X			C	vapor mole fraction
GYMF_		X			C	vapor mole fraction for separator stages
GZMF		X			C	total mole fraction

## 3.7 Facility network items

The network summary items report quantities pertaining the surface networks modeled in the integrated Facility Network Solver (FNS).

Name	BO	CMP	Field Units	Metric Units	Indices	Description
NCPUNSL	X	X	sec	sec		CPU time per network solve
NCPUNSLT	X	X	sec	sec		total CPU time per network solve
NELAPNSL	X	X	sec	sec		elapsed time per network solve
NELPNSLT	X	X	sec	sec		total elapsed time per network solve
NFAILS	X	X				solve fails per network
NJALL	X	X				junction all properties
NJGFR	X	X	Mscf/d	sm <sup>3</sup> /d		junction gas flow rate
NJGIR	X	X	Mscf/d	sm <sup>3</sup> /d		junction gas injection rate
NJGLFR	X	X	Mscf/d	sm <sup>3</sup> /d		junction gas lift flow rate
NJGLR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		junction gas-liquid ratio
NJGOR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		junction gas-oil ratio
NJGPR	X	X	Mscf/d	sm <sup>3</sup> /d		junction gas production rate
NJGWR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		junction gas-water ratio
NJLGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		junction liquid-gas ratio
NJLPR	X	X	stb/d	sm <sup>3</sup> /d		junction liquid production rate
NJMR	X	X			C	junction molar rate
NJOFR	X	X	stb/d	sm <sup>3</sup> /d		junction oil flow rate
NJOGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		junction oil-gas ratio
NJOPR	X	X	stb/d	sm <sup>3</sup> /d		junction oil production rate
NJPR	X	X	psi	bar		junction pressure
NJWCT	X	X				junction water cut
NJWFR	X	X	stb/d	sm <sup>3</sup> /d		junction water flow rate
NJWGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		junction water-gas ratio
NJWIR	X	X	stb/d	sm <sup>3</sup> /d		junction water injection rate
NJWPR	X	X	stb/d	sm <sup>3</sup> /d		junction water production rate

NNEWT	X	X					newtons per network solve
NNEWTTOT	X	X					cumulated newtons per network solve
NPALL	X	X					pipe all properties
NPGFR	X	X	Mscf/d	sm <sup>3</sup> /d			pipe gas flow rate
NPGLFR	X	X	Mscf/d	sm <sup>3</sup> /d			pipe gas lift flow rate
NPMR	X	X			C		pipe molar rate
NPOFR	X	X	stb/d	sm <sup>3</sup> /d			pipe oil flow rate
NPPRD	X	X	psi	bar			pipe pressure drop
NPWFR	X	X	stb/d	sm <sup>3</sup> /d			pipe water flow rate
NSCGFR	X	X	Mscf/d	sm <sup>3</sup> /d			source gas flow rate
NSCGIR	X	X	Mscf/d	sm <sup>3</sup> /d			source gas injection rate
NSCGPR	X	X	Mscf/d	sm <sup>3</sup> /d			source gas production rate
NSCLPR	X	X	stb/d	sm <sup>3</sup> /d			source liquid production rate
NSCOFR	X	X	stb/d	sm <sup>3</sup> /d			source oil flow rate
NSCOPR	X	X	stb/d	sm <sup>3</sup> /d			source oil production rate
NSCPR	X	X	psi	bar			source pressure
NSCWFR	X	X	stb/d	sm <sup>3</sup> /d			source water flow rate
NSCWIR	X	X	stb/d	sm <sup>3</sup> /d			source water injection rate
NSCWPR	X	X	stb/d	sm <sup>3</sup> /d			source water production rate
NSKGFR	X	X	Mscf/d	sm <sup>3</sup> /d			sink gas flow rate
NSKGIR	X	X	Mscf/d	sm <sup>3</sup> /d			sink gas injection rate
NSKGLFR	X	X	Mscf/d	sm <sup>3</sup> /d			sink gas lift flow rate
NSKGPR	X	X	Mscf/d	sm <sup>3</sup> /d			sink gas production rate
NSKLPR	X	X	stb/d	sm <sup>3</sup> /d			sink liquid production rate
NSKMR	X	X			C		sink molar rate
NSKOFR	X	X	stb/d	sm <sup>3</sup> /d			sink oil flow rate
NSKOPR	X	X	stb/d	sm <sup>3</sup> /d			sink oil production rate
NSKPR	X	X	psi	bar			sink pressure
NSKWFR	X	X	stb/d	sm <sup>3</sup> /d			sink water flow rate
NSKWIR	X	X	stb/d	sm <sup>3</sup> /d			sink water injection rate
NSKWPR	X	X	stb/d	sm <sup>3</sup> /d			sink water production rate
NSOLVES	X	X					solve attempts per network
NWALL	X	X					well all properties
NWERRG	X	X					well gas flow rate coupling error
NWERRL	X	X					well liquid flow rate coupling error
NWERRM	X	X			C		well molar rate coupling error
NWERRO	X	X					well oil flow rate coupling error
NWERRP	X	X					well pressure coupling error
NWERRW	X	X					well water flow rate coupling error
NWGFR	X	X	Mscf/d	sm <sup>3</sup> /d			well gas flow rate
NWGIR	X	X	Mscf/d	sm <sup>3</sup> /d			well gas injection rate
NWGIRCW	X	X	Mscf/d	sm <sup>3</sup> /d			well gas injection rate of coupled well
NWGLFR	X	X	Mscf/d	sm <sup>3</sup> /d			well gas lift flow rate
NWGLR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>			well gas-liquid ratio
NWGGR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>			well gas-oil ratio
NWGPR	X	X	Mscf/d	sm <sup>3</sup> /d			well gas production rate
NWGPRCW	X	X	Mscf/d	sm <sup>3</sup> /d			well gas production rate of coupled well
NWGWR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>			well gas-water ratio
NWLFR	X	X	stb/d	sm <sup>3</sup> /d			well liquid flow rate
NWLGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>			well liquid-gas ratio
NWLPR	X	X	stb/d	sm <sup>3</sup> /d			well liquid production rate
NWLPRCW	X	X	stb/d	sm <sup>3</sup> /d			well liquid production of coupled well
NWMR	X	X			C		well molar rate
NWMRCW	X	X			C		well molar rate of coupled well
NWOFR	X	X	stb/d	sm <sup>3</sup> /d			well oil flow rate
NWOGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>			well oil-gas ratio
NWOIR	X	X	stb/d	sm <sup>3</sup> /d			well oil injection rate

<code>NWOPR</code>	X	X	stb/d	sm <sup>3</sup> /d		well oil production rate
<code>NWOPRCW</code>	X	X	stb/d	sm <sup>3</sup> /d		well oil production rate of coupled well
<code>NWPR</code>	X	X	psi	bar		well pressure
<code>NWPRCW</code>	X	X	psi	bar		well pressure of coupled well
<code>NWWCT</code>	X	X				well water cut
<code>NWWFR</code>	X	X	stb/d	sm <sup>3</sup> /d		well water flow rate
<code>NWWGR</code>	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		well water-gas ratio
<code>NWWIR</code>	X	X	stb/d	sm <sup>3</sup> /d		well water injection rate
<code>NWWIRCW</code>	X	X	stb/d	sm <sup>3</sup> /d		well water injection rate of coupled well
<code>NWWPR</code>	X	X	stb/d	sm <sup>3</sup> /d		well water production rate
<code>NWWPRCW</code>	X	X	stb/d	sm <sup>3</sup> /d		well water production rate of coupled well

## 3.8 Performance analysis items

Performance summary items give diagnostic information about the simulation run itself, which may yield useful information about convergence, efficiency, and required resources. Looking at these quantities through time may yield insight into particular periods in which the simulator may struggle to progress through time, for example. Performance keywords do not expect any data records.

Name	BO	CMP	Field Units	Metric Units	Indices	Description
<code>DAY</code>	X	X				simulation day
<code>ELAPSED</code>	X	X	sec	sec		Elapsed simulation time
<code>MAXMEMGB</code>	X	X	GB	GB		maximum GPU memory usage
<code>MEMGB</code>	X	X	GB	GB		current GPU memory usage
<code>MLINEARS</code>	X	X				linear iterations per timestep
<code>MONTH</code>	X	X				simulation month
<code>MSUMLINS</code>	X	X				cumulative linear iterations
<code>MSUMNEWT</code>	X	X				cumulative newton iterations
<code>NAIMFRAC</code>	X	X				implicit fraction
<code>NBYTOT</code>	X	X	B	B		maximum memory usage
<code>NEWTON</code>	X	X				newton iterations per timestep
<code>NLINEARS</code>	X	X				average newtons per linear
<code>TCPU</code>	X	X	sec	sec		cumulative CPU time
<code>TCPUDAY</code>	X	X	sec/d	sec/d		CPU time per reservoir day
<code>TCPUTS</code>	X	X	sec	sec		CPU time for this timestep
<code>TIMESTEP</code>	X	X	Day	Day		timestep
<code>YEAR</code>	X	X				simulation year

## 3.9 Region items

Region summary items report cumulative or average quantities for regions of cells in specified fluid-in-place (see `FIPNUM`) regions. These keywords should be followed by a single record specifying the FIP regions for which the quantity should be reported.

