



INNOVA
Drilling & Intervention

Innova Engineering
OPERATING MANUAL
Rev 3.3

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System Requirements

- 1 gigahertz (GHz) or faster 32-bit (x86) or 64-bit processor
- 2 GB of RAM
- 500MB of hard disk space
- Microsoft Windows 7, 8 or 10
- Windows XP and Apple are NOT supported

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- (c) fire, explosion, storm, flood, earthquake, subsidence, epidemic or other natural disaster;
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1.0 - Software Overview

Innova Engineering is a complete well engineering software solution combining the power of multiple packages into one application. Incorporating Hydraulics, Torque & Drag, BHA Analysis, Casing Centraliser Placement and standoff, Jar Placement, Cementing Design, Casing Design, Survey Correction (SAG / Short Collar / Multi-Station Analysis) & Q.C. & BHA Magnetic Interference Calculator, Innova Engineering provides a comprehensive engineering package to plan and drill your well successfully.

Innova Engineering was developed by engineers for engineers to provide the premier engineering software package for the oil and gas industry. With exceptional functionality and an intuitive yet powerful interface, Innova Engineering delivers an innovative and integrated solution for Operators and Service Providers alike.

Main features

- Simple to use interface, in a standalone package
- Extremely fast calculations; results for complex BHAs at multiple flow rates / friction factors are calculated in seconds
- Copy and paste data from Well Seeker, Excel, Notepad or any other file type directly into Innova Engineering
- Easy to interpret graphical and numeric outputs available for all calculation modules
- Create professional, user customized reports in both PDF and Excel formats for all outputs
- Detailed Summary Reports for each module
- Fully customisable charts complete with screen reader to allow quick interpretation of generated data
- Overlay data collected from the wellsite against the modelled outputs for quick and easy comparison
- Supports modelling of complex drilling assemblies with multiple hole opener / under reamer combinations as well as casing / liner runs
- Complete support for complex 3D directional wells
- Import / Export BHA assemblies
- Editable Fluids Library & Components Catalogue

Torque and Drag Module

- Latest soft string model with stiffness correction factor
- Model **Viscous Drag**, **additional side force due to buckling** & **Contact Surface Correction**
- **Conservative** (Unloading) & **Standard** (Loading) Helical Buckling Models
- Calculate T&D for multiple rig operations simultaneously Tripping In / Out, Rotating On / Off Bottom, Sliding and Reaming
- Ability to model for both pumps on and pumps off and account for string differential pressure
- Calculate Sinusoidal and Helical buckling limits
- Full support for casing, liner, tubing & drilling assemblies

- Full support for complex 3D directional wells
- Friction factor sensitivity analysis for unlimited number of friction factors, or single calculation
- Models casing flotation / drill string fill
- Friction reduction devices (Non-rotating drill pipe protectors) can be modelled
- Calculates expected pipe stretch and torque induced pipe twist
- Elemental (snapshot) view available for all calculations
- Calculate side forces & casing wear for all operations
- Drill string fatigue prediction
- Real time data can be modelled & displayed alongside the calculated data in order to back calculate real time friction factor
- Actual and apparent WOB and overpull calculations, visualize how much overpull / WOB is experienced at the bit for a given value seen at surface. Useful for determine trip / overpull margins and for setting packers & liner hangers
- Casing Standoff & Centralizer Spacing Calculation. Use to optimise standoff and achieve proper zonal isolation
- Ability to model expandable liners including max pull, pull at cone, expected expansion hookload as well as outer & inner string running loads
- Ability to model different materials such as Aluminium as well as steel
- Model the effect of casing centralisers / stabilisers
- Ability to model Air Drilling
- Option to select the fluid level in the wellbore

Hydraulics Module

- Support for multiple hydraulic models:
 - Bingham Plastic
 - Power Law
 - Herschel Bulkley
 - Robertson Stiff
- Calculated Outputs:
 - Standpipe Pressures
 - ECD: cuttings loaded and clean hole
 - Surge and Swab
- Complete set of hole cleaning outputs:
 - Annular Velocity Profile
 - Cuttings Carrying Index (CCI)
 - Cuttings %
 - Minimum Flowrate required for good hole cleaning (sensitivity analysis for ROP)
- Options for single calculation or sensitivity analysis for unlimited number of flowrates and tripping speeds simultaneously
- Full support for riser-less / dual gradient drilling
- Split flow modelling for complex BHAs with multiple hole openers / under reamers / circulating subs

- Incorporate data gathered at the well site into the hydraulics model and overlay the real-world data and the theoretical hydraulics model
- Enter multiple pore pressures & fracture gradients and plot against modelled data
- Surge and swab calculations can be calculated for any reference:
 - Bit
 - Casing Shoe
 - Bottom Hole
 - Any User Defined depth
- Surge and swab model can also include the effects of pipe acceleration, gel strength, coil tubing operations such as continuous tripping and continuous circulation
- Model the effect of stabilisers and casing centralisers
- Quick bit hydraulics calculator, determine bit pressure losses and impact force without having to setup a complete project
- Pump Pressure Safety Factor: Option to allow the user to increase the SPP by a specified percentage

Survey Correction Module

- Correct raw MWD surveys for Z axis magnetic interference with latest short collar correction (SCC) algorithm
- QC raw MWD surveys for G total, B total and Dip with user definable limits
- Multi Station Analysis (MSA) can be used to calculate an optimal bias and scale factor for XYZ magnetometers
- Option to include inclination weighting on least squares fit (LSQ) calculation
- Optimise the non-mag spacing requirements and determine the best survey correction method for a given well trajectory / BHA
- Full support for the following Survey Calculation Methods:
 - Minimum Curvature
 - Radius of Curvature
 - Tangential
 - Balanced Tangential
- Supports survey interpolation for both MD and TVD, results can be exported to text or Excel
- Produce fully customisable plots for both section and plan views and overlay well plan and actual surveys on one chart
- QC raw MWD surveys for G total, B total and magnetic dip with user definable limits

SAG Correction & BHA Analysis

- Survey SAG correction algorithm, to correct survey inclinations for BHA deflections
- Can model bent motors and rotary steerable systems
- Rotary BHA modelling to aid in build / walk rate predictions (equilibrium rate)

- Predicted build / walk Rate for Sliding based on motor bend, hole size and Bit Formation Index
- Predicated build / walk rates for both push and point the bit rotary steerable systems
- Take in to account bit aggressiveness and bit type (PDC, rollercone)
- Vibration analysis calculates Critical RPM

Magnetic Interference Calculator Module

- BHA magnetic Interference Calculator Module
- Well path magnetic interference analysis; calculate the expected error in azimuth for a given amount of non-mag spacing. Fully supports intermediate steel above and below the MWD sensor or both
- Calculate non-magnetic spacing requirements and azimuth error for any well trajectory and BHA configuration

Casing Standoff & Centralizer Spacing Module

- Model rigid and bow spring centralizers
- Automatically optimize centralizer placement based on a desired standoff value
- Calculate deflection at centralisers and mid joint
- Ability to model bow spring running and restoring forces
- Model the additional side force created by the compression of bow spring centralizers
- One click standoff summary report, including tabulated results accompanied by standoff, side forces and hookload charts.

Jar Placement Module

- Calculates neutral point road map which shows WOB to avoid at every depth along the well path
- Calculates pump open force
- Model the impact / impulse of all types of jars, accelerators & intensifiers
- Optimize the hammer length / jar type to maximize impulse / impact
- Calculates weight above and below jar when vertical in air and mud
- Calculates weight above and below jar at bottom hole location in air and mud

Cementing Design

- Cementing Schematic Animation gives a visual representation of the well geometry, string and fluids at any given stage in the cement job
- Calculate annular pressure, equivalent circulating density and pump pressure during cementing operations

- User definable Pumping Schedule
- Ability to model calculations with inner string
- Select from Bingham, Power Law, Herschel Bulkley or Robertson Stiff Hydraulics Models
- Calculate capacities and displacements
- Calculate Top Down, Bottoms up and Full Circulation times.

Casing Design

- Accurately determine casing setting depths, using Bottoms Up or Top Down analysis, allowing the user to determine viable casing and wellbore schemes
- Enables quick, systematic, and accurate valuation of casing wear limit
- Automatically create the minimum cost design
- Provides comprehensive tri-axial and working-stress design for burst, collapse, and axial installation
- Provides service-life loads to maximize the use of the most cost-effective casing for each specific situation.

Well Control

- Determine kick tolerance and perform sensitivity analysis to show how the kick tolerance changes throughout the section and the effect of mud weight changes
- Calculate MASP, MAASP in order to determine surface pressure control equipment requirements
- Quickly determine required kill mud weight and pumping schedule to kill the well

2.0 – Getting Started

2.1 – Program Installation

Innova Engineering is downloaded from the Innova Drilling & Intervention website in an unzipped format. However, if Innova Engineering is supplied via email it will be attached as a zipped installation file, which must be unzipped before use. Right click on the file and select “Extract All....” From the context menu.

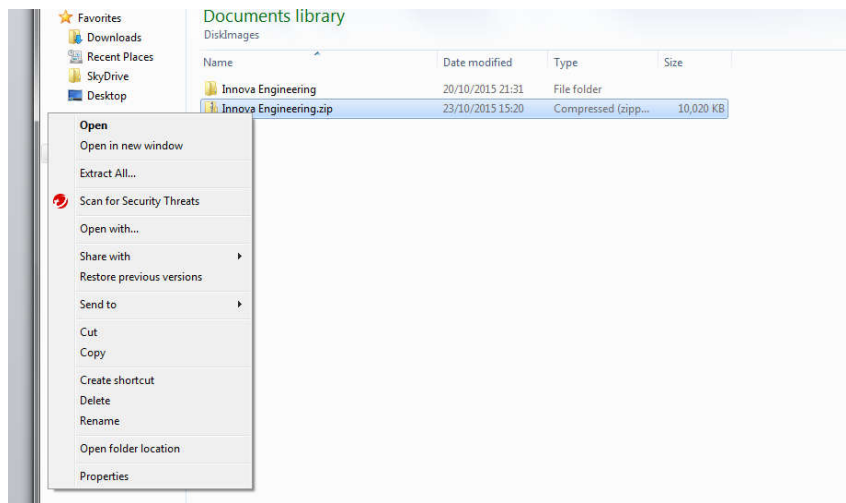


Figure 1: Extracting Install File

Select a location which you wish to extract the files to and click “Extract”. The installation files will be extracted to the selected location in a folder called “Innova Engineering”

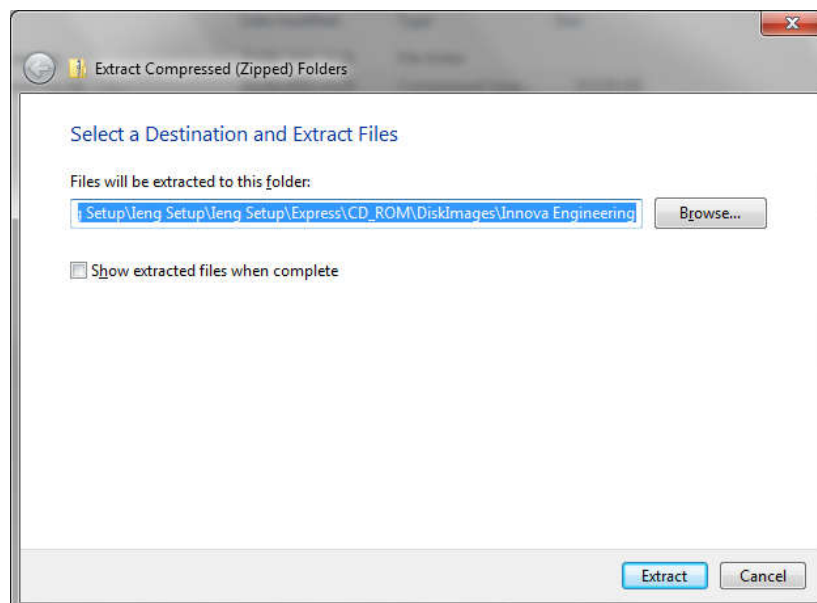


Figure 2: Extract installer location

Once the Installation file has been extracted, open the Innova Engineering folder and double click on the “Innova Engineering vx.x.x.msi” file to begin the installation process. Click on the “Next” button to begin the installation process.

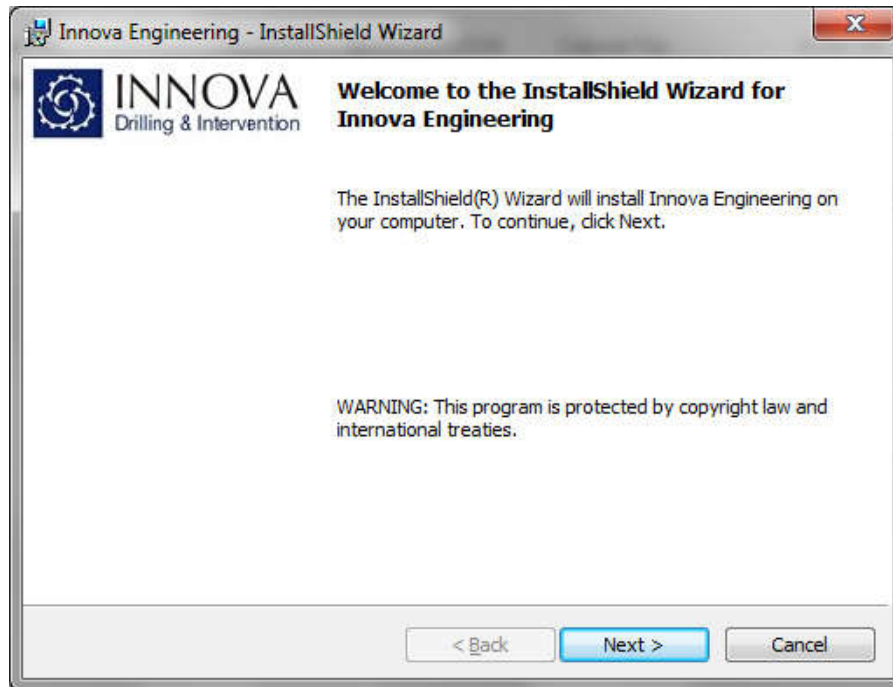


Figure 3: Install page 1

The next dialog will present the license agreement. Read the license agreement, click the “I accept the terms in the license agreement” radio button and then click on the “Next” button.

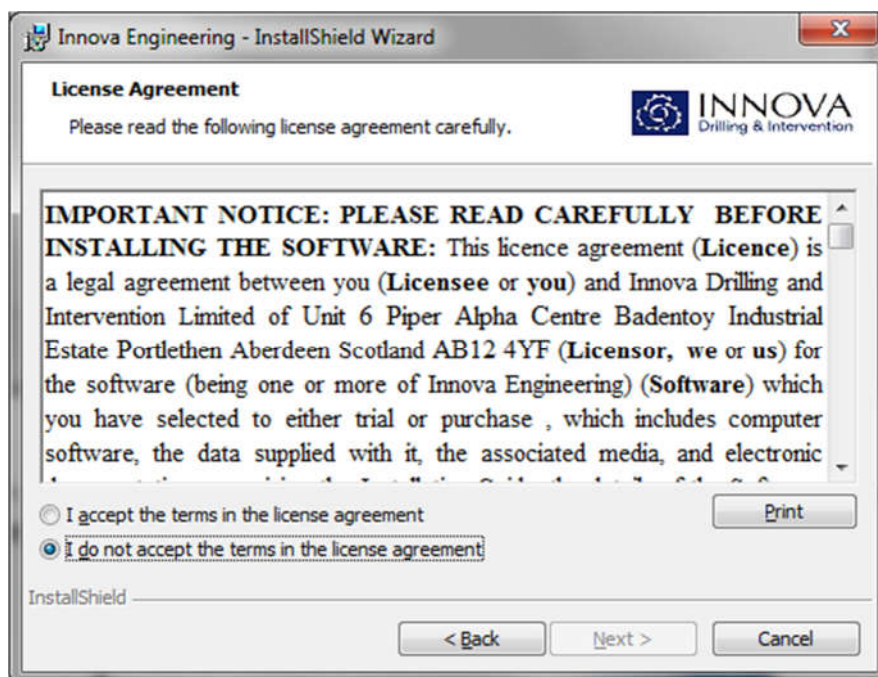


Figure 4: Install page 2 user license agreements

The next screen will allow you to select the location in which you wish to install Innova Engineering. The default location is “C:\Program Files (x86)\Innova Drilling and Intervention\Innova Engineering”. If you wish to change the location the program is installed to click on the change button.

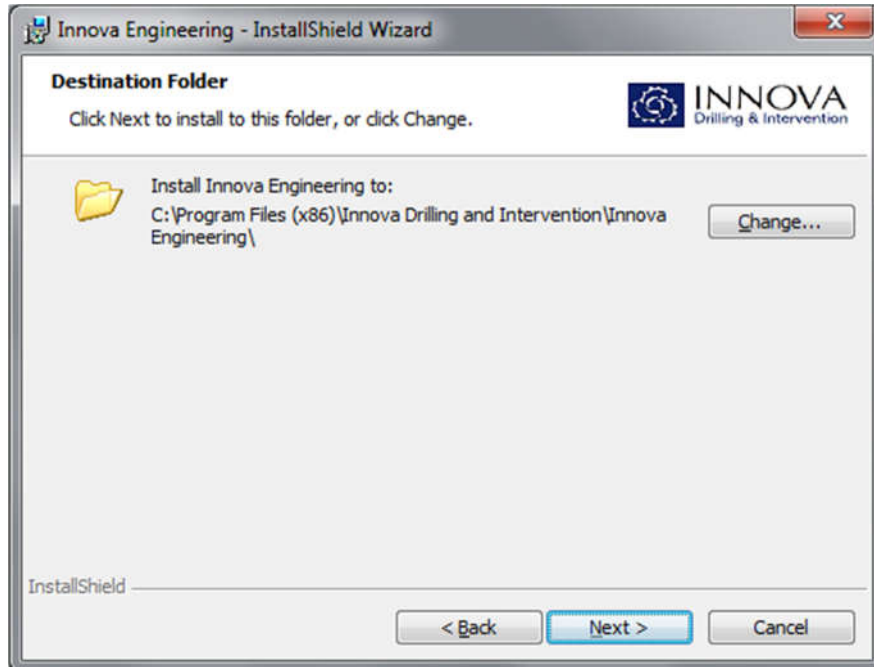


Figure 5: Install page 3 select program location

The final page will show the installation options selected, click “Install” to install the software with the displayed settings.

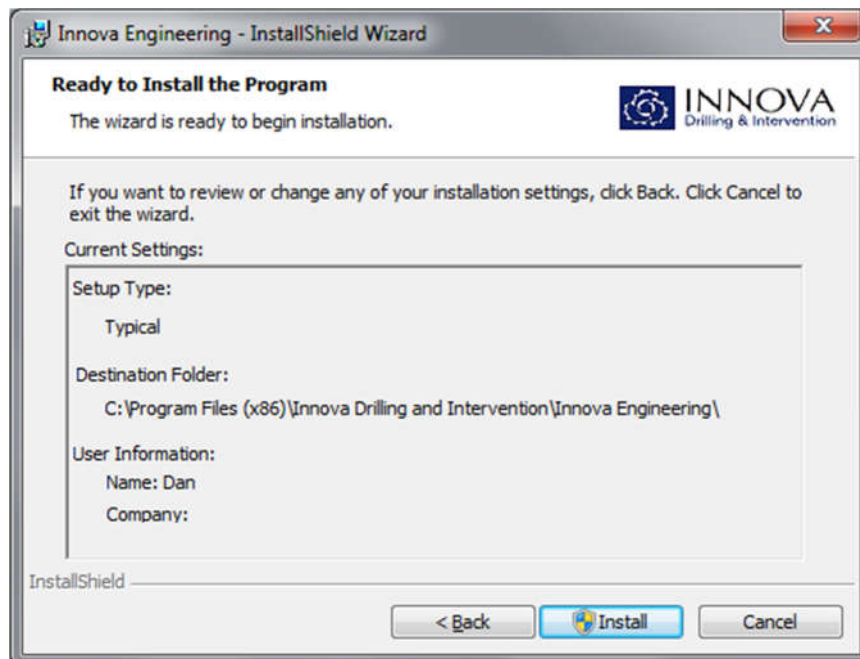


Figure 6: Install page 4 installation settings

At this point, you may be asked “Do you want to allow this app to make changes to your device?”. Click “Yes” to continue the installation. The final window will display “InstallShield Wizard Completed”. Click “Finish” to complete the installation process.

Once the installation is complete an icon will have been added to the desktop and an entry for “Innova Drilling & Intervention” will be in the start menu.

3.0 – Main User interface

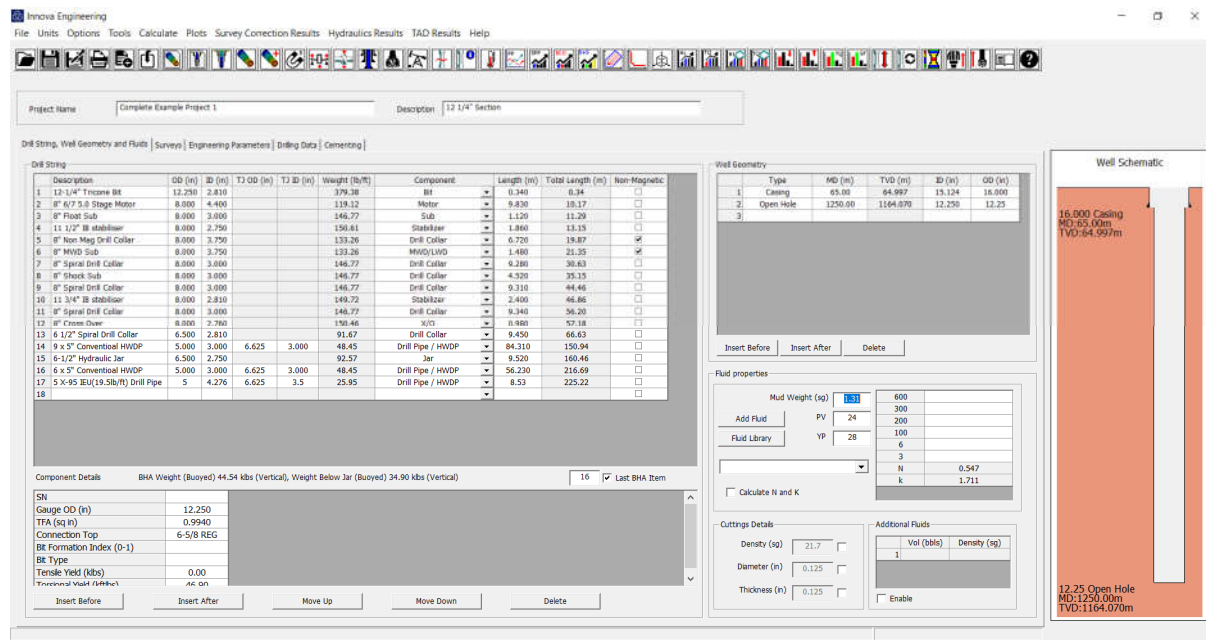


Figure 7: Main user interface

When Innova engineering is first opened the main user interface will be presented which consists of three main parts.

1. Main Menu
2. Main Tool bar
3. Tabbed data entry pages

These will be discussed in detail throughout the manual.

4.0 - Menus

4.1 – Main Menu

Many of the Innova Engineering functions are accessed from the main menu; the functions common to all modules will be covered in this section. The details on other menu options will be covered in the relevant manual section.



Figure 8: Menu Bar

4.2 – File Menu

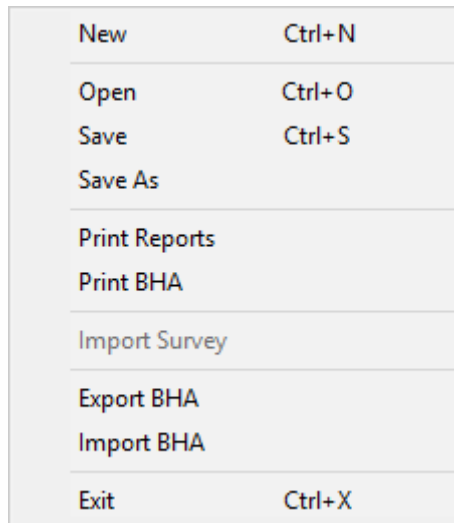


Figure 9: File Menu

New: Create a new blank engineering project. This can also be accessed by pressing Ctrl + N

Open: Open an existing engineering project. This can also be accessed by pressing Ctrl + O

Save: Save current project. Projects are saved as a **.leng** file. This can also be accessed by pressing Ctrl + S

Save As: Save existing project under a new name

4.2.1 - Print Reports

Access the Generate Reports dialog

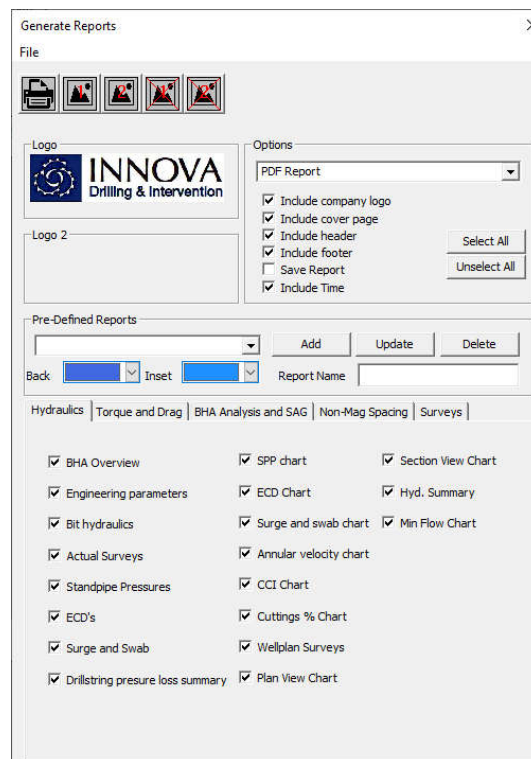


Figure 10: Report generator

Once results have been generated by the various program modules, reports can be printed to PDF or excel from the report generator dialog. Two company logos can be included in the reports and the logos are selected via **file menu -> select logo / select logo 2**. The logo must be in a .bmp format and once selected will be displayed in the logo frame on the report generator. Please note that logo 2 will not be included in any excel reports.

The reporting options common to all report types are available from the **Options** frame. Select the report type, either PDF or Excel, from the combo box and select whether the header footer and cover page are to be included. The company logo is displayed in three elements and if none are selected the logo will not be displayed.

In addition, the PDF report colour scheme can be selected from the drop down colour menus **Back** and **Inset**. The **Back** colour is the predominant colour of the headings in the report and the **Inset** colour will appear behind section titles for better contrast if required. This selection will not affect any excel reports generated.

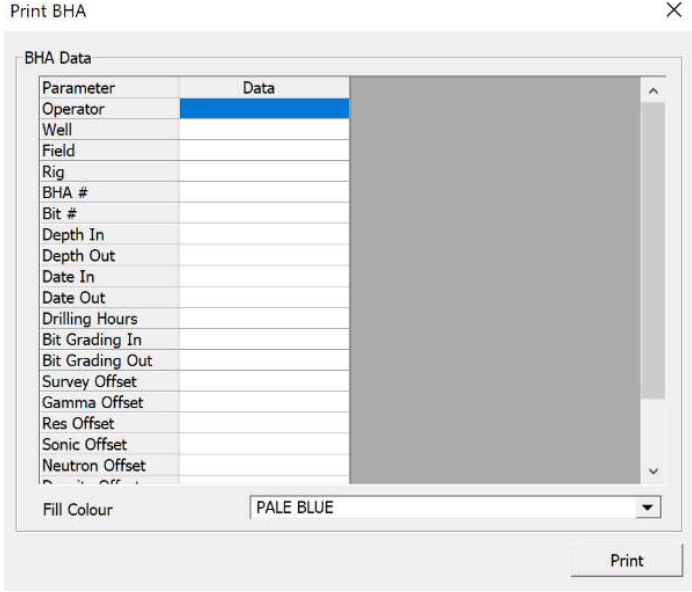
Five different report types are available from the tabs in the lower half of the dialog: Hydraulics, Torque & Drag, BHA Analysis & SAG, Non-Mag Spacing and Surveys. The tab selected when the print button is pressed will be the report that is generated. Select the various report specific options by checking and unchecking the text boxes. Note that graphs are not available in the Excel reports. The charts displayed in the PDF reports will print the last setting applied to the charts in the main program.

If the charts have not been viewed, default settings will be used. Once all the report options have been selected click on the **Print** option from the file menu and save the report as either a PDF or Excel file. Once the report has been printed the Excel or PDF viewer will be launched and the report previewed. From here the report can be sent to any currently installed printer.

The user can create **Pre-Defined Reports**, based on common report selections. When in a relevant report tab, the user makes the desired selection for the report output. They can then insert a Report Name and select **Add**. This report will now be available from the drop-down menu. It is important to note that the pre-defined report will only save the selection in 1 tab. Additional reports are required for each tab, and different selections within individual tabs. Pre-defined reports can be updated and deleted using the **Update** and **Delete** buttons.

4.2.2 - Print BHA

Prints an excel report containing the BHA details as they are entered in the Drill String section of the main screen. Selecting this option Opens the **Print BHA Dialogue**, allowing the user to enter additional BHA data which is included in the report and select the cell fill colour. Selecting **Print** generates the report. Note, that these cells do not need to be populated to generate the BHA report.



The screenshot shows a dialog box titled "Print BHA" with a close button (X) in the top right corner. Inside the dialog, there is a section labeled "BHA Data" containing a table with two columns: "Parameter" and "Data". The "Data" column is highlighted with a blue header. Below the table, there is a "Fill Colour" dropdown menu set to "PALE BLUE" and a "Print" button at the bottom right.

Parameter	Data
Operator	
Well	
Field	
Rig	
BHA #	
Bit #	
Depth In	
Depth Out	
Date In	
Date Out	
Drilling Hours	
Bit Grading In	
Bit Grading Out	
Survey Offset	
Gamma Offset	
Res Offset	
Sonic Offset	
Neutron Offset	
...	

Figure 11: Print BHA Dialogue

4.2.3 - Import Survey

This option can only be selected if the Surveys tab has been selected from the main user interface. Once on the surveys tab, this option will become available and the surveys will be imported into the survey grid selected in the Survey Selection combo box.

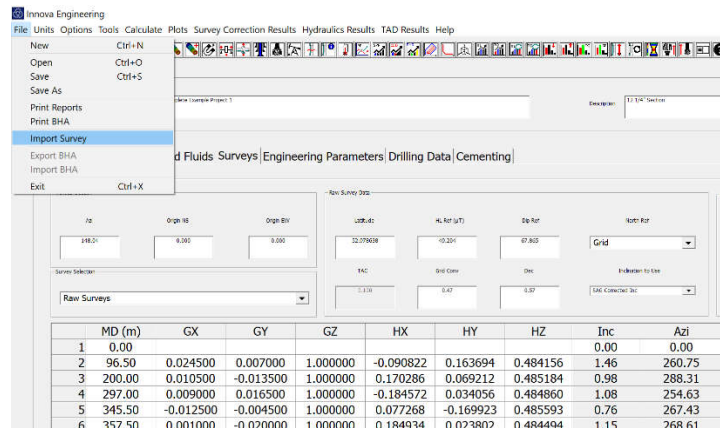


Figure 12: Import Survey

Select a survey file from the dialog, and select its file type from the filter drop down menu. Supported file types are tab delimited text, comma delimited text, space delimited text, Excel 2003 files, Excel 2007 and Navigator SCC text files. The file type must be selected correctly, or the file will not open correctly. The survey file can contain column headers, but must contain the measured depths, inclinations and azimuths in separate columns.

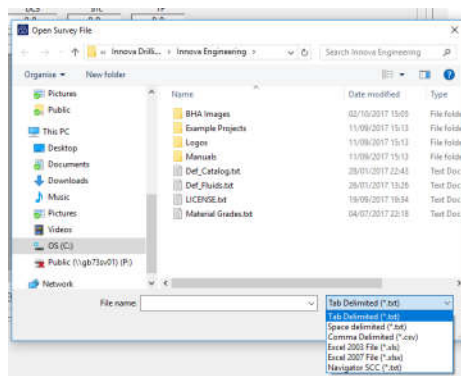
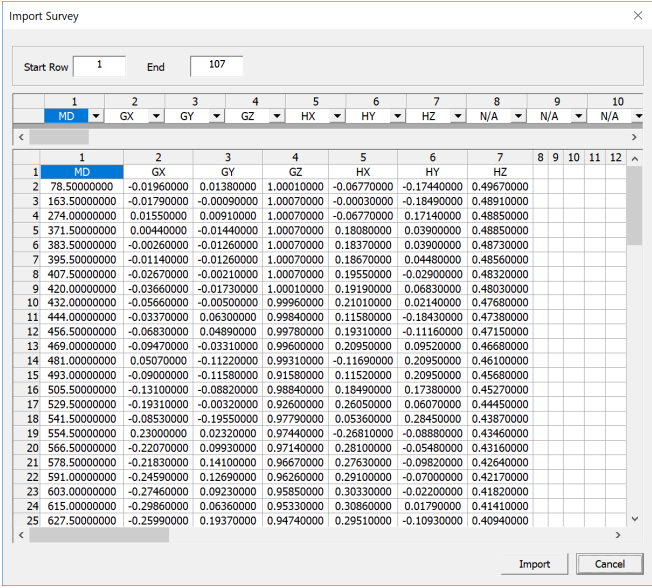


Figure 13: Select survey file

If Raw Surveys are selected, the file must contain measured depth, HX, HY, HZ, GX, GY and GZ values in separate columns. The columns do not have to be in any order and the file can contain other data columns. Once selected the following dialog will be displayed.



Import Survey

Start Row: 1 End: 107

1	2	3	4	5	6	7	8	9	10
MD	GX	GY	GZ	HX	HY	HZ	N/A	N/A	N/A
1	MD	GX	GY	GZ	HX	HY	HZ		
2	78.50000000	-0.01960000	0.01380000	1.00010000	-0.06770000	-0.17440000	0.49670000		
3	163.50000000	-0.01790000	-0.00090000	1.00070000	-0.00030000	-0.18490000	0.48910000		
4	274.00000000	0.01550000	0.00910000	1.00070000	-0.06770000	0.17140000	0.48850000		
5	371.50000000	0.00440000	-0.01440000	1.00070000	0.18080000	0.03900000	0.48850000		
6	383.50000000	-0.00260000	-0.01260000	1.00070000	0.18370000	0.03900000	0.48730000		
7	395.50000000	-0.01140000	-0.01260000	1.00070000	0.18670000	0.04480000	0.48560000		
8	407.50000000	-0.02670000	-0.00210000	1.00070000	0.19550000	-0.02900000	0.48320000		
9	420.00000000	-0.03660000	-0.01730000	1.00010000	0.19190000	0.06830000	0.48030000		
10	432.00000000	-0.05660000	-0.00500000	0.99960000	0.21010000	0.02140000	0.47680000		
11	444.00000000	-0.03370000	0.06300000	0.99840000	0.11580000	-0.18430000	0.47380000		
12	456.50000000	-0.06830000	0.04890000	0.99780000	0.19310000	-0.11160000	0.47150000		
13	469.00000000	-0.09470000	-0.03310000	0.99600000	0.20950000	0.09520000	0.46680000		
14	481.00000000	0.05070000	-0.11220000	0.99310000	-0.11690000	0.20950000	0.46100000		
15	493.00000000	-0.09000000	-0.11580000	0.91580000	0.11520000	0.20950000	0.45680000		
16	505.50000000	-0.13100000	-0.08820000	0.98840000	0.18490000	0.17380000	0.45270000		
17	529.50000000	-0.19310000	-0.00320000	0.92600000	0.26050000	0.06070000	0.44450000		
18	541.50000000	-0.08530000	-0.19550000	0.97790000	0.05360000	0.28450000	0.43870000		
19	554.50000000	0.23000000	0.02320000	0.97440000	-0.26810000	-0.08880000	0.43460000		
20	566.50000000	-0.22070000	0.09930000	0.97140000	0.28100000	-0.05480000	0.43160000		
21	578.50000000	-0.21830000	0.14100000	0.96670000	0.27630000	-0.09820000	0.42640000		
22	591.00000000	-0.24590000	0.12690000	0.96260000	0.29100000	-0.07000000	0.42170000		
23	603.00000000	-0.27460000	0.09230000	0.95850000	0.30330000	-0.02200000	0.41820000		
24	615.00000000	-0.29860000	0.06360000	0.95330000	0.30860000	0.01790000	0.41410000		
25	627.50000000	-0.25990000	0.19370000	0.94740000	0.29510000	-0.10930000	0.40940000		

Import Cancel

Figure 14: Survey import dialog

A preview of the survey file will be displayed in the main grid with the row numbers down the left hand side of the lower grid. Select the start row and the end row of the surveys you wish to import and select which column is which from the combo boxes in the upper grid. If normal surveys are selected MD INC and AZI columns must be defined. If RAW surveys are selected MD, HX, HY, HZ, GX, GY and GZ columns must be defined. If the column is not to be imported, selected NA from the combo box.

Once happy with the selection click the import button and the surveys will be imported.

4.2.4 - Export BHA

Exports the BHA which the user has populated in the **Drill String** section of the **Drill String, Well Geometry and Fluids** tab on the main user interface. This option is only available when in this tab and creates a **.bha** file. It is worth noting that this **.bha** file can also be imported into Innova's Well Seeker Pro Drill String Editor dialog.

4.2.5 - Import BHA

Imports any **.bha** file into the **Drill String** section of the **Drill String, Well Geometry and Fluids** tab on the main user interface. This option is only available when in this tab. Care should be taken as this option will overwrite any information populated in the Drill String section.

4.2.6 - Exit

Exit the application. This can also be accessed by pressing Ctrl + X

4.3 – Units Menu

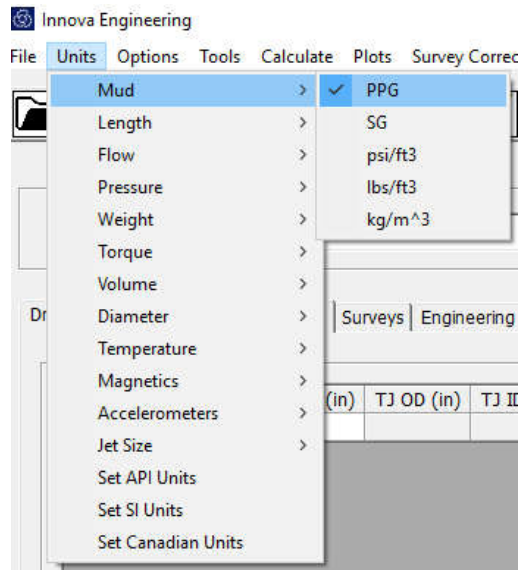


Figure 15: Units Menu

The Units menu controls the units for the entire project. The selected units will have a tick next to them. By default, Innova Engineering uses API units; however, these can be changed at any point.

- **Mud:** Pounds per Gallon (PPG), Specific Gravity (SG), PSI per Cubic Foot (psi/ft³), Pounds per Cubic Foot (lbs/ft³), Kilograms per Cubic Meter (kg/m³) or Kilopascals per meter (kPa/m)
- **Length:** Feet, Us Feet or Meters - Note the length units govern the lengths of components as well as the local units for surveys and global depth units
- **Flow:** Gallons per min (GPM), Litres per min (LPM), Cubic meters per min (m³/m) or Standard Cubic Feet per Minute (SCFM). **Note, when SCFM is selected, air drilling mode is activated.**
- **Pressure:** Pounds per Square Inch (PSI), BAR or Kilopascals (KPa)
- **Weight:** Kilopounds (klbs), Metric tons or Kilo-decanewtons (kdaN)
- **Torque:** Kilo-foot-pounds (Kftlbs) or Kilonewtonmeters (kNm)
- **Volume:** Barrels (bbls) or Cubic meters (m³)
- **Diameter:** Either inches (in) or Millimeters (mm), this will affect all OD's and ID's
- **Temperature:** Fahrenheit or Celsius
- **Magnetics:** Geolink / Tensor (mv), SSP / SUCOP (uT), nT, nT no XY inversion, EVO / Applied Physics or Vertex
- **Accelerometers:** G or mG. The option to Invert Z Axis can be checked or unchecked irrespective of the accelerometer unit choice
- **Jet Size:** 1/32^{nds} of an inch or Millimeters (mm)

Set API Units: Automatically sets the above units to match the standard API unit scheme:

- **Mud:** Pounds per Gallon (PPG); **Length:** Feet; **Flow:** Gallons per min (GPM); **Pressure:** Pounds per Square Inch (PSI); **Weight:** Kilopounds (klbs); **Torque:** Kilo-foot-pounds (Kftlbs); **Volume:** Barrels (bbls); **Diameter:** inches (in); **Temperature:** Fahrenheit; **Jet Size:** 1/32^{nds} of an inch.

Set SI Units: Automatically sets the above units to match the standard SI unit scheme:

- **Mud:** Specific Gravity (SG); **Length:** Meters; **Flow:** Litres per min (LPM); **Pressure:** BAR; **Weight:** Metric Tons; **Torque:** Kilonewton meters (kNm); **Volume:** Barrels (bbls); **Diameter:** inches (in); **Temperature:** Celsius; **Jet Size:** 1/32^{nds} of an inch.

Set Canadian Units: Automatically sets the above units to match the standard Canadian unit scheme:

- **Mud:** Kilograms per Cubic Meter (kg/m³); **Length:** Meters; **Flow:** Litres per min (LPM); **Pressure:** Kilopascals (KPa); **Weight:** Kilo-decanewtons (kdaN); **Torque:** Kilo-foot-pounds (Kftlbs); **Volume:** Barrels (bbls); **Diameter:** Millimeters (mm); **Temperature:** Celsius; **Jet Size:** Millimeters (mm).

4.4 – Options Menu

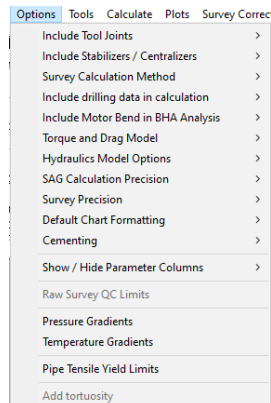


Figure 16: Options Menu

4.4.1 - Include Tool joints

This option selects whether the OD and ID of the tool joint is included in the calculations. This option only affects torque and drag and hydraulics calculations and by default is set to **Yes**.

4.4.2 - Include Stabilisers / Centralizers

This option enables or disables drill string stabilisers or casing centralisers in hydraulics and torque and drag calculations. By default, this option is set to **Yes**.

4.4.3 - Survey Calculation Method

Determines the survey calculation method used for the surveys entered in the Surveys tab on the main user interface. Options are Minimum Curvature, Radius of Curvature, Balanced Tangential and Tangential. By default, **Minimum Curvature** is selected.

4.4.4 - Include Drilling Data in Calculations

Option determines if data entered in the drilling data tab is used in the hydraulics and torque and drag calculations. If yes is selected the mud weight, mud rheology, ROP and RPM are used at the depths specified in the calculations. This option is useful for comparing field data to modelled data. By default, this option is set to **Yes**.

4.4.5 - Include Motor Bend in BHA Analysis

Determines if the motor bend is used in the BHA Analysis calculation. By default, this is set to **Yes**.

4.4.6 - Torque & Drag Model

Options which relate to the T&D calculations.

- **Viscous Drag:** Refers to the drag caused by pulling the string through the mud. This only affects the PU weights. Default is **No**.
- **Buckling Friction:** The additional friction added if the pipe is buckled and being pushed through the well. Only applies to SO weights. Default is **No**.
- **Contact Surface Correction:** Additional friction applied based on the surface area of the tubular touching the well bore i.e. casing has more friction because more surface area. Default is **No**.
- **Calculate Casing Wear:** If No is selected, there will be no output in the Casing Wear Plot. Default is **Yes**.
- **Buckling Lines:** User can select between Sliding & Rotary. This selection determines which buckling lines are displayed on the Tension On & Off Bottom Snapshot Charts. Default is **Sliding**.
- **Buckling Model:** Determines the way the Helical Buckling limit is calculated.
 - **Conservative (Unloading Model):** Sinusoidal limit x 1.4. This is the **default**.
 - **Standard (Loading Model):** Sinusoidal limit x 2.1
- **Include Friction Reduction Subs:** Friction reduction inputs are available in the DP & HWDP component details. This option determines whether these inputs are used in the calculation. Default is **Yes**.
- **Include Overpull in stretch calcs:** Stretch calculations will take into consideration the overpull entered in the Engineering Parameters tab. Default is **No**.
- **Outer String Properties:** Required input for Expandable Liner calculations.

Figure 17: Outer String Dialogue

Properties: This section allows the user to enter the outer string properties, which are used in the liner expansion calculation. The expanded OD and ID need to be added manually. This section models an inner string of tubing and a liner run as an outer string.

Friction Factors: The pick-up (PU) and Slack-off (SO) friction factors used in the calculation. These will override the friction factors entered in the main grid

Liner Shrinkage: The length difference expected between the expanded and un-expanded liner

Catalogue: This radio button takes the user to the Component Catalogue, where they can select the relevant component to add to the Properties section.

Calculate Shrinkage: This radio button runs the liner shrinkage calculation, and the results will be populated in the Liner Shrinkage section.

- **Step Interval:** Determines the interval between calculated points i.e. with a step interval of 10 outputs are generated every 10 meters or feet. This will be apparent when viewing the data tables. Default is **10** when unit length is **Meters** and is **30** when unit length is **Feet** or **US Feet**.
- **Air Drilling:** To be used when the section is air drilled. User enters the expected standpipe pressure here. This will calculate the additional string weight caused by drilling on air.
- **Fluid Level:** This option allows the user to select the fluid level in the wellbore. The depth entered is Measured Depth, and the program will assume no fluid from surface to this depth. Over this range, there will be no buoyancy factor considered, therefore the hookload will increase as a result.

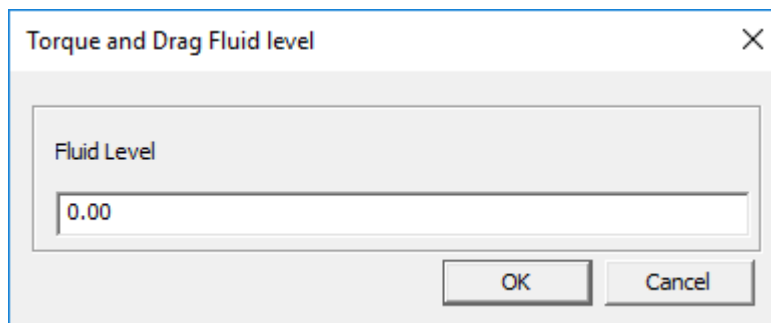


Figure 18: Fluid Level Dialogue

Include Bow Spring Force: When bow spring centralizers are included on casing or liner runs, this option allows the user to select whether the bow spring force is included in the torque and drag calculation or not. Note that if a bow spring force has been entered, this will be included in the casing standoff calculation regardless of what is selected here.

4.4.7 - Hydraulics Model Options

Options which relate to the Hydraulics calculations. More specifically, the surge and swab calculations.

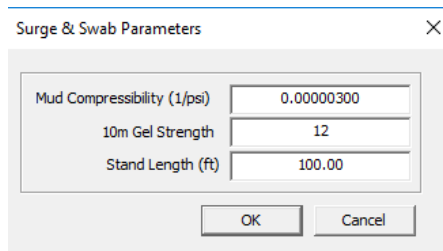


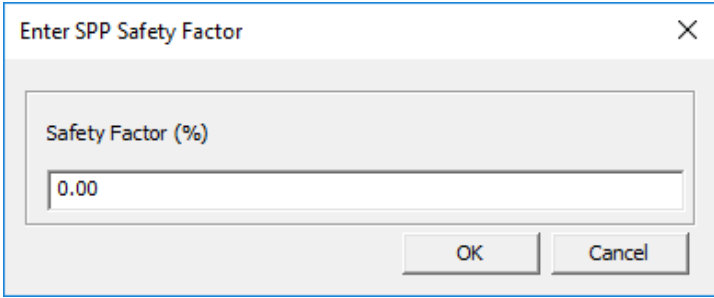
Figure 19: Surge and Swab Parameters

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 current trip speed being calculated, 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:**
 - 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 fairly small. 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**

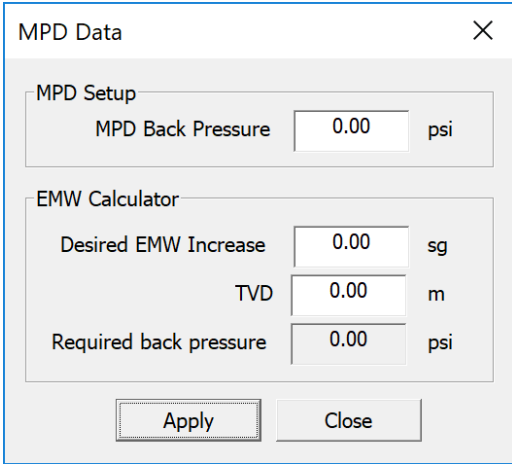
- **SnS: Continuous Tripping:** This option assumes continuous tripping, and as a result will only calculate one acceleration phase (on the first stand length) and one deceleration phase (on the last stand length). This option is best used to model coiled tubing. Default is **Off**.
- **SnS: Use Bit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



The dialog box is titled "Enter SPP Safety Factor" and has a close button (X) in the top right corner. It contains a text input field labeled "Safety Factor (%)" with the value "0.00" entered. Below the input field are two buttons: "OK" and "Cancel".

Figure 20: Pump Pressure Safety Factor Dialogue

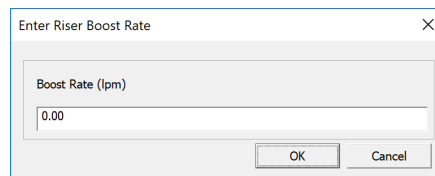
- **MPD Data:** This option allows the user to enter a back pressure for Managed Pressure Drilling.
 - **MPD Setup.** The MPD Back Pressure is added as a fixed value to all of the SPP calculation totals and will also be reflected in the ECDs.
 - **EMW Calculator:** The user inputs the desired EMW increase 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.



The dialog box is titled "MPD Data" and has a close button (X) in the top right corner. It contains two sections: "MPD Setup" and "EMW Calculator".
MPD Setup: Includes a text input field for "MPD Back Pressure" with the value "0.00" and the unit "psi".
EMW Calculator: Includes three text input fields: "Desired EMW Increase" with value "0.00" and unit "sg", "TVD" with value "0.00" and unit "m", and "Required back pressure" with value "0.00" and unit "psi".
At the bottom of the dialog are two buttons: "Apply" and "Close".

Figure 21: MPD Data Dialog

- **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.



A dialog box titled "Enter Riser Boost Rate" with a close button (X) in the top right corner. It contains a text input field labeled "Boost Rate (lpm)" with the value "0.00" entered. At the bottom right, there are "OK" and "Cancel" buttons.

Figure 22: Riser Boost Rate Dialog

4.4.8 - SAG Calculation Precision

Determines the number of decimal places displayed in the Inc SAG column in the raw surveys tab.

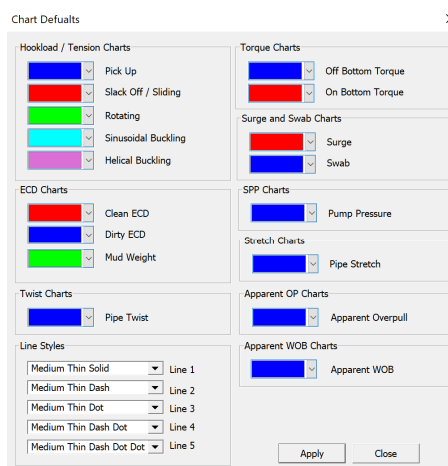
4.4.9 - Survey Precision

Determines the number of decimal places displayed in the MD, Inc and Azi columns in the Actual Surveys and Well Plan tabs.

4.4.10 - Default Chart Formatting

Allows the user to pre-set some of the default chart settings.

- **Auto Chart Colours:** User can select Yes or No. Yes sets the default line colours to the options selected in Customize Colours / Line Styles. No sets the default line colours to random.
- **Auto Chart Line Styles:** User can select Yes or No. Yes sets the default line styles to the options selected in Customize Colours / Line Styles. No sets the default line styles to random.
- **Customize Colours / Line Styles:** Allows the user to manually alter the default colour of lines based upon the chart type and the series. The user can also select a default line style for up to five variants of a series.



A dialog box titled "Chart Defaults" with a close button (X) in the top right corner. It contains several sections with dropdown menus for selecting colors and line styles:

- Hookload / Tension Charts:** Pick Up (Blue), Slack Off / Sliding (Red), Rotating (Green), Sinusoidal Buckling (Cyan), Helical Buckling (Purple).
- ECD Charts:** Clean ECD (Red), Dirty ECD (Blue), Mud Weight (Green).
- Twist Charts:** Pipe Twist (Blue).
- Line Styles:** Medium Thin Solid (Line 1), Medium Thin Dash (Line 2), Medium Thin Dot (Line 3), Medium Thin Dash Dot (Line 4), Medium Thin Dash Dot Dot (Line 5).
- Torque Charts:** Off Bottom Torque (Blue), On Bottom Torque (Red).
- Surge and Swab Charts:** Surge (Red), Swab (Blue).
- SPP Charts:** Pump Pressure (Blue).
- Stretch Charts:** Pipe Stretch (Blue).
- Apparent OP Charts:** Apparent Overpull (Blue).
- Apparent WOB Charts:** Apparent WOB (Blue).

At the bottom right, there are "Apply" and "Close" buttons.

Figure 23: Pump Pressure Safety Factor Dialogue

4.4.11 - Cementing

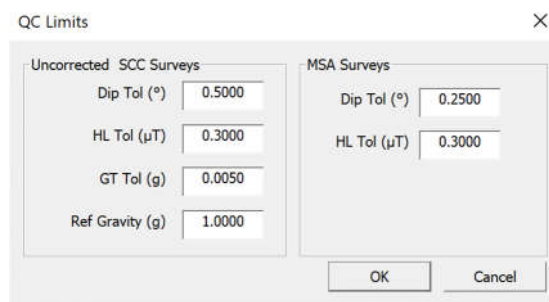
The default flow rate in the Cementing tab is barrels per minute (bbls/min). This option allows the user to “Use flow units as pump rate”, which means the flow rate used in the cementing tab will match whatever the user has selected as the flow units from the units menu. This is useful when using the cementing section to simulate pumping pills etc.

4.4.12 - Show / Hide Parameter Columns

This affects the drilling data tab and allows columns to be shown / hidden. If a column is visible it will have a tick next to it. By default, all columns are visible.

4.4.13 - Raw survey QC Limits

Allows the user to change the default raw survey QC parameters. The default values are displayed below. This can only be accessed when Raw Surveys are selected in the Survey Selection drop down menu of the Surveys tab.



The image shows a dialog box titled "QC Limits" with a close button (X) in the top right corner. The dialog is divided into two main sections: "Uncorrected SCC Surveys" and "MSA Surveys".

Parameter	Value
Dip Tol (°)	0.5000
HL Tol (μT)	0.3000
GT Tol (g)	0.0050
Ref Gravity (g)	1.0000

Below the "MSA Surveys" section, there are "OK" and "Cancel" buttons.

Figure 24: Raw survey QC limits

4.4.14 - Pressure Gradients

Selecting this option displays a dialog which allows pore pressure, fracture gradient, casing burst and collapse pressures to be displayed.

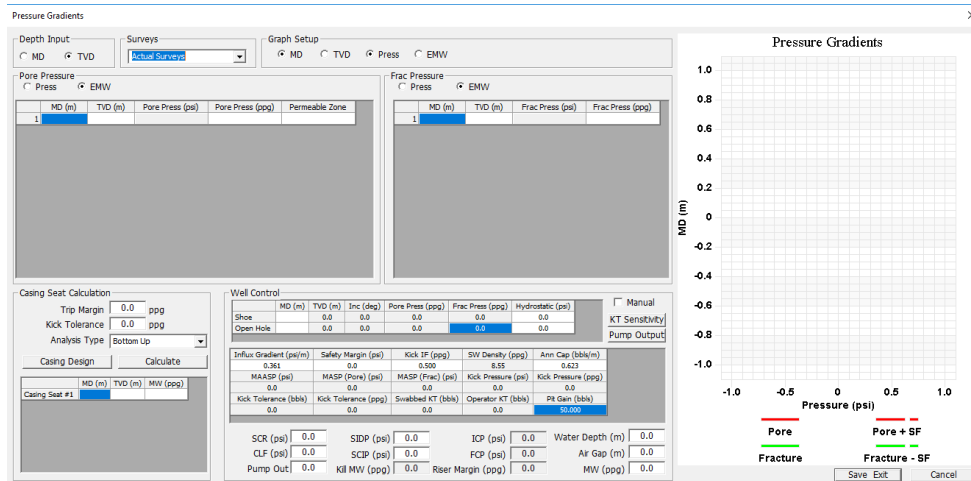


Figure 25: Pressure Gradients Dialog

Depth Input: Determines the depth input for the Pore and Fracture Pressure.

Surveys: This selection relates to the pore and fracture pressure sections. Whatever depth (MD or TVD) is input in these sections, the other value is interpolated from the survey selection.

Graph Setup: User can choose between MD & TVD for the Y-axis and Pressure & EMW for the X-axis.

Pore Pressure: The user can enter the MD or TVD, along with the relevant Pore Pressure. This can be entered as Pressure or EMW, based on the selected input. The corresponding value will be automatically calculated based on these inputs. In the Permeable Zone column, the user can choose from a choice of yes or no. Permeable zones are used for casing design and is used to calculate the external pressure profile named permeable zones.

Fracture Pressure: The user can enter the MD or TVD, along with the relevant Fracture Pressure. This can be entered as Pressure or EMW, based on the selected input. The corresponding value will be automatically calculated based on these inputs.

Casing Seat Calculation: This section calculates the optimum setting depths for casings based on the pore and fracture pressures. The program picks a suitable mud weight to drill with and picks the fewest mud weights to get from top to bottom.

- **Trip Margin:** The input value is **added** to all the pore pressure values and plotted on the pressure gradients plot. This is a safety factor which takes into consideration reductions in the EMW while tripping out. When entered, the casing seat calculations will take this value into account.
- **Kick Tolerance:** The input value is subtracted from all the fracture pressure values and plotted on the pressure gradients plot. This is a safety factor which takes into

consideration increases in the EMW while tripping in. When entered, the casing seat calculations will take this value into account.

- **Analysis Type:** This affects the way the program carries out the casing seat calculation. User can choose between Top Down or Bottom Up. When Top Down is selected, the calculation begins at surface and works its way down. With Bottom Up, the calculation begins at the deepest depth and works its way to surface. The results can vary slightly depending on the analysis type selected.

Casing Design: This function is not currently supported but will be in a future release. For more information on the casing design dialogue see Section 4.5.11: [Casing Design](#).

Well Control: This section deals with Well Control and basic well control calculations, such as maximum allowable annulus surface pressure MAASP. Calculate the required kill mud weight by entering the shut-in drill pipe pressure, and kick tolerance can be calculated in both barrels and ppg.

Shoe: Depth of the Casing Shoe, entered as MD. The corresponding TVD and inclination will be populated based on the survey selected. The Pore and Fracture pressure will also be automatically populated, based on the data entered in these sections.

Open Hole: The open hole depth at which the calculation will be run. The corresponding TVD and inclination will be populated based on the survey selected. The Pore and Fracture pressure will also be automatically populated, based on the data entered in these sections.

Hydrostatic: The Hydrostatic Pressure in psi expected at the shoe and open hole depths entered.

Influx Gradient: The expected pressure gradient for the influx fluid (gas is usually expressed as 0.1 psi / ft)

Safety Margin: The safety margin in psi

Kick IF: The kick Intensity Factor. This value represents the value of the kick above the pore pressure. This is an input.

SW Density: Sea Water Density. This is used for riser less drilling calculations. The value displayed here is the one entered in the Engineering Tab on the main screen.

Ann Cap: The Annular Capacity in bbls/ft or bbls/m. This value is generated based on the hole size and the BHA OD

MAASP: Maximum Allowable Annulus Surface Pressure

MASP (Pore): Maximum allowable surface pressure based on the maximum pore pressure

MASP (Frac): Maximum allowable surface pressure which will not fracture the weak point

Kick Pressure (psi): Expected kick pressure in psi

Kick Pressure (ppg): Expected kick pressure expressed in EMW

Kick Tolerance (bbls): The volume of influx that can be tolerated in bbls. This is a calculated value.

Kick Tolerance (ppg): The volume of influx that can be tolerated in ppg. This is a calculated value

Swabbed KT: Kick tolerance for a swabbed kick (no ECD)

Operator KT: The operators kick tolerance

Pit Gain: Expected pit gain before the well is shut in

SCR: Slow circulating rate pressure

SIDP: Shut in Drill Pipe Pressure.

ICP: Initial Choke Pressure

Water Depth: If the well is offshore this is the water depth

CLF: Choke line friction pressure

SCIP: Shut in casing pressure

FCP: Final Choke Pressure.

Air Gap: Rig air gap expressed as the RKB to the top of the flow line or MSL if drilling riserless

Pump Out: Pump output expressed in bbls/stk

Kill MW: Kill Mud Weight. This is the calculated mud weight required to kill the well.

Riser Margin: The riser margin represents the increase in mud weight required to compensate for loss of hydrostatic head if the riser is disconnected.

MW: Mud weight of the mud in the current hole section

KT Sensitivity: This radio button opens the Kick Tolerance Sensitivity Analysis Plot.

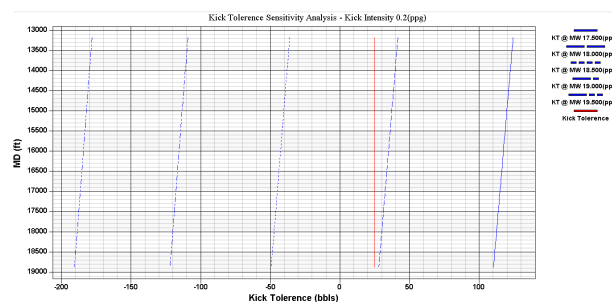


Figure 26: Kick Tolerance Sensitivity Analysis Plot

Pump Output: This radio button opens the Pump Data dialogue, which is explained in more detail in the Tools section of this manual.

Pressure Gradients Chart: This chart displays a graphical output of the data entered in this section. The chart can be manipulated and exported in the same way as all the other charts in Engineering.

4.4.15 - Temperature Gradients

This section is for reference and the inputs do not currently have any effect on any of the calculations. Four temperature profiles are plotted on the Temperature Gradients Chart: Static, Drilling, Cementing and Production.

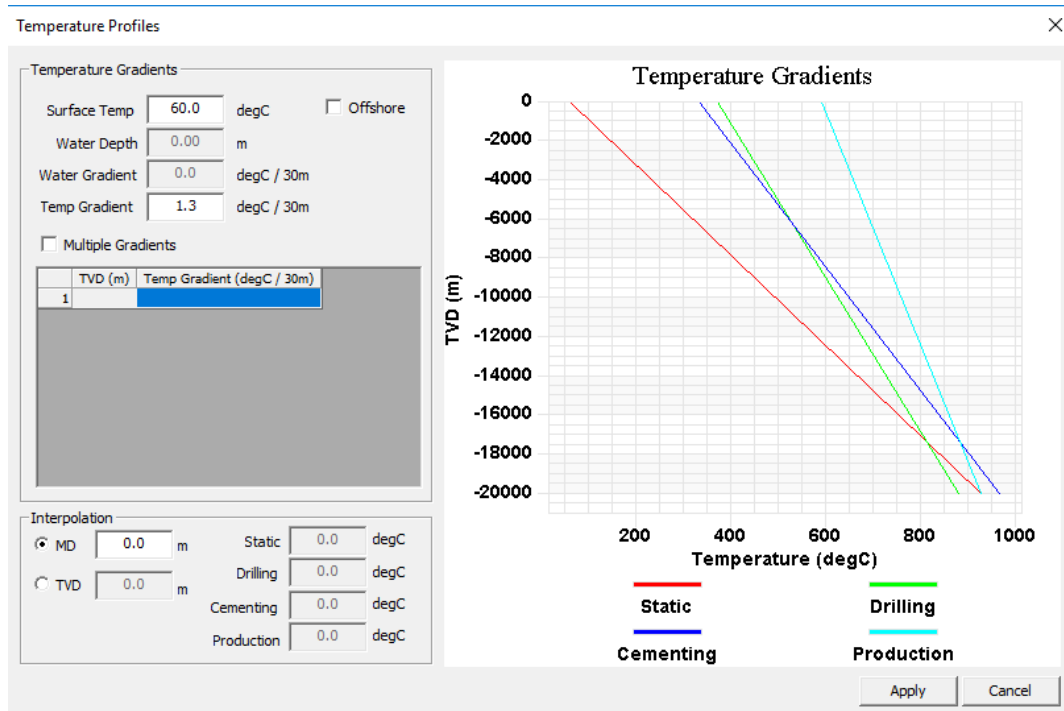


Figure 27: Temperature Profile Dialog

Temperature Gradients: The values input in this section directly relate to the Static Temperature. The other three temperatures are calculated based on these values.

- **Surface Temperature:** The temperature at surface. This will be the starting point on the X-Axis for the Static Temperature line.
- **Water Depth:** The depth of the water when drilling offshore. This option is activated when the offshore box is checked.
- **Water Gradient:** The gradient of the water temperature. This option is activated when the offshore box is checked. NOTE, this can be a negative value.
- **Temp Gradient:** The temperature gradient from surface / mudline.
- **Multiple Gradients:** When checked, the user can input as many temperature gradients as required.
- **Interpolation:** User can interpolate the Static, Drilling, Cementation and Production temperatures, at any given MD or TVD.

Temperature Profiles: The formulae used to create the four temperature profiles modelled in this section are detailed below.

Static Temperature Profile:

Onshore: $T_{d-st} = T_s + DG_{st}$ (eqn 1)

Where

- T_{d-st} = static temperature of interested depth (F or C)
- T_s = surface temperature (F or C)
- D = true vertical depth of interest (ft or m)
- G_{st} = geothermal gradient in degree per depth unit (F/100ft or C/30m)

Offshore: $T_{d-st} = T_{ml} + (D - D_w)G_{st}$ (eqn 2)

Where

- T_{d-st} = static temperature of interested depth (F or C)
- T_{ml} = mud line temperature (F or C)
- D_w = water depth (ft or m)
- D = true vertical depth of interest (ft or m)
- G_{st} = geothermal gradient in degree per depth unit (F/100ft or C/30m)

Cementing Temperature Profile:

$T_{b-circ} = (1.342 - 0.2228G_{st})T_{b-st} + 33.54G_{st} - 102.1$ (eqn 3)

$T_{b-cmt} = T_{b-circ} + (T_{b-st} - T_{b-circ}) / 4$ (eqn 4)

$T_{s-cmt} = T_s + 0.3(T_{b-cmt} - T_s)$ (eqn 5)

Where

- T_{b-circ} = bottom hole circulating temperature (°F)
- T_s = surface temperature (°F)
- G_{st} = geothermal gradient (°F/100ft)
- T_{b-cmt} = bottom hole as cemented temperature (°F)
- T_{s-cmt} = surface as cemented temperature (°F)

Drilling Temperature Profile:

$$T_{s-d} = 0.9T_{b-st} - \frac{2}{3}D_{SOH}(0.8G_{st})/100 \quad (\text{eqn 6})$$

$$T_{DSOH-d} = 0.95T_{b-st} \quad (\text{eqn 7})$$

Where:

T_{s-d} = drilling temperature at surface (°F)

T_{DSOH-d} = drilling temperature at the depth of deepest subsequent open hole (°F)

T_{b-st} = bottom hole static temperature (°F)

D_{SOH} = deepest subsequent open hole depth (ft)

G_{st} = geothermal gradient (°F/100ft)

Production Temperature Profile:

For production casing

$$T_{s-p} = 0.95T_{b-st} - \frac{2}{3}D_p(0.7G_{st})/100 \quad (\text{eqn 8})$$

For tubing

$$T_{s-p} = 0.95T_{b-st} - \frac{2}{3}D_p(0.5G_{st})/100 \quad (\text{eqn 9})$$

Where:

T_{s-p} = surface production temperature (°F)

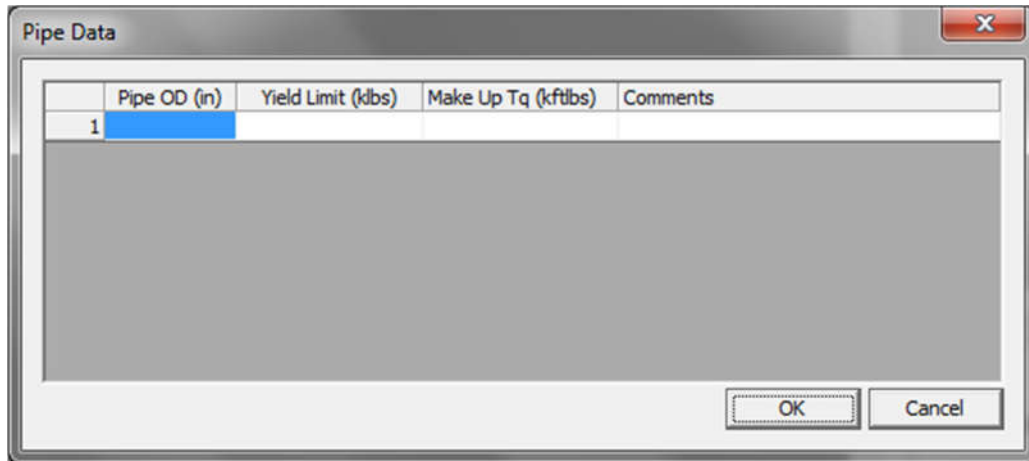
T_{b-st} = bottom hole static temperature (°F)

D_p = depth of production zone (ft)

G_{st} = geothermal gradient (°F/100ft)

4.4.16 - Pipe Tensile Yield Limits

Allows the user to enter a pipe size and yield limit into the grid. This can then be displayed on any of the charts via the **add additional series** button. *This input does not affect any calculation. It is instead a reference which can be added to the required charts.*



The image shows a 'Pipe Data' dialog box with a table and two buttons. The table has four columns: 'Pipe OD (in)', 'Yield Limit (kibs)', 'Make Up Tq (kftlbs)', and 'Comments'. The first row is highlighted with a blue background. Below the table is a large grey rectangular area. At the bottom right are 'OK' and 'Cancel' buttons.

	Pipe OD (in)	Yield Limit (kibs)	Make Up Tq (kftlbs)	Comments
1				

Figure 28: Pipe Yield Limits dialog

4.4.17 - Add Tortuosity

This option allows the user to add tortuosity to a plan or survey. This option will be greyed out unless the user is in the **Surveys tab** on the main screen. This option is only available for Actual and Well Plan surveys and **cannot** be used with raw surveys. In some situations, it may be necessary to add tortuosity to a well plan or survey to better simulate real life conditions. Well plans which contain purely vertical sections are a typical example of this. See **Section 7.5.1: Tortuosity for more details.**

4.5 – Tools Menu

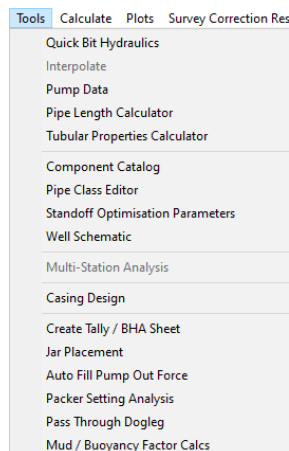


Figure 29: Tools Menu

4.5.1 – Quick Bit Hydraulics

Access the quick bit hydraulics tool. This allows bit hydraulics to be calculated without having to enter all the details for a complete hydraulics calculation.

	Size (1/32 in)	Qty
1	12	2
2	14	4
3		

☐ Fixed TFA

Results

Bit Pressure Drop (psi)

Bit HHP

Bit HHP / sqin

Bit Jet Velocity (ft/sec)

Jet Impact Force / sqin

Parameters

Flow Rate (gpm)

Mud Weight

Bit Size (in)

Units

Flow Rate

Mud Weight

Pressure

Figure 30: Bit hydraulics calculator

Enter the bit jet details into the jets grid. The left-hand column is the size of the jet and the right hand column is for the number of that particular jet size. If you do not know the exact jet details, click the fixed TFA check box and enter the TFA into the edit box.

Enter the flow rate, mud weight and the bit size in to the edit boxes in the parameters section. The units can be adjusted from the combo boxes in the units frame. This does not affect the units in the main project. The results are displayed in the results section. Note that all data entered in this calculator will be reset when the dialogue is closed.

4.5.2 – Interpolate

This option is only available if the surveys tab is selected, and is only available for Actual and Well Plan surveys and cannot be used with raw surveys. It allows the user to perform both MD and TVD interpolations from which ever survey grid is currently active. This is determined by the survey selection combo on the survey tab.

	MD (ft)	Inc	Azi	TVD (ft)	NS (ft)	EW (ft)	VS (ft)
1							

Figure 31: Interpolate Dialog

Enter a depth into either the MD or TVD cell to perform the interpolation. Interpolations for multiple depths can be performed simply by typing a value in to the next available blank line. The results can be exported to a tab delimited text file by clicking on the export button. Alternatively, the contents of the grid can be copied by selecting the cells of interest and pressing Ctrl + C.

4.5.3 – Pump Data

This gives the user access to the Pump Data dialog.

Figure 32: Pump Output Dialog

The pump output in barrels / stroke can be calculated by entering the pump liner size, stroke length and pump efficiency. By default, the efficiency is set to 97%. Select if the pump type being used is duplex or triplex from the pump type combo box.

Pump liner size and rating can also be input here. This can then be displayed on any of the charts via the **add additional series** button. *This input does not affect any calculation. It is instead a reference which can be added to the required charts.*

4.5.4 – Pipe Length Calculator

A calculator which lets the user calculate the total length of pipe by entering the nominal length of 1 joint of pipe along with the number of joints.

Figure 33: Pipe Length Calculator Dialogue

4.5.5 – Tubular Properties Calculator

Allows the user to calculate the tubular properties of Drill Pipe, Casing and Tubing.

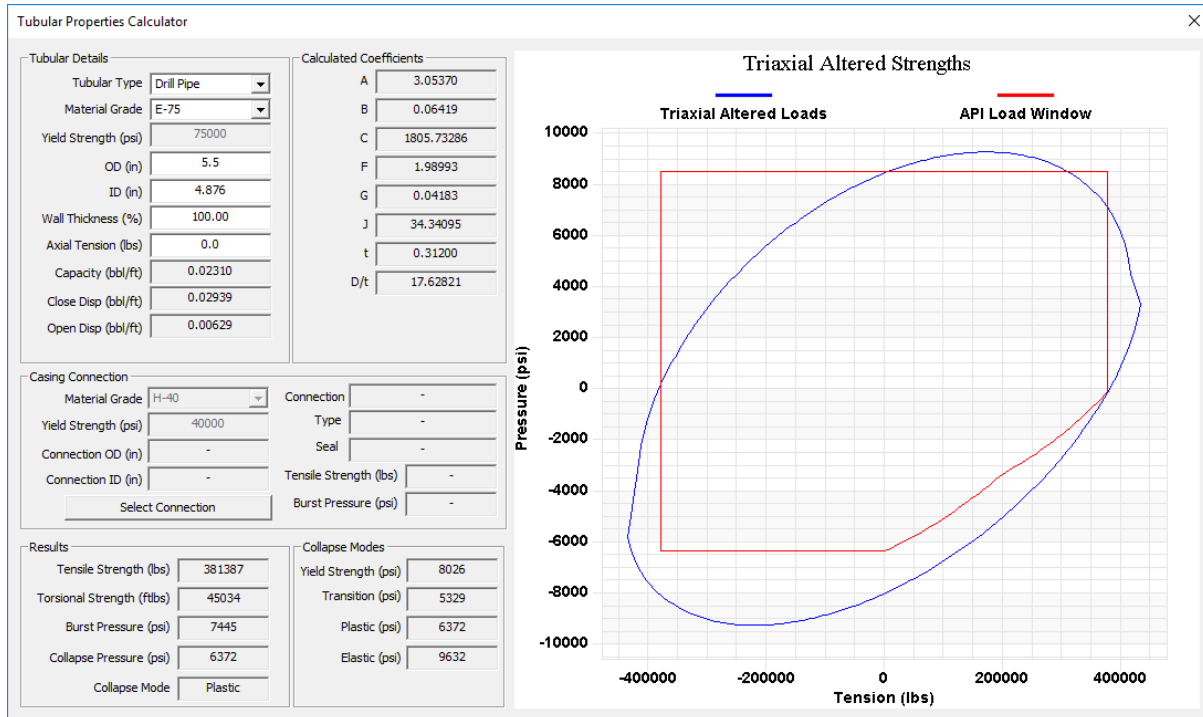


Figure 34: Tubular Properties Calculator Dialogue

Tubular Details: Where the user enters the details of the relevant tubular.

- **Tubular Type:** Select Drill Pipe, Casing or Tubing from the drop-down menu.
- **Material Grade:** Select the appropriate grade of steel from the drop-down menu
- **Yield Strength:** The yield strength of the pipe, based on the selected Material Grade
- **OD:** Outside Diameter of the pipe
- **ID:** Inside Diameter of the pipe
- **Wall Thickness:** Wall thickness of the pipe. New pipe will be 100%
- **Axial Tension:** The Axial Tension expected on the tubular (+ve for tension and -ve for compression). This value affects the Results and Collapse Modes output.
- **Capacity:** Internal Capacity of the pipe in barrels per foot
- **Closed Disp:** Closed end displacement of the pipe in barrels per foot.
- **Open Disp:** Open ended displacement of the pipe in barrels per foot. This is the Closed Displacement minus the Capacity.

Calculated Coefficients: The coefficients used for the collapse calculation (see API 5CT)

Casing Connection: This section allows the user to select the appropriate Casing connection and is only available to edit when Casing is selected from the Tubular Type drop-down in the Tubular Details section. The Material Grade can be selected on the main dialogue and the Casing Connection Selector Dialogue can be accessed from the **Select Connection** radio button.

Casing Connection Selector

Select Connection

API - BTC
API - LTC
API - STC
API - XL
HSC - HSC
Hunting - Big O
Hunting - FJ150
Hunting - LTC
Hunting - SL APEX
Hunting - SL BOSS
Hunting - SL
Hunting - SLHC
Hunting - SLHT

Connection Properties

Name: API - BTC Coupling: Regular Material Grade: H-40 Selected Pipe OD (in): 5.5
Connection Type: Threaded and Coupled Yield Strength (psi): 40000 Selected Pipe ID (in): 4.876
Seal Type: Thread Tensile Strength (psi): 60000 Selected Pipe Weight (ppf): -

Tube OD (in)	Weight (ppf)	Tube ID (in)	Connection OD - Reg (in)	Connection OD - Spec Clearance(in)	L4 - M (in)	EI Pitch Diameter (in)	L1 Length (in)	d1 (in)	Tensile Strength (kips)	Burst Pressure (psi)
4.5000	9.5000	4.0900	5.0000	4.8750	4.4540	1.6535	0.40	4.39	147	3644
4.5000	9.5000	4.0900	5.0000	4.8750	4.4540	1.6535	0.40	4.39	147	3644
4.5000	10.5000	4.0520	5.0000	4.8750	4.4540	1.6535	0.40	4.39	160	3982
4.5000	11.6000	4.0000	5.0000	4.8750	4.4540	1.6535	0.40	4.39	178	4444
4.5000	9.5000	4.0900	5.0000	4.8750	4.4540	1.6535	0.40	4.39	147	3644
4.5000	10.5000	4.0520	5.0000	4.8750	4.4540	1.6535	0.40	4.39	160	3982
4.5000	11.6000	4.0000	5.0000	4.8750	4.4540	1.6535	0.40	4.39	178	4444
4.5000	9.5000	4.0900	5.0000	4.8750	4.4540	1.6535	0.40	4.39	147	3644
4.5000	10.5000	4.0520	5.0000	4.8750	4.4540	1.6535	0.40	4.39	160	3982
4.5000	11.6000	3.9200	5.0000	4.8750	4.4540	1.6535	0.40	4.39	204	4880
4.5000	11.6000	4.0000	5.0000	4.8750	4.4540	1.6535	0.40	4.39	178	4444
4.5000	13.5000	3.9200	5.0000	4.8750	4.4540	1.6535	0.40	4.39	204	4880

Select Cancel

Figure 35: Casing Connection Selector Dialogue

Connection types are selected from the top menu. This selection will populate the bottom table with the relevant tubular sizes, which can be selected by the user. Highlighting the relevant line and pressing select, closes the window and populates the casing connection values.

Collapse Modes: See API 5CT

Triaxial Altered Strengths Chart: This chart plots a comparison of the Triaxial Altered Loads with the API Load Window. This shows the adjusted burst and collapse pressures when tension or compression is applied.

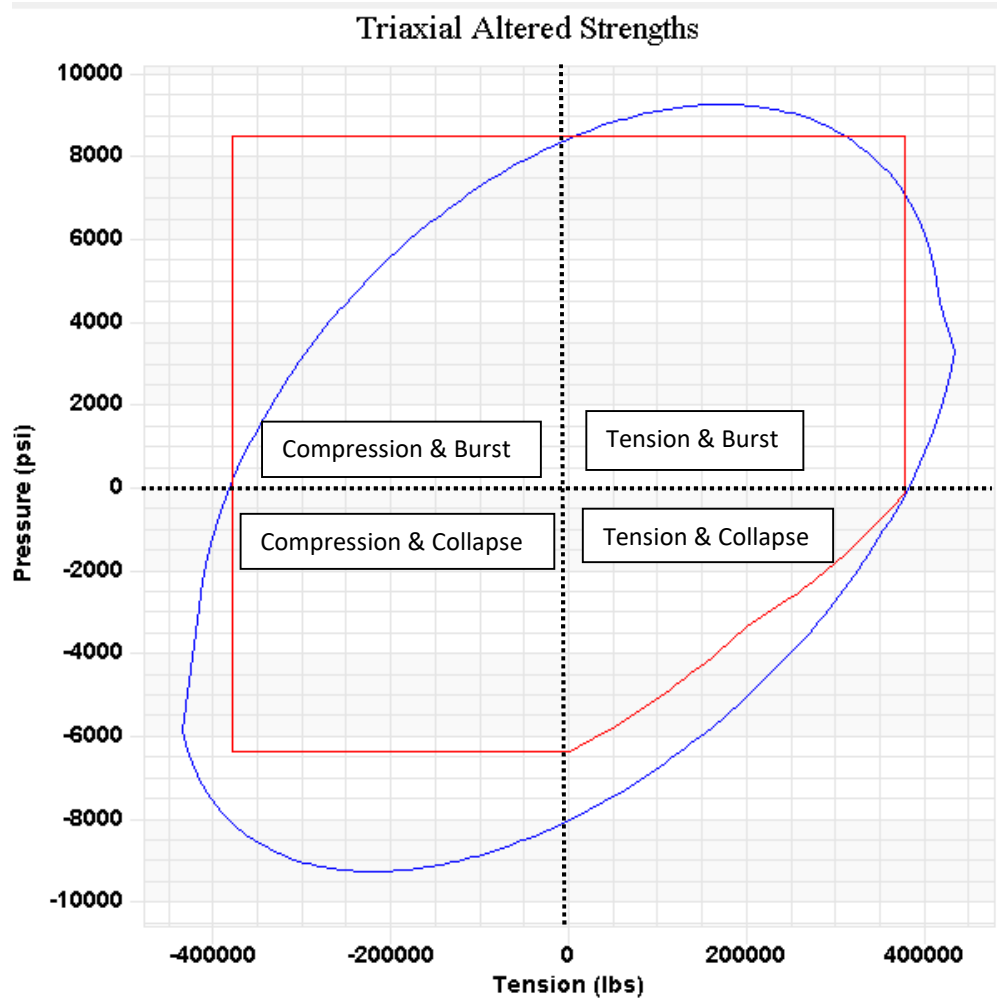


Figure 36: Triaxial Altered Strength Chart

4.5.6 – Component Catalogue

Displays the Component Catalogue. This can also be accessed from the toolbar  on the main page and by right clicking on the drill string grid on the first tab of the main screen and selecting “**Select from library**” from the context menu. This enables the “Insert into Drill String” button and the details of the selected library item will be added to the selected row of the drill string grid. Custom items can be added by clicking the “add new” button and items can be removed by clicking the delete button. Note that if the program is re installed all customizations will be lost. To prevent this from happening the catalogue file should be copied (located in the install directory) and the default catalogue replaced with the customised one after the install.

Component Catalogue

File

Component	None	OD	None	Grade	None	Nominal Weight	None											
Description	Pipe OD (in)	Pipe ID (in)	T1 OD (in)	T2 ID (in)	Nominal Weight (lb/ft)	Grade	Adjusted Weight Inc T2 (lb/ft)	Wall Thick (in)	Connection	Tensile Yield Strength (ksi)	Torsional Yield (ft/lbs)	Collapse Pressure (psi)	Burst Pressure (psi)	Length (ft)	St	A		
2.375 E-75 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.75	6.65	E-75 EU	7.17	0.28	NC26	138200	6300	15599	15474	28				
2.375 E-75 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.75	6.65	E-75 EU	7.25	0.28	HT26	138200	6300	15599	15474	28				
2.375 E-75 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.8125	6.65	E-75 EU	7	0.28	SLH90	138200	6300	15599	15474	28				
2.375 X-95 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.75	6.65	X-95 EU	7.17	0.28	NC26	175100	7900	19759	19600	28				
2.375 X-95 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.75	6.65	X-95 EU	7.25	0.28	HT26	175100	7900	19759	19600	28				
2.375 X-95 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.8125	6.65	X-95 EU	7	0.28	SLH90	175100	7900	19759	19600	28				
2.375 G-105 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.75	6.65	G-105 EU	7.17	0.28	NC26	193500	8800	21839	21663	28				
2.375 G-105 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.75	6.65	G-105 EU	7.25	0.28	HT26	193500	8800	21839	21663	28				
2.375 G-105 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.8125	6.65	G-105 EU	7	0.28	SLH90	193500	8800	21839	21663	28				
2.375 S-135 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.625	1.5	6.65	S-135 EU	7.62	0.28	NC26	248800	11300	28079	27853	28				
2.375 S-135 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.625	6.65	S-135 EU	7.35	0.28	HT26	248800	11300	28079	27853	28				
2.375 S-135 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.6875	6.65	S-135 EU	7.1	0.28	SLH90	248800	11300	28079	27853	28				
2.375 S-135 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.5	1.6875	6.65	S-135 EU	7.35	0.28	GPOS26	248800	11300	28079	27853	28				
2.375 Z-140 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.125	1.5	6.65	Z-140 EU	7.32	0.28	HT24	258000	11700	29119	28884	28				
2.375 Z-140 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.625	6.65	Z-140 EU	7.52	0.28	XT26	258000	11700	29119	28884	28				
2.375 Z-140 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.625	6.65	Z-140 EU	7.35	0.28	HT26	258000	11700	29119	28884	28				
2.375 Z-140 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.5	1.625	6.65	Z-140 EU	7.39	0.28	GPOS26	258000	11700	29119	28884	28				
2.375 V-150 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.125	1.375	6.65	V-150 EU	7.41	0.28	HT24	276400	12500	31199	30947	28				
2.375 V-150 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.5	6.65	V-150 EU	7.62	0.28	XT26	276400	12500	31199	30947	28				
2.375 V-150 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.375	1.5	6.65	V-150 EU	7.45	0.28	HT26	276400	12500	31199	30947	28				
2.375 V-150 EU(6.65lb/ft) Drill Pipe	2.375	1.815	3.5	1.5	6.65	V-150 EU	7.48	0.28	GPOS26	276400	12500	31199	30947	28				
2.875 E-75 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.375	1.75	6.85	E-75 IU	7.19	0.217	NC26	135900	8100	10467	9907	28				
2.875 E-75 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.375	1.75	6.85	E-75 IU	7.27	0.217	HT26	135900	8100	10467	9907	28				
2.875 E-75 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4.125	2.15625	6.85	E-75 IU	7.88	0.217	NC31	135900	8100	10467	9907	28				
2.875 E-75 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.375	1.75	6.65	E-75 IU	7.43	0.217	XT26	135900	8100	10467	9907	28				
2.875 E-75 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4	2.15625	6.85	E-75 IU	7.83	0.217	HT31	135900	8100	10467	9907	28				
2.875 E-75 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4	2.375	6.85	E-75 IU	7.75	0.217	XT31	135900	8100	10467	9907	28				
2.875 X-95 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.5	1.5	6.85	X-95 IU	7.5	0.217	NC26	172100	10200	12940	12548	28				
2.875 X-95 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.375	1.75	6.85	X-95 IU	7.27	0.217	HT26	172100	10200	12940	12548	28				
2.875 X-95 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4.125	2.15625	6.85	X-95 IU	7.88	0.217	NC31	172100	10200	12940	12548	28				
2.875 X-95 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.375	1.75	6.65	X-95 IU	7.43	0.217	HT26	172100	10200	12940	12548	28				
2.875 X-95 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4	2.15625	6.85	X-95 IU	7.83	0.217	HT31	172100	10200	12940	12548	28				
2.875 X-95 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4	2.375	6.85	X-95 IU	7.75	0.217	XT31	172100	10200	12940	12548	28				
2.875 G-105 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.625	1.75	6.85	G-105 IU	7.46	0.217	NC26	190300	11300	14020	13869	28				
2.875 G-105 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.375	1.75	6.85	G-105 IU	7.27	0.217	HT26	190300	11300	14020	13869	28				
2.875 G-105 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4.125	2.15625	6.85	G-105 IU	7.88	0.217	NC31	190300	11300	14020	13869	28				
2.875 G-105 IU(6.85lb/ft) Drill Pipe	2.875	2.441	3.375	1.75	6.65	G-105 IU	7.43	0.217	XT26	190300	11300	14020	13869	28				
2.875 G-105 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4	2.15625	6.85	G-105 IU	7.83	0.217	HT31	190300	11300	14020	13869	28				
2.875 G-105 IU(6.85lb/ft) Drill Pipe	2.875	2.441	4	2.375	6.85	G-105 IU	7.75	0.217	XT31	190300	11300	14020	13869	28				

Insert into Drilling | Add New | Delete | Edit | Reset to Defaults

Figure 37: Component Catalogue

4.5.7 – Pipe Class Editor

This dialogue shows the percentage wall thickness of the different classes of Drill Pipe. The industry standard values are included. These values are editable and affect torque and drag buckling calculations.

Pipe Class Editor

Class	Percentage Wall thickness (%)
New	100
Premium Plus	90
Premium	80
Class 1	70
Class 2	60

OK Cancel

Figure 38: Pipe Class Editor Dialogue

4.5.8 – Standoff Optimisation Parameters

These inputs affect the casing standoff calculation.

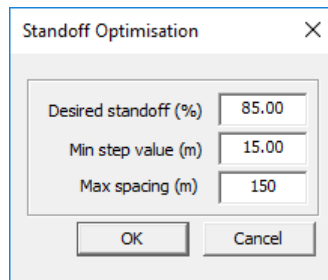


Figure 39: Standoff Optimisation Dialogue

- **Desired Standoff:** This is the standoff which will be calculated when Optimise Standoff is selected
- **Max Step Value:** The minimum step value between one optimum spacing and the next. Engineering looks at the **required spacing** values which provide the **desired standoff**, and groups similar values (which land within the step range) together to provide a single optimum spacing output for each of these points. This is basically a smoothing parameter. Larger step values encompass more of the optimum spacing values providing more of a smoothing effect.
- **Max Spacing:** The spacing value at which no centralisers will be recommended. This affects the Centralizer Spacing Summary in the Standoff Summary Report.

4.5.9 – Well Schematic

This shows a graphical representation of the well geometry section on the first tab of the main screen. Depending on the size of the screen the user has, this may already be visible in a pain at the right of the screen. Due to the limited size of most laptop screens, this schematic will be hidden from view to maximise the rest of the interface.

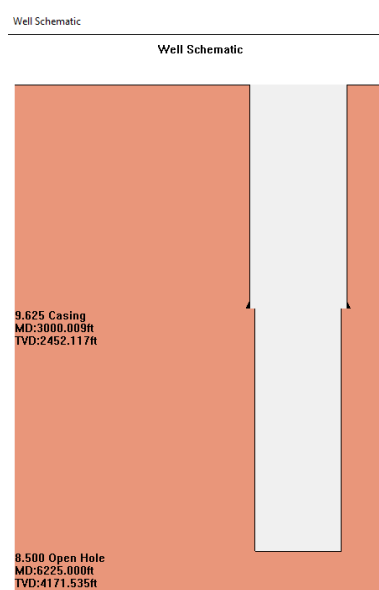


Figure 40: Well Schematic

4.5.10 – Multi-Station Analysis

This opens the Multi Station Analysis (MSA) dialogue and is only available to select when raw surveys are selected in the survey tab on the main screen.

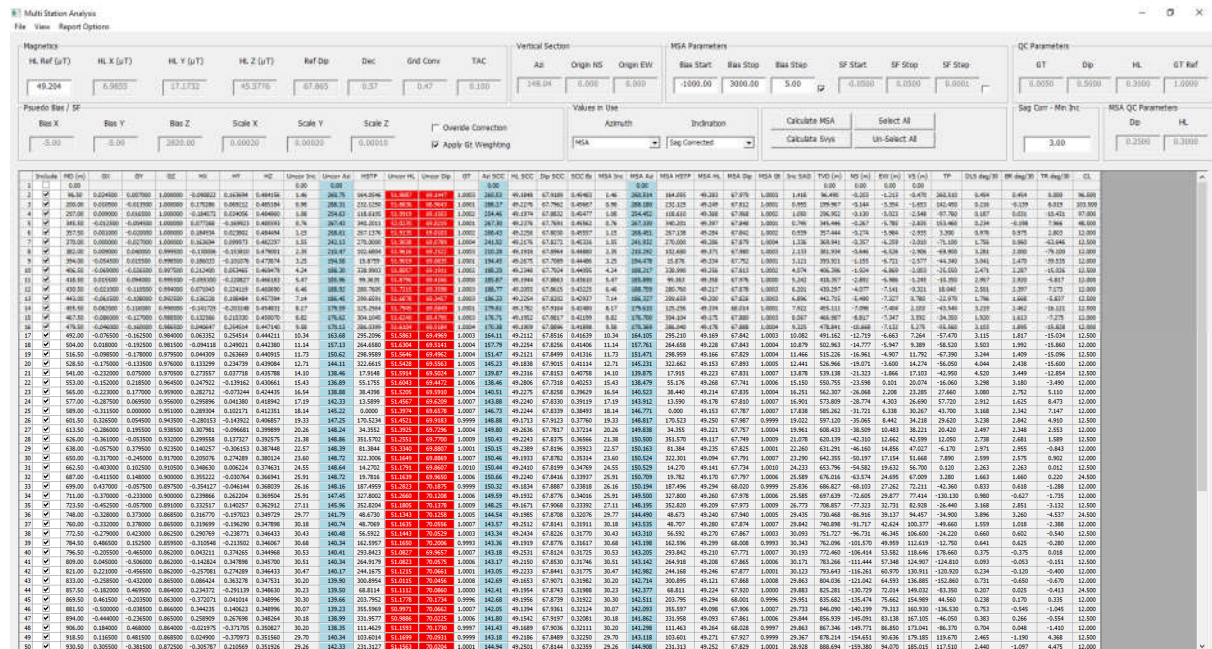


Figure 41: Multi Station Analysis Dialogue

Magnetics: Mostly populated from the values entered in the raw survey data section of the surveys tab. Only the **HL Ref** can be edited from this screen. This cell contains the HL value entered on the main surveys tab but, can be edited here if a more accurate value is supplied e.g. from an IFR model.

Vertical Section: Populated from the values entered in the vertical section cells of the surveys tab. These cells can't be edited from this dialogue.

MSA Parameters: The user can select the required Bias and SF start, stop and Step values. If the LSQ fit does not show a good curve with a minimum found these values can be adjusted to extend the range of the calculation. Changing the step size can speed up / slow down the calculation but a smaller step size can increase the accuracy.

QC Parameters: Populated from the values entered in the raw survey QC limits. These cells can't be edited from this dialogue.

MSA QC Parameters: Populated from the values entered in the raw survey QC limits. These cells can't be edited from this dialogue.

Pseudo Bias /SF: Calculated X, Y & Z magnetometer Bias and Scale results. Only populated after Calculate MSA radio button has been clicked.

Override Correction: When this box is ticked the user can manually edit the Bias X, Y, Z and Scale X, Y, Z values.

Apply Gt Weighting: Surveys at a higher inclination are given more weighting in the calculation than surveys at lower inclinations. This is because they have more of an effect on azimuth. Ticking this box defines if the weighting is applied.

Values in Use: The user can choose which values to use for the calculation:

- **Azimuth:** This selection determines which azimuth is used in the survey calculation and only affects TVD, NS, EW, VS, DLS etc. Choose between MSA, SCC and RAW.
- **Inclination:** This selection determines which inclination is used in the survey calculation and only affects TVD, NS, EW, VS, DLS etc. Choose between RAW and SAG Corrected.

Calculate MSA: This selection runs the MSA calculation.

Select All: Selects all the survey stations in the survey grid.

Un-Select All: Un-Selects all the survey stations in the survey grid.

Survey Grid: All raw surveys entered into the surveys tab on the main screen will be entered in this grid when the dialogue is first opened. The MSA columns will then be populated once the calculate MSA radio button has been selected. As with the main survey grid, all values out of spec will be highlighted red. Additionally the Uncor Azi, Azi SCC and MSA Azi columns are highlighted blue for easy of comparison. In the event that the MSA calculation is run and an MSA Azi value is out with the QC Parameters then that surveys MSA Azi will be highlighted red. If the MZA Azi is within QC Parameters but out with MSA QC Parameters then that surveys MSA Azi will be highlighted orange.

At the left-hand side of the screen, if required the user can deselect any survey station which is out of spec. Once the relevant surveys have been deselected it is possible to rerun the calculation. The lines which have been deselected will have blank cells in the MSA columns, and this station will not be included in the calculation.

File Menu: At the top left of the MSA dialogue are the **File** and **View** toolbar menu options, which gives the user a range of additional reporting and chart options relating to the MSA calculation.

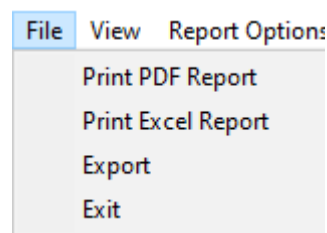


Figure 42: MSA File Menu

Print PDF Report: This generates a PDF report which includes the MSA results, Magnetics, Pseudo Bias & SF values and a listing of the corrected surveys. Note that any stations which were deselected will not appear in this listing, and that this report is NOT available from the Print Reports section. The following charts are also included in the report: BH BV Scatter Plot, B Total Comparison, MSA Azimuth

Comparison, Dip Comparison, HSTF v Azimuth Correction, Corrected vs Uncorrected surveys (Plan and Section View) and GT Plot.

Print PDF Report: This generates an Excel report which includes a Survey Comparison, Uncorrected Surveys and Corrected Surveys tab. The same charts included in the PDF report are also included in the excel report.

Export: Exports the main MSA data table, as displayed on the main MSA interface. This can be exported as a .txt or Excel file.

Exit: Closes the MSA Dialogue

View Menu: The View menu contains QA/QC and other tools to evaluate the data.

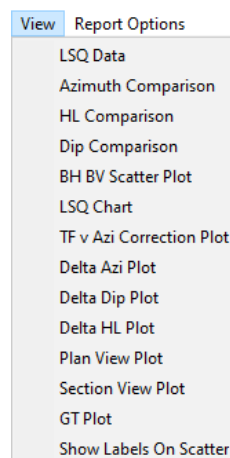


Figure 43: MSA View Menu

LSQ Data: Shows the data from the least squares fit

BIAS	SCALE FACTOR	LSQ BX	LSQ BY	LSQ BZ	LSQ SX	LSQ SY	LSQ SZ
-1000.00000000	-0.05000000	8333.01861016	8337.77291780	8361.55665852	13240.29384019	11292.49964860	8482.41294497
-995.00000000	-0.04990000	8292.05906991	8296.81628695	8320.55268158	13214.37416300	11270.63103195	8465.37029470
-990.00000000	-0.04980000	8251.10002393	8255.86017896	8279.54875732	13188.45451728	11248.76243845	8448.32766420
-985.00000000	-0.04970000	8210.14147963	8214.90460165	8238.54488652	13162.53490323	11226.89386822	8431.28505361
-980.00000000	-0.04960000	8169.18344455	8173.94956299	8197.54106999	13136.61532103	11205.02532140	8414.24246303
-975.00000000	-0.04950000	8128.22592639	8132.99507112	8156.53730854	13110.69577087	11183.15679813	8397.19989259
-970.00000000	-0.04940000	8087.26893300	8092.04113436	8115.53360301	13084.77625294	11161.28829856	8380.15734241
-965.00000000	-0.04930000	8046.31247240	8051.08776116	8074.52995425	13058.85676743	11139.41982281	8363.11481262
-960.00000000	-0.04920000	8005.35655275	8010.13496017	8033.52636313	13032.93731453	11117.55137103	8346.07230335
-955.00000000	-0.04910000	7964.40118242	7969.18274021	7992.52283053	13007.01789444	11095.68294336	8329.02981471
-950.00000000	-0.04900000	7923.44636991	7928.23111029	7951.51935737	12981.09850736	11073.81453995	8311.98734684
-945.00000000	-0.04890000	7882.49212392	7887.28007960	7910.51594457	12955.17915348	11051.94616093	8294.94489985
-940.00000000	-0.04880000	7841.53845333	7846.32965751	7869.51259306	12929.25983301	11030.07780645	8277.90247390
-935.00000000	-0.04870000	7800.58536720	7805.37985362	7828.50930382	12903.34054614	11008.20947667	8260.86006909
-930.00000000	-0.04860000	7759.63287478	7764.43067769	7787.50607783	12877.42129308	10986.34117172	8243.81768556
-925.00000000	-0.04850000	7718.68098553	7723.48213972	7746.50291609	12851.50207404	10964.47289175	8226.77532346
-920.00000000	-0.04840000	7677.72970909	7682.53424991	7705.49981962	12825.58288921	10942.60463692	8209.73298290
-915.00000000	-0.04830000	7636.77905533	7641.58701868	7664.49678948	12799.66373881	10920.73640738	8192.69066402
-910.00000000	-0.04820000	7595.82903431	7600.64045667	7623.49382673	12773.74462304	10898.86820327	8175.64836696
-905.00000000	-0.04810000	7554.87965632	7559.69457476	7582.49093247	12747.82554213	10877.00002476	8158.60609186
-900.00000000	-0.04800000	7513.93093188	7518.74938405	7541.48810782	12721.90649627	10855.13187199	8141.56383885
-895.00000000	-0.04790000	7472.98287173	7477.80489591	7500.48535391	12695.98748569	10833.26374512	8124.52160807
-890.00000000	-0.04780000	7432.03548686	7436.86112193	7459.48267191	12670.06851060	10811.39564431	8107.47939967

Figure 44: LSQ Data Table

Azimuth Comparison Chart: Provides the user with a visual representation of the Uncorrected azimuth against the SCC corrected azimuth and the MSA azimuth.

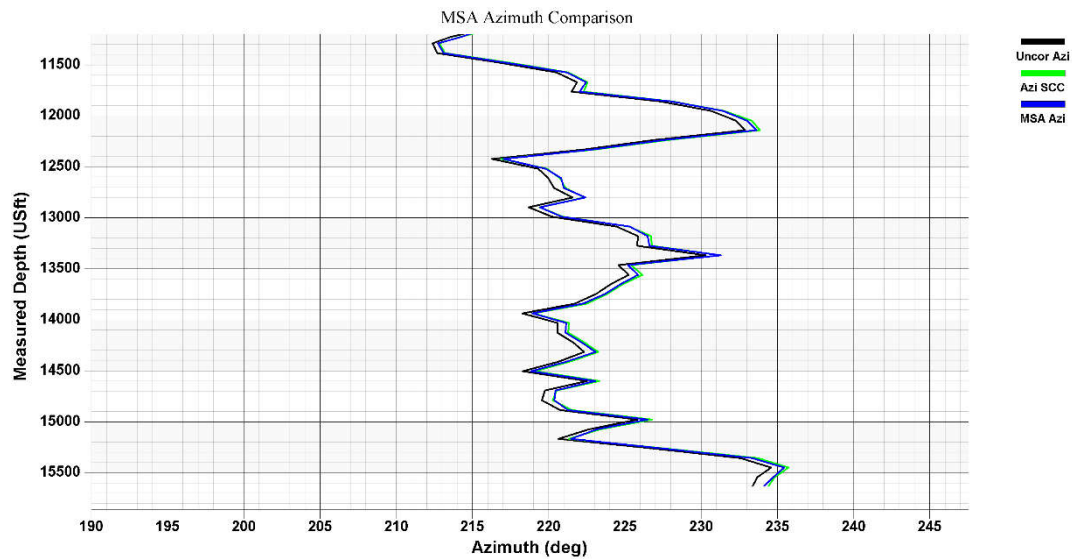


Figure 45: Azimuth Comparison Chart

HL Comparison Chart: Gives the user a visual representation of the reference HL against the measured (uncorrected) HL and the SCC & MSA corrected HL values. The chart also includes the tolerance lines which make it very easy to quickly identify any points which are out with the QC parameters

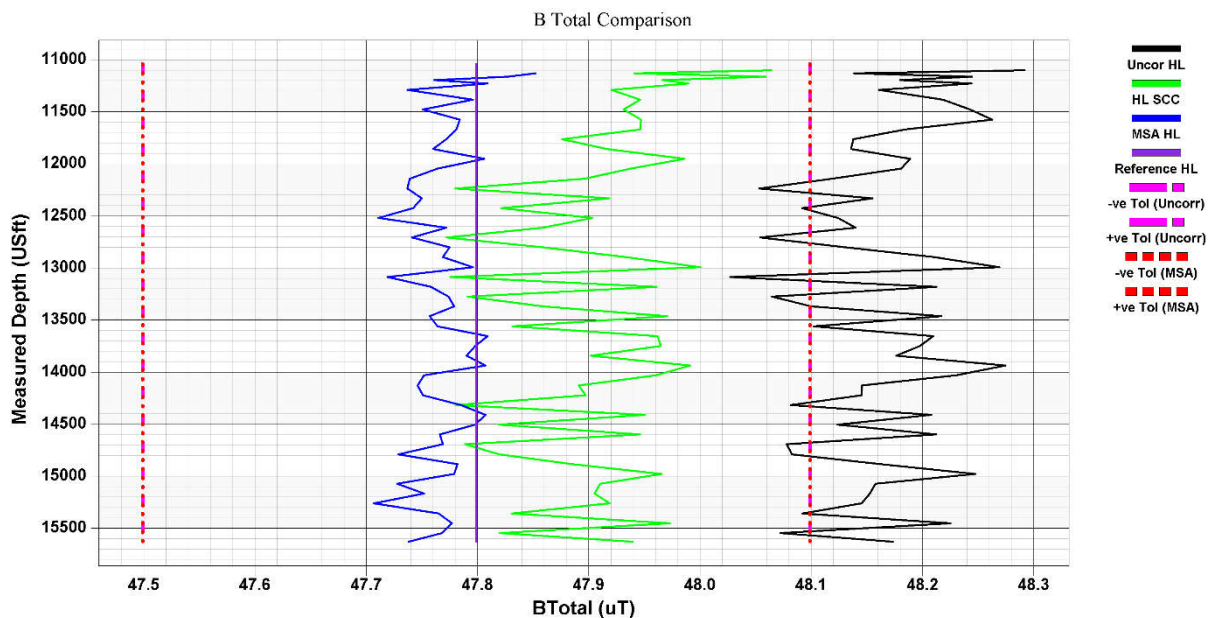


Figure 46: HL Comparison Chart

Dip Comparison Chart: Gives the user a visual representation of the reference Dip against the measured (uncorrected) Dip and the SCC & MSA corrected Dip values. The chart also includes the tolerance lines which make it very easy to quickly identify any points which are out with the QC parameters

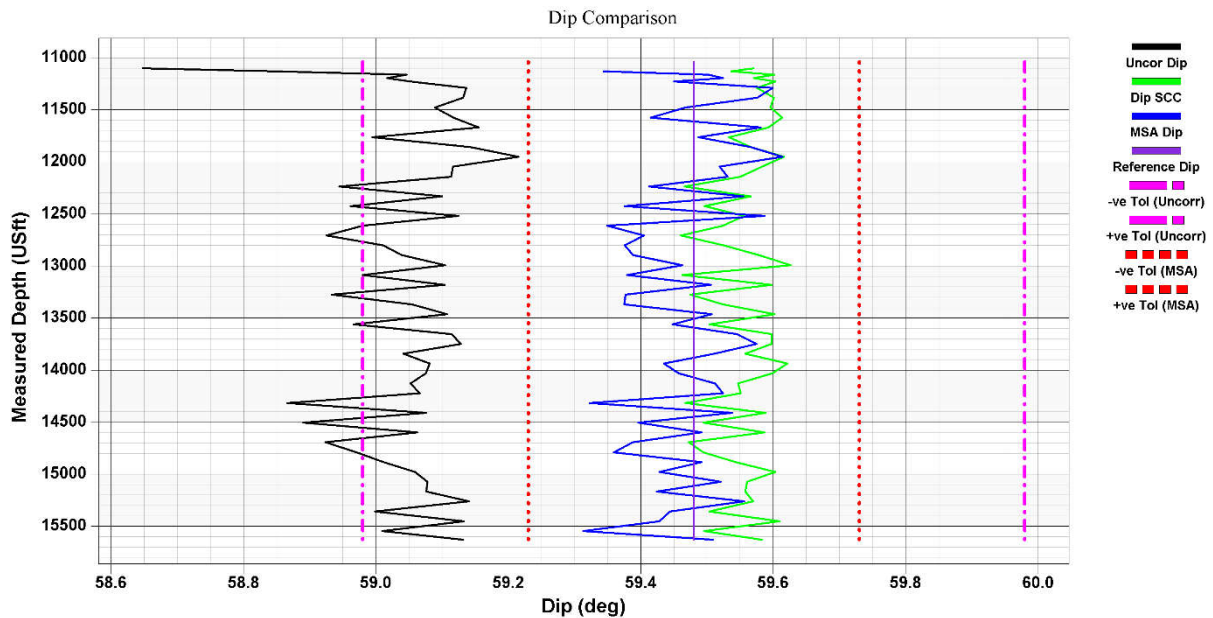


Figure 47: Dip Comparison Chart

BH BV Scatter Plot: Shows the horizontal and vertical components of the sensor readings plotted against the QC values. Ideally, they should all reside within the limits

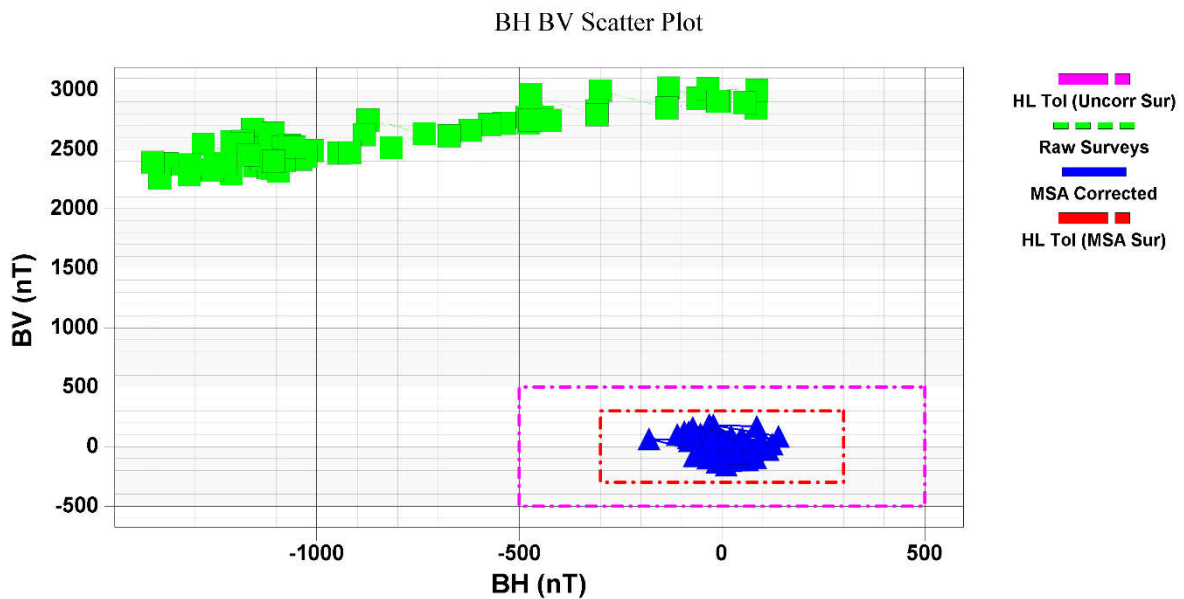


Figure 48: BH BV Scatter Plot

LQS Chart: Shows the least squares fit. If a V shape curve is seen the minimum has been found and the calculation is a success. If any one of the charts does not show a “*minimum found*” the calculation must be re-run.

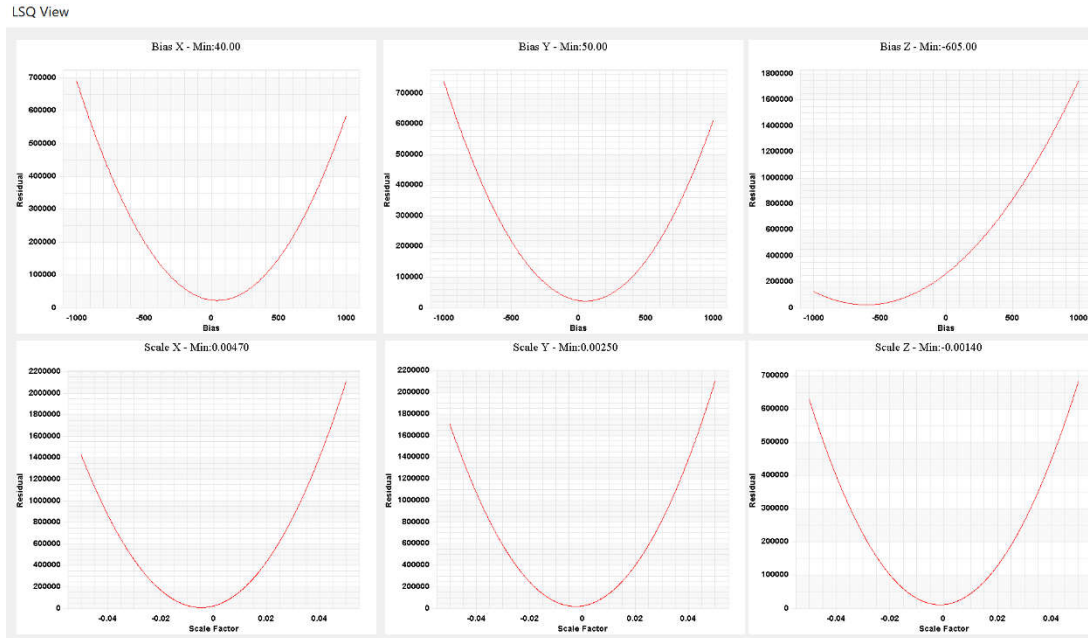


Figure 49: LQS Chart

TF vs Azimuth Correction Plot: This Chart plots the difference in the RAW and MSA corrected azimuths against the HSTF recorded when the survey was taken. This chart gives a good visual representation of the number of surveys taken in each quadrant. For best results, an even spread is ideal, but it is **essential** that there are at least some survey points in each quadrant.

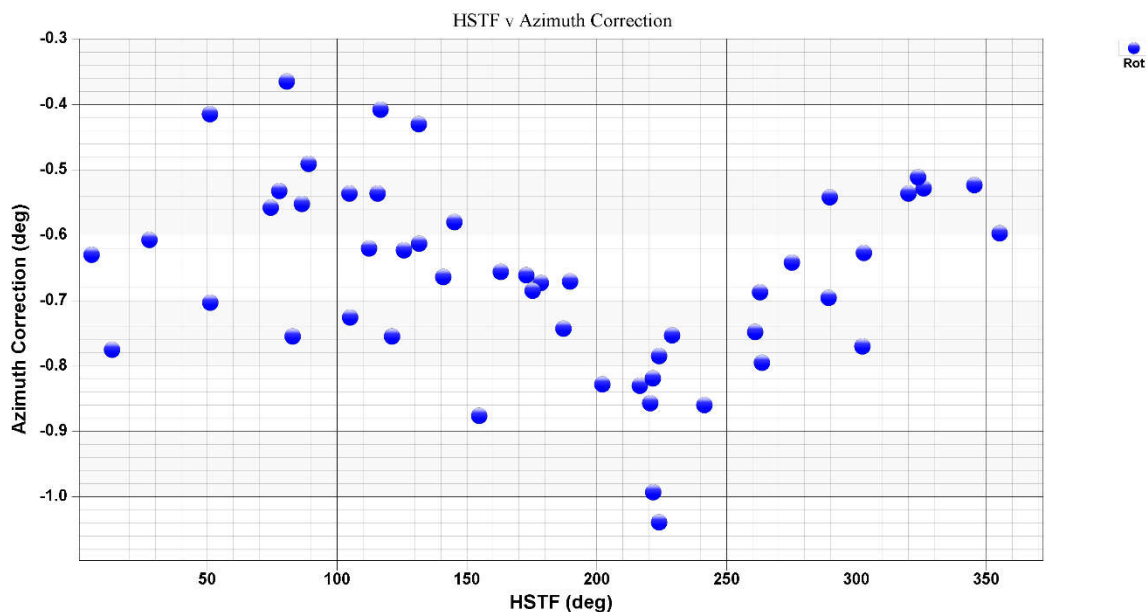


Figure 50: TF vs Azimuth Correction Plot

Delta Azi Plot: