



INNOVA
Drilling & Intervention

Hydraulics Quick Start Guide

Rev 1.3

Contents

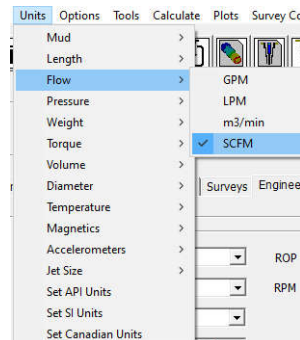
1.0 - Hydraulics Module Quick Start Guide.....	3
1.1 - Setup	3
1.2 - Required Inputs.....	6
1.3 - Running the Calculation.....	9
1.4 - Output.....	9
1.4.1 - Hydraulics Results	9
1.4.2 - Reports.....	10
1.5 - Hydraulics Charts	11
1.5.1 - Pump Pressure Chart	11
1.5.2 - ECD Chart	11
1.5.3 - Surge & Swab Chart	11
1.6 - Hole Cleaning Charts.....	12
1.6.1 - Annular Velocity Profile Chart	12
1.6.2 - CCI (Cuttings Carrying Index) Chart.....	12
1.6.3 - Cuttings % Chart.....	12
1.6.4 - Minimum Flow Rate Chart	13

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.

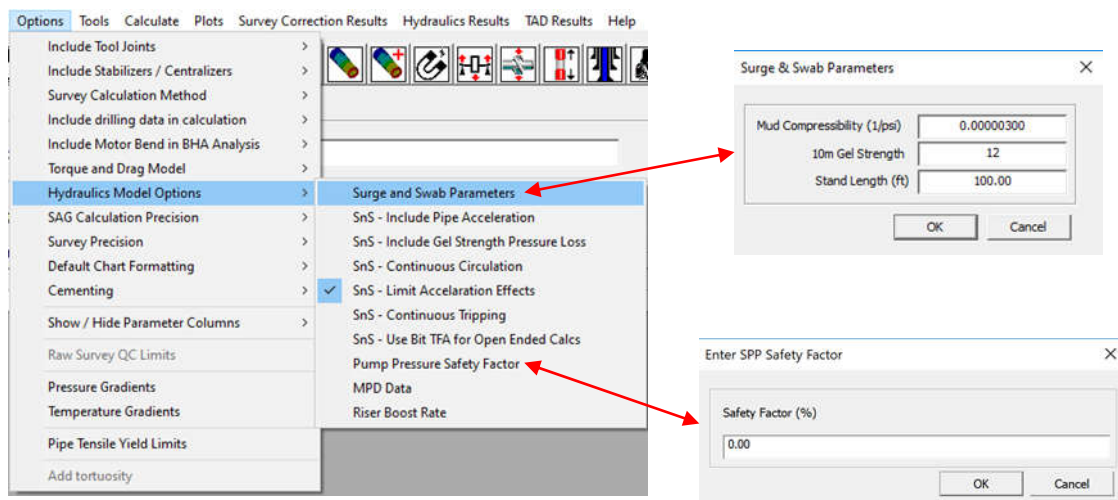
1.1 - Setup

Units: 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. **Note: If air drilling is being modelled, SFCM must be selected as the Flow units to activate air drilling mode.**



Note: If the unit for Flow is selected as SFCM in the Units Menu, Engineering will assume that **air drilling** is being modelled. In this case the calculation will ignore Mud Weight, PV, YP and Mud Rheology, and instead assume the properties of air as the drilling fluid.

Hydraulics Model Options should then be checked from the Options menu. These mostly relate 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.

Below is a description of each option:

- **Surge and Swab Parameters:**
 - Mud Compressibility: A compressibility factor for the mud in 1/psi. Default for most oil-based fluids is 3×10^{-6} .
 - 10m Gel Strength: 10-minute gel strength, used to calculate the additional surge pressure required to break down the gels. Default is **12**.
 - 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.
- **MPD Data:** This option allows the user to enter a back pressure for Managed Pressure Drilling.

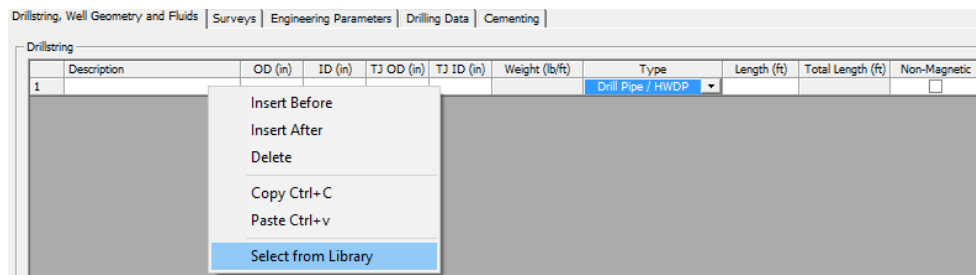
-
- **MPD Setup.** The MPD Back Pressure is added as a fixed value to all of the SPP calculation totals and will also be reflected in the ECDs.
 - **EMW Calculator:** The user inputs the desired EMW increase at a specific TVD and the required back pressure to be applied is calculated. The user can then enter this value in the MPD setup.
 - **Riser Boost Rate:** The boost flow rate across the riser is entered here. This additional flow in the riser annulus affects the annular pressure loss, annular velocity, hole cleaning and ECDs in the riser only. This in change in the riser values affects the SPP, annular pressure loss, hole cleaning and ECDs for the section. This is only applicable in wells where the **Well Geometry** includes a '**Riser**'. If the well geometry does not include a riser, any value entered here will have no effect on the calculated outputs.

1.2 - 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.



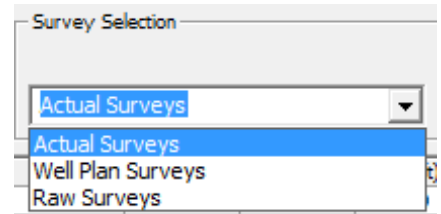
Input the dimensions of the drill sting components into the Drill String grid:

- **Description:** A description of the component entered, this is only used in the generation of reports and plays no part in any of the calculations.
 - **OD:** The outer diameter of the component in inches.
 - **ID:** The inside diameter of the component in inches.
 - **TJ OD:** If the component has a tool joint (such as drill pipe) enter the OD in inches into this column. If the "Include TJ in calculations" menu option is turned off this column will be disabled.
 - **TJ ID:** If the component has a tool joint (such as drill pipe) enter the ID in inches into this column. If the "Include TJ in calculations" menu option is turned off this column will be disabled.
 - **Length:** The length of the component in the system units.
 - **Component:** Select the component type from the drop-down list. The type of component that is selected will determine the properties displayed in the lower components grid.
- **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, required for all hydraulics models except Bingham plastic.

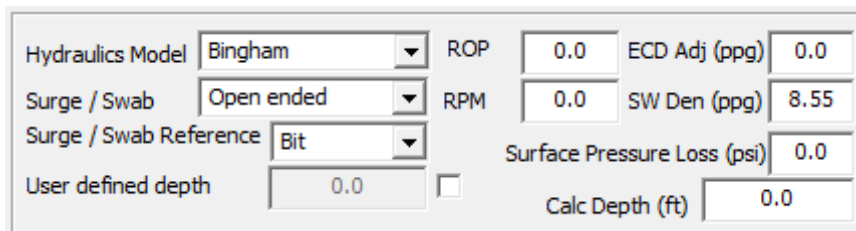
Surveys Tab

- **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.



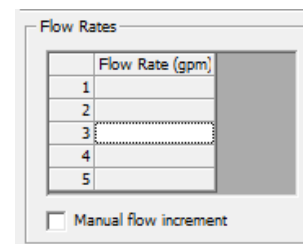
Engineering Parameters Tab

This 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 into account.
- **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.

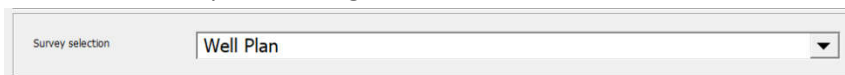
- **RPM** – The rotational speed of the drill string. Additional pressure will be added based on the RPM.
- **ECD Adj** – ECD adjustment is manual adjustment to all the ECD curves in order to better match the model with MWD PWD data.
- **SW Den** – Sea water density, which is used for riserless drilling calculations
- **Surface Pressure Losses** – The pressure loss through the surface equipment. This value is added to the total standpipe pressure calculated by the model.
- **Calc Depth** – This is the depth you wish the calculation to stop at and the depth at which snapshot calculations will be performed. The depth must be within the range of the surveys for a directional well.
- **Flow rate:** This grid allows the flow rates for the hydraulics model to be entered. By default, the manual flow increment box is unchecked, and the user enters a flow rate in the middle cell of the grid. The software then automatically calculates flow rates above and below this base rate ($\pm 25\%$ & 50%) with which to perform a sensitivity analysis. If you wish to override the automatic values generated, click the enable manual flow increment check box. This will leave the user with a single line and once filled a new line will be added. An unlimited number of flowrates can be entered.
- **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 into the well plan surveys to create a composite listing.



Flow Rates

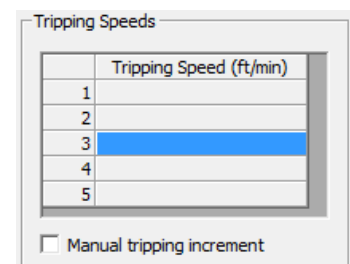
	Flow Rate (gpm)
1	
2	
3	
4	
5	

☐ Manual flow increment



Survey selection: Well Plan

- **Tripping Speed:** This grid allows the tripping speeds for the hydraulics model to be entered. By default, the manual tripping increment box is unchecked, and the user enters a tripping speed in the middle cell of the grid. The software then automatically calculates tripping speeds above and below this base rate ($\pm 25\%$ & 50%) with which to perform a sensitivity analysis. If you wish to override the automatic values generated, click the enable manual trip increment check box. This will leave the user with a single line and once filled a new line will be added. An unlimited number of trip speeds can be entered but the first trip speed entered will be used for the reports. The tripping speed is used in Surge Swab calculations.



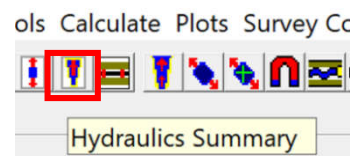
Tripping Speeds

	Tripping Speed (ft/min)
1	
2	
3	
4	
5	

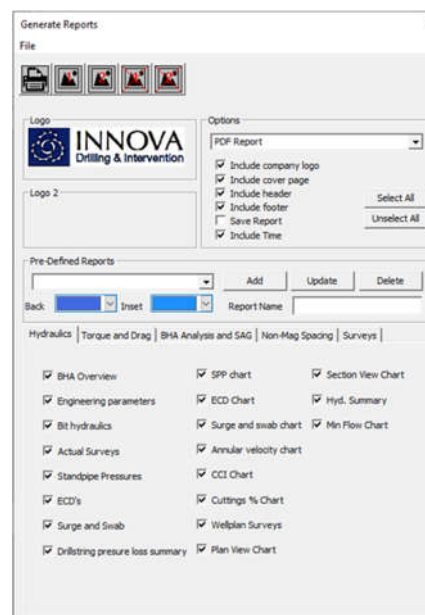
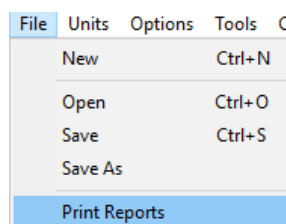
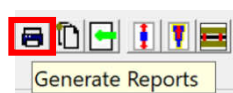
☐ Manual tripping increment

1.4.2 - Reports

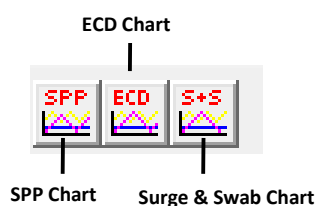
Once the calculation has been run, the **Hydraulics Summary Report** can be viewed by selecting the icon from the toolbar at the top of the screen. This contains an overview of the main values associated with the calculation and can be saved as a pdf.



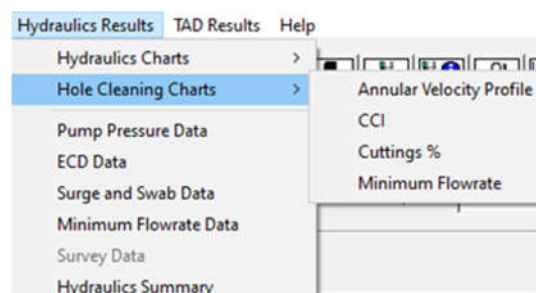
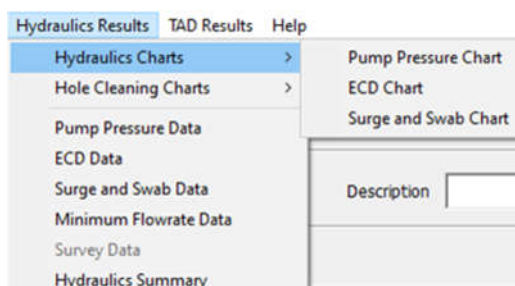
If required, a more detailed report can be generated by selecting "File" - "Print Reports" or selecting the icon on the toolbar (highlighted above). The required data can be selected, and a report can be generated either as excel or pdf. Note that when excel is selected the chart selection will be greyed 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 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.



1.5 - 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.

1.5.1 - Pump Pressure Chart

This chart displays the standpipe pressure (SPP) expected at surface when the assembly is at any given depth. There will be a line displayed for each of the flowrates entered in the hydraulics section of the Engineering Tab. If pump liner data has been added to the pump data dialog in the tools menu, then this can also be represented on the chart via the add series dialog.

1.5.2 - ECD Chart

This chart displays the following lines for each of the flowrates entered in the hydraulics section of the Engineering Tab:

- **Clean ECD:** The ECD at the end of the string, for any given depth, based on a cutting's free annulus.
- **Dirty ECD:** The ECD at the end of the string, for any given depth, based on a cutting's loaded annulus. The volume of cuttings in the annulus is calculated based on the ROP entered in the hydraulics section of the Engineering Tab. If the ROP is entered as zero then the clean and dirty ECD lines will lie on top of each other.
- **ECD Snapshot:** The ECD snapshot line shows the expected ECD at each point in the annulus when the string is at a given depth. This depth relates to the deepest depth represented on the chart. This line is generated based on a cuttings free annulus, which means that the last point for both the Clean ECD line and the ECD Snapshot line will be the same.

A line representing the **Mud Weight** is also displayed on the chart.

1.5.3 - Surge & Swab Chart

This chart displays the surge and swab lines for each of the tripping speeds entered in the hydraulics section of the Engineering Tab.

The Y axis corresponds to the bit depth (bottom of the assembly being run) regardless of what has been selected as the reference point. The results, however, display the calculated values at the reference point based on the bit position. So if for example you have the reference point selected as the bottom of the hole, when you look at the chart, it will be displaying the surge and swab pressures at the bottom of the hole, when the bit is at any given depth.

The reference point is selected in the hydraulics section of the Engineering Tab and is displayed at the top of the chart.

1.6 - 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**".

1.6.1 - Annular Velocity Profile Chart

Flow rate is the dominant factor in cuttings removal while drilling directional wells. An increase in flow rate will result in more efficient cuttings removal under all conditions. However, how high a flow rate can be increased may be limited by:

- The maximum allowed ECD
- The susceptibility of the open hole section to hydraulic erosion
- The availability of rig hydraulic power

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 the various flow rates.

1.6.2 - CCI (Cuttings Carrying Index) Chart

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

- 0.5 or less and hole cleaning is poor & problems may be seen
- Greater than or equal to 1.0 indicates good hole cleaning

Annular Velocity and Mud weight (along with PV & YP values) are used in this calculation. The higher the annular velocity, the higher the CCI.

For sections of the wellbore where the inclination is greater than 35°, hole cleaning should be evaluated using the **Cuttings % Chart**.

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 the various flow rates.

1.6.3 - Cuttings % Chart

The Cuttings % plot represents the percentage of the annulus which is taken up with cuttings. Anything above 5% should be considered a problem.

Unlike the CCI plot, this measure of hole cleaning is not limited by inclination and can be used for any well profile. This calculation is also affected by ROP and RPM. Increased ROP, increases the 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.

1.6.4 - Minimum Flow Rate Chart

The minimum flow rate plot 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.

The ROP value selected in the hydraulics setup (e.g. 10m/hr) will be used as the lowest ROP and 4 additional ROP values will be displayed which are automatically generated by the program and are pre-set percentages of the original (125%, 150%, 200% & 250%). These percentages are built into the program and are not adjustable by the user.

To interpret the plot, the user needs to find the largest flow rate for any one ROP and that will be the minimum flow that is required at that depth to keep the hole clean. This can be done by using the Screen Reader or the data table.