For example, the following will report the oil-in-place for FIP regions 5 and 7:

```
ROIP
  5 7 /
```

It is also possible to report these quantities for named FIP regions. In this case, the keyword name should be appended with the first three characters of the named region *if* the keyword has five characters in its name. For example, the following will give the average gas saturation for regions 1 and 3 of FIP region FRAC:

RGSATFRA
1 3 /

If the keyword name is fewer than five characters, the name should be padded with underscores to reach five before appending the region name. The following reports the gas-in-place for the same region specifications:

RGIP_FRA
1 3 /

Name	BO	CMP	Field Units	Metric Units	Indices	Description
FCAD	X	X	lb	kg		Field adsorbed polymer
FCIP	X	X	lb	kg		Field polymer in place
FSIP	X	X	lb	kg		Field salt in place
RAGIP	X	X	Mscf	sm <sup>3</sup> /d		region aqueous-phase gas in place
RAPI	X					region oil API
RCAD	X	X	lb	kg		Region adsorbed polymer
RCIP	X	X	lb	kg		Region polymer in place
RGFT	X	X	Mscf	sm <sup>3</sup> /d		inter-region gas flow total
RGIP	X	X	Mscf	sm <sup>3</sup> /d		region gas in place
RGIPG	X	X	Mscf	sm <sup>3</sup> /d		region gas-phase gas in place
RGIPL	X	X	Mscf	sm <sup>3</sup> /d		region liquid-phase gas in place
RGIR	X	X	stb/d	sm <sup>3</sup> /d		region gas injection rate
RGIT	X	X	stb/d	sm <sup>3</sup> /d		region gas injection total
RGPR	X	X	stb/d	sm <sup>3</sup> /d		region gas production rate
RGPT	X	X	stb/d	sm <sup>3</sup> /d		region oil production total
RGPV	X	X	rb	rm <sup>3</sup>		region dynamic pore volume containing gas
RGSAT	X	X				region gas saturation
RHPV	X	X	rb	rm <sup>3</sup>		region dynamic pore volume containing hydrocarbons
RNLIP	X	X	stb	sm <sup>3</sup>		region ngl in place
ROE	X	X				region oil recovery efficiency w.r.t initial OIP
ROEW	X	X				region oil production efficiency w.r.t initial OIP
ROFT	X	X	stb	sm <sup>3</sup>		inter-region oil flow total
ROIP	X	X	stb	sm <sup>3</sup>		region oil in place
ROIPG	X	X	stb	sm <sup>3</sup>		region gas-phase oil in place
ROIPL	X	X	stb	sm <sup>3</sup>		region liquid-phase oil in place
ROIR	X	X	stb/d	sm <sup>3</sup> /d		region oil injection rate
ROIT	X	X	stb/d	sm <sup>3</sup> /d		region oil injection total
ROPR	X	X	stb/d	sm <sup>3</sup> /d		region oil production rate
ROPT	X	X	stb/d	sm <sup>3</sup> /d		region oil production total
ROPV	X	X	rb	rm <sup>3</sup>		region dynamic pore volume containing oil
ROSAT	X	X				region oil saturation
RPPG	X	X	psi	bar		region gas potential (gas pressure corrected to a datum depth)
RPPO	X	X	psi	bar		region oil potential (oil pressure corrected to a datum depth)
RPPW	X	X	psi	bar		region water potential (water pressure corrected to a datum depth)
RPR	X	X	psi	bar		region oil pressure
RPRH	X	X	psi	bar		region oil pressure
RPRP	X	X	psi	bar		region oil pressure

<b>RRPV</b>	X	X	rb	rm <sup>3</sup>		region dynamic pore volume
<b>RRS</b>	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		region gas liquid ratio
<b>RRV</b>	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		field liquid gas ratio
<b>RSALT</b>	X	X				region salt concentration
<b>RSIP</b>	X	X	lb	kg		Region salt in place
<b>RTIPF</b>	X	X				region tracer in place (free)
<b>RTIPS</b>	X	X				region tracer in place (solution)
<b>RTIPT</b>	X	X				region tracer in place
<b>RWFT</b>	X	X	stb	sm <sup>3</sup>		inter-region water flow total
<b>RWIP</b>	X	X	stb	sm <sup>3</sup>		region water in place
<b>RWIR</b>	X	X	stb/d	sm <sup>3</sup> /d		region water injection rate
<b>RWIT</b>	X	X	stb/d	sm <sup>3</sup> /d		region water injection total
<b>RWPR</b>	X	X	stb/d	sm <sup>3</sup> /d		region water production rate
<b>RWPT</b>	X	X	stb/d	sm <sup>3</sup> /d		region water production total
<b>RWPV</b>	X	X	rb	rm <sup>3</sup>		region dynamic pore volume containing water
<b>RWSAT</b>	X	X				region water saturation

## 3.10 Well items

Well summary items report quantities through time for the properties of wells. Each keyword should be followed by a single record containing a list of the names of the wells for which the quantity should be reported. If the well list is defaulted or left blank, the quantity will be reported for all wells. For example, the following will report the bottom-hole pressure of wells AG19 and AL3:

```
WBHP
'AG19' 'AL3' /
```

Quantities associated with particular components are indicated with a 'C' in the Indices column in the table below. These keywords require a different format to allow the specification of which components to report. They should be followed by a sequence of slash-terminated records each containing a well name followed by a list of integers specifying the components to report. The keyword is terminated by a slash on its own line. For example, the following can be used to report the molar production rate of component 3 in well LM13:

```
WCGMR
'LM13' 3 /
/
```

Name	BO	CMP	Field Units	Metric Units	Indices	Description
<b>WALQ</b>	X	X				well artificial lift
<b>WAPI</b>	X	X				well API
<b>WAPI</b>	X	X				well API
<b>WBGLR</b>	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		gas-liquid ratio at BHP
<b>WBHP</b>	X	X	psi	bar		bottom hole pressure
<b>WBPH</b>	X	X	psi	bar		bottom hole pressure history
<b>WBP</b>	X	X	psi	bar		well average block pressure
<b>WBPC_1</b>	X	X	psi	bar		well block average pressure 1
<b>WBPC_2</b>	X	X	psi	bar		well block average pressure 2
<b>WBPC_3</b>	X	X	psi	bar		well block average pressure 3
<b>WBPC_4</b>	X	X	psi	bar		well block average pressure 4
<b>WBPC_5</b>	X	X	psi	bar		well block average pressure 5
<b>WCGMR</b>		X	lb-moles/d	kg-moles/d	C	well component molar production rate in gas phase
<b>WCIC</b>	X	X	lb/stb	kg/sm <sup>3</sup>		Polymer injection concentration
<b>WCIR</b>	X	X	lb/d	kg/d		Polymer injection rate

