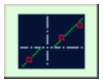
D09 • Interpretation panel

Accessed in the control panel with PL Interpretation



Infos/New: create a new interpretation or edit the current interpretation settings



Calibrate: spinner calibration



V apparent: calculation of an apparent velocity log



PVT: definition/editing of the PVT model, selection of correlations



Zone Rates: calculation of rates on the zones defined by option above



Log: generation of rate logs, schematic (rates and/or ratios) or complete



Time Lapse: Creation of time-lapse tracks for the schematic production profiles.

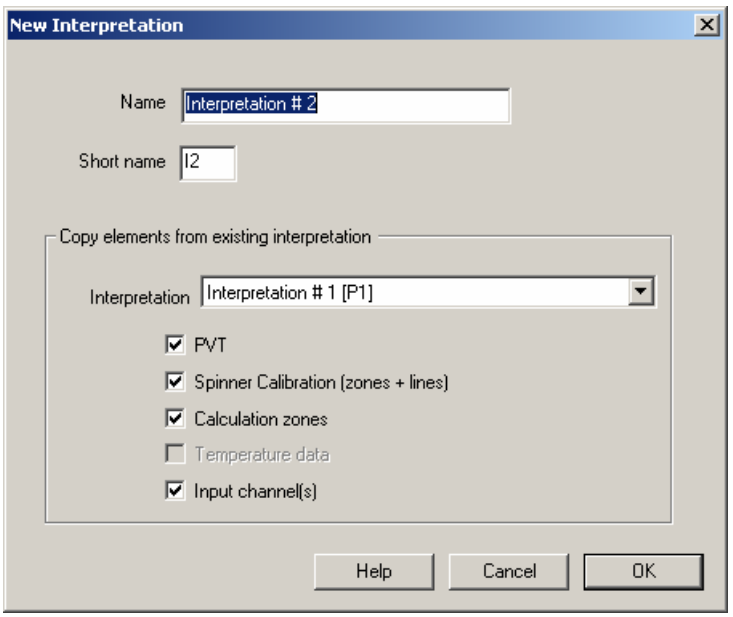
D09.1 • Elements of an interpretation

A typical interpretation, as shown in the data browser, will contain the following elements:

Interpretation # 1		
Input Calibration Zones	⊟	Input spinner calibration zones. Defined interactively with the Calibration zones option of the Interpretation panel, or copied from an existing interpretation.
Fluid Velocity (VAPP)	⊟	Input apparent velocity channel. Calculated from the calibration and selected spinner channels with the V apparent option of the control panel.
Pressure (PPRE) Temperature (PTEM) Density (PRH)	⊟	Input interpretation temperature, pressure, density, phase holdup, velocity, or rate. Defined in the Infos/New dialog, or copied/created in the interpretation from the browser.
PVT	⊟	Input PVT model defined by a fluid type, a choice of correlation possibly matched to some entered flash points. May be created with the PVT option, or copied from an existing interpretation when initializing the interpretation, or duplicated by drag and drop from the data browser.
Rate calculation Zones	⊟	Input intervals for zonal rate calculation, actually storing all associated results/settings. Created with the Rate calculation zones option of the panel or copied from an existing interpretation (when initializing, or later in the data browser).
Inflow Zones	⊟	A new type of zone that corresponds by default to where the production was assigned in earlier Emeraude versions. An inflow zone is automatically assigned between two calculation zones. Inflow zones appear on the Z track, in white. The new explicit inflow zones can be resized.
Output – Schematic Water rate (QWZT) Gas rate (QGZT) Oil rate (QOZT)	⊟	Cumulative zone rates. Generated by the Log option of the interpretation panel, "**Schematic**" selected.
Water rate (QWZI) Gas rate (QGZI) Oil rate (QOZI)	⊟	Output incremental zone rates. Generated by the Log option of the interpretation panel, "**Schematic**" selected.
Density, Zoned (PRHZ) Vapp, Zoned (VAPPZ)	⊟	Zoned simulated measurements. Generated automatically with the schematic log. Not plotted by default they can be seen on user views to visualize the goodness of the fit.
Output - Complete Water rate (QWAT) Oil rate (QOIL) Gas rate (QGAS) Mixture rate (QTOT)	⊟	Cumulative continuous rates. Generated by the Log option of the interpretation panel, "**Complete**" selected.
V mixture (VMIX) Corr. Density (DENC) Holdup, Y_0	⊟	Mixture velocity, corrected density, phase holdups. Generated with the **complete** rate logs.

D09.2 • Initializing an interpretation

The initialization dialog is opened when creating a new interpretation. The interpretation is defined by a Name, and a Short name (see Data naming convention, section D02.3).



If the session already contains interpretations, a drop list is displayed allowing duplication of the following data from a selected interpretation to the new one:

- PVT
- Spinner calibration zones
- Rate calculation zones
- Temperature data
- Input Channels

Such duplication can also be made at any time by drag and drop in the data browser.
After creation, Emeraude displays the Info/New dialog where reference channels can be defined and the spinner selected see section D09.4. Interpretation views and temperature data is also defined in this dialog.

D09.3 • Interpretation reference channels

An interpretation will typically contain reference channels for temperature and pressure used to calculate PVT properties (temperature can also be part of the simulation process, see Section D09.4), and one reference channel for any available measurement (density, phase holdup, phase velocity, or direct rate measurement). The reference channels can result from any manipulation of the original data (editing, filtering, lateral averaging, merging of several channels, etc), and can be defined in several ways:

1. “Define” button of the Interpretation Info/new dialog: calls the Lateral average or Merge facilities depending whether data is searched in Up/Down passes or Stations.
2. Lateral average: compute from list, option of the data browser (section D05.16)
3. Lateral average: compute from object, option of the data browser (section D05.17)
4. Merge: compute from list, option of the data browser (section D05.18)
5. Merge: compute from object, option of the data browser (section D05.19)
6. Drag and drop of desired channel inside the interpretation.

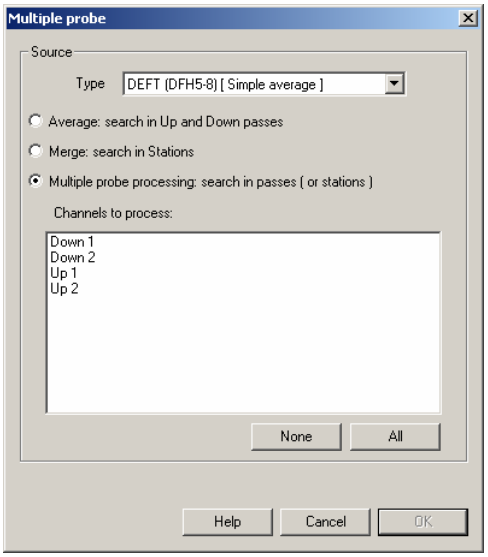
In most situations, the first solution will be used. However, if for example two pressure gauges were run, say a strain and a quartz gauge, the following path could be followed:

- Construction in the data store of an average of all the strain gauge channels
- Construction in the data store of an average of all the quartz gauge channels
- Construction of a user view to compare the averages
- Drag and drop of the selected average to the interpretation node

Note also that when defining the reference channel for a gradio with options 1 and 2, Emeraude automatically constructs, and adds to the interpretation an equivalent cable speed channel used for tool frictions calculation. The same applies in case 4, when the source of the drag & drop is an Up or Down pass (see Frictions/Acceleration, section E03.1).

Multiple probe tools

When a Multiple Probe Tool such as the DEFT, GHOST, or CAT is present and recognized in the current survey (see D06.6 and D08.4b) the “Define” button will give access to a tailored processing >>

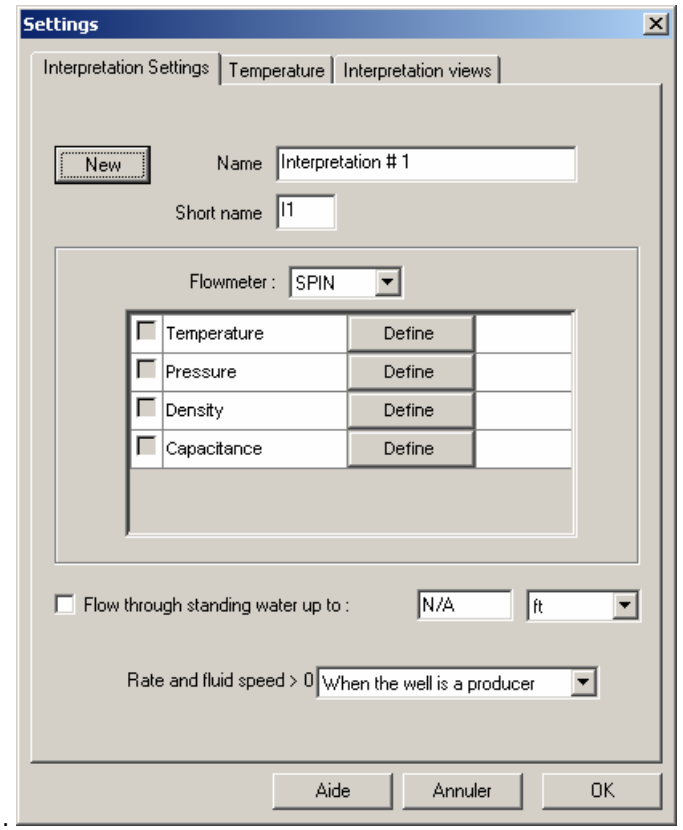


The reference channels are used only from the Zone rate option onward and do not need to be defined before that stage.

D09.4 • Infos/New (interpretation)

The first time the Info/New button of the interpretation panel is opened for a given survey, Emeraude automatically creates a first interpretation, “Interpretation#1” and displays an initialization dialog that can be used to copy elements from existing interpretations.

Interpretation settings tab



Name/Short name

Already entered when the interpretation was created, can be edited in this dialog.

Spinner selection

The spinner used in the interpretation is selected from the list of available spinners in the survey.

Interpretation reference temperature, pressure, density, phase holdup, velocity, or rate

A list of the measurements available in the current survey is displayed.

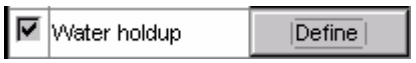
The Define button connects to a dialog behaving as the Lateral average dialog or the Merge dialog where the desired channels of the survey can be selected and averaged/merged. If at least one channel belongs to a station the Merge is called. If all belong to either Up or Down passes, the Average is called instead. The constructed channels are copied inside the interpretation node, as can be seen in the data browser. When defining a density channel for a gradio tool by averaging, Emeraude automatically constructs, and adds to the interpretation an equivalent cable speed channel that will be used for tool friction calculations.

The interpretation reference channels are not used until the Zone Rates option is called, and they do not have to be defined when creating the interpretation.

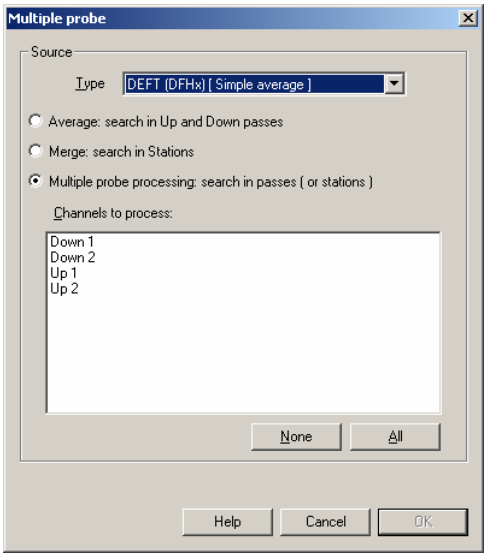
If a Multiple Probe Tool is present and recognized (see D06.6 and D08.4b), options will be given to generate the relevant reference channel(s):

DEFT (GHOST)

For DEFT (GHOST), one will find in the Interpretation dialog a line for water (gas) holdup where the corresponding “Define” button calls a dialog with a new choice specific to MPT (opposite):



>



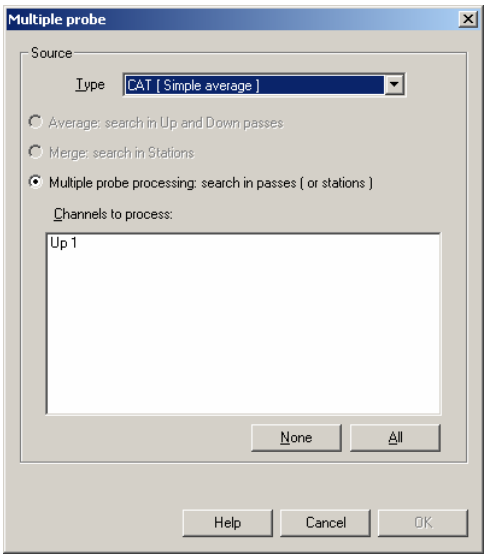
The processing selected in Tool/Info is applied to all selected passes, and a lateral average of the results is calculated. The processing for each pass is either Simple average or Stratified average.

CAT

A similar situation occurs with the CAT. This time, in the Interpretation Infos/new dialog a line appears for “3 phase holdup” where the corresponding “Define” button calls a dialog with a new choice specific to MPT (opposite):



>



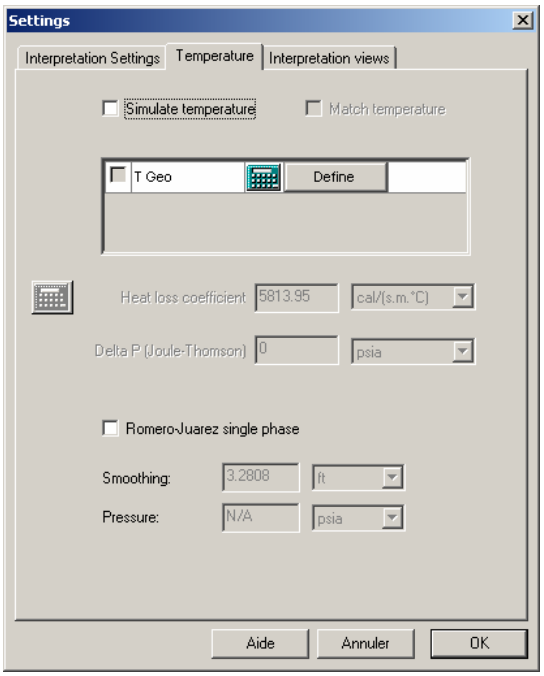
The processing selected in Tool/Info is applied to all selected pass, and a lateral average of the results is calculated. The processing for each pass is either Simple average or Tool Specific processing for stratified flow.

Flow through standing water

When the standing water model is selected, it is now possible to have a water velocity equal to 0 yet a non zero water holdup. The holdup value corresponds to an extrapolation of Yw as Vw tends to 0.

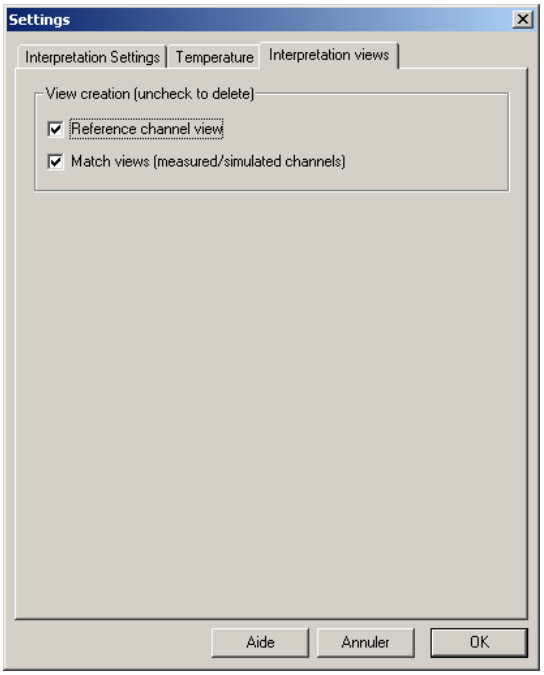
Temperature tab

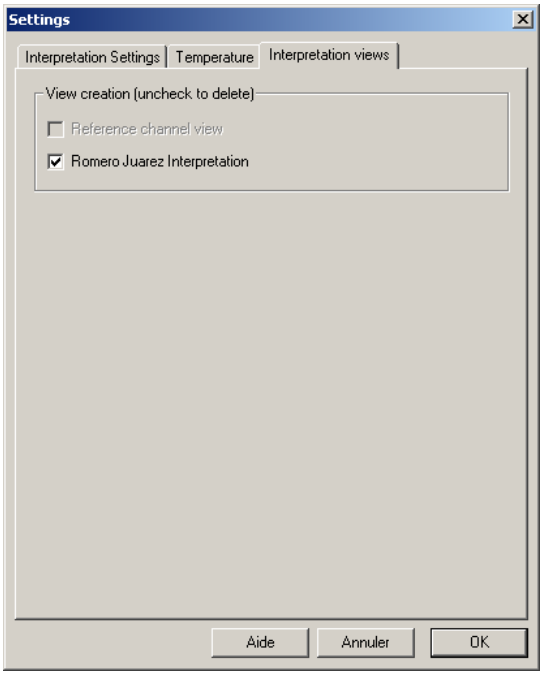
This dialog is used to activate the temperature model. The temperature can be simulated only, or matched. In the latter case the temperature can be used to replace a poor spinner response or to provide closure to an otherwise undetermined problem. In addition a single-phase simplified analysis method (Romero-Juarez) is available thorugh this dialog. See details on the options in “Temperature” .



