Saphir Guided Session # 4

A01 • Requirements

It is assumed that you have already studied the guided sessions # 1 and # 2. The guided session # 1 already covered the initialization process and the loading of data. In this session we will repeat this to remind you of how to properly proceed. This session is also with a different reference fluid that requires you to go through more initialization dialogs, in particular of how to setup and build the PVT model for this gas test.
You will require the rate and pressure files stored during installation in the Examples directory; SapGS04.pre and SapGS04.rat.

B01 • Modified isochronal gas test

This guided session covers a modified isochronal gas test of five rates and four buildups with approximate duration of 0.5 hours prior to the extended flowing period of 1 hour followed by a final build up of some 20 hours duration.

B01.1 • Initialization

Launch Saphir as stand alone or through the Ecrin workstation suite. Click on new  and make sure you choose gas as the reference phase, standard analysis and default parameters. Set the reference date to 30 July 2001 at midnight. When you click on “Next” you will see that you are automatically taken to the PVT parameters dialog in order to define the gas properties necessary to construct pseudo pressures which is used for analytical gas test analysis by default. To define the gas properties and correlations click on , but leave the default parameters. Next will call up the dialog where you can define the pseudopressure range. Click create and proceed to load the pressure file.
Make sure you choose the “Field format” with the first field as date (DD-MM-YYY) the second field as time of day and the third field as the pressure as illustrated in Fig B01.1 left. Pick up the flowrate file as free format as per Fig. B01.1 right.

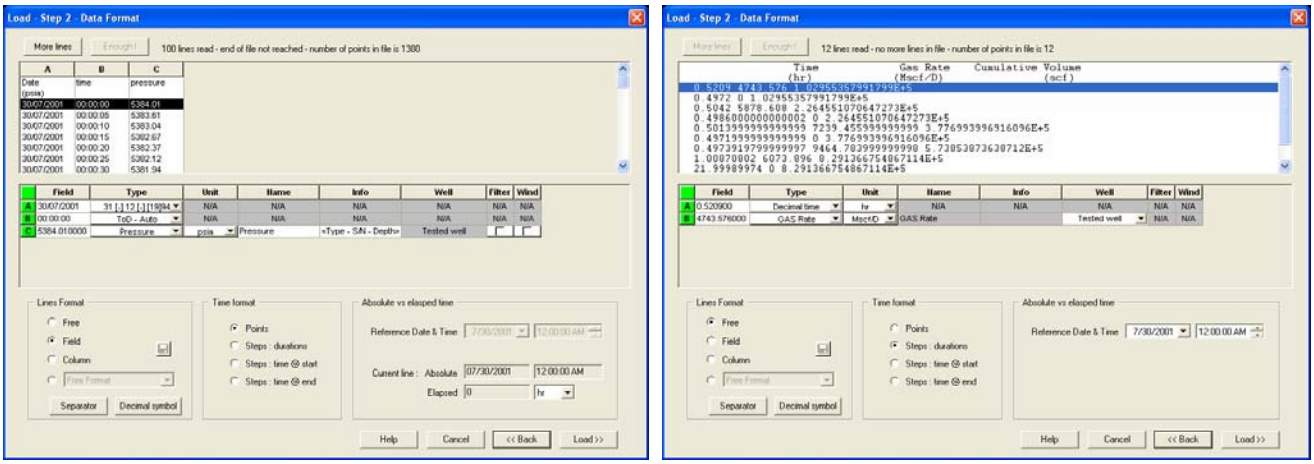


Fig B01.1 Load formatting

B01.2 • Analysis

Proceed to extract the final buildup and run the automatic model. Adjust your match manually by click and drag in the loglog plot and run the automatic model again. Continue until the match is satisfactory. The late time data in the buildup appears to be affected by a boundary or some composite system. We will illustrate how to deal with this later. The Saphir screen should look like Fig B01.2.

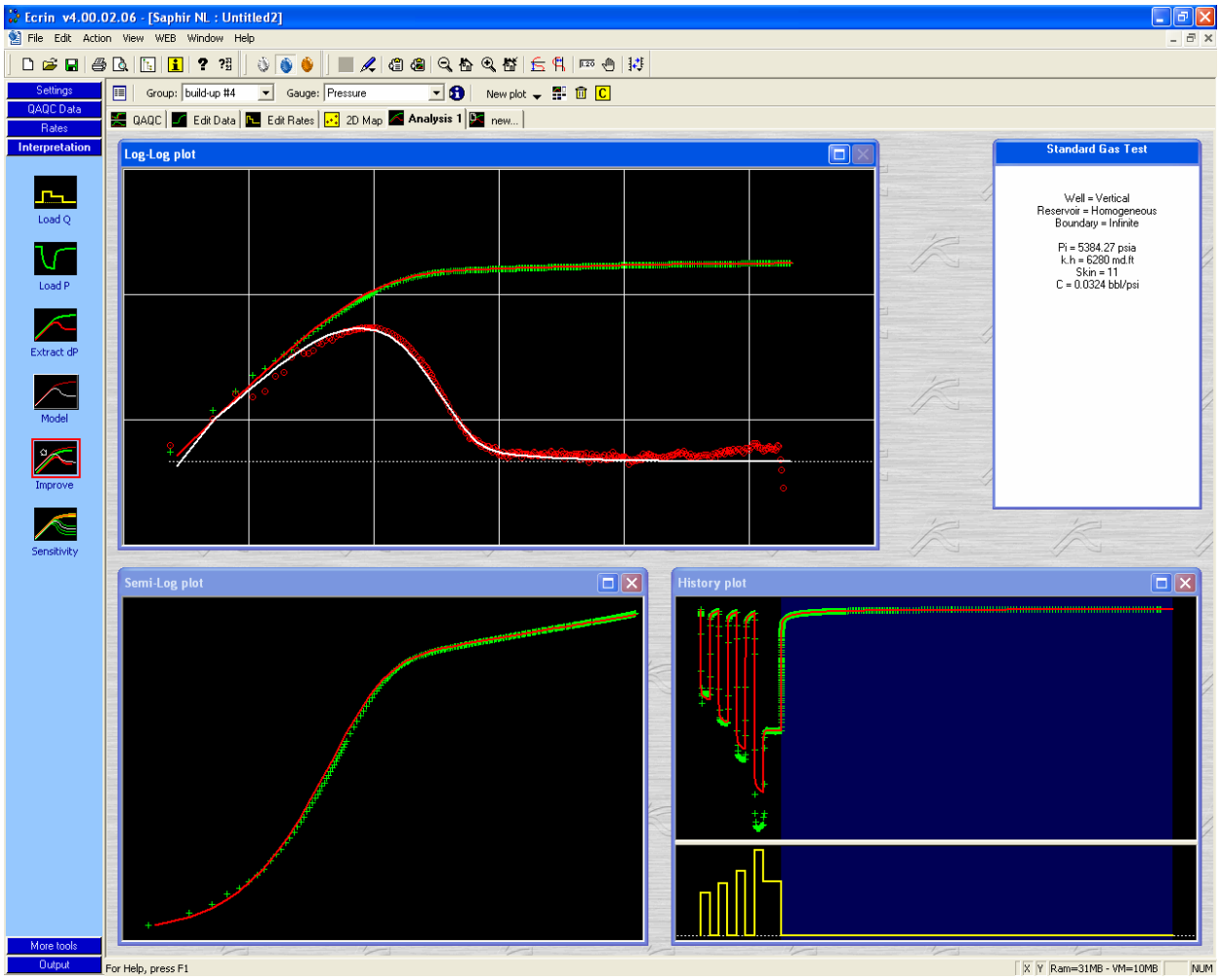
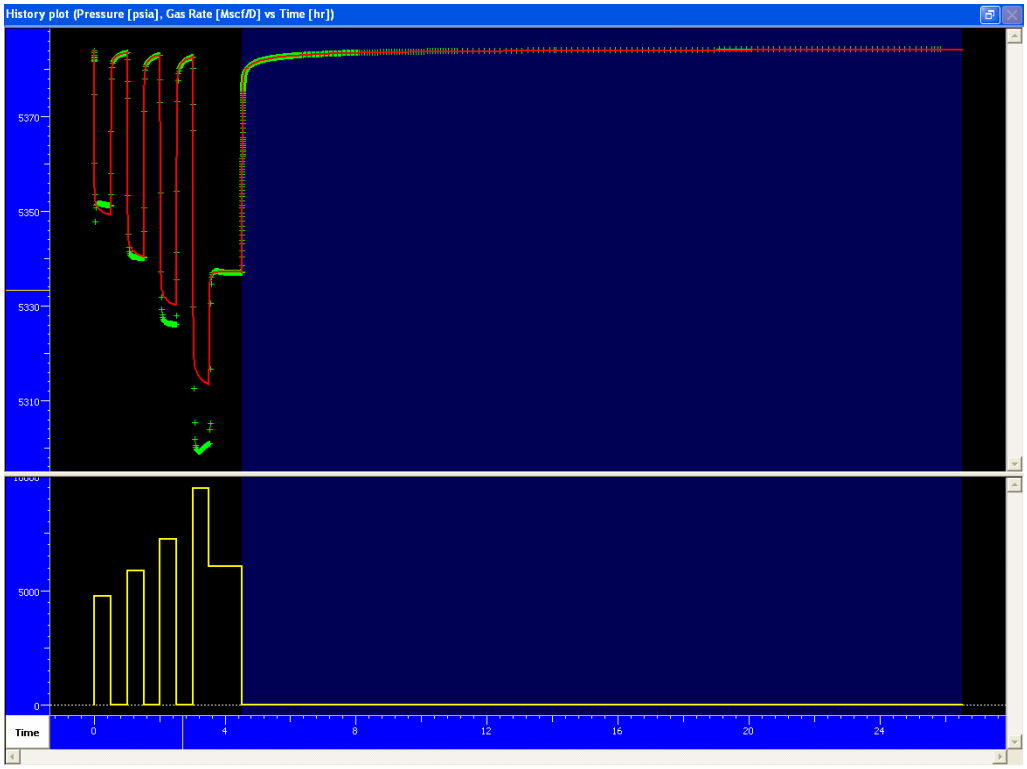


Fig B01.2

The results can be checked and browsed by a click on the  icon. There appears to be no anomalies. Maximize the history plot and observe that although the simulated pressure matches very well the final buildup there are discrepancies between the model and the real data early on in the test. See Fig B01.3.



