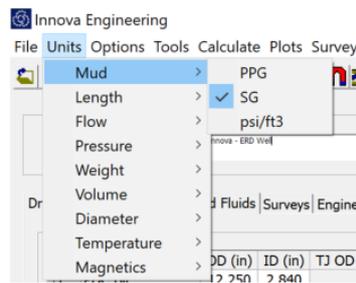# 1.0 - Hydraulics Module Quick Start Guide

This document will deal with the Hydraulics module within Innova Engineering and will detail the steps required to run these calculations.

1.1 - Setup

It is important to ensure that the correct Units are selected before you do anything else as changing units after the data has been input can lead to mistakes.

Hydraulics Model Options should then be checked from the Options menu. These relate specifically to the surge and swab calculations.
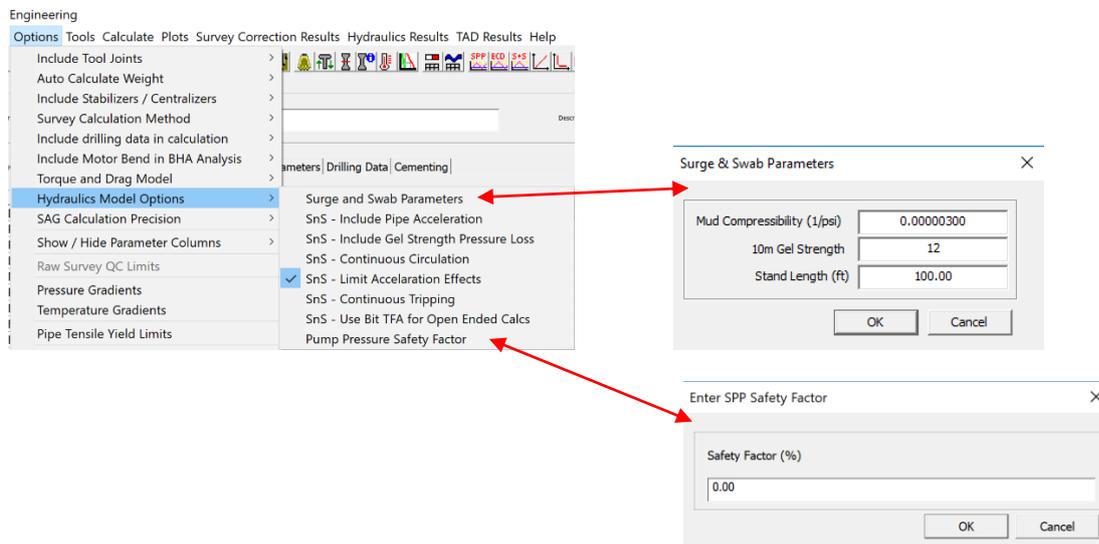
Surge and swab is calculated by breaking down the measured depth into sections of a given length (Stand Length), where 30m / 100ft is the default. The program then does a lumped surge and swab calculation over this course length, where the pipe accelerates from 0 to the desired trip speed and then decelerating back to zero.

The acceleration and deceleration phases are calculated based on the trip speeds entered in the Engineering Parameters tab; the higher the trip speed the larger the acceleration effect. The generated outputs in the plot and data table, are the maximum surge or minimum swab values calculated over this interval.

- **Surge and Swab Parameters**:

    o Mud Compressibility: A compressibility factor for the mud in 1/psi. Default for most oil based fluids is 3×10^{-6}

    o 10m Gel Strength: 10 minute gel strength, used to calculate the additional surge pressure required to break down the gels. Default is **12**.

    o Stand Length: Length of the stand used in the calculations. Default is **30m / 100ft**.

- **SnS - Include Pipe Acceleration**: This option allows the user to include or exclude pipe acceleration. When this is included, the calculation will use an acceleration and deceleration phase for each stand length. When it is not included, the trip speed will be used for the whole stand with no acceleration or deceleration phase. Default is **Off**.

- **SnS - Include Gel Strength Pressure Loss**: Include the additional pressure required to break down the gels. This is normally a relatively small value. Default is **Off**.

- **SnS – Continuous Circulation**: Used to model coiled tubing. Assumes circulation while tripping, this means that swab affects will be less and surge effects will be more depending on flow rate. The first flow rate in the flow grid of the Engineering Parameters tab is used to determine the annular velocity generated by the circulating fluid. Default is **Off**.

