E01 • Tool handling

E01.1 • Density

The density measurement is in most situations a major input of the rate calculation. It may be the result of a measurement possibly followed by some post-processing. It may also be a pseudo-density channel, calculated by taking the derivative of a pressure channel with respect to depth.
Except with a nuclear density tool, the value of a density channel is not the actual mixture fluid density but a function of the density, the deviation, the fluid velocity and viscosity, etc. It is therefore critical to define the tool accurately so that Emeraude can simulate the measurement in a consistent fashion. The following types are distinguished:

Pseudo-density channel

The nature of the channel is known internally by Emeraude and no user input is required. When simulating a pseudo-density value, Emeraude will:
• multiply the actual density by *cos(deviation)*
• Compute and add tool frictions

Tool density channel

The channel characteristics MUST be defined properly in the Tool Info dialog. Emeraude distinguishes 6 different situations, as shown below. The second table column shows what settings should be selected for those tools in the Survey Tool info dialog:

Tool / channel info	Apply deviation correction
Gradio / corrected for deviation	None
Schlumberger PTS / not corrected for deviation	Schlumberger PTS
Sondex FDP / not corrected for deviation	Sondex FDP
Gradio / not corrected (not PTS or FDP)	/cos(deviation)
Nuclear density	None
Pressure derived density **	/cos(deviation) ; [dP/dZ]

** When a pressure derivative is calculated inside Emeraude the choice will be internally set to this correction. The dPdZ channel will not even appear in Tool Infos.

For all gradios the internal correction removes pipe and tool frictions, except for the “Pressure derived density” for which tool frictions are ignored.

E01.2 • Capacitance

There are two ways to calibrate Capacitance tools: Yw vs Normalized resp or Diel vs cps:

Yw vs Normalized resp

The calibration is defined by a table of water holdup (Yw) versus normalized tool response, and the in-situ responses for 100% Water and 100% Hydrocarbon:

• *Yw = f(Normalized response)*

• *Resp(100%H20),* and *Resp(100%HC)*

Using the calibration data, the water holdup *Yw* is obtained from any log value *Resp as:*

• *Yw = f(Normalized response) where*

• *Normalized response = [Resp(100%HC) - Resp] / [Resp(100%HC) – Resp(100%H20)]*

Linear interpolation is used to estimate the result.

The calibration chart obtained in a flow loop is unique to the particular tool or tool type. When no chart is available a default chart can be selected in the Tool info dialog for the followings:

• Sondex (CAPI)

• Atlas (FCAP)

• Schlumberger (HUM)

When entered manually, the table X-values must be in increasing order. The in-situ tool readings as read from the log (ideally in a shut-in survey) are entered in the lower part of the dialog.

Diel vs. cps

In this mode, the calibration is defined by a table of dielectric values versus tool response, and the in-situ dielectric readings in 100% Water and 100% Hydrocarbon:

• *Diel = f(Resp)*

• *Diel(100%H20),* and *Diel(100%HC)*

Using the calibration data, the water holdup *Yw* is obtained by first interpolating the table to find the dielectric value *Diel* corresponding to *Resp*. Then:

• *Yw = [Diel – Diel(100%HC)] / [Diel(100%H^2O) – Diel(100%HC)]*

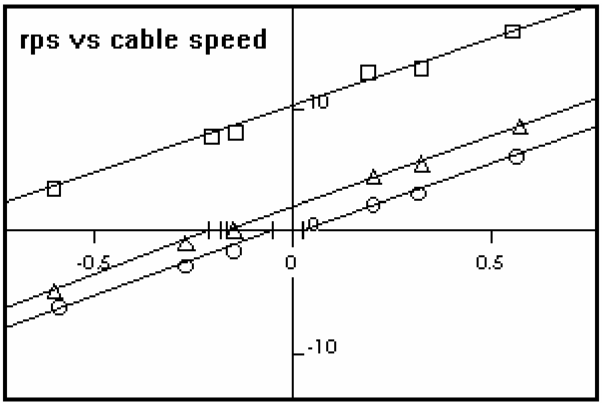
Interpolation in the table may be linear or semi-log.

When entered manually, the table X-values must be in increasing order. The in-situ tool readings as read from the log (ideally in a shut-in survey) are entered in the lower part of the dialog.

The “View Plot” option displays the chart graphically. Selecting “View Plot” will give an indication of the most appropriate scale (linear or semi-log).

E01.3 • Spinner Calibration

In the spinner calibration plot, the flowmeter response and the cable speed are averaged for each pass and each zone and plotted against each other for each pass in each of the selected calibration zones.



The above plot considers 3 zones, 3 Up and Down passes. The cable speed is considered positive for Down passes, the spinner rotation is counted positive when logging down in a producer. We distinguish the positive lines, corresponding to positive rps, and negative lines, corresponding to negative rps. Each line is defined by a **slope** and **intercept** value:

Line(+) : rps = slope(+) x [cs – Intercept(+)]
Line(-) : rps = slope(-) x [cs – Intercept(-)]

For each zone and each direction, the spinner will not rotate until the apparent velocity reaches a certain **threshold** value. Due to the blade geometry, the fluid velocity required to initiate the rotation may not be the same for negative and positive fluid velocities, and there are two distinct threshold values: **threshold(+)** and **threshold(-)**.

If the spinner is well centralized and there is a calibration zone with static fluid, the threshold values can be set from the lines intercepts on this zone. For other zones, Ideally, the slopes should be exactly the same as for the no-flow case, and the intercepts shifted by an amount equal to the opposite of the fluid velocity. So the ideal case for all zones would give:

Intercept(+) – Intercept(-) = Threshold(+) – Threshold(-) [1]

For several reasons (lack of centralization, viscosity change, etc) this situation may not occur in practice. Two calibration methods are available in Emeraude.

Mode 1: Unique value of (+) and (-) thresholds for all zones

The apparent velocity for a point on a positive line is calculated based on the slope of that line and the common positive threshold. The apparent velocity for a point on a negative line is calculated based on the slope of that line and the common negative threshold.

For a given calibration zone, as the relation [1] above does not hold, this mode typically produces different Vapp values for positive and negative lines. In the calculation of the Vapp channel, these values are averaged with user-defined weighting.

On the calibration plot, the apparent velocity for each line is indicated by an arrow, pointing down for the Line(+), and up for the Line(-) Vapp.

<u>This mode has no restriction on the intercept positions with respect to each other.</u>

Mode 2: **Distinct thresholds but unique ratio: threshold(-)/[Intercept(-) – Intercept(+)]**

This ratio is equal by default to **7/12** = **0.583** but can be set from the value on a no-flow zone.

The apparent velocity for a point on given line is calculated based on the slope and the threshold of that line.

<u>This mode requires that for any zone with 2 intercepts defined: Intercept(-) < Intercept(+)</u>

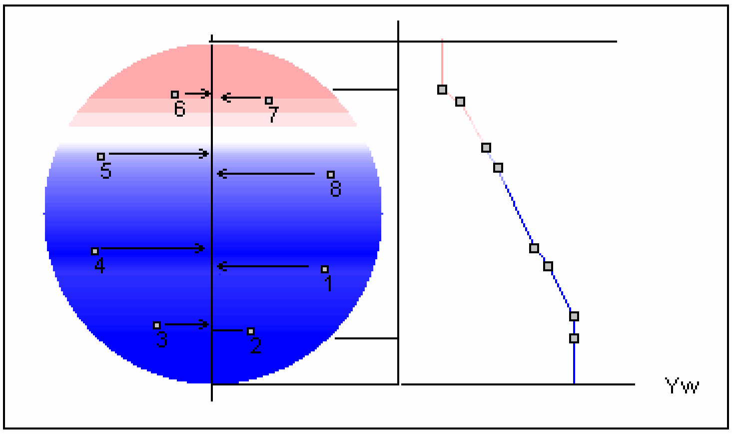
E01.4 • Multiple Probe Tools

Emeraude includes dedicated options for tools having multiple probe distributed on one or several circumferences. These options apply to the Schlumberger DEFT, GHOST, the dual DEFT situation, as well as the Sondex CAT tool. For the CAT, it is assumed that the supplied probe data must be normalized readings, between 0 , corresponding to gas, and 1 corresponding to water. Furthermore, the normalization which will have been done beforehand should have been made is such a way that the oil point has a fixed value between 0 and 1.

When a MPT is present in the survey, you will be able to generate corresponding reference channels directly from the Interpretation Infos/New dialog (see section D09.4). How to get reference channels lies on the ability to calculate for each pass, a representative average holdup. The following options are offered:

<u>Simple average</u> (all tools)
When simple average is selected the average holdup(s) for a given pass is (are) defined as an arithmetic average of the holdup(s) at the active probes.

<u>Stratified average</u> (all tools except the built-in CAT tool for which a dedicated processing exists - see below)
A projection of the probe readings is done on the vertical axis. A linear interpolation is used on this axis up to the top and bottom values. Outside, the last value is extrapolated.



At every depth the average holdup is calculated based on the cross-section map. The simple stratified average option requires the definition of the tool geometric dimensions, Lp/La, IDmax, and the internal diameter. The internal diameter is read in the pass, if found, or else in the General Well Data.

Sondex stratified average (CAT only)
With segregated flow, a simple average will not give a realistic holdup value. For the CAT, Emeraude connects to a tailored processing developed by Sondex.

⚠ For tools other than the CAT you should use the average holdup provided by the Service Company when segregated flow is encountered if this curve includes specific corrections taking into account the flow geometry.