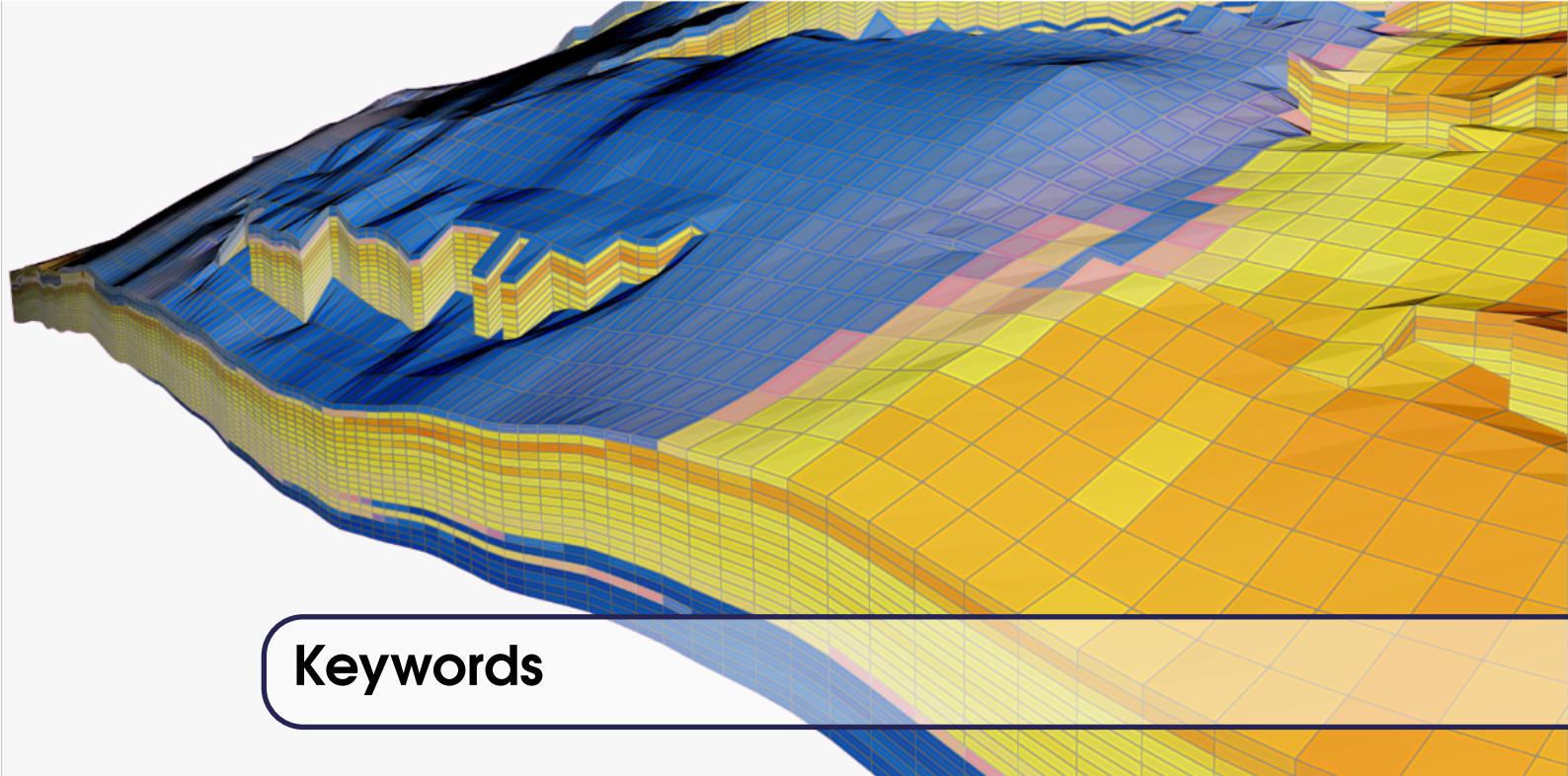
WCIT	X	X	lb	kg		Polymer injection total
WCMIR		X	lb-moles/d	kg-moles/d	C	well component molar injection rate
WCMIT		X	lb-moles	kg-moles	C	well component molar injection total
WCMPR		X	lb-moles/d	kg-moles/d	C	well component molar production rate
WCMPT		X	lb-moles	kg-moles	C	well component molar production total
WCNMR		X	lb-moles/d	kg-moles/d	C	well component molar production rate in ngl phase
WCOMR		X	lb-moles/d	kg-moles/d	C	well component molar production rate in oil phase
WCPC	X	X	lb/stb	kg/sm <sup>3</sup>		Polymer production concentration
WCPR	X	X	lb/d	kg/d		Polymer production rate
WCPT	X	X	lb	kg		Polymer production total
WDRPR	X	X				well drilling priority
WEFF	X	X				well efficiency factor
WEFFG	X	X				well total efficiency factor
WGDN	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		well gas surface density
WGFR	X	X	Mscf/d	sm <sup>3</sup> /d		gas flow rate
WGIGR	X	X	Mscf/d	sm <sup>3</sup> /d		well gas injection guide rate
WGIP	X	X	Mscf/d	sm <sup>3</sup> /d		gas injection potential
WGIP2	X	X	Mscf/d	sm <sup>3</sup> /d		gas injection potential
WGIR	X	X	Mscf/d	sm <sup>3</sup> /d		gas injection rate
WGIRH	X	X	Mscf/d	sm <sup>3</sup> /d		gas injection rate history
WGIRT	X	X	Mscf/d	sm <sup>3</sup> /d		well gas injection rate limit
WGIT	X	X	Mscf	sm <sup>3</sup> /d		gas injection total
WGITH	X	X	Mscf	sm <sup>3</sup> /d		gas injection total history
WGLIR	X	X	Mscf/d	sm <sup>3</sup> /d		well gas lift injection rate
WGLR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		gas-liquid ratio
WGLRH	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		gas-liquid ratio history
WGOR	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		gas-oil ratio
WGORH	X	X	Mscf/stb	sm <sup>3</sup> /sm <sup>3</sup>		gas-oil ratio history
WGPGR	X	X	Mscf/d	sm <sup>3</sup> /d		well gas production guide rate
WGPI	X	X	Mscf/d	sm <sup>3</sup> /d		gas injection potential
WGPI2	X	X	Mscf/d	sm <sup>3</sup> /d		gas injection potential
WGPP	X	X	Mscf/d	sm <sup>3</sup> /d		gas production potential
WGPP2	X	X	Mscf/d	sm <sup>3</sup> /d		gas production potential
WGPR	X	X	Mscf/d	sm <sup>3</sup> /d		gas production rate
WGPR1	X	X	Mscf/d	sm <sup>3</sup> /d		gas production rate above GOC
WGPR2	X	X	Mscf/d	sm <sup>3</sup> /d		gas production rate below GOC
WGPR4A	X	X	Mscf/d	sm <sup>3</sup> /d		gas production rate above GOC
WGPRB	X	X	Mscf/d	sm <sup>3</sup> /d		gas production rate below GOC
WGPRF	X	X	Mscf/d	sm <sup>3</sup> /d		free-gas production rate
WGPRH	X	X	Mscf/d	sm <sup>3</sup> /d		gas production rate history
WGPRS	X	X	Mscf/d	sm <sup>3</sup> /d		solution-gas production rate
WGPRT	X	X	Mscf/d	sm <sup>3</sup> /d		well gas production rate limit
WGPT	X	X	Mscf	sm <sup>3</sup> /d		gas production total
WGPT1	X	X	Mscf	sm <sup>3</sup> /d		total gas production above GOC
WGPT2	X	X	Mscf	sm <sup>3</sup> /d		total gas production below GOC
WGPTA	X	X	Mscf	sm <sup>3</sup> /d		total gas production above GOC
WGPTB	X	X	Mscf	sm <sup>3</sup> /d		total gas production below GOC
WGPTF	X	X	Mscf	sm <sup>3</sup> /d		free-gas production total
WGPTH	X	X	Mscf	sm <sup>3</sup> /d		gas production total history
WGPTS	X	X	Mscf	sm <sup>3</sup> /d		solution-gas production total
WG_PR	X	X	Mscf/d	sm <sup>3</sup> /d		well stage gas production rate
WG_PT	X	X	Mscf	sm <sup>3</sup> /d		well stage gas production total
WLFR	X	X	stb/d	sm <sup>3</sup> /d		liquid flow rate
WLIR	X	X	stb/d	sm <sup>3</sup> /d		liquid injection rate
WLIT	X	X	stb	sm <sup>3</sup>		liquid injection total

WLLTR	X	X				well liquid production liquid target ratio
WLPR	X	X	stb/d	sm <sup>3</sup> /d		liquid production rate
WLPRH	X	X	stb/d	sm <sup>3</sup> /d		liquid production rate history
WLPRT	X	X	stb/d	sm <sup>3</sup> /d		well liquid production rate limit
WLPT	X	X	stb	sm <sup>3</sup>		liquid production total
WLPTH	X	X	stb	sm <sup>3</sup>		liquid production total history
WMCLS	X	X				well closure mode
WMCON	X	X				Number of flowing connections in the well
WMCTL	X	X				well control mode
WMVFP	X	X				well VFP table
WNLPR	X	X	stb/d	sm <sup>3</sup> /d		NGL production rate
WNLPRT	X	X	stb/d	sm <sup>3</sup> /d		well ngl production rate limit
WNLPT	X	X	stb	sm <sup>3</sup>		NGL production total
WODN	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		well oil surface density
WOFR	X	X	stb/d	sm <sup>3</sup> /d		oil flow rate
WOGLR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		well gas lift incremental gradient
WOGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		oil-gas ratio
WOGRH	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		oil-gas ratio history
WOIGR	X	X	stb/d	sm <sup>3</sup> /d		well oil injection guide rate
WOIP	X	X	stb/d	sm <sup>3</sup> /d		oil injection potential
WOIP2	X	X	stb/d	sm <sup>3</sup> /d		oil injection potential
WOIR	X	X	stb/d	sm <sup>3</sup> /d		oil injection rate
WOIRH	X	X	stb/d	sm <sup>3</sup> /d		oil injection rate history
WOIERT	X	X	stb/d	sm <sup>3</sup> /d		well oil injection rate limit
WOIT	X	X	stb	sm <sup>3</sup>		oil injection total
WOITH	X	X	stb	sm <sup>3</sup>		oil injection total history
WOPGR	X	X	stb/d	sm <sup>3</sup> /d		well oil production guide rate
WOPI	X	X	stb/d	sm <sup>3</sup> /d		oil injection potential
WOPI2	X	X	stb/d	sm <sup>3</sup> /d		oil injection potential
WOPP	X	X	stb/d	sm <sup>3</sup> /d		oil production potential
WOPP2	X	X	stb/d	sm <sup>3</sup> /d		oil production potential
WOPR	X	X	stb/d	sm <sup>3</sup> /d		oil production rate
WOPR1	X	X	stb/d	sm <sup>3</sup> /d		oil production rate above GOC
WOPR2	X	X	stb/d	sm <sup>3</sup> /d		oil production rate below GOC
WOPRA	X	X	stb/d	sm <sup>3</sup> /d		oil production rate above GOC
WOPRB	X	X	stb/d	sm <sup>3</sup> /d		oil production rate below GOC
WOPRF	X	X	stb/d	sm <sup>3</sup> /d		free-oil production rate
WOPRH	X	X	stb/d	sm <sup>3</sup> /d		oil production rate history
WOPRS	X	X	stb/d	sm <sup>3</sup> /d		vaporized-oil production rate
WOPRT	X	X	stb/d	sm <sup>3</sup> /d		well oil production rate limit
WOPT	X	X	stb	sm <sup>3</sup>		oil production total
WOPT1	X	X	stb	sm <sup>3</sup>		total oil production above GOC
WOPT2	X	X	stb	sm <sup>3</sup>		total oil production below GOC
WOPTA	X	X	stb	sm <sup>3</sup>		total oil production above GOC
WOPTB	X	X	stb	sm <sup>3</sup>		total oil production below GOC
WOPTF	X	X	stb	sm <sup>3</sup>		free-oil production total
WOPTH	X	X	stb	sm <sup>3</sup>		oil production total history
WOPTS	X	X	stb	sm <sup>3</sup>		vaporized-oil production total
WO_PR	X	X	stb/d	sm <sup>3</sup> /d		well stage oil production rate
WO_PT	X	X	stb	sm <sup>3</sup>		well stage oil production total
WPI	X	X				well productivity index
WPI1	X	X				well productivity index
WPIG	X	X				well productivity index
WPIGC_1	X	X				Gas PI using block average pressure 1
WPIGC_2	X	X				Gas PI using block average pressure 2
WPIGC_3	X	X				Gas PI using block average pressure 3

WPIGC_4	X	X				Gas PI using block average pressure 4
WPIGC_5	X	X				Gas PI using block average pressure 5
WPIL	X	X				well productivity index
WPILC_1	X	X				Liquid PI using block average pressure 1
WPILC_2	X	X				Liquid PI using block average pressure 2
WPILC_3	X	X				Liquid PI using block average pressure 3
WPILC_4	X	X				Liquid PI using block average pressure 4
WPILC_5	X	X				Liquid PI using block average pressure 5
WPIO	X	X				well productivity index
WPIOC_1	X	X				Oil PI using block average pressure 1
WPIOC_2	X	X				Oil PI using block average pressure 2
WPIOC_3	X	X				Oil PI using block average pressure 3
WPIOC_4	X	X				Oil PI using block average pressure 4
WPIOC_5	X	X				Oil PI using block average pressure 5
WPIW	X	X				well productivity index
WPIWC_1	X	X				Water PI using block average pressure 1
WPIWC_2	X	X				Water PI using block average pressure 2
WPIWC_3	X	X				Water PI using block average pressure 3
WPIWC_4	X	X				Water PI using block average pressure 4
WPIWC_5	X	X				Water PI using block average pressure 5
WSIC	X	X	lb/stb	kg/sm <sup>3</sup>		Salt injection concentration
WSIR	X	X	lb/d	kg/d		Salt injection rate
WSIT	X	X	lb	kg		Salt injection total
WSPC	X	X	lb/stb	kg/sm <sup>3</sup>		Salt production concentration
WSPR	X	X	lb/d	kg/d		Salt production rate
WSPT	X	X	lb	kg		Salt production total
WSTAT	X	X				state indicator
WTCM	X	X	lb-moles/d	kg-moles/d		tracer carrier molar rate
WTHP	X	X	psi	bar		tubing head pressure
WTHPH	X	X	psi	bar		tubing head pressure history
WTIC	X	X				tracer injection concentration
WTIR	X	X	Mscf/d	sm <sup>3</sup> /d		tracer injection rate
WTIT	X	X	Mscf	sm <sup>3</sup> /d		tracer injection total
WTLM	X	X	lb	kg		traced liquid mass total rate
WTML	X	X	lb/d	kg/d		traced liquid mass rate
WTMR	X	X	lb/d	kg/d		traced mass rate
WTMT	X	X	lb	kg		traced mass total
WTMV	X	X	lb/d	kg/d		traced vapor mass rate
WTPC	X	X				tracer production concentration
WTPR	X	X	Mscf/d	sm <sup>3</sup> /d		tracer production rate
WTPT	X	X	Mscf	sm <sup>3</sup> /d		tracer production total
WTQR	X	X	lb-moles/d	kg-moles/d		traced molar rate
WTTL	X	X	stb	sm <sup>3</sup>		traced liquid volume total rate
WTVV	X	X	Mscf	sm <sup>3</sup> /d		traced vapor volume total rate
WTVL	X	X	stb/d	sm <sup>3</sup> /d		traced liquid volume rate
WTVM	X	X	lb	kg		traced vapor mass total rate
WTVV	X	X	Mscf/d	sm <sup>3</sup> /d		traced vapor volume rate
WVIR	X	X	rb/d	rm <sup>3</sup> /d		Reservoir volume injection rate

WWIT	X	X	rb	rm <sup>3</sup>		Reservoir volume injection total
WVPR	X	X	rb/d	rm <sup>3</sup> /d		Reservoir volume production rate
WVPT	X	X	rb	rm <sup>3</sup>		Reservoir volume production total
WWCT	X	X				water cut
WWCTH	X	X				water cut history
WWDN	X	X	lb/ft <sup>3</sup>	kg/m <sup>3</sup>		well water surface density
WWFR	X	X	stb/d	sm <sup>3</sup> /d		water flow rate
WWGIR	X	X	Mscf/d	sm <sup>3</sup> /d		Wet gas injection rate
WWGIT	X	X	Mscf	sm <sup>3</sup> /d		wet gas injection total
WWGPR	X	X	Mscf/d	sm <sup>3</sup> /d		Wet gas production rate
WWGPT	X	X	Mscf	sm <sup>3</sup> /d		wet gas production total
WWGR	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		water-gas ratio
WWGRH	X	X	stb/Mscf	sm <sup>3</sup> /sm <sup>3</sup>		liquid-gas ratio history
WWIGR	X	X	stb/d	sm <sup>3</sup> /d		well water injection guide rate
WWIP	X	X	stb/d	sm <sup>3</sup> /d		water injection potential
WWIP2	X	X	stb/d	sm <sup>3</sup> /d		water injection potential
WWIR	X	X	stb/d	sm <sup>3</sup> /d		water injection rate
WWIRH	X	X	stb/d	sm <sup>3</sup> /d		water injection rate history
WWIRT	X	X	stb/d	sm <sup>3</sup> /d		well water injection rate limit
WWIT	X	X	stb	sm <sup>3</sup>		water injection total
WWITH	X	X	stb	sm <sup>3</sup>		water injection total history
WWMIR	X	X	lb-moles/d	kg-moles/d		well molar water injection rate
WWMIT	X	X	lb-moles	kg-moles		well molar water injection total
WWMPR	X	X	lb-moles/d	kg-moles/d		well molar water production rate
WWMPT	X	X	lb-moles	kg-moles		well molar water production total
WPGR	X	X	stb/d	sm <sup>3</sup> /d		well water production guide rate
WPPI	X	X	stb/d	sm <sup>3</sup> /d		water injection potential
WPPI2	X	X	stb/d	sm <sup>3</sup> /d		water injection potential
WPPP	X	X	stb/d	sm <sup>3</sup> /d		water production potential
WPPI2	X	X	stb/d	sm <sup>3</sup> /d		water production potential
WPVR	X	X	stb/d	sm <sup>3</sup> /d		water production rate
WPVRH	X	X	stb/d	sm <sup>3</sup> /d		water production rate history
WPVRT	X	X	stb/d	sm <sup>3</sup> /d		well water production rate limit
WPVT	X	X	stb	sm <sup>3</sup>		water production total
WPVTH	X	X	stb	sm <sup>3</sup>		water production total history
WXMF	X	X			C	liquid phase component mole fraction
WYMF	X	X			C	vapor phase component mole fraction
WZMF	X	X			C	total component mole fraction





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2015 Emmorton Rd. Suite 204  
Bel Air, Maryland 21015, USA  
<https://www.stoneridgetechnology.com>  
[info@stoneridgetechnology.com](mailto:info@stoneridgetechnology.com)

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