- **SnS – Limit Acceleration Effects**: This option limits the additional surge pressures due to acceleration to a maximum of 2 x the current max surge pressure. This stops very large (artificial) equivalent mud weights being generated when very shallow. Default is **On**

- **SnS – Continuous Tripping**: This option assumes continuous tripping, and as a result will only calculate one acceleration phase (on the first stand length) and one deceleration phase (on the last stand length). This option is best used to model coiled tubing. Default is **Off**.

- **SnS – Use Bit TFA for Open Ended Calcs**: This option allows the user to use the bit TFA when running open ended surge and swab calculations. This will only work for assemblies which have a bit and a TFA entered. When this selection is off, the program uses the internal diameter of the last component. Default is **Off**.

- **Pump Pressure Safety Factor:** This option allows the user to increase the SPP by a specified percentage. Pipe Pressure Loss, Annular Pressure Loss and SPP values are all adjusted to reflect the input Safety Factor.

1.1 - Required Inputs

In order to run Hydraulics, the following inputs are required.

**Drill String, Well Geometry & Fluids Tab**

- **Drill String**: Input the assembly as accurately as possible including the drill pipe to surface (note, for the last component e.g. DP to surface, the user does not have to input the exact length as the program will do this automatically based on the calculation depth. Inputting a value of 10 is fine). Note that once you have selected the component type it is possible to right click on the line and select "*select from Library*", which will open the components library.
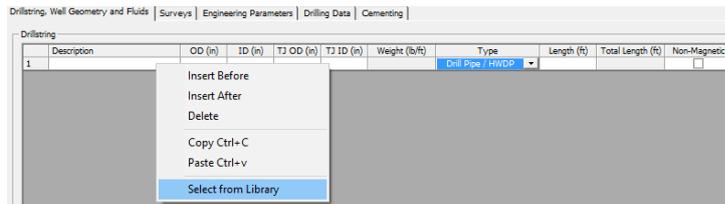

- **Bit TFA**: This is selected in the component details section when the bit is selected. The user can select a fixed TFA or can input multiple nozzles and sizes and a TFA will be generated based on this selection.
- **Motor Pressure Drop**: This is selected in the component details section when the motor is selected.
- **MWD Pressure Drop**: This is selected in the component details section when the MWD is selected.
- **Well Geometry**: Input casing, liner and open hole details including depths and ID's. For Open hole, the ID is the OD of the bit.
- **Mud weight:** Mud density used in all hydraulics calculations
- **PV:** Mud plastic viscosity only used if Bingham Plastic hydraulics model is selected
- **YP:** Mud yield point only used if Bingham Plastic hydraulics model is selected
- **Mud Rheology**: The Fann dial readings of the drilling fluid, used for all hydraulics models except Bingham plastic.
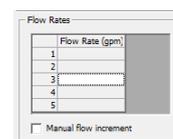
Surveys Tab

- **Survey Selection**: Hydraulics calculations can be run against surveys and well plans. Data can be input as measured depth, inclination and azimuth in both Actual Surveys or Well Plan Surveys and the program will generate the rest of the numbers using whichever survey calculation method you have selected (Minimum Curvature Default). Hydraulics cannot be run against surveys input the RAW surveys section. Either enter the plan or surveys manually, import them or copy and paste the data directly into the cells.

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Drilling & Intervention
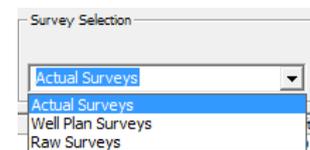
The **Engineering Parameters** Tab, is where the user can select the parameters they want, to run the Hydraulics calculation.
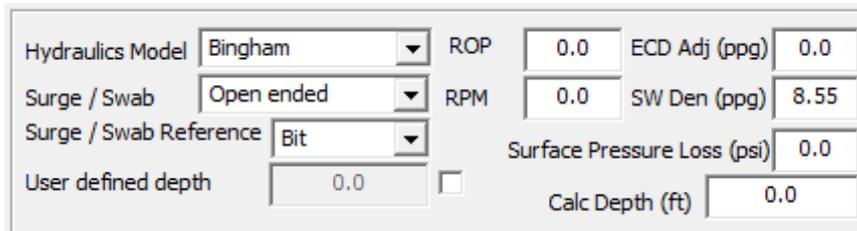

- **Hydraulics Model** –four models are included as standard
  - Bingham Plastic
  - Power Law
  - Herschel Bulkley
  - Robertson Stiff
  - Bingham plastic uses PV and YP and mud weight, all other models use the fann readings and mud weight.
- **Surge / Swab** – Specifies if the surge and swab calculation to be carried out is open or close ended. If modelling for a casing or liner assembly and close ended is used, the pressure loss through the float / shoe is taken in to account
- **Calc Depth** – This is the depth you wish the calculation to stop at and the depth at which snap shot calculations will be performed. The depth has to be within the range of the surveys for a directional well.
- **Surge / Swab Reference** – This is the reference point for the surge / swab calculation, select some common references from the combo box such as bit, shoe and bottom hole or click on the check box to enable a user defined depth.
- **User defined depth** – Only active if the enable check box has been ticked, this will disable the surge / swab reference combo above and the surge and swab reference depth can be entered in the edit box.
- **ROP** – Rate of penetration, this is used to calculate the cuttings loaded ECD's and other hole cleaning parameters
- **RPM** – the rotational speed of the drill string
- **ECD Adj** – ECD adjustment is manual adjustment to all the ECD curves in order to better match the model with MWD PWD data.
- **SW Den** – Sea water density, which is used for riserless drilling calculations
- **Surface Pressure Losses** – The pressure loss through the surface equipment. This value is added to the total standpipe pressure calculated by the model.

- **Flow rate**: The user enters a flow rate in cell 3 and the program automatically generates 4 additional flows (±25% &±50% of the input). If manual flow increment is selected, the user can enter as many or as few flow rates as required.

- **Survey Selection**: The user can select either **Well Plan Surveys** or **Actual Surveys**. There is also an option to select **Composite Listing**, which splices the actual surveys in to the well plan surveys to create a composite listing.
- **Tripping Speed**: The user enters a tripping speed in cell 3 and the program automatically generates 4 additional tripping speeds (±25% &±50% of the input). If manual tripping increment is selected, the user can enter as many or as few tripping speeds as required. The tripping speed is used in Surge Swab calculations.
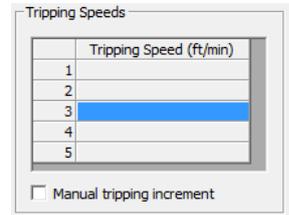
1.3 - Running the Calculation

Once the user has completed all the required inputs the calculation can be run. To do this, select either the icon displayed below, or select **Calculate - Hydraulics**
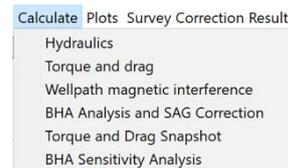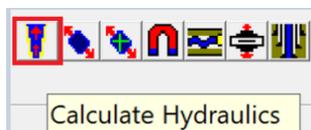
1.4 - Output

Hydraulics Results

Once a calculation has been run, the hydraulics results section of the Engineering Parameters tab will be populated with the results. The results displayed are for the flow selected at the top right of this section. This flow is a drop-down menu which will contain the same flows input during the setup, so if only one flow was used, there will be only one available here. The depth can also be adjusted by clicking on the arrows to the right of the depth and it will scroll in 30m / 100ft intervals and display the results based on the depth and flow selected.

Note that whatever results are displayed in this section (based on the flow and depth selected), will be output in the summary report.
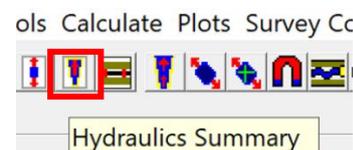
Reports

Once the calculation has been run, the **Hydraulics Summary Report** can be viewed by selecting the icon from the toolbar at the top of the screen. This contains an overview of the main values associated with the calculation and can be saved as a pdf.

If required, a more detailed report can be generated by selecting "**File**" - "**Print Reports**", or selecting the icon on the toolbar (highlighted above). The required data can be selected and a report can be generated either as excel of pdf. Note that when excel is selected the chart selection will be greyed out as these can only be output as pdf.
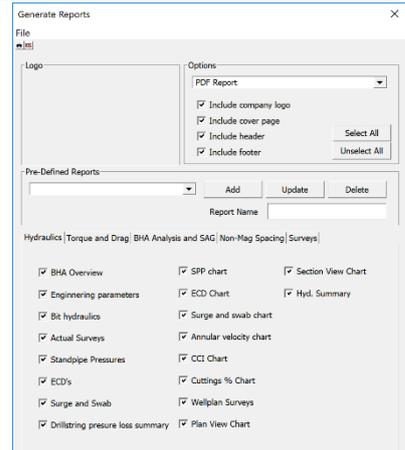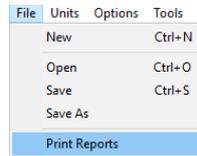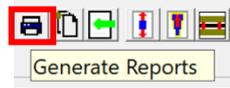
Some of the Hydraulics results are available to view by selecting the toolbars along the top. This is a quick way to access some of the more commonly used plots.
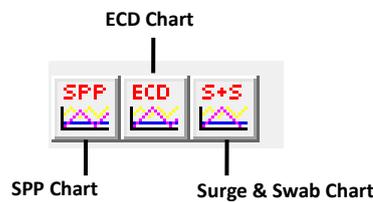
All of the Hydraulics plots and data are available to view by selecting the Hydraulics results at the top of the screen. The Data options display the numerical data used to generate the charts. Note that there is no option to view the data for the Annular Velocity Profile, CCI and Cuttings % Charts.
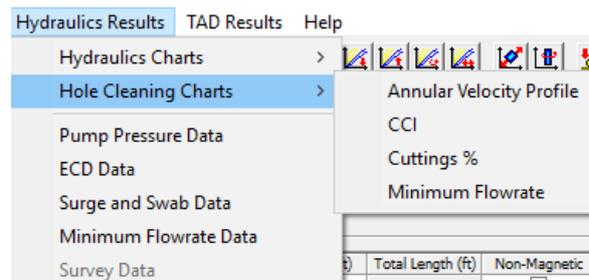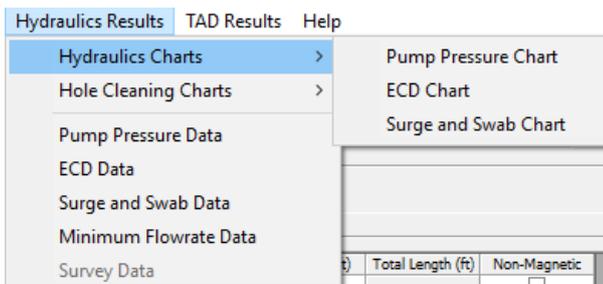
Hydraulics Charts

The hydraulics charts give a graphical representation of the theoretical values you would expect to see as the well is being drilled. Therefore, at each depth, the numbers displayed on the charts and the data tables can be directly compared with values recorded from the SPP gauge and down hole tools, as the well is being drilled.

SPP Chart

The Stand Pipe Pressure (SPP) Chart, displays the SPP that is calculated at each depth as the well is drilled. This chart will include a line for each flow rate which has been selected in the flow rate section of the Engineering Tab.

ECD Chart

The ECD Chart will display the calculated ECD values at each depth as the well is drilled. For each flow rate there will be 3 lines.

Clean ECD - This is the ECD at a given flow based on a clean annulus i.e. no cuttings loading

Dirty ECD - This is the ECD at a given flow, based on a cuttings loaded annulus. The level of cuttings loading is determined by the ROP selected in the Engineering Tab. The higher the ROP value, the more cuttings loading. If an ROP of zero is selected, the clean and dirty ECD lines will match.

ECD Snapshot - This is a snapshot chart and shows the Clean ECD at all different points in the wellbore when the assembly is at a given depth. Unlike the other 2 lines, the numbers generated are only relevant to one calculated depth. The snapshot value generated at the bit will be the same as the clean ECD value at the final calculated depth.

Mud Weight is also displayed on this chart.

Surge & Swab Chart

The Surge & Swab chart displays the calculated ECD values at each depth as the well is drilled, based on the tripping speed entered in the Engineering Tab. For each tripping speed entered there will be a Surge line and a Swab line displayed.

Mud Weight is also displayed on this chart.

Hole Cleaning Charts

Innova Engineering Hydraulics Module contains 4 (snapshot) hole cleaning charts. A basic explanation is given below. For a more detailed explanation of these, see Innova's "*Hole Cleaning Guide*".

Annular Velocity Profile Chart

This is a snapshot chart and shows the Annular Velocity at all different points in the wellbore when the assembly is at a given depth for various flow rates.

CCI (Cuttings Carrying Index) Chart

CCI (Cutting Carrying Index) is a measure of how clean a vertical (0-35° inc) well is.

This is a snapshot chart and shows the CCI at all different points in the wellbore when the assembly is at a given depth for various different flow rates.

Cuttings % Chart

The Cuttings % Chart represents the percentage of the annulus which is taken up with cuttings.

This is a snapshot chart and shows the Cuttings % at all different points in the wellbore when the assembly is at a given depth for a given ROP at various different flow rates.

Minimum Flow Rate Chart

The minimum flow rate Chart is a snapshot chart which shows the minimum flow required to keep the hole clean at all points in the wellbore for a range of ROPs at a certain depth.