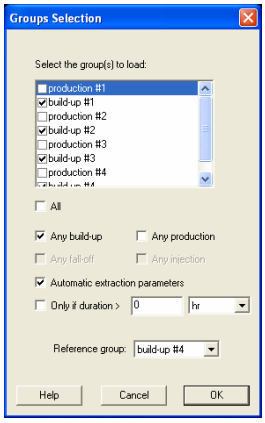
B01.3 History match

The cause for this is quite obvious rate dependent skin. The model was generated with a constant skin determined after the rate at some 6 MMSCF/D and this skin does not apply for the other rates.

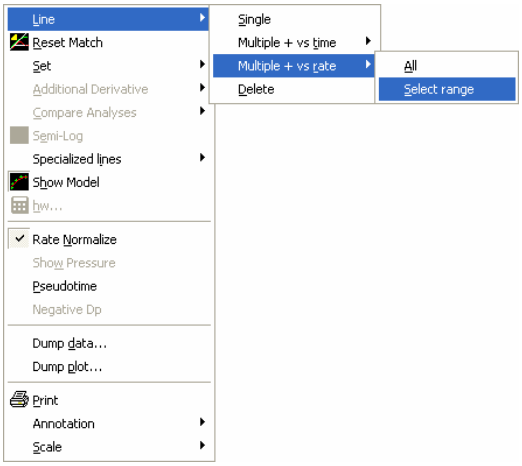
C01 • Rate dependent skin

C01.1 • Skin versus rate

One method to determine the rate dependency is to plot skin versus rate, determining the skin without turbulence (S0) and the slope (dS/dQ). Saphir can make this plot automatically if you extract all the periods or in this case the buildups that are less noisy.You estimate where the infinite acting radial flow is located and place multiple semilog straight lines in this place. Go to the group droplist in the toolbar and choose list. Select all the buildups as indicated in the figure to the left.



Right click in the loglog plot and from the popup menu choose the option Line Multiple + vs rate and select range. Select the range as indicated by the white square in the loglog plot in Fig. C01.1. This option will run a non-linear regression over the chosen range to determine permeability and the different skins for each period within the range. This will return the same kh from the semilog slope (same slope) but different skins.



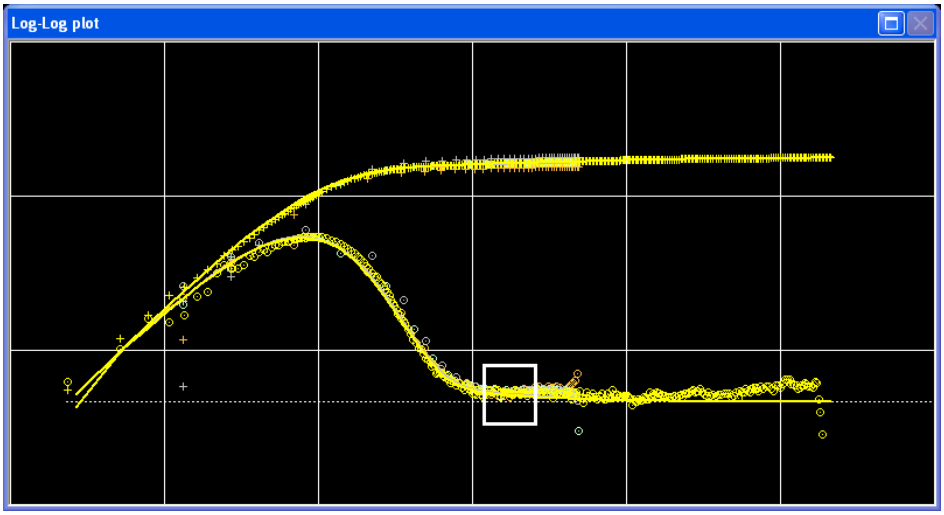


Fig C01.1 Select semilog straight line by range

The skin versus rate plot it is already displayed. The Saphir screen should look like Fig C01.2 after having rearranged the plots by using the  icon in the analysis toolbar.

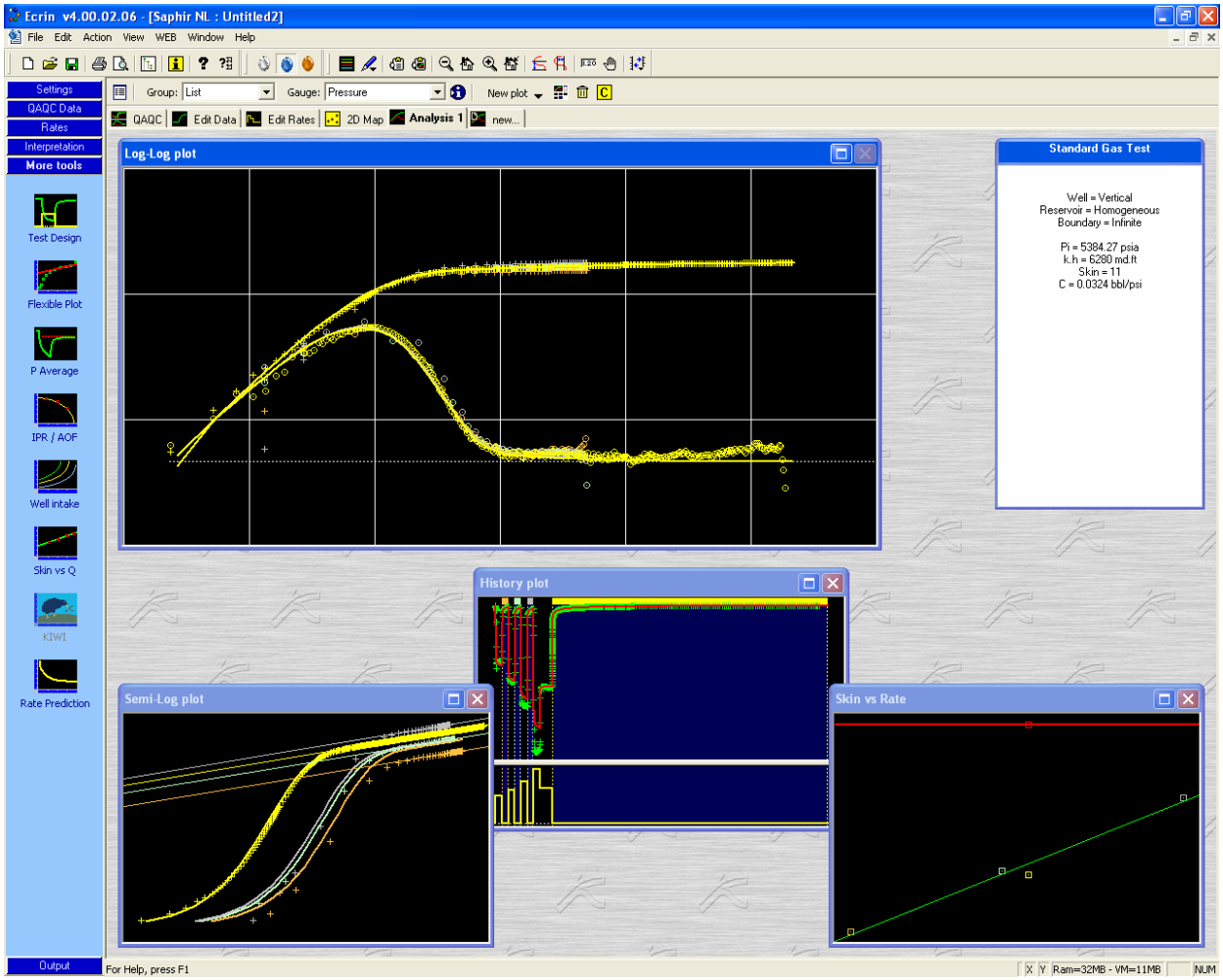


Fig C01.2 Saphir screen after generation of skin versus rate plot

The skin versus rate plot contains two straight lines, the red is the constant model skin and the green is the regressed line through the skin values transported from the semilog lines. The red point is associated with the model skin from buildup # 4, the yellow point is the semilog skin from the same buildup. The reason they do not coincide is because the semilog lines were placed too early in order to capture some information about the skin from the much shorter buildups of the isochronal sequence (0.5 hours versus 20 hours final buildup time). This is a common problem and highlights the fact that the isochronal sequence duration was too short. Maximize the skin versus rate plot and click on the  icon to see the rate dependency result.

C01.2 • How to apply the rate dependency in the model

Click on the model icon to access the model dialog. Check the option rate dependent skin, this will add two parameters in the model dialog. Click on the calculator button besides Skin0 and chose the option From skin vs rate plot, do the same for dS/dQ. Now generate the model, the history match is not perfect so we will run the improve option, but this time on the simulation (history plot). Check only the values of Skin0, dS/dQ and Pi as shown in Fig C01.3, note that the regression is run on simulation.

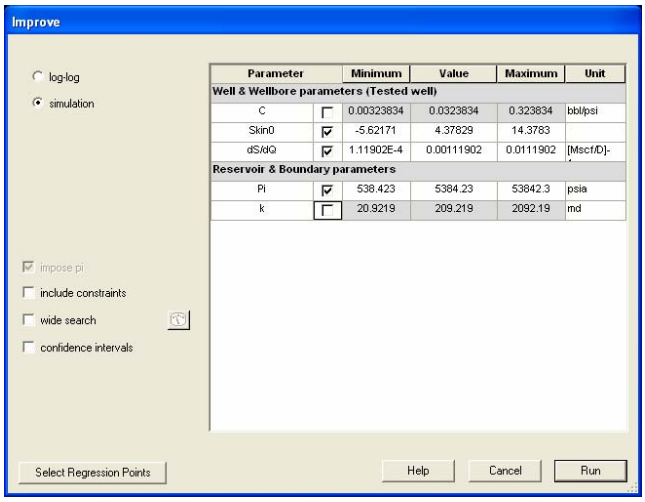


Fig C01.3 Improve setup

The history match is now nearly perfect. The skin versus rate plot shows the red line as the resulting rate dependency of the model after regression and clearly shows the problem discussed before as the red line does not overlay the green straight line resulting from the semilog analysis. Fig C01.4.

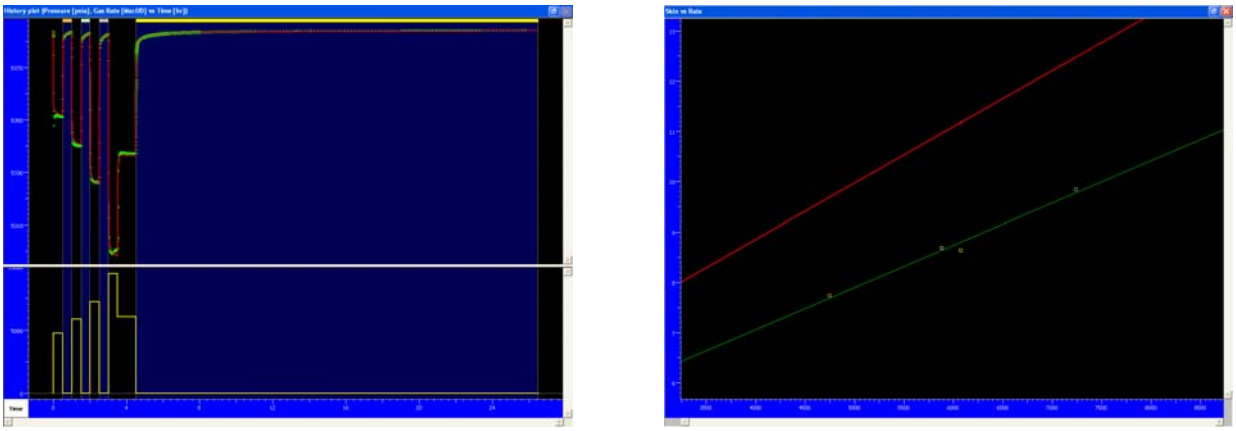
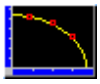


Fig C01.4 History match and skin versus rate plot

D01 • Inflow performance (IPR)

The modified isochronal test is normally carried out to assess the potential of the well and to determine its absolute open flow. For gas wells in addition to Darcy and Jones methods, we have multi-rate IPRs incorporated in Saphir for the C and n and the LIT methods.

Select the More tools panel and then the IPR option through the  icon. Choose vertical well and the method C and n. Select Modified isochronal test and input the value for the average pressure as 5384 psia. We will use the pick option to choose the test points and the extended period. You should not impose the power of N or any constraints. See Fig D01.1 left. Proceed to pick the sandface test points, make sure you check the radio button “Rates” rather than “Groups”, pick the first four points with the mouse as shown in Fig D01.1 right. And then pick the extended rate before the build up. The AOF plot is constructed as seen in Fig D01.2.

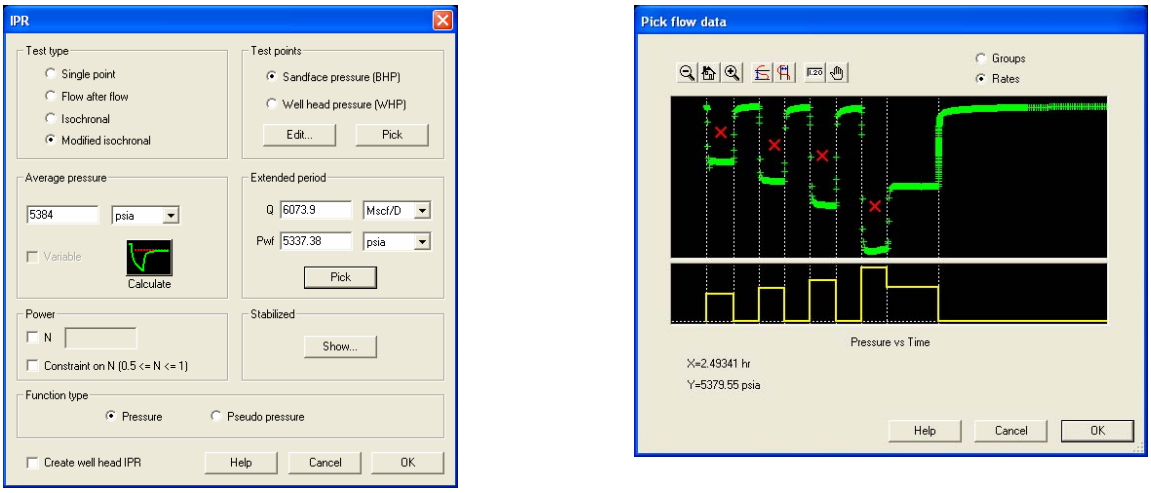


Fig D01.1 Setting up and picking points for AOF/IPR plot

The yellow line is the extended curve and the red line is the transient rates. The test points line up perfectly and the results from this analysis is perfectly acceptable with an exponent well within the allowable range (0.5<n<1).

The plot can also be displayed as the classical IPR curve (bottom hole pressure versus rate) by clicking the  icon in the plot specific toolbar, Fig D01.3.

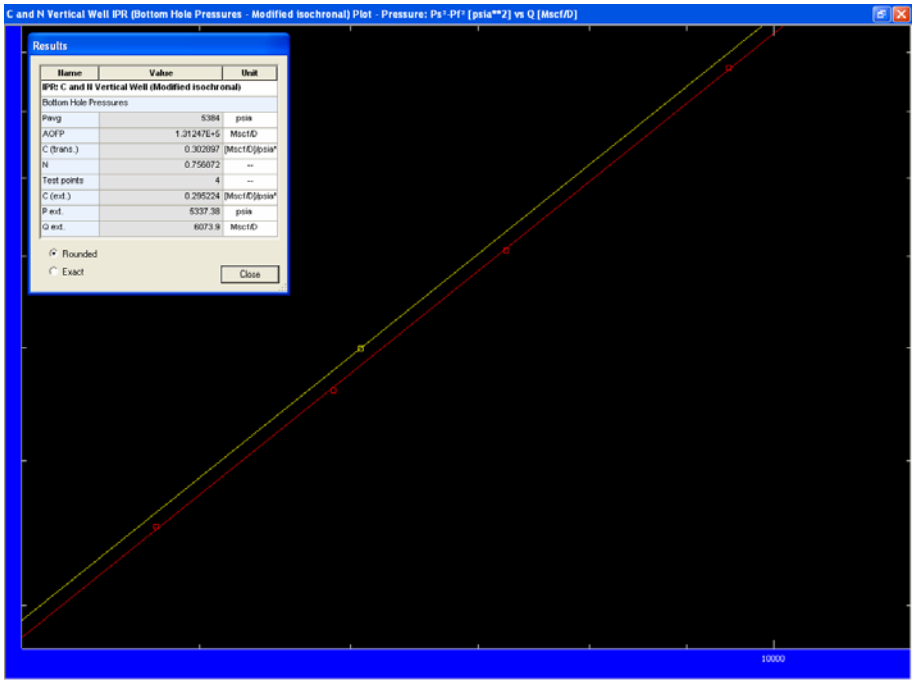


Fig D01.2 AOF plot

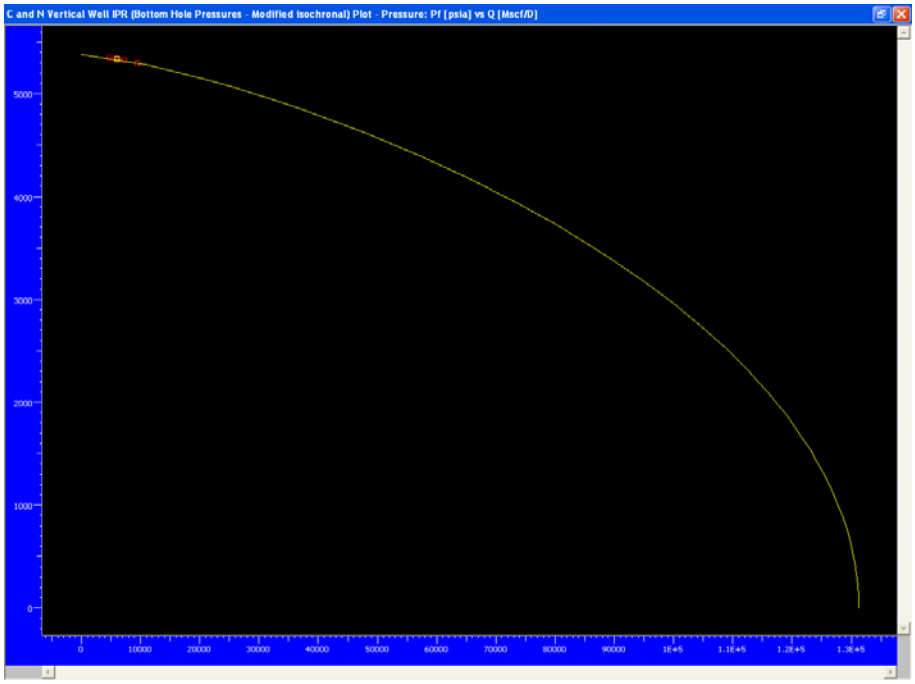


Fig D01.3 IPR plot

E01 • Finalizing the model match

Lets work on the final buildup. Go to the group droplist in the analysis toolbar and choose buildup #4. The late time data of the derivative does not match properly, this is most probably caused a change in mobility due to the proximity of bottom water.

In order to model this phenomenon analytically you can use an equivalent linear composite model. Click on the model dialog icon and change the homogeneous reservoir option to linear composite. This adds the distance to the gas/water interface, the mobility and diffusivity ratio to the model parameters. A leakage factor of the interface is also added.

Use the pick options to set the parameters.

You should end up with a loglog match similar to the one illustrated in Fig E01.1.

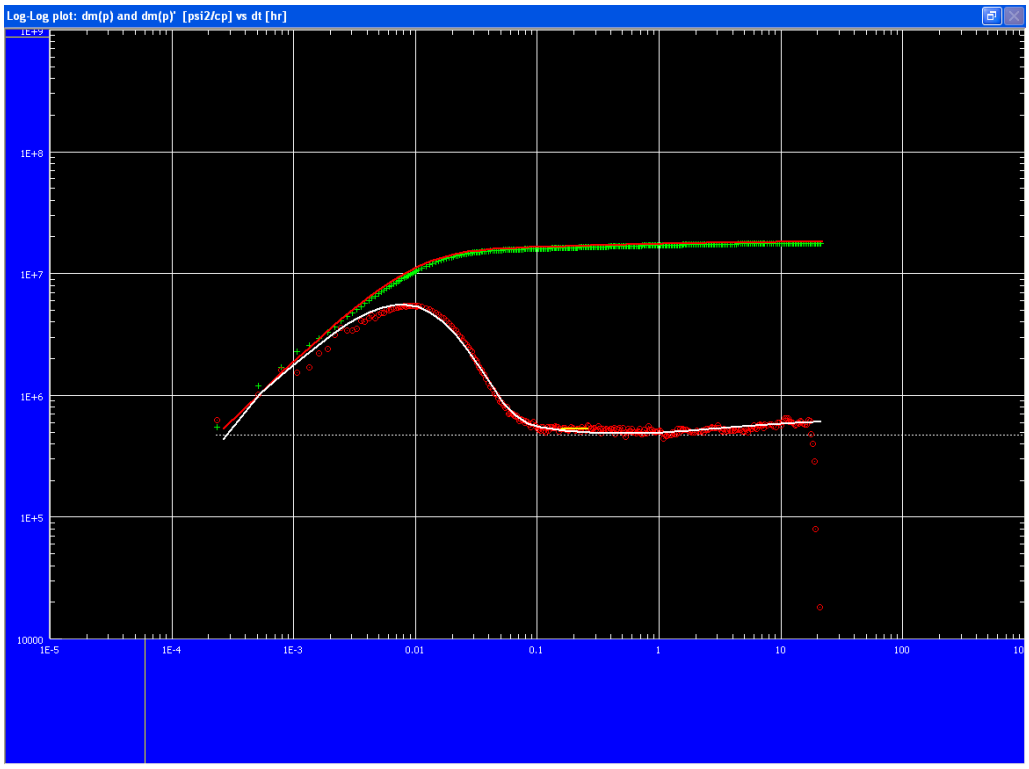


Fig E01.1 Final loglog match

F01 • Material Balance

The material balance option is available in the model dialog to model gas tests in a closed system. It takes into account the changing fluid compressibility with respect to the depleting average pressure.

Open the session with the file SapGS04_2.ks3 loacted in the Example directory.
The pressure data has been generated with a numerical simulator and takes into account the exact PVT at the actual pressure at any point of the reservoir.