See Temperature modeling, section E05 for a Technical Reference.

Interpretation views tab





- A view showing all interpretation reference channels
- Match views: one view per channel used as a residual where the input is compared to the corresponding zoned simulated channel.
- When the Romero Juarez option is selected in the “Temperature tab” dialog, the view creation is restricted to the “Romero Juarez Interpretation” selection.

Interpretation views appear and disappear on the sole basis of those checkbox. The content of the views is pre-defined and no other channel can be added to them.

D09.5 • Calibration zones

The Calibration zones option is used to interactively define the zones used in the spinner calibration. In these zones, the spinner and cable speed responses should be reasonably stable. The interactive definition process is the same as for other zones, and the calibration zones are shown by yellow markers in the Z plot .

Zone creation

After clicking the icon of the zones toolbar 

, the zone is selected in any plot using the mouse. With the cursor at the top (or bottom) of the zone, click on the mouse and drag, holding the button down, to the other end of the zone.

Edit

If one double-clicks on a zone in the Z plot, opens a spreadsheet with the limits of the zones of this type. Existing values can be modified. It is possible to add and delete calibration zones inside the grid. The same dialog is also accessed with the 

option of the zones toolbar.

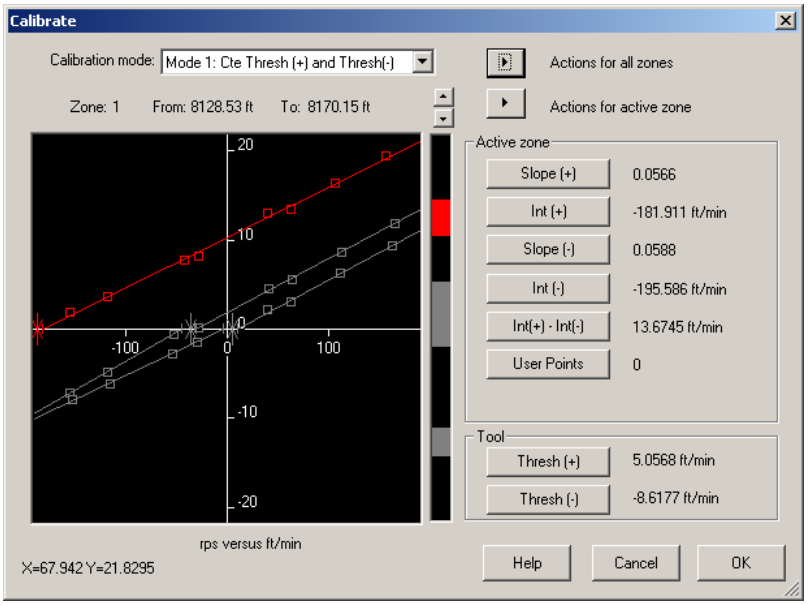
Adjust
Click once on the graphic representation of the zone in the Z plot, the zone is shaded and two white handles are opened at the top and bottom. Click and drag these handles to adjust the limits of the zone.

Delete
After selecting a zone by clicking on it in the Z plot, press the Del key.

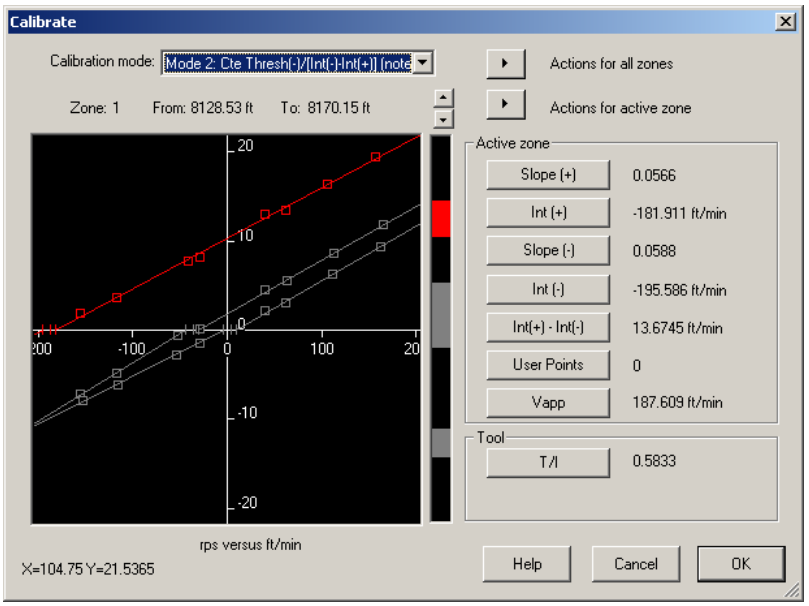
D09.6 • Calibrate

There are two different calibration modes in Emeraude (see section E01.3 for details).

• Mode 1**:** Assumes the same thresholds for all zones
• Mode 2**:** Assumes a constant ratio = Thresh(-) / [Int(-) – Int(+)] (noted T/I)



Calibration dialog - mode 1



Calibration dialog - mode 2

The dialog can be enlarged by dragging its bottom right corner. The new size/position will be used for future calls/sessions.

A drop list at the top of the calibration dialog allows switching from one mode to another. The default mode is defined in the Interpretation Settings (default after installation is mode 1).
When the “Calibrate” option is invoked, Emeraude computes average cable speed and spinner values for all the visible passes across the calibration zones. For a new calibration zone, the program computes both positive and negative lines by linear regression. When the lines are defined, they are not modified when entering the dialog again. The sign of the cable speed is directly inferred from the pass type: positive for a down pass / negative for an up pass.

So it does not matter what sign is used on the original cable speed channels. For the spinner however, the signs are not inferred by Emeraude and for an unsigned spinner, reversal depths will normally need to be defined (see Spinner reversal option of the Survey panel).
A plot of spinner rps against cable speed is displayed. Zoom options for this plot can be accessed by a right click in the plot area. For each zone the calibration plot indicates, with markers, the position of intercepts and apparent velocity. This is handled differently depending on the calibration mode.

If all you have are stationary measurements, you should then use Calibration Mode 2 together with the Schematic Vapp option.

Active zone

The active calibration zone is highlighted in red. To the right of the plot is a small schematic showing the position of the calibration zones. Click in this schematic or use the up/down arrows at the top to change the active zone.

Identify / Disable points

Points in the calibration plot can be identified by clicking with the left mouse button close to the point. Only the points of the active zone are considered in the pick. The identification dialog allows the selected point to be included or ignored in regressions. Disabled points are plotted with a crossed circle.

User points

Select this option to add points corresponding for instance to stationary readings. The points are added to the active calibration zone (in red), plotted with a + in a square symbol. They will be taken into account the next time a calculation on the corresponding line is requested. User points can only be deleted from the grid.

Actions for all zones

- Recompute all with tool threshold
- Recompute all (no imposed threshold)
- Set all positive/negative slopes to average (of positive/negative slopes)

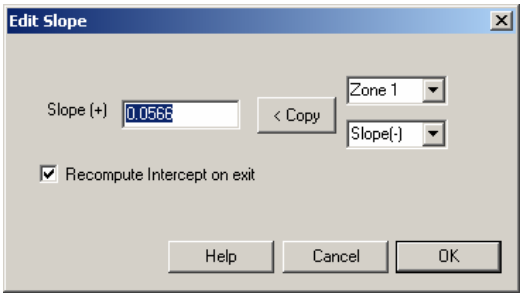
Actions for active zone

- Recompute zone with tool threshold
- Recompute zone (no imposed threshold)
- Recompute positive/negative line
- Recompute positive/negative slope
- Recompute positive/negative intercept

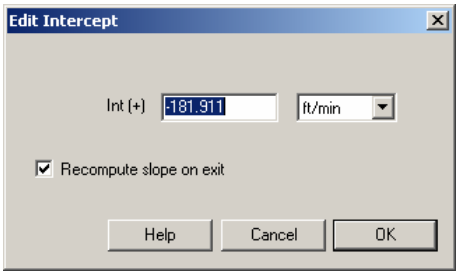
Note: Recompute with tool threshold means that the slope and intercept are calculated by non-linear regression with the constraint: Int(+) – Int(-) = Threshold(+) – Threshold(-)

Edit

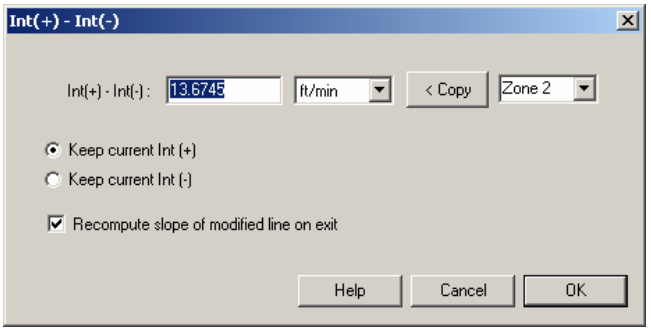
Values of slopes, intercepts, intercept difference, for the active zone are displayed at the right of the dialog. (see Spinner Calibration, section E01.3 for the definition of these parameters) and can be edited by clicking on the appropriate button. The subsequent dialogs contain shortcuts to copy from one zone to another:



Edit the current value manually and press OK or Select a Zone/Line whose slope should be copied, select Copy, then OK to validate.
The default is to recalculate the intercept when the slope value is validated.

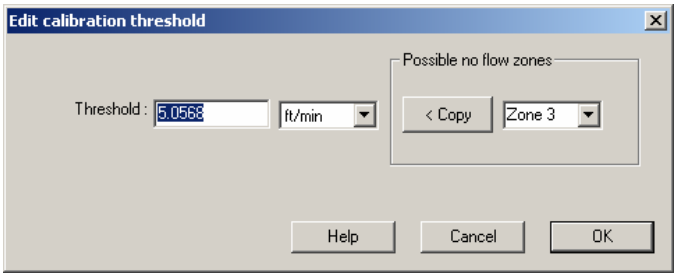


Edit the current value manually and press OK.
The default is to recompute the slope on OK.



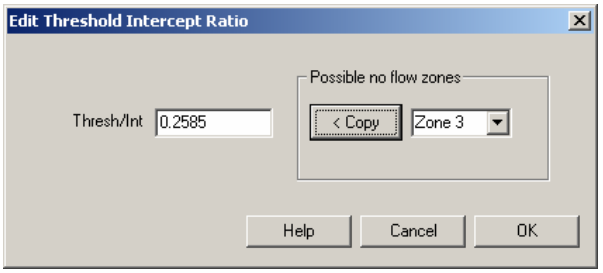
Edit the current value manually and press OK or Select a Zone whose threshold should be copied, select Copy, then OK to validate.
It is possible to set which intercept should remain fixed, and to recompute the slope of the other line.

Calibration mode 1 only



Edit the current value manually and press OK or Select a Zone whose threshold should be copied, select Copy, then OK to validate.
In the no flow zone drop list appear the zones with a negative Int(-) and positive Int(+) and provides a shortcut to copy those intercepts to the tool thresholds.

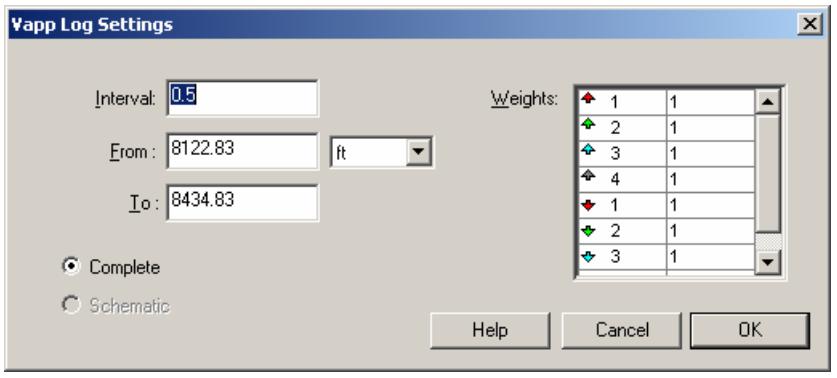
Calibration mode 2 only:



The ratio used to locate the apparent velocity between the two intercepts can be entered manually or copied from a no-flow zone. In this case, one can also activate the no-flow zone and set the corresponding Vapparent to 0.

D09.7 • V apparent

Once the spinner calibration is satisfactory, the user can generate an apparent velocity channel. This is called V apparent because it only corresponds to the speed of the fluid where the spinner is located in the well (hopefully at the center of the well). By default the Vapp calculation is Complete, i.e. at each depth the V apparent value results from an average of the calculations for each spinner pass. It is possible to assign different weights (possibly 0) to the passes. The weights are normalized internally so they do not have to add up to 1. In the Vapparent dialog, one can edit the generation interval and the depth increment. To change a weight, double click on the weight value: a control appears in which you can edit the value.



If the calibration mode is mode 2 (see “Spinner Calibration”) the option is given to generate a Schematic apparent velocity channel. This channel is only defined across the calibration zones and reproduces the exact Vapp values given by the calibration on those zones. When using a schematic Vapp, rate calculation zones should match the spinner calibration zones. Also, the generation of a complete rate log is in this case is disabled.

If all you have are stationary measurements, you should then use Calibration Mode 2 together with the Schematic Vapp option.

Note : the Vapp button is not enabled as long as the minimum necessary information and data have not been provided:

- Log Well Data
- Survey info
- PLT data loaded

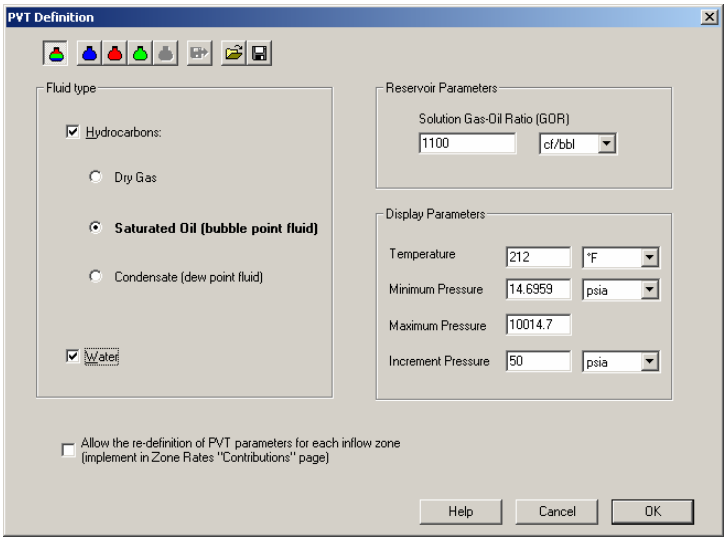
- Tool Info
- Calibration Zones
- Calibration Coefficients Options

D09.8 • PVT

This PVT dialog is used to define and edit the PVT model for the current interpretation. When a calculation is done, the PVT model provides the properties of all the phases at the particular temperature and pressure conditions. The PVT for each phase is defined by a choice of Black Oil correlations. By default, a single PVT model is used anywhere in the logged interval but it is also possible to redefine the properties for each inflow zone (see section D09.26). The rate calculation is obviously heavily influenced by values such as the individual phase densities, viscosities, etc. It is therefore critical that all those properties be representative. In each phase dialog, there are tabs for all the relevant properties where the correlations can be viewed (graphically and inside a table), and matched to user-entered data.

Note that when several interpretations are created within the same document, the PVT needs to be created only once, and can then be copied from one interpretation to another. This is done either inside the data browser (a PVT node appears below an interpretation node only after the PVT model has been defined) or when creating a new interpretation, section D09.2. Also, once a PVT is defined it is possible to save this PVT to a file and to load that same file in the PVT of other documents.

D09.8.1 • PVT Main dialog



When selecting the PVT option, the dialog below is displayed. To the left of the dialog is the definition of the flowing mixture type, a hydrocarbon model with or without water.

In Display Parameters, the temperature is the default one for viewing the correlations. Note that if user data have been entered, the display will switch to the temperature of the first constraint point. The pressure range and increment are used to display the correlations in a table.

Some reservoir parameters may be also required depending on the fluid type, e.g. the solution GOR for a bubble point fluid. When the PVT model is created or changed, each phase present should be defined from left to right, using the corresponding toolbar.

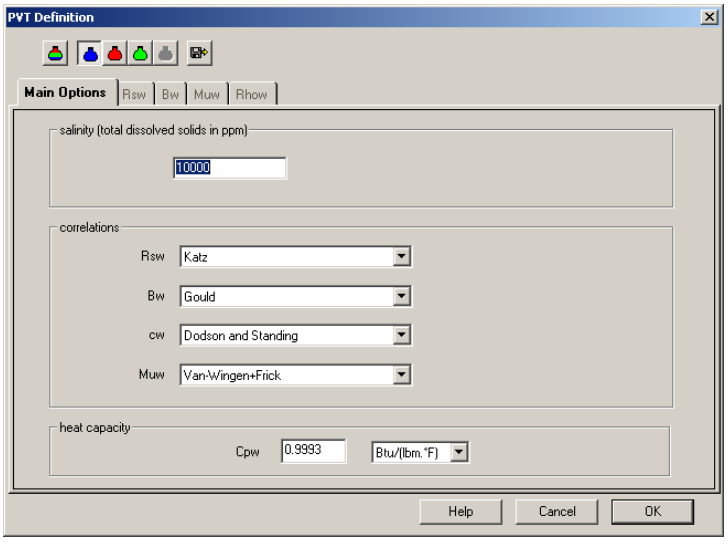
Toolbar

Return to the main page	Condensate input (gas+ condensate)
Gas phase input	Read PVT from a file
Oil phase input	Save PVT to a file
Water input	

Inside the data browser, a PVT node appears below the interpretation node only after the PVT model has been defined. This node can be dragged and dropped to another interpretation in order to duplicate the PVT model.
Copying from an existing interpretation can also be made when creating a new interpretation.

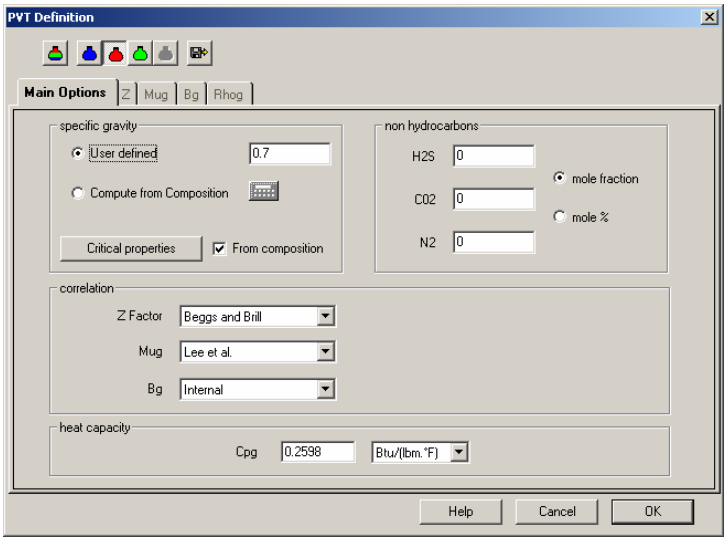
D09.8.2 • Water data input

The water phase properties are defined in the dialog below. Note that you can use only subsets of the built-in correlations, and also redefine the application default. This is done in the Interpretation option of the Settings panel. The sole input is the water salinity. All properties can be viewed/matched using the tabs: Rsw, cw, Bw, Muw, Rhow. All parameters except Rhow (which is a deduced value) can be set to constant values.

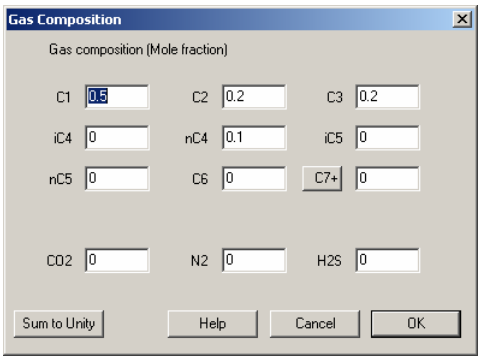


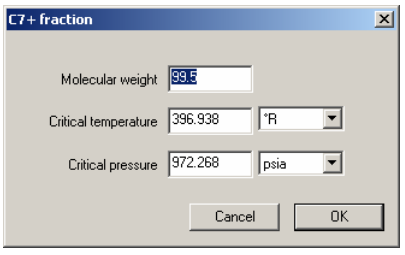
D09.8.3 • Gas data input

The gas phase properties are entered in the next dialog. The compressibility factor, the viscosity, and the formation volume factor can be defined with a choice of correlation. All parameters except ρg (which is a deduced value) can be set to constant values. Note that you can use only subsets of the built-in correlations, and also redefine the application default. This is done in the Interpretation option of the Settings panel.



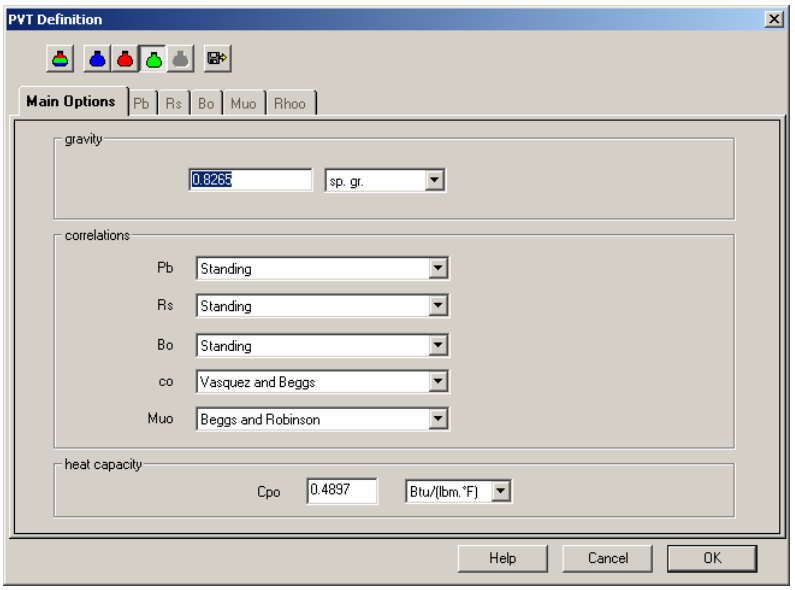
The gas correlations are driven by the critical properties. They can be estimated from the specific gravity, and the non hydrocarbon content, or entered directly. The gas gravity can be calculated from composition using .





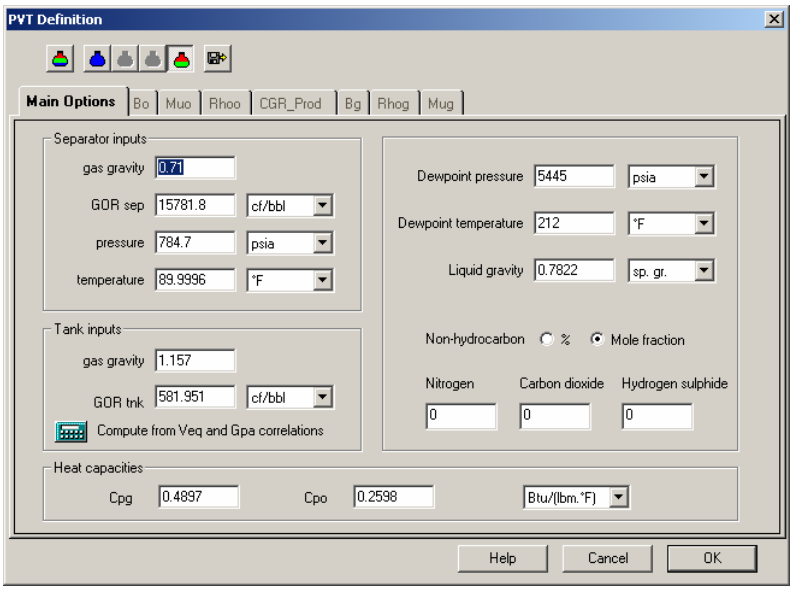
D09.8.4 • Oil data input

Oil correlations are driven by the oil gravity and the GOR entered on the main screen. As for other phases, all properties can be matched to user-entered points. There is however a specific behavior associated with the matching of Pb and Rs and their influence on the entered GOR. Basically if you know the Pb but not the GOR, matching the Pb will suggest the adequate GOR value. Similarly if you have flash data for Rs, matching those data will have an influence of the bubble point.



For Bo, co, and Muo a constant value can be used.

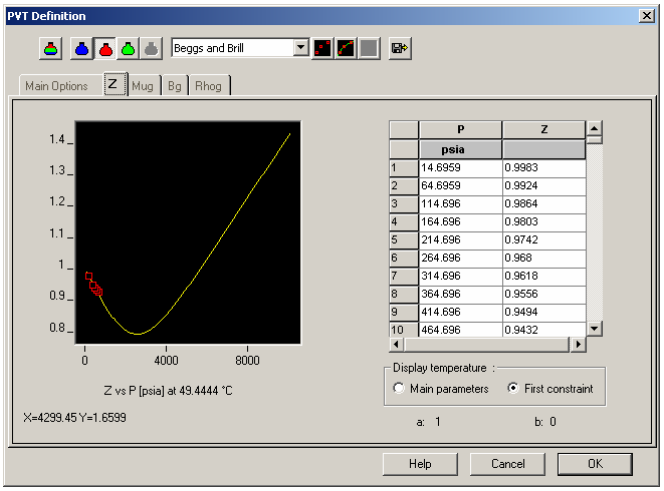
D09.8.4 • Condensate data input



The condensate model is based on a special correlation for the vaporized condensate. This correlation is initialized from the knowledge of the dew point conditions, the separator, and the tank conditions. The tank values can be calculated automatically using the compute button . This computation uses the method after D.K. Gold, W.D. McCain Jr & J.W. Jennings described in their paper *"An improved method for the Determination of the Reservoir-Gas Specific Gravity for Retrograde Gases"*, Journal of Petroleum Technology, July 1989.

D09.8.5 •View/Match PVT correlation

PVT correlations are displayed in a specific dialog with a plot and a non-editable table. A property function of both temperature and pressure is plotted against pressure at a given temperature (indicated in the plot legend).



Toolbar

	Correlation	The current choice is displayed in a drop list and can be modified.
	Constraints	The Constraints option opens a grid where measured values can be entered. The constraint points are shown on the plot at the same temperature as the measured value. Selecting Match when constraints have been entered fits the correlation to the constraint points. *It is possible to paste clipboard values in the grid by clicking the top left header button of the grid to activate, followed by "Shift Ins" or "Ctrl V".*
	Match	The factor **a** and the shift **b** which achieve the best fit are displayed in the dialog (for Z the transformation is not linear in order to keep Z(p=0)=1.
	Reset	Reverts a to 1 and b to 0.
	Load Table	Load a table for a PVT property in an Ascii file. The file is read, and Emeraude asks the temperature corresponding to the table. Typically several tables, for several temperatures should be loaded. Emeraude will then interpret linearly inside and in-between the tables. The load table option is also accessible from each phase data input dialog.

The matching must be made in the order the properties appear in the tabbed-dialog for the considered phase.

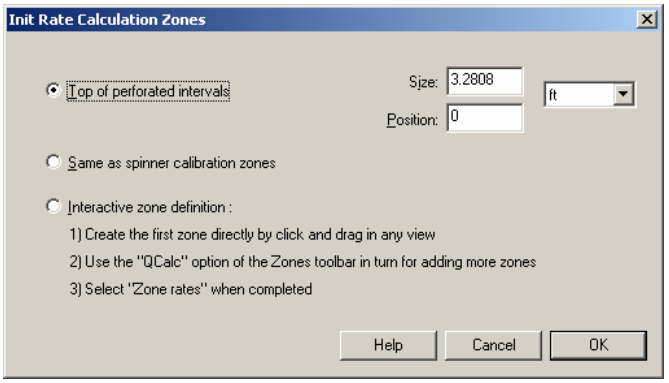
To change scales on a PVT plot, click with the right-hand mouse button anywhere on the plot area and a popup menu with scaling options is displayed (see XY Plots, section D03.13).

Note: For the bubble point pressure and water viscosity, a plot of the property against temperature is displayed.

D09.9 • Rate calculation zones

Qcalc in the Interpretation panel .

The first time this icon is pressed (or if all existing calculation zones have been deleted) a dialog appears with the default parameters for creating the zones.



The zones can either match the spinner calibration zones, be located above all the perfos (plus one zone below the last perfo), or be created interactively. The initialization based on the perfs defines a position above the perfs (default 0) and size (default 1 m). These defaults can be changed.

When calculation zones exist, the Rate calculation zones option can be used to define new zones interactively, as for spinner calibration zones. Zones can be added anywhere, for instance to distinguish several contributing intervals in a perforated section, or to capture a particular local behavior (e.g. Apparent Downflow). It is possible to create a zone with 0 height. In the particular situation where no spinner calibration is available, and no perforations have been entered, the zones are defined interactively from the first time the button is pressed onwards.

The calculation zones appear in the Z plot as gray markers. A zone can be activated by a single click and its limits changed by dragging its top and bottom handles. One can also delete an activated zone by pressing the Del key.

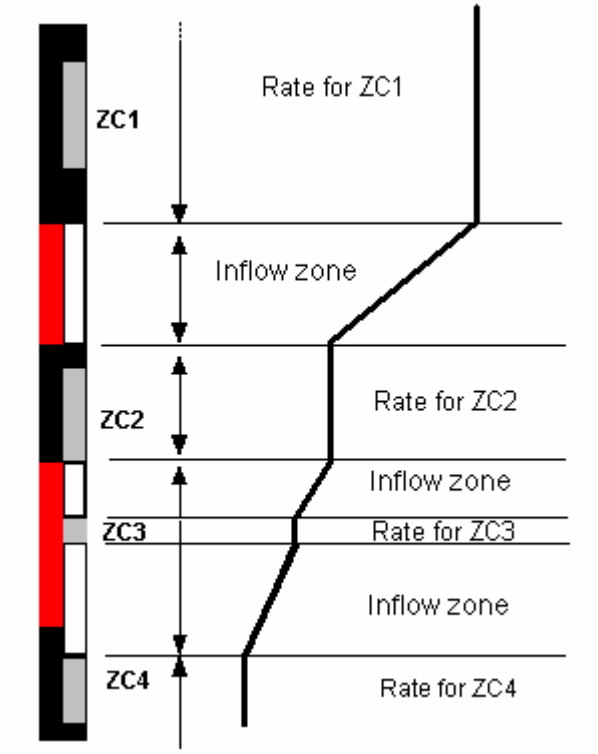
Inflow zones are created automatically between each pair of calculation zones. They appear in white on the Z track. Inflow zones drive the logic from drawing the schematic logs.

D09.10 • Inflow zones

Inflow zones are created automatically between each pair of calculation zones. They appear in white on the Z track.

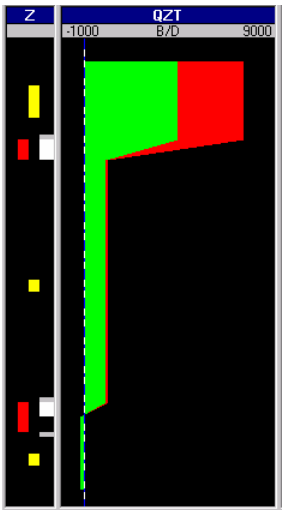
Inflow zones correspond by default to where the production will be assigned on the schematic logs.

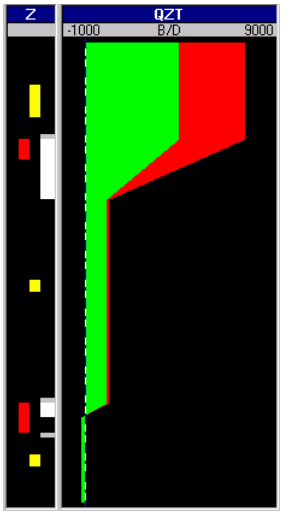
The new explicit inflow zones can be resized (within the calculation zones above and below) so they provide an easy way to modify the shape of the schematic logs.



Note that for a cased-hole example where your contributions do come from reported perforations, and unless you use the temperature, you will not have to deal with/modify inflow zones at all.

The two figures opposite illustrate the influence of resizing an inflow zone (top zone), and re-generating the schematic logs.





D09.11 • Parameters for rate calculations

Rate calculations are made from values recalculated dynamically every time the calculation is invoked. The first step in getting the input parameters is the selection of the appropriate channels, followed by a particular process which could be an averaging over a depth interval, an interpolation, or an extrapolation.

Channel selection

Internal diameter: If a caliper curve is present inside the interpretation (could have been copied from the browser), Emeraude will use it. Otherwise it will use the zoned ID channel defined in the general well data.
Deviation, or TVD: A channel is sought first inside the Interpretation, then in General well data (a deviation channel can be copied directly inside the interpretation). If there is no deviation channel the well is assumed vertical. Note that deviation is used if both deviation and TVD are found.
T, P, Density, Vapp, input Density, Holdups, Velocities, or Rates: Interpretation channels are used.

Parameter calculation

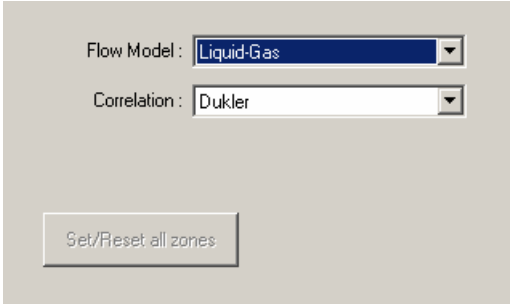
Zone rates: The selected channel values are averaged over the calculation zones. If the zone is given a 0 thickness, an interpolation is made instead. If they are defined but do not cover the zone, the following channels are extrapolated: zoned ID channel, roughness, TVD, or deviation.
Log rates: Interpolation is made for all channels. Extrapolation if required for a zoned ID channel, roughness, TVD, or deviation.

PVT parameters

They are also obtained dynamically calling the PVT model for whatever calculated T and P.

D09.12 • Zone rate init

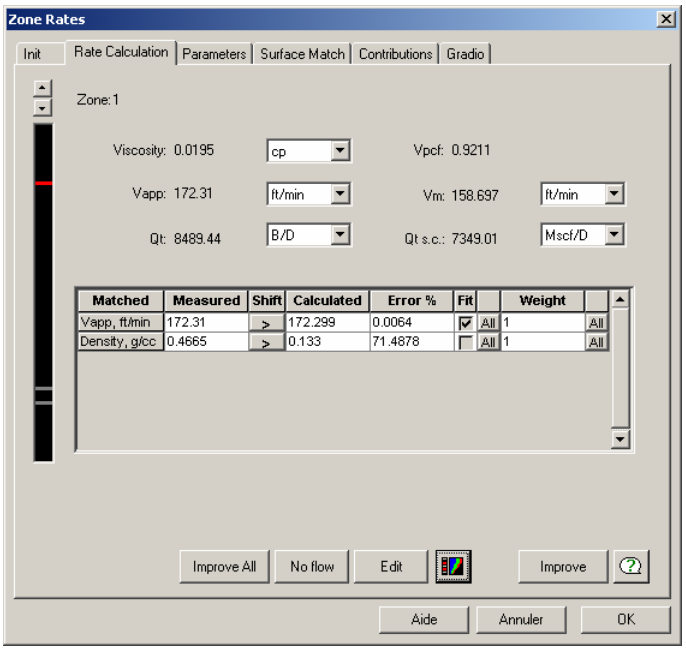
The first time the Zone Rate option  is called it is necessary to set-up the calculation by choosing an initial flow model and associated flow correlation. The offered models are based on the fluid type, as defined by the PVT (see section E03.6). The suggested model is based on available measurements, as well as user defaults.



When the Init dialog is first displayed, all calculations have already been run for the suggested model. The "Set/Reset all zones" button is disabled in this case. Pressing **OK** when in the Init page for the first time, or when modifications have been made, sets/resets all zones if necessary and moves to the "Rate calculations" tab. The "Set/Reset all zones button" is especially useful to reset all zones for the currently selected model/correlation.
The Zone rate dialog allows changing the model/correlation for a particular zone but when they have to be changed for all zones return to the Zone rate init dialog to do so.
Note that the list of correlations for a given flow model, other than single-phase, can be customised in the Interpretation settings.

D09.13 • Single-phase calculation dialog

Details on the variables/calculation scheme used in this dialog are given in chapter E03.3.
When the selected flow model is single phase, the single-phase calculation dialog is the second page in Zone rates. This dialog allows the determination of Vm, the average mixture velocity, for each zone.



The calculation is based on the relation (see section E03.2) :

$$Vm = Vpcf_Mult \times Vpcf(\rho, Vm, \mu, \ldots) \times Vapp$$

When first entering this dialog, and if the necessary input are present, Emeraude solves automatically for Vm on all zones. This initial calculation is done without taking the surface rates into account. The solution is obtained using a non-linear regression scheme described in Single-phase interpretation. This scheme can be invoked manually with the "Improve" button, typically when values of input parameters (ρ, μ, Vapp, etc.) are changed after the first initialization step. As in the Calibration dialog, a schematic shows the calculation zones, and the active zone is highlighted in red. Click on the schematic or on the up/down arrows at the top to change the active zone. The detail of the dialog controls is as follows:

Edit

Using this button it is possible to edit the following: **Mixture Viscosity,** m, Vpcf, or the mixture velocity. The corresponding actions are detailed below:

Viscosity, m:

Only active zone affected; Automatic improve called after the modification.
If T, and P are available, a value of μ is originally computed from the PVT model. The "Mixture viscosity" button can be used to change it manually, or to reset it to the PVT default. When a value is entered manually, a warning icon appears on this line to indicate that in a rate log calculation, the same value of μ will be used anywhere this calibration zone applies.
A change of μ causes an automatic call to Improve.

Vpcf

Only active zone affected; No automatic improve
The value can be edited manually. When user defined or equal to the default 0.83, a warning icon indicates that the same value will be used when calculating complete rate logs, anywhere this calculation zone applies (see Complete Log, section D09.23).
A change of Vpcf does not have other effect than changing the error on Vapp.

Improve

The procedure is described in "Single-phase interpretation", section E03.3.

Mixture velocity (Vm) and **Rate**

These are displayed at the bottom of the dialog. The rate is the mixture rate, expressed at downhole conditions. By default a production is positive but this can be changed in the conventions.

NoFlow

Set the rate on the current zone to zero.

Improve

Improve on the active zone. The procedure is described in Single-phase interpretation.

Matching the surface conditions can be done in the "Surface Match" tab (see section D09.16 below).

D09.14 • Multiphase calculation dialog

See section E03.5 for a definition of the variables and the basis for the graphical presentation used in this dialog. Section E03.7 describes the underlying calculation scheme.
The results and the plot correspond to a given calculation zone. As in the calibration dialog, a small schematic shows the active zone and can be used to change the selection. The first time this dialog is opened, or after resetting the model/correlation in the “Zone rate init ” page, Emeraude automatically solves for each zone by invoking the Improve option. The schematic allowing changing the Zone in display is implemented in all dialogs tabs.

At the top of the dialog, the Model, and correlations are displayed, and could be changed for the current zone only. Below are the values of rates at downhole and standard conditions, slippage velocities, and holdups. A green check mark ☑ in front of a variable indicates that this variable can be determined by the non-linear regression. The display in this page is set to either **Table** or **Plot**.

Table mode

For the current zone, the dialog gives a summary of the results as well as several controls of the non-linear regression that can be accessed in a grid as shown below:

Matched	Measured	Shift	Calculated	Error %	Fit		Weight	
Vapp, ft/min	105.911	>	93.6077	11.6163	☑	All	1	All
Density, g/cc	0.7882	>	0.7632	3.174	☑	All	1	All
Yw	0.577	>	0.5692	0.781	☑	All	1	All

For each channel used to calculate a residual the grid displays:

Measured value.
Calculated value. *This integrates any relevant function such as frictions for a gradio, inverse calibration for a capacitance, etc.*
Error %: relative error between simulated and measured values.
Shift option
Measurement offset. This button shifts the measured channel (using the ”y -> a.y + b” Update option) and the error with the predicted value becomes 0. This can be used, for instance in a shut-in interpretation, when the nature of the fluid in a given zone is known. Vsh can be set in the Zone rate dialog to obtain the desired single-phase fluid, then the Shift button selected. In case of a capacitance, Emeraude back-calculates the shift to be applied to the raw cps values.
Fit
Enable or disable the use of the particular measurement in the non-linear regression. This option is enabled only when redundant measurements exist, i.e. when there are more information than unknowns.
Weight value
Sets for the non-linear regression, the weight for the error term corresponding to the particular measurement.
All option.
Set the current weight or fit for the particular measurement, in all the calculation zones.



In the table, some lines may appear in red. They correspond to residuals added internally by some models. For instance, a water-hydrocarbon model assumes that fg is given by a PVT flash. This is expressed as an additional residual.

After a change of weight(s) or fit status, Emeraude does not re-run the regression. This must be done manually, on all zones where a weight/fit status has been modified.

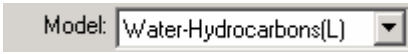
Plot

The default plot shows the density tool response vs possible values of Vsh for the current Vm. Values on the X-axis are between 0 and Vm. The value Vm-Vsh represents Vsl (light)
The following indications are plotted:

• vertical dashed line: current value of Vm
• horizontal dashed line: measured density tool response for the zone
• coloured curves: simulated density tool responses for the applicable flow correlations
• vertical dotted line: Vsh for the current solution
• horizontal dotted line : simulated density tool response for the current solution

Also if the surface rates have been defined, and the zone in view is the top calculation zone:
• white triangle pointing down on the X-axis: downhole mixture velocity as computed from the surface rates (and the PVT model).
• colored squares: the density tool response the correlations would predict if the downhole rates were those corresponding to surface conditions.
When a water holdup or a gas holdup measurement is available, it is possible to change the plot to a display of Water holdup or Gas holdup vs Vsh. The description of the plot symbols above still applies, replacing “density tool response” by “water holdup” or “gas holdup”.

The details of the dialog options follows:



Only current zone affected – Automatic improve

The model drop list can be used to change the flow model for a particular zone. After the model is changed, Emeraude runs an automatic non-linear regression on the solution (for this zone). *If a model change is required for all zones, the Zone Rate Init page should be used instead.*



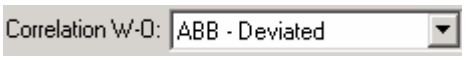
Only current zone affected – No automatic improve

The correlation is changed but the solution is not improved. Call “Improve” manually if the best solution for the new correlation is searched. For the constant slip model, a button labeled “Slip” can be used to define the slippage value for the particular zone. If after calling Improve with a Constant Slippage model, a green

light appears next to the “Slip” button, it means that the slippage was taken as a variable of the non-linear regression.



Only current zone affected – No automatic improve



Only current zone affected – No automatic improve

When the flow model is “3-Phase L-G” two slippage correlations are used: one for the slippage between gas and liquid, the other one for slippage between oil and water. In this case there are thus two correlation drop lists, one labeled “L-G” for “Liquid-Gas”, the other one labeled “W-O” for Water-Oil. Call “Improve” manually after a change if the best solution for the new correlation is searched.



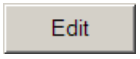
Invokes a non-linear regression scheme to solve for the rates on the current zone. Called automatically for each zone at start up, and following some of the actions below.



Invokes a non-linear regression to solve for the rates on all zones in turn (bottom up).



If this button appears next to Improve then the current problem admits an infinity of solutions. You should increase the number of fitted measurements or decrease the number of variables for instance by changing the selected flow model.



Through the Edit button once can edit the following: rates (phase or cumul), Vslip/Vm limit, Vpcf, Slip velocities when the Constant slippage model is used.

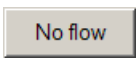
Vslip/Vm

Affects all rate results - No automatic improve.

Set a bound to the ratio Vslip/Vm. An absent value (N/A) means that no limit is applied. Most of the time this value is left unchanged except when problem are encountered (see “The complete rate logs show a sharp discontinuity in a section of the well”).

Rates

Affects current zone only - No automatic improve



Sets the current zone to No Flow.



Updates the schematic logs (if they were already created) without leaving the dialog. Note that calling this option disallows the Cancel button.

Apparent Downflow (see section E03.9)

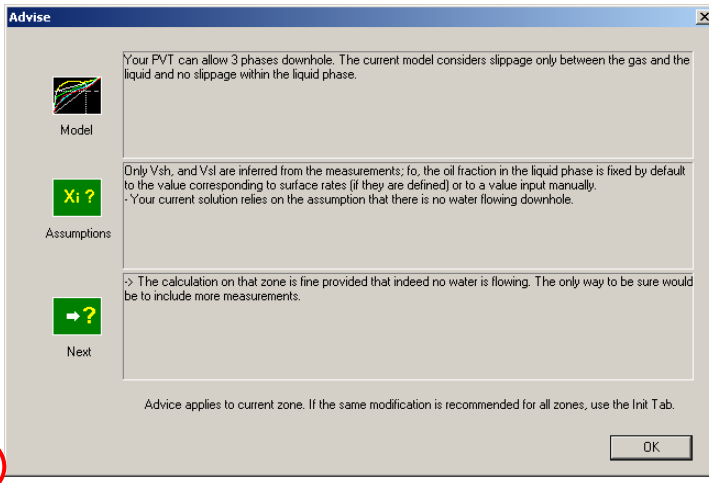
This check box is visible only when the mixture velocity on the zone is negative. Checking this box switches the calculation to Apparent Downflow where only an upflow of the light phase is calculated. The Improve is run automatically by Emeraude in this case. In Apparent Downflow, the plot X-scale gives the Ql (light phase rate).



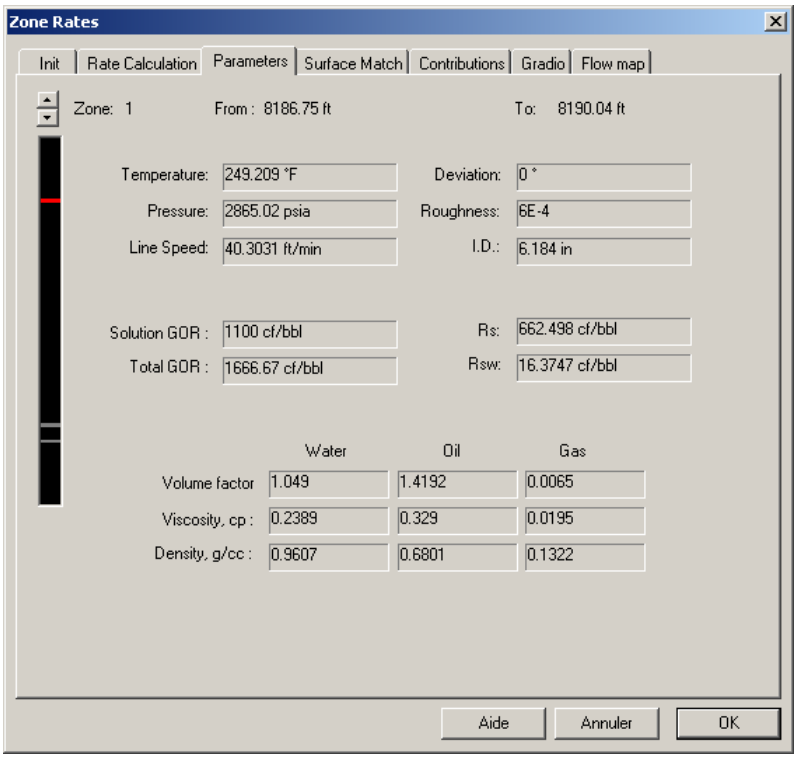
Rate calculation advisor

Provides some advices on the current calculation. This option checks the PVT, the selected model, and suggests when applicable, alternative ways for the calculation.





D09.15 • Parameters

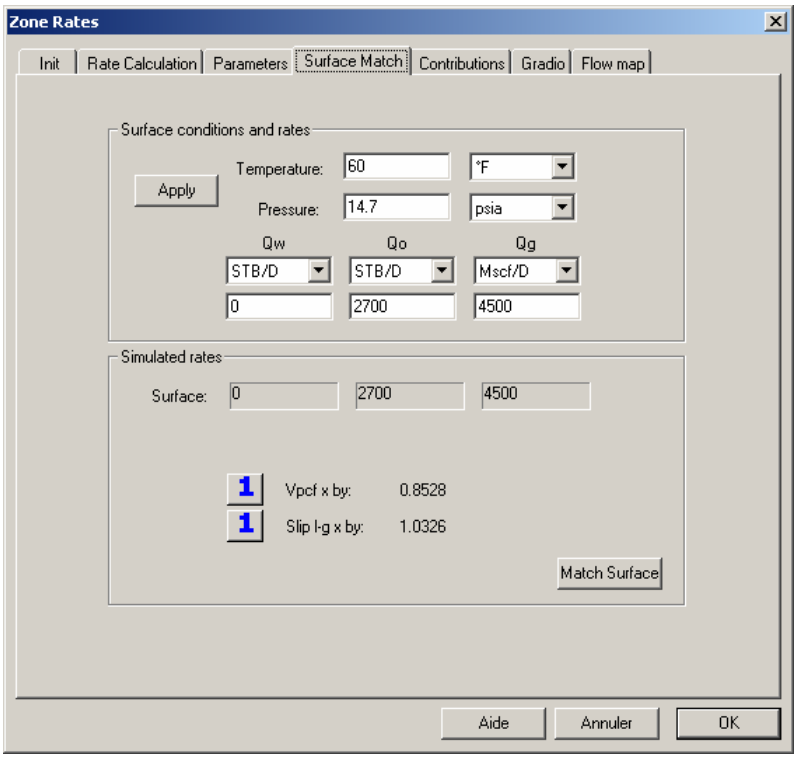


Displays the PVT properties, well characteristics, and input channel values, as calculated for the zone. Values of interpretation reference channels are the result of an average across the calculation zone. Other measurements come from the general well data (e.g. deviation, roughness).

See Parameters for rate calculations.

D09.16 • Surface Match

In this dialog it is possible to enter the value of the surface rates (and their Temperature & Pressure conditions). The simulated rates are displayed and can be compared to the measured ones.



Apply

After a change of surface conditions press this button to update the simulated rates.

Match Surface

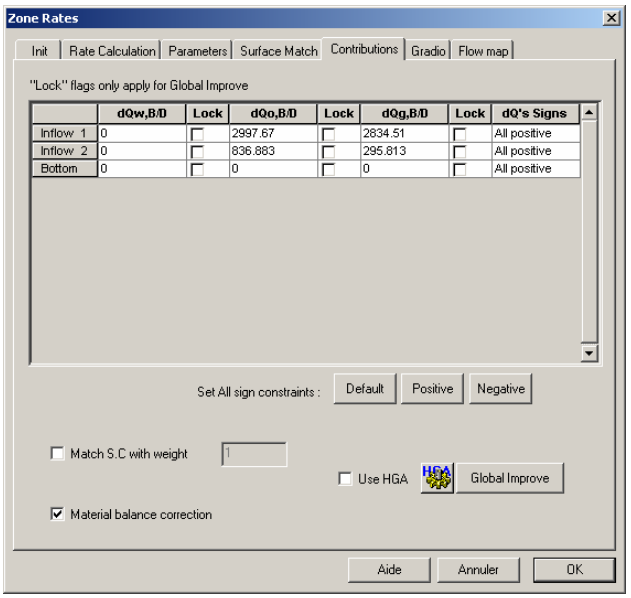
Affects all zones. This option computes the value of the Vpcf multiplier, and Vslip multiplier(s) in multiphase, to match the surface conditions, and the measured values (see Surface Conditions). This option is enabled when surface rates have been entered, Temperature and Pressure are values are available on the top zone, and the rates on that zone are not null. Downhole rates are set to comply with the surface rates. A non-linear regression is then re-run on all zones with the new multipliers.

1 Resets to 1 the Vpcf multiplier and the Vslip multiplier(s)

For Vslip L-G and Vslip W-O in case of 3 phase with 2 slippage velocities. Affects all rate results. Vslip multiplier only: automatic improve for all zones, except top one- using the considered flow correlation.
These two or three coefficients are applied to the Vpcf model and the current slip correlation(s). They are used for matching surface conditions. When not equal to 1, can be reset to 1 with the button beside them.

See also “Matching surface conditions - Single phase case”.

D09.17 • Contribution (Global regression)



The Contribution dialog displays the value of the rate contributions, calculated for each inflow zones. The values can be edited directly inside the table, or a global regression can be called.

Except in the case of Zone PVT, the contributions are calculated using a mass balance between the calculation zones above and below the inflow. More precisely, if the top, and bottom depths are characterized by:

Top: temperature = T_top, pressure = P_top, Rate of phase "p" = Qp_top, and
Bottom: temperature = T_bot, pressure = P_bot, Rate of phase "p" = Qp_bot

Then the contribution of phase "p" is calculated with mass balance as:

$dQ = Qp_top - Qp_bot \times \rho_bot / \rho_top$

This can be modified after activating the necessary flag. In “Settings – Interpretation” first tab, check the option “Enable access to material balance correction flag for dQi’s”. In the “Contributions” tab you will then see and have access to the check box “Material balance correction”.

Global regression

The global regression solves at once for the contributions (rather than cumulative rates) with the objective, not only to match the measurements, but also to satisfy some constraints. Emeraude never calls the global regression automatically.

The possible constraints are Positive or Negative contribution, for each zone. Also, contribution values can be locked. Surface conditions can be included in the constraints, with a user-defined weight. Also, when Temperature is matched, the heat loss coefficient can be made a variable.

Once the choices are made the global regression is called with the Global Improve option. Right after the run, the value of the final objective function is displayed below the Improve button.

Constrained regression will provide local errors (i.e. at calculation zone level) larger than a local unconstrained regression. The match views can be used to visualize the fit on the logs. In extreme cases, imposed constraints might not be compatible with the data and the algorithm will give up after a few iterations.

It is recommended to use Global Regression whenever the Temperature is matched. See Section…

The Contribution screen also gives access to the Zone PVT if this was selected in the PVT main dialog.

HGA

It is possible to couple the Global Regression with a pre-processing called HGA, for “Hybrid Genetic Algorithm”. This pre-processing is particularly suited at avoiding local traps or finding a better starting point for the regression. Access to HGA is enabled in the Interpretation option of the Settings panel. When enabled, the Global regression dialog shows 2 additional controls:

- A check box to use HGA in the next run (off by default)
- A button to view/edit the HGA parameters. *This should normally not be changed.*

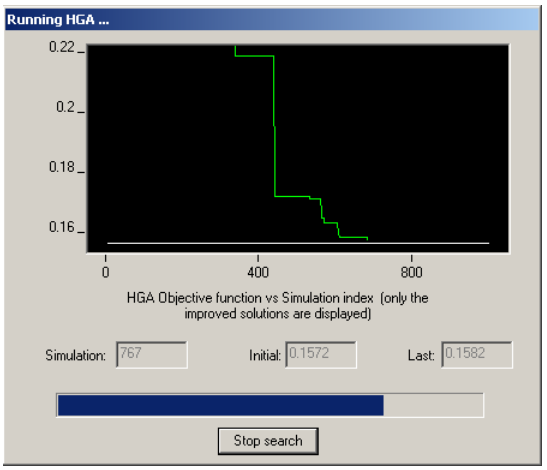
See Also Global regression with HGA, and HGA, Section 09.18 and …

D09.18 • Global regression and HGA

It is possible to couple the Global Regression with a pre-processing called HGA, for “Hybrid Genetic Algorithm”. This pre-processing is particularly suited at avoiding local traps or finding a better starting point for the regression. Access to HGA is enabled in the Interpretation option of the Settings panel. When enabled, the Global regression dialog shows 2 additional controls:

- A check box to use HGA in the next run (off by default)
- A button to view/edit the HGA parameters. *This should normally not be changed.*

When running a global regression with the HGA option checked, a dialog appears to show the HGA progress.



In this dialog, the following information is plotted/displayed:

- In white, the value of the objective function corresponding to the solution before the call (base case)
- In green, the value of the objective function for the consecutive improvements in HGA

Typical behavior

HGA is not "biased" by the starting point and it will usually start with solutions having a much higher (worse) objective functions than the base case. Also, a Genetic Algorithm improves the solution iteratively, but unlike a classical optimization, it does not provide a systematic improvement at each iteration. This will be translated in the plot where new points are drawn only when there is an improvement. So the plot may seem to be halted for some time and then start again. An automatic scaling is executed every 5 new points.

If HGA finds a solution with an objective function smaller than the base case, then after completion/or termination, this solution will be used as the new starting point of the global regression. If HGA stops without such a better solution, the global regression starts from the base case.
Note that you can stop HGA at any point, in particular if you see that it successfully reduced the objective function.

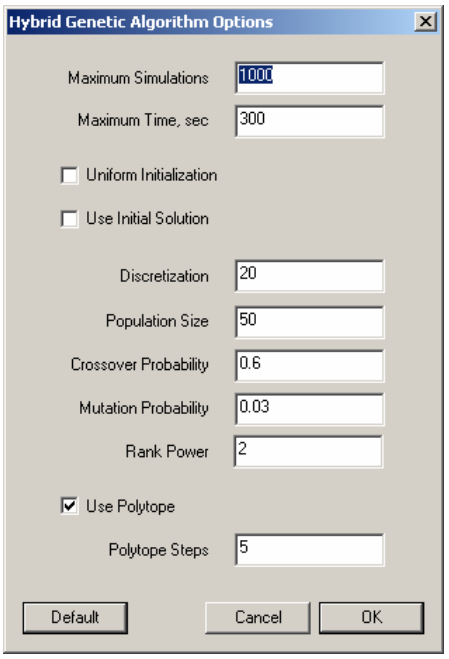
More on HGA…

The Hybrid Genetic Algorithm (HGA) carries out a stochastic search which is based on the Genetic Algorithm (GA) and the polytope algorithm. GA's are based on the mechanics of natural selection and natural genetics. They employ a randomized though structured search technique. The polytope algorithm is a hill-climbing method that does not require gradient information. The HGA is useful because of its ability to avoid sub optimal solutions, if any.

Different from gradient search, where a single point is kept, a group of solutions, referred to as the population, is modified at the same time. The polytope algorithm is used at the end of each GA iteration to introduce gradient effects into the search. The HGA search is carried on discrete space.

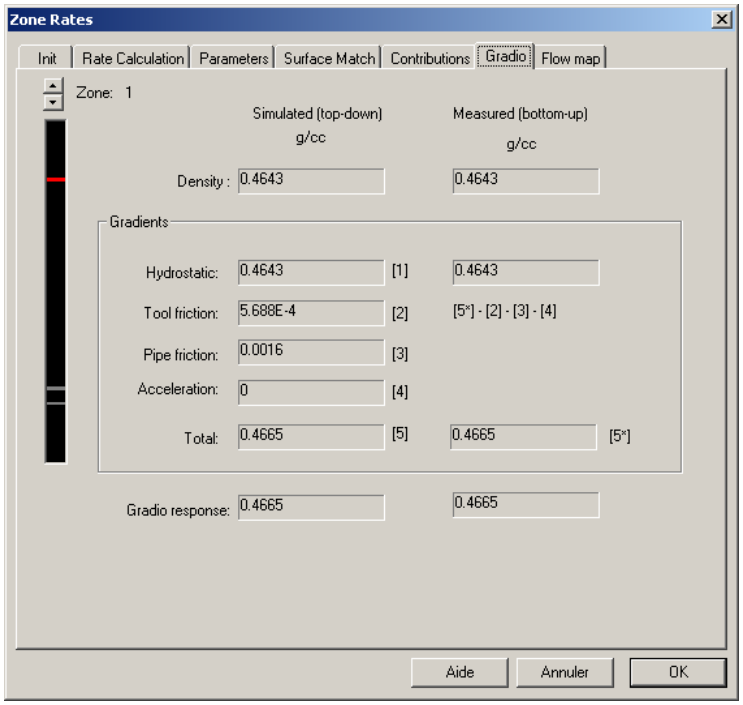
The Settings option  let the user control the balance between randomness and the convergence speed of the search. More randomness helps avoid sub optimal solutions while decreasing convergence speed. The default parameters are suitable for a broad range of problems.

- Maximum Simulations: Maximum number of fits to data allowed.
- Maximum Time: Maximum time allowed.
- Discretization: Number of points at which the regressed variables are sampled uniformly. Closest larger power of 2 is used.
- Population Size: Number of individuals in the GA run.
- Crossover Probability: Probability of the GA crossover operator.
- Mutation Probability: Probability of the GA mutation operator.
- Rank Power: Power of rank used as fitness (evaluation function value).
- Use Polytope: Use the polytope algorithm after each GA iteration.
- Polytope Steps: Number of polytope steps to carry out.



D09.19 • Gradient components

When the density tool is not a nuclear tool, this page gives the details of the friction calculation (see section E03.1 for details).



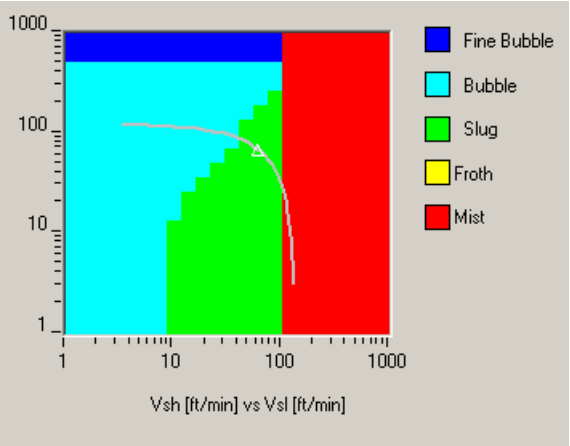
The left column, read from top to bottom, gives the simulated values:
• Density: mixture density as calculated from current solution
• Hydrostatic gradient: ρ.g.cos(deviation)
• Tool friction gradient term [1]
• Pipe friction gradient term [2]
• Acceleration gradient term [3]
• Total value of pressure gradient
• Simulated gradio response accounting for deviation

The right column, read from bottom to top, gives the measured values:
• Measured gradio response
• Pressure gradient dP/dZ along the tool [1*]
• Hydrostatic gradient after correction for friction/acceleration
• Corrected density

When there is no error between simulated and measured values, all lines present in both columns show identical values.

D09.20 • Flow Map

For Liquid-Gas models, it is possible to view the flow map describing the boundary between the considered flow regimes.

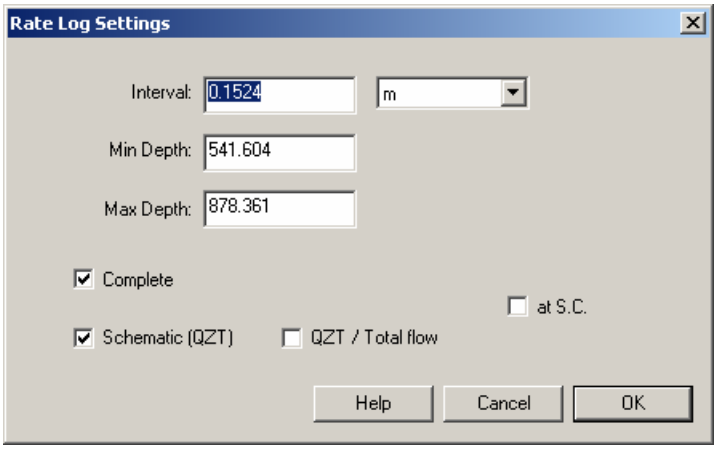


The flow map is displayed as Vsh vs Vsl on log-log scale. The gray line on the plot is for Vsh + Vsl = Vm. The white triangle shows the current solution.

It is possible to change the resolution of the flowmap with the “Number of points” button.

D09.21 • Rate Log Calculations

The rate log option  is used to generate the Schematic and/or Complete rates. For complete rates, the depth interval/window can be defined. These parameters have no influence on the schematic log.



Schematic

The schematic option presents the results of the zone rate calculation as logs. The location of the inflow zones drives the drawing of the schematic logs, namely where to assign. There are three types of schematic logs: incremental, total (or cumulative) rates, and cumulative ratios. The mnemonics of the corresponding curves are fixed by software default as:

QZXT for total, where
Z stands for zoned
X is a letter representing the phase: O=Oil, G=Gas, W=Water
T stands for Total
QZXI for incremental, where
Z stands for zoned
X is a letter representing the phase: O=Oil, G=Gas, W=Water
I stands for Incremental
QZXTR for cumulative ratio, where
Z stands for zoned
X is a letter representing the phase: O=Oil, G=Gas, W=Water
T stands for Total
R stands for ratio

Zoned simulated measurements

If the user has checked to automatically display the match channels, when the schematic log is calculated, Emeraude outputs the simulated zoned channels containing the simulated values of each channel used to calculate a residual and the measured log in the same track for visual comparison.

Complete log

The calculation depends on the position with respect to calculation/inflow zones. For some points a single computation is done, for others the result is a weighted average of 2 computations made using 2 consecutive calculation zones. The average is weighted in such a way as to ensure the log continuity.

At S.C.

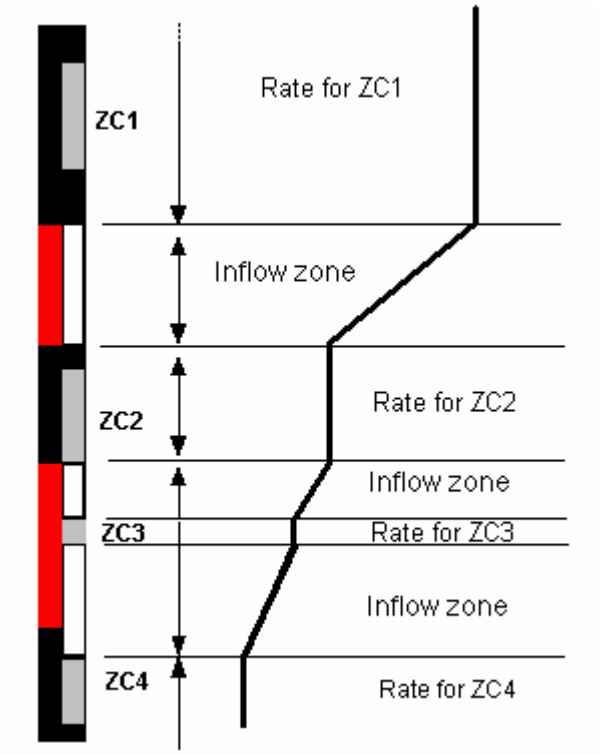
When this option is selected Emeraude outputs the downhole rates expressed at surface conditions. This is not equivalent to surface rates, as the dissolved gas is not accounted for in the gas rates. This option is not enable when "QZT / Total flow" is selected.

QZT / Total flow

When this option is selected, Emeraude makes the schematic log profile in terms of ratios with respect to the total flow rate. The total flow rate value is taken at the topmost point of the QZT vector. This option is not enable when "S.C." has been selected.

D09.22 • Schematic log

The schematic logs are generated with the Rate Logs option. They are also updated when exiting the Zone Rate dialog with OK (if the rates already existed).
The results found for a particular calculation zone apply from the bottom of the inflow zone above down to the top of the inflow zone below (see Figure below).



Only the mass rates are assumed to be constant between two inflow zones, not the velocities. From the mass rates, Emeraude recalculated at each point the new velocities and volumetric rates. No calculation takes place within the inflow zones where the log is completed with linear interpolation.
The schematic log is therefore driven only by calculation and inflow zones.
By resizing the inflow zone the user has an easy way to modify the shape of the schematic log. Note that it will then be necessary to re-generate the schematic logs.

D09.23 • Zoned simulated measurements

For any measurement matched in the rate calculation, the schematic logs come with a zoned simulated equivalent. For instance in a 2-phase interpretation using the apparent velocity (VAPP) and the density (GRAD), the schematic log generation will produce the two channels GRADZ and VAPPZ. These channels are plotted with the measured value automatically if the user has chosen this option in the interpretation initialisation (Info/New). All schematic logs have entries at regular intervals outside inflow zones. These entries are calculated based on a material balance assumption as explained below.
Between any 2 successive inflow zones, there is by definition a single calculation zone. On that calculation zone, all rates and deduced results are available, and in particular the mass rates can be calculated from the rates and PVT. It is assumed that the mass rates remain constant on the interval between the 2 neighbouring inflow zones. At every point where a calculation is required, Emeraude estimates the local PVT and ID, calculates the local velocities, and inputs those velocities in the same model as used on the calculation zone. This leads to the estimation of all deduced parameters. The zoned simulated channels are thus not constant between inflow zones and for instance, simulated holdups may change as a result of a change in internal diameter.

Temperature
The zoned simulated temperature channel TEMPZ has a specific treatment, and contains points even within the inflow zones. In addition, Emeraude generates an output called HLCZ, which is the heat loss coefficient calculated from the logs as: $[dT/dZ \times \rho.Cp.q]/ (Tw - Tg)$. This can be used as a quality indicator, to see whether the assumption that this value is fairly constant is OK, and also to check the current value.

Zoned simulated channel updates
When schematic logs exist, they are systematically updated every time the Zone Rate option is executed. On the other hand, some other modifications may impact the results and the update will not be done automatically. Some cases to remember where it is necessary to re-generate the schematic logs manually are:

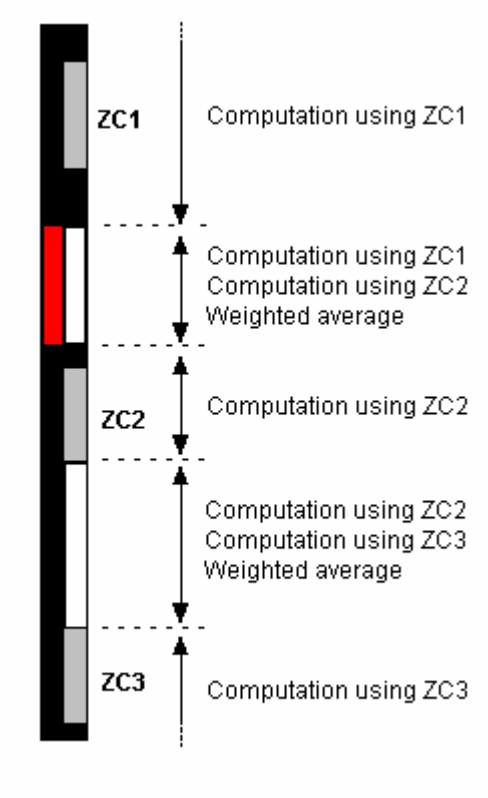
- Edition of the inflow zones
- Interactive edition of a geothermal profile (when temperature is matched)

D09.23 • Complete Log

In the Complete log calculation, the same non-linear regression scheme as used in Zone rates is applied at every depth specified by the user. The input parameters are obtained by interpolation of the interpretation channels, and typically some general well data channel (see Parameters for rate calculations, section E09.10).

Each calculation requires a flow model, a flow correlation, and associated values, which are only known for the calculation zones. At a given depth, one needs to decide from which calculation zone the settings should be retrieved. For each calculation zone one has to define an application range in the same manner as what is done for the schematic log. Within this range, the settings of that zone are used. As seen on the figure below, there are some intervals, the inflow zones (in white), where calculation zones do not apply.

On such an interval, two calculations are made and averaged. These calculations are done with the settings of the calculation zones directly above and below each inflow zone. A depth-weighted average of the results is taken to ensure log continuity.



Each single calculation proceeds as follows:

Single phase

Velocity correction factor, Vpcf is set to the value found for the considered calculation zone

If Vpcf is 0.83, or has been entered by hand, no further processing is done; otherwise, Emeraude attempts to improve the value:
If the viscosity for the considered calculation zone was entered manually, use this value, or else compute the viscosity from the PVT model.
Improve (Single phase scheme, section E03.3)
In addition to the rate channels, Emeraude also outputs: a mixture velocity, and if a gradio is used, a corrected density channel.

Multiphase

Init the calculation recovering from the calculation zone: flow model, flow correlation, Oil fraction for a Liquid-Gas or 3-Phase L-G model, value of superficial velocities, flags indicating whether or not measurements should be fitted, weights.

Improve (see Multiphase Scheme, section E03.7)

Values of multipliers (Vpcf, Vslip) obtained by matching the surface conditions are global and they are taken into account in the log calculation. Also, even if Apparent Downflow is selected in Zone Rates, the flag is disregarded in the complete log calculation, which honors the apparent velocity channel.
In addition to the rate channels, Emeraude also outputs: a mixture velocity and, if a gradio is used, a corrected density channel, and a holdup channel for each phase.
In Liquid-Gas, the breaks occurring in the holdup models when changing flow regimes make the regression heavily influenced by its starting point. This problem is solved by using as a starting point of the rate log regression the solution found in zone rates.

Warning: constraints

Whereas the Zone Rate calculation and hence the schematic logs can be calculated with constraints on the contribution, the Complete Log only honors the measurements.

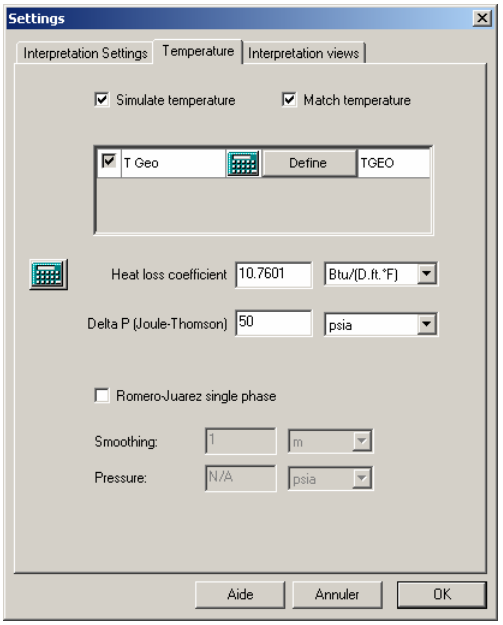
Warning: temperature

Because it is solving for the cumulative rates at every depth, the Complete log does not use the temperature residuals at all. In a situation where the temperature is required to provide a sufficient number of residuals, the complete log will not be generated.

D09.24 • Temperature

Temperature parameters & options

The temperature controls are in the second tab of the Infos/New option (Interpretation control panel).

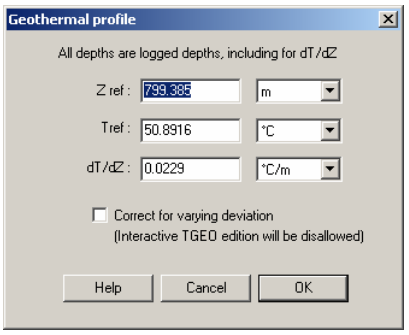


The temperature can be simulated only, or simulated AND used in the calculation.
The following information must be given:

- A geothermal profile which can be defined in one of 3 ways:
  - Loaded from a file
  - Defined by a point and a gradient
  - Defined interactively
- A "heat loss coefficient" (see explanation in E05)
- A pressure drop representing the difference in pressure between the reservoir and the wellbore, used to calculate the Joule-Thomson effect. This can be inferred from a comparison between shut-in and flowing pressure.

Geothermal profile

 This button calls the dialog on the right where a reference point, and a temperature gradient is entered. If this method of input is used, you should first note where the geothermal profile is on you reference temperature, pick a point on that section (Zref, and Tref) and calculate a temperature derivative using the browser "**f**" option to get the gradient.



Like any other Emeraude channels, the geothermal profile is with reference to the measured depth, not the TVD. If necessary, the  option can correct for a varying deviation. Typically two distinct paths could be followed:

Tgeo defined interactively: The browser interactive definition was chosen. The geothermal profile was defined based on some local linearity of the temperature response, and the same linear relationship (with respect to measured depth) was extrapolated elsewhere. To correct for, or simply assess the effect of a varying deviation in the logged interval you can:

- Go to the PL Interpretation Infos/New option, Temperature tab,
- Select  for the geothermal profile, check "correct for varying deviation" and OK.

Tgeo defined manually: In this case, simply check “correct for varying deviation”.

When you exit the Infos/New dialog you will see the newly calculated geothermal profile. Most of the times the correction for a varying deviation will not bring any significant differences, i.e. the geothermal profile will remain linear with respect to measured depth. In that case it is suggested that you follow the converse path, returning to the  option to uncheck the “correct for varying deviation” box. By doing so, you will later on be able to use the interactive editing of the geothermal profile (part of the data browser), which would otherwise be disallowed.



This can be used to copy any geothermal profile already exiting inside the survey (typically loaded from a file).

Interactive definition

The geothermal profile can be defined interactively in the following manner when the reference temperature has been selected:

- Have a view with your reference temperature on the screen
- In the data browser open the interpretation input node and select that reference temperature
- Select the  icon of the browser toolbar or the equivalent “Create/edit Tgeo” option of the browser popup menu, click and drag on the view showing the temperature to define the profile.

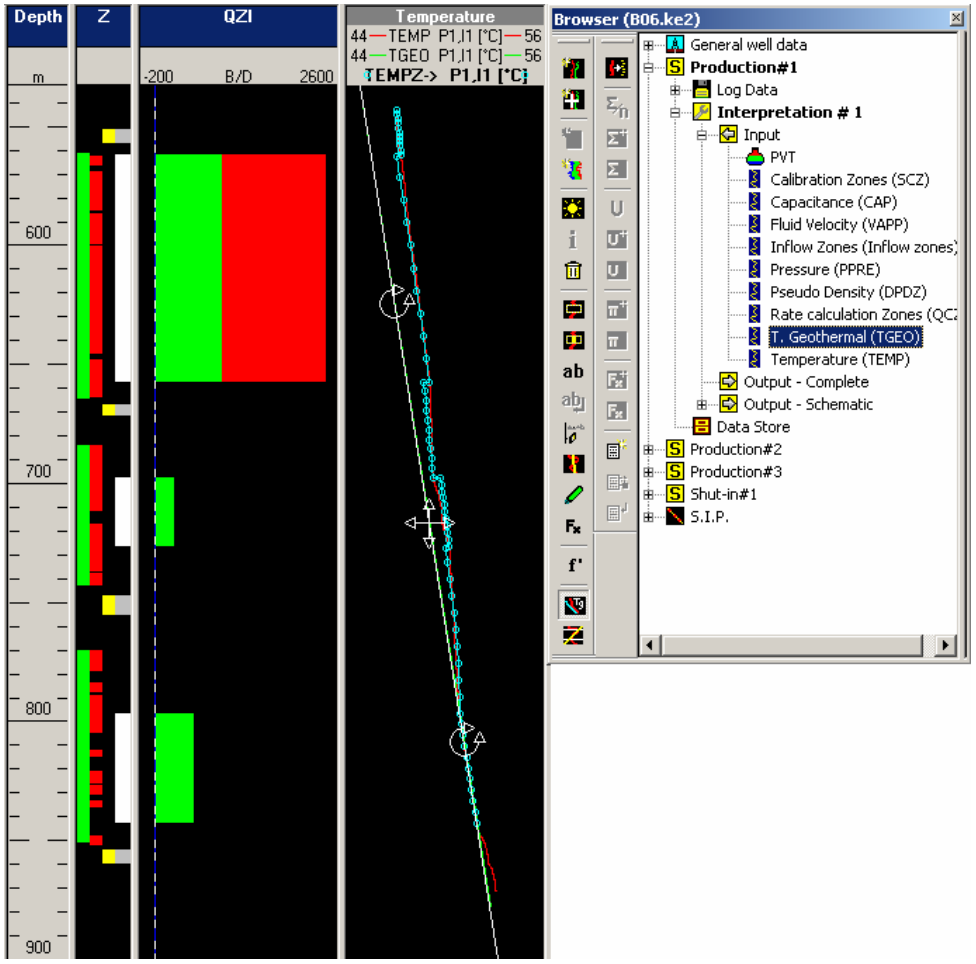
The geothermal profile is defined and is added inside the Interpretation Input.

The geothermal profile can be added to any user view. It will be plotted automatically by Emeraude on the “Temperature interpretation view”. This view appears if the following conditions are met:

- In the “Interpretation view” tab of the Interpretation Infos/New dialog you check “Measured/Simulated views”
- In the “Temperature” tab of the interpretation Infos/New dialog you checked at least the option “Simulate Temperature”



When the geothermal profile exists, this option can be used to translate, or modify it interactively. Interactive editing is offered when the geothermal comprises two, and only two points. A 2-point profile is obtained using either the interactive creation, or the manual creation without correction for varying deviation.



dp Joule-Thomson

The temperature model in Emeraude accounts for the Joule-Thomson effect, a temperature change linked to the change in compressibility of the fluid undergoing a pressure drop. The pressure drop can be estimated by comparing a flowing and a shut-in runs. It is assumed to be the same for every layer.

Heat loss coefficient



The calculate option can be used provided that, surface rates are available, the PVT has been defined, and inflow zones exist. Note that when the Temperature is “on”, the first time you enter the Zone Rates options, or when you call a Set/Reset All zones in this dialog, the heat loss coefficient is re-calculated automatically. In addition, this coefficient can be a variable of the global regression.

Simulated temperature log

When the flag “Simulate temperature” is on and schematic logs are generated, a simulated temperature “TEMPZ” is added in the Interpretation Schematic-Output. This channel is plotted automatically on the “Temperature match view”.

The simulated temperature is generated by sections, within and between the inflow zones, as described in E05:

Within an inflow zone
At the bottom of any inflow zone, the starting point is the measured temperature. The inflow zone is segmented up to the top and the enthalpy balance equation is used to solve for the successive steps.

Above an inflow zone (and up to the next one)
The starting point is the actual temperature at the top of the inflow zone. The section is then segmented up to the bottom of the next inflow zone and the heat loss equation is used at each step.

With the above algorithm, the simulated curve is forced back to the actual curve at the beginning of each segment. Typically, a poor match will exhibit kinks.

Using the temperature in the regression

In order to use the temperature in the regression it is necessary to attribute to each calculation zone, some residuals related to the temperature channel. For each calculation zone, Emeraude uses the following:

- (Simulated – Measured) Temperature at the top of the inflow zone below
- (Simulated – Measured) Temperature at the bottom of the inflow zone above (or top temperature point)

The first residual is governed by the contribution of the inflow zone below and the enthalpy balance.
The second residual is governed by the Ramey's equation and the cumulative rate on the calculation zone.
When the "Match temperature" flag is on, information about those 2 residuals is given in the Zone Rate Results:

Matched	Measured	Shift	Calculated	Error %	Fit		Weight	
Density, g/cc	0.3618	>	0.3341	7.6711	☑	All	10	All
T below, °C	47.2606	>	46.9919	0.5686	☑	All	1	All
T above, °C	47	>	46.9993	0.0015	☑	All	1	All
Yw	0	>	0	0	☑	All	10	All

Warning about temperature usage

In the event of inadequate spinner response the temperature channel can be interpreted instead, or be used to complete an otherwise undetermined problem. One should not expect however that temperature will be the key to all problems. A good match of the temperature will not always be achievable, simply because the model is based on some simplifying assumptions. Still, in some cases, a proper usage of the model will bring a much improved interpretation, as in Guided Interpretation#6 (chapter B06). This example shows a case of re-circulation where the temperature was used rather than Vapp where apparent downflow occurs.

D09.25• Standing water column

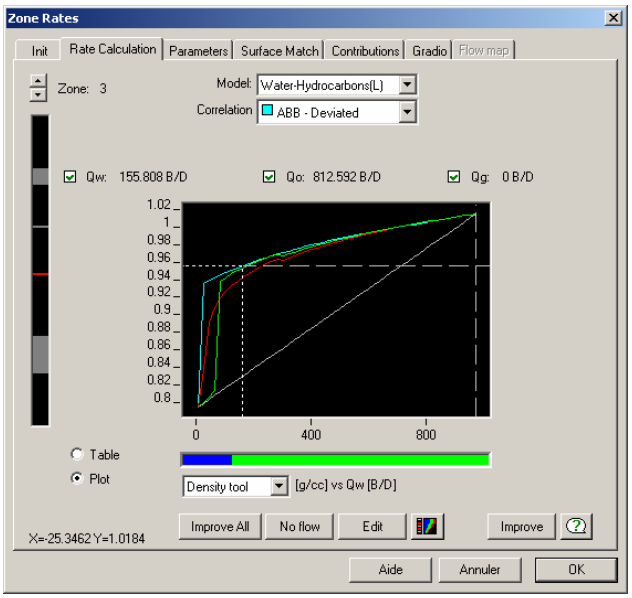
Access

This option is triggered in the Interpretation Infos/New dialog. One needs to check the option and enter the top depth of the column



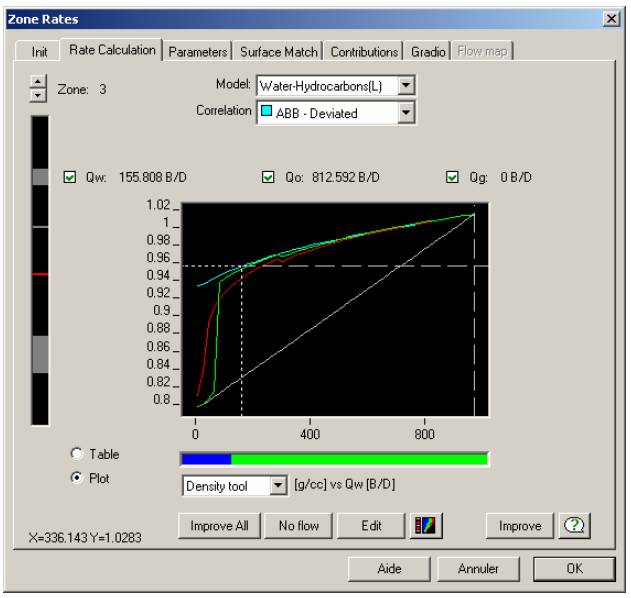
Rate calculation with standing water

The figure opposite shows a typical Zone Rate screen, in a Water-Hydrocarbon situation with low velocity. In this case, the slippage being significantly higher than Vm, all models show a sharp discontinuity for small Vsh. In essence it means that as soon as there is a little flow of water, it suddenly occupies the majority of the volume because oil is going so much faster. When Vsh is 0, the solution reverts to a single phase hydrocarbon problem so the model does not accept that the water is present yet immobile.
The “Standing water” option in 2.20 changes precisely this situation and the solution for Vsh = 0 is simply the normal extrapolation of the solution for small Vsh values



The dialog on the right shows the same situation with the “Standing water” flag activated. It can be seen that the models do not return to the hydrocarbon density for Vsh=0. The modification is essentially affecting the ABB-deviated model here.

There are two additional differences in this case:
- A residual is added on Vsh, to represent that Vsh should ideally be 0.
- If the constant slippage model is used, and because there is an additional residual, the slippage value is taken as a variable.



D09.26 • Zone PVT

This facility allows the PVT properties of the fluids to be modified for each particular inflow zone. The calculations are based on ideal mixture principles and treat each phase independently. Furthermore, the PVT parameters of each incoming fluid are estimated at the conditions of the calculation zone above the considered inflow, and those properties are assumed to remain the same throughout the logged interval. This is different from what is done in the case of a single PVT where parameters of a given fluid are estimated at every depth based on the temperature and pressure at that depth. The objective of this simplification in the zoned PVT case is to allow a reasonably simple solution and is based on the fact that if zone PVT is used, the contrast in the incoming PVT properties is an order of magnitude higher in the solution, than the variation of those properties along the logged interval.

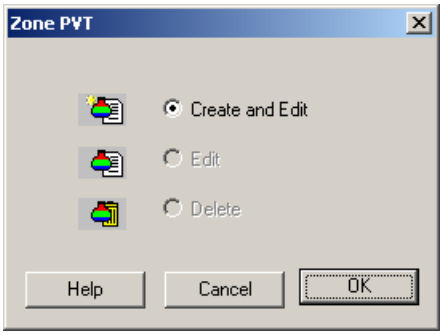
D09.26.1 • Access and init

In the Contribution page of the Zone rate dialog new controls are added:

- A checkbox “Allow zone PVT”
- A specific PVT button for each inflow zone.

	dQw,B/D	Lock	dQo,B/D	Lock	dQg,B/D	Lock	dQ's Signs	PVT
Inflow 1	0	☐	2997.67	☐	2834.51	☐	All positive	
Inflow 2	0	☐	836.883	☐	295.813	☐	All positive	
Bottom	0	☐	0	☐	0	☐	All positive	

By default, each inflow zone uses the PVT defined in the interpretation. By checking the “Allow zone PVT” option, you may select the PVT icon for a given inflow zone to:



- Create and edit a new PVT. The fluid type is fixed to that of the interpretation but any property can be modified, by a change of correlation, constraints, etc.
- Edit the zone PVT, if previously created
- Delete the zone PVT, which resets that zone to use the interpretation PVT.

Note that a zone with its own PVT definition (e.g. zone 2 below) shows a different PVT icon:

	dQw,B/D	Lock	dQo,B/D	Lock	dQg,B/D	Lock	dQ's Signs	PVT
Inflow 1	0	☐	2997.67	☐	2834.51	☐	All positive	
Inflow 2	0	☐	836.883	☐	295.813	☐	All positive	
Bottom	0	☐	0	☐	0	☐	All positive	

D09.26.2 • Calculation logic

As a rule in the Zone Rates option, all computations are done at the level of calculation zones using the local cumulative rate values. The PVT properties on the zone need to be known and in the normal case they are estimated by simply flashing the interpretation PVT at the temperature and pressure of that zone. With zone PVT, the first question is to know what fluid is present at the level of the calculation zone.

Mixture definition / Estimate of the mixture properties

A particular assumption of rates within the well determines the contribution of each inflow zone. Knowing those contributions, it is possible at every level in the well, to calculate the "composition" of the mixture. In an "all zone producing" configuration this is very straightforward; consider for instance a well with three inflow zones numbered from top to bottom.

- Above zone 3 the fluid is 100% that of zone 3.
- Above zone 2 the mixture comprises volumetric proportions defined as:
    - dQ2/(dQ2+dQ3) for the fluid of zone 2
    - dQ3/(dQ2+dQ3) for the fluid of zone 3
- Above zone 1 the mixture comprise volumetric proportions defined as:
    - dQ1/(dQ1+dQ2+dQ3) for the fluid of zone 1
    - dQ2/(dQ1+dQ2+dQ3) for the fluid of zone 2
    - dQ3/(dQ1+dQ2+dQ3) for the fluid of zone 3

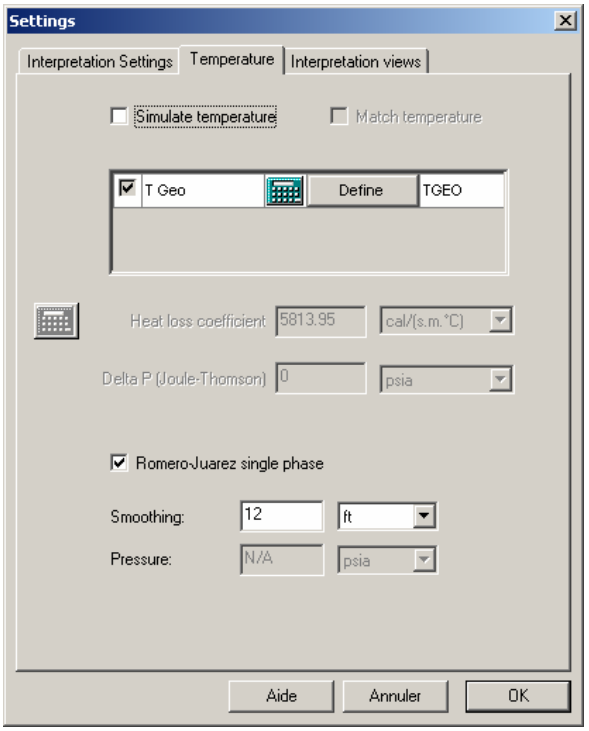
When the flow configuration is not as simple (cross-flow, thief zones, etc) the above method is modified to account properly for the removal of fluids, leading to a general scheme for calculating the volume based mixture at any level of the well.

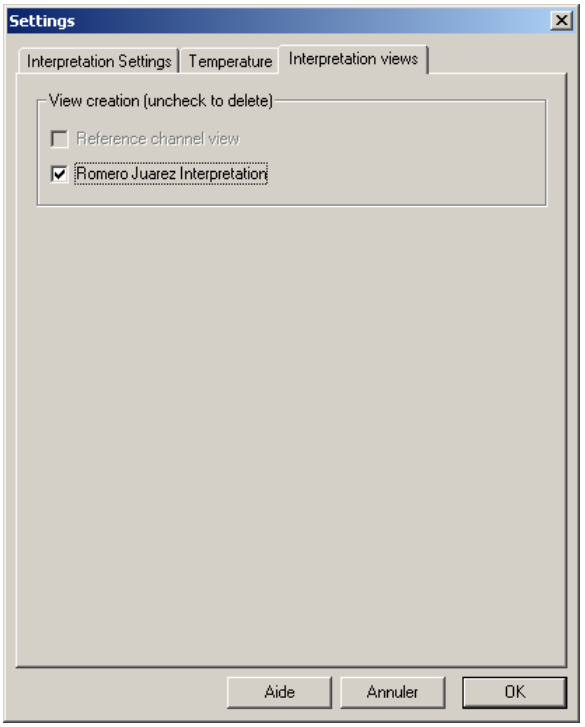
The PVT properties of the mixtures are then calculated as a volume weighted average of the individual properties (except for formation volume factors, which are redefined based on the strict comparison of downhole / reservoir volumes). The interface considers all defined inflows, as well as a "bottom zone" to which a different PVT can also be attributed. Internally, Emeraude also considered a "top zone", used in injection, for which the PVT is always the one defined in the interpretation.

Result dependence

In the simple "all zone producing" case, it can be seen that a zone contribution influences the PVT properties anywhere above. In a case with mixed flow conditions (inflow, outflow) one particular contribution may influence zones above or below. In the general case, any change of rate, on any zone, must be followed by a new calculation of the PVT properties everywhere and a re-evaluation of holdups, slippage, etc. Hence, a change of rate anywhere in the well may impact the residuals anywhere else. For the all-zone producing case, the order of dependence is well defined, and is from bottom to top. The "Improve All" option that precisely respects the same order will work fine in this case. In the general case, a final solution requires that the global regression be used.

D09.27 • Romero Juarez temperature interpretation for single-phase productions





This is a simple Temperature interpretation method designed for single-phase production. The method is selected in the Temperature tab of the Interpretation Infos/New option. After defining the formation temperature profile (T_G,see section D09.24 • Temperature and a reference temperature channel (T_w), Emeraude calculates the relaxation distance ACOEF:

$$A = \frac{T_w - T_G}{\frac{dT}{dZ}}$$

which can also be expressed:

$$A = q \times r_f \times C_{pf} \frac{f(t)}{2 \times p \times k_h}$$

with: T_G geothermal gradient,

T_w flowing well temperature,

$\frac{dT}{dZ}$ temperature gradient in the wellbore,

Q volumetric flow rate,

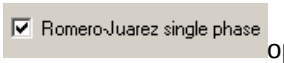
r	fluid density,
Cpf	fluid heat capacity**,**
$f(t)$	time-dependent function,
l	reservoir thermal conductivity,
A	relaxation distance.

Assuming that the formation and fluid properties are constant, A (or ACOEF) is thus proportional to the rate, and should exhibit stabilization in-between inflow zones. The ratio of the successive stabilization levels is the ratio of the rates, and if we know the cumulative production we can therefore deduce the cumulative between each inflow:

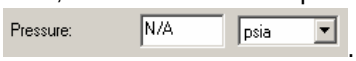
$$Q_i = Ratio_i \times Q_{Top} = \frac{ACOEF_i}{ACOEF_{Top}} \times Q_{Top}$$

Reference Input Channels

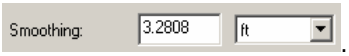
Temperature and Pressure input reference channels are defined in the “Interpretation Settings” dialog tab page.

The 

option is enabled only if a temperature input channel is present in the interpretation.

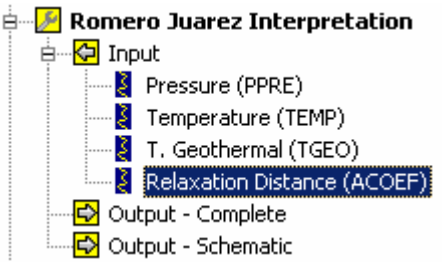
If no reference pressure is available, the user has the capability to edit a constant pressure value: 

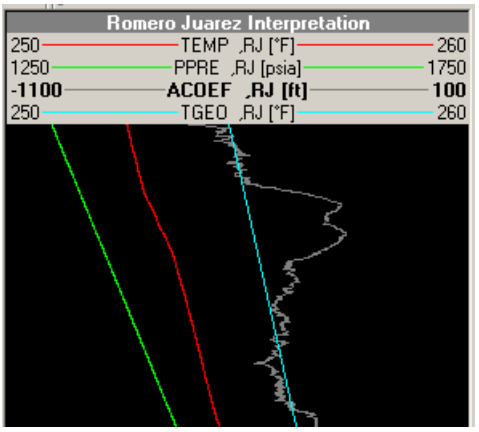
.

The “Smoothing” parameter will be used to filter the relaxation distance “ACOEF” when computed: 

.

Once a geothermal gradient has been defined, the relaxation distance channel “ACOEF” is automatically computed: this channel is put, in the data browser, under the input node of current interpretation, and plotted in the “Romero Juarez Interpretation” view

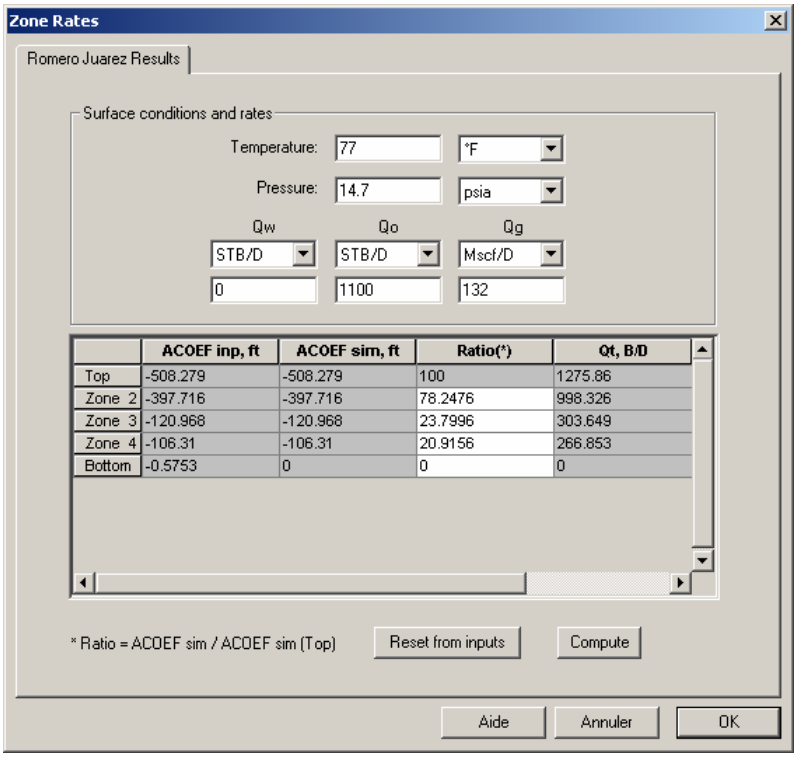




PVT definition

Romero Juarez option only applies for single-phase flow conditions: standalone “Dry Gas” or “Saturated Oil”, or “Water” are the only valid choices. The “Saturated oil” option is considered as a single oil flow conditions (Reference input pressure must be below the bubble point pressure for the interval of interest).

Rate calculation



The user should define the calculation zones by picking up intervals where the relaxation distance channel ACOEF is stable, preferably away from the suspected zone of inflow.

The zone rate computation requires the knowledge of the total cumulative rate Q_{Top} as a starting point; Emeraude will use the surface conditions and rates specified by the user along with the defined PVT, to derive the top zone cumulative rate at downhole conditions.

Grid results parameters

ACOEF inp: Computed average of the relaxation distance channel over the zone interval.
ACOEF sim: Derived from the Ratio value and *ACOEF sim (Top)*; equals to *ACOEF inp* by default.
Ratio(*): *ACOEFsim / ACOEF sim (Top) = Qt / Qt (Top);* value is editable.
Qt: Cumulative rate derived from *Ratio(*)* and *Qt (Top).*

The Compute button update the simulated ACOEF values and the corresponding rates according to the Ratio(*) values, while the Reset from inputs button reset those values according to the ACOEF input values.

D09.28 • Time Lapse Flowmeter

The objective of this option is to produce at the end of the report an additional log presenting in chronological order, the past and present productions in terms of schematic rates QTZT or ratios QTZTR (see section D09.2). The Time Lapse icon, accessed in the control panel by PL interpretation, calls the “Time Lapse” dialog.

In this dialog, you have the possibility to load from files as many sets of previous rate (or ratios) channels as desired; typically one set is made of QWZT, QOZT, QGZT, and QTZT (or QWZTR, QOZTR, QGZTR, and QTZTR). You are also able to include and copy the set of rate channels corresponding to the current interpretation. You can name and order the sets. You have the capability to apply a common horizontal scale for all the time-lapse QZT tracks.

The time-lapse display is generated automatically and presents the various QZT tracks in the current chronological order, for the current log range and using the current rate scale. The corresponding log is created on a single “Time-lapse” page of the print report (see section D13.2).

D09.28.1 • Creating tracks

The Time Lapse Icon 

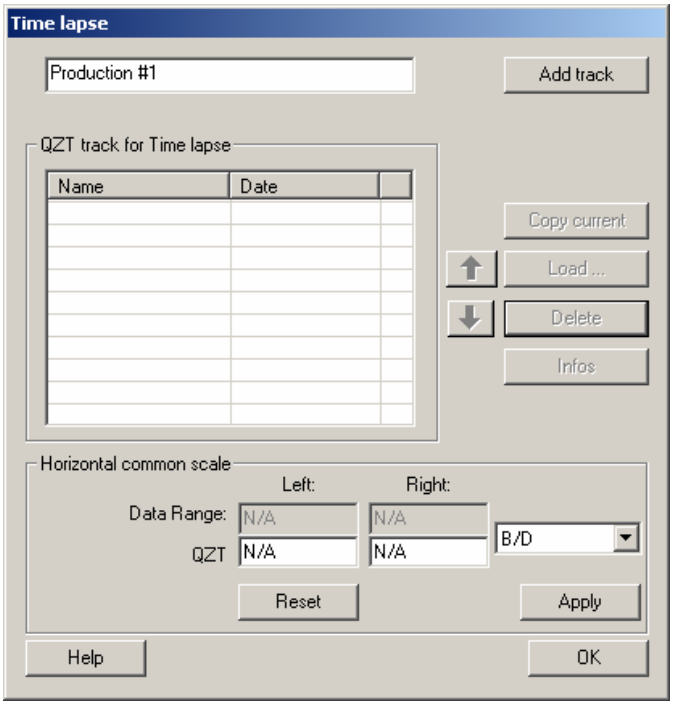
in the PL interpretation panel opens the dialog beside.

Typing a name in the top edit box enables the “Add track“ button and allows the user to create a new Time-lapse track.

A new node 

is created in the data browser tree under the current interpretation. This node shows all the existing Time-lapse tracks and their corresponding Rates or Ratios channels.

An existing track can be deleted from the Time-lapse dialog Delete option, or within the data browser (like any other channels).



In order to define the channels for a newly created Time-lapse track, the user can use the following alternatives:

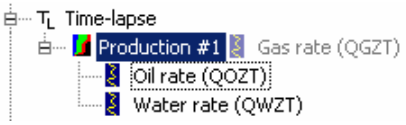
- Copy the current interpretation schematic rates or ratios.



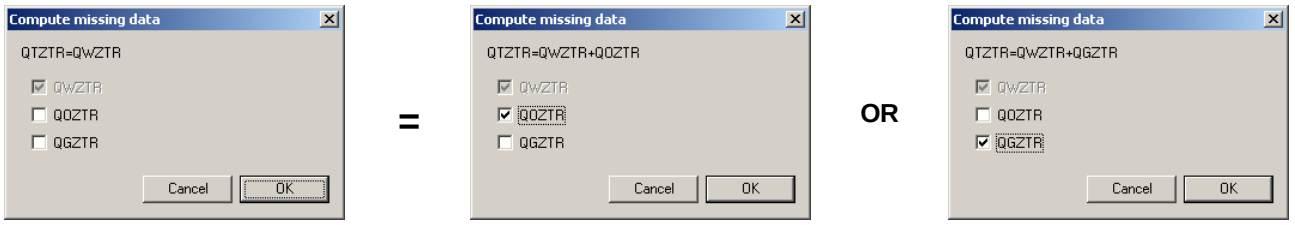
- Call the generic “Import Data” dialog by using the Load ... option (see chapter D04).
  The loading is restricted to the schematic rates QWZT, QOZT, QGZT, QTZT, or ratios mnemonics QWZTR, QOZTR, QGZTR, QTZTR.
  You cannot load a mix of rates and ratios mnemonics into the same time-lapse track.



- Use the "drag and drop" capability within the data browser Time-lapse node. The authorized channel mnemonics are similar to the ones listed above.



When using the Load ... option, if you attempt loading the total mixture rate QTZT plus one of the individual phase rate (QWZT in the example illustrated below), Emeraude computes the complementary rate (QOZT or QGZT) according to the selection made by the user in the "Compute missing data" dialog:

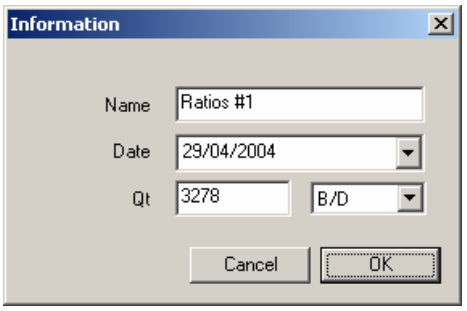


The loading process follows the same logic dealing with the schematic ratios QTZTR, QWZTR, QOZTR, QGZTR.

D09.28.2 • Defining the tracks

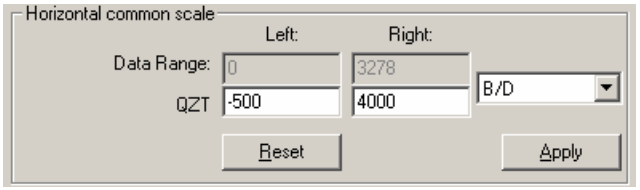
The Infos button calls a dialog allowing you to set/change some specific information for the currently selected track such as the track name, the survey date, and the total mixture rate value Qt.

The Qt value is only available in case of a Time-lapse track defined by ratios channels. When using the "Copy current" option, it is automatically obtained from the topmost rate value of the QTZT channel.



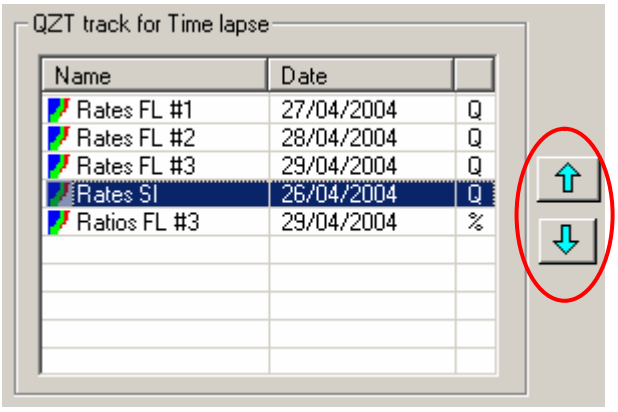
D09.28.3 • Setting a horizontal common scale

When defining the Time-lapse track with the schematic rates, this option allows you to set an optimum common scale for all tracks for a visual comparison of the different profiles.



D09.28.4 • Modifying the track sequence

The Time-lapse table lists all the existing QZT tracks with their respective date and type (Q for rates and % for Ratios). If necessary, the user has the ability to reorder the QZT's by using the up and down arrow keys located on the right side of the table. In the Emeraude Time-lapse page report (see section D13.2), the tracks will be printed out in the same sequence. However the specified order does not affect the way the main screen display is organized.



D09.29 • Interpretation levels and logic

The layout of the options in the interpretation panel represents, from top to bottom, the default interpretation path. In version 2.10, it is not required any longer to go through all the options in sequence. In particular, an interpretation can be conducted without spinner calibration or V apparent, if a substitute velocity or rate measurement is available. It is possible at any point to go backwards in the panel and to edit/change an existing element. For some options, invalidated results are automatically deleted by the software. In other situations, this is left to the user to make the necessary updates.

Spinner calibration zones
When a calibration zone is added/deleted/modified Emeraude automatically deletes all interpretation results starting with the Vapp channel. In the spinner calibration, only the parameters for the current zone are reset.

Spinner calibration
When calibration results are changed inside the calibration dialog (slopes, intercepts, etc) there is no automatic destruction/reset of invalidated results.

V apparent
Deleting/generating Vapp deletes all rate results. On the other hand, after editing the Vapp channel, there is no automatic destruction/reset but the change will be taken into account in all panel options.

PVT
When the PVT model is changed, Emeraude automatically deletes all results from the Zone Rate option onwards. When the Zone rate option is selected next, it will show the “Zone rate init” page where the default flow model/correlation will have to be re-defined.
When the PVT model is not changed but only parameters modified, the current results are not discarded. In particular, the Zone rate option after such a change will show the previous solution, but the model and the comparison between models and data for the solution will reflect the change.

Reference channels
Deleting or editing an interpretation reference channel (other than VAPP) does not delete interpretation results. There is no automatic destruction/reset

Calculation zones
Deleting all calculation zones deletes in turn all rate results/logs. Deleting/Adding/Modifying a single calculation zone does not delete existing rate channels. In Zone rates, the results for the non modified zones are kept. For a newly created, or modified zone, an automatic calculation is made using the default flow model/correlation defined in the “Zone rate init”.

Zone rates
Making a modification in the Zone rate dialog does not automatically reset all the interpretation output logs, except the schematic logs if they are present. For complete logs, the reset must be done manually.