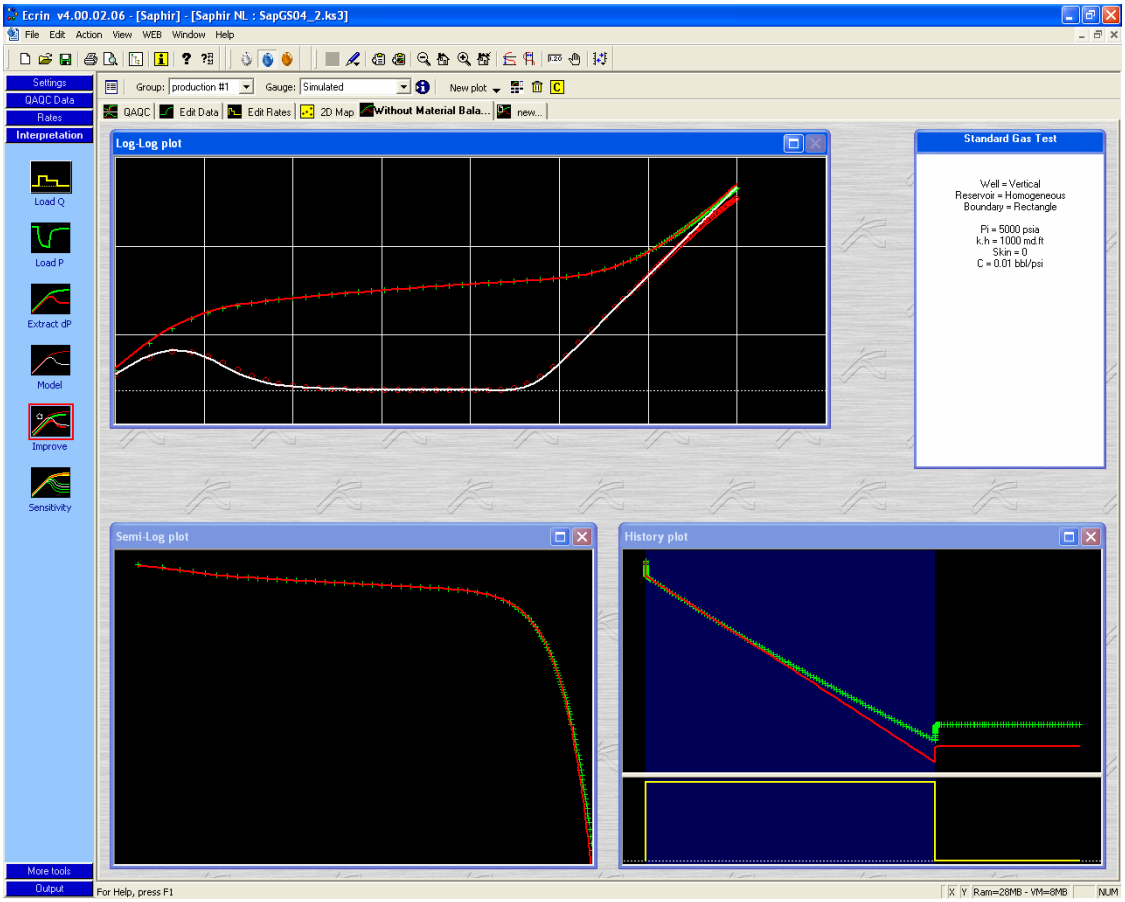


Fig F01.1 Analytical model match closed square without material balance

The data clearly exhibits the pseudo-steady state behavior of a closed reservoir.
The match is made with an analytical model of a well in a 4000ft x 4000ft square closed rectangle without the gas material balance option. The analytical model simulation exhibits a constant linear pressure decline higher than the decline given by the numerical simulation. This is due to the fact that the fluid compressibility increases when the pressure depletes. In other words, the same amount of extracted fluid makes the pressure decline less. The match is poor at late time in the loglog plot (production #1) and does not match the buildup at all in the History plot.

Create a new analysis from the previous.
Click on the Model icon to call the Model dialog:
Check the “material balance” option check box and Generate.

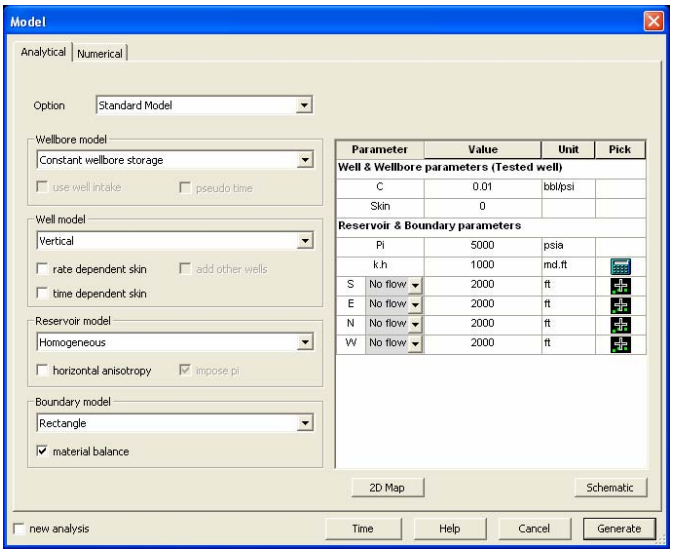


Fig F01.2 Model dialog

The Saphir screen should now look like Fig F01.3.

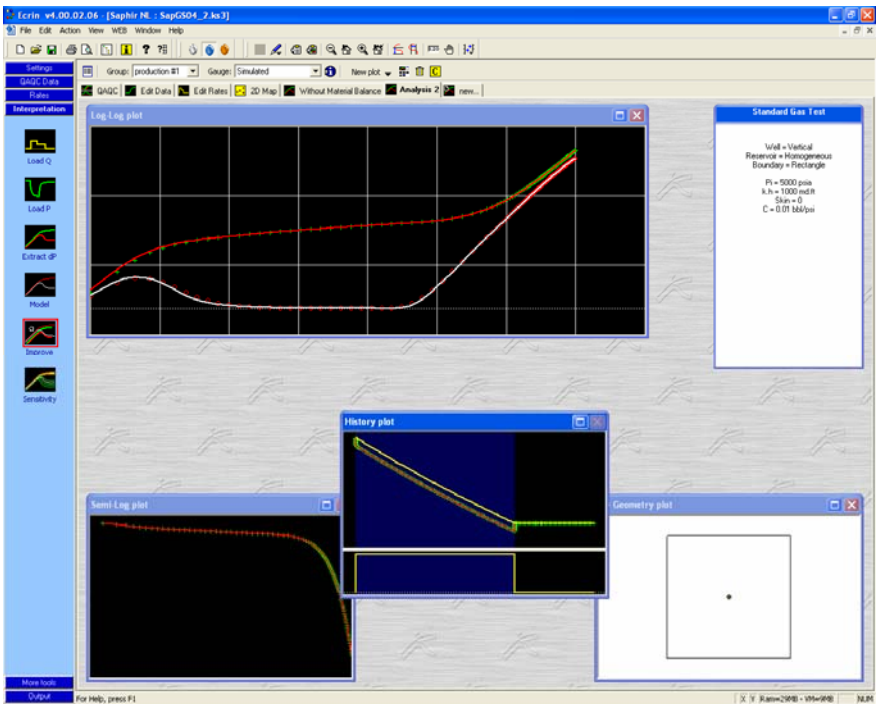


Fig F01.3 Closed system model with material balance option

Note: the “2D Geometry plot” shown on this screen copy can be enabled in the “Settings” control panel, “Interpretation” icon, “Misc” tab, by checking the “Reservoir Geometry” box on.

The analytical model utilizing the “material balance” calculation option now shows complete agreement with the simulator results. The History plot also displays a yellow curve that is the result of the “calculated average pressure versus time” during the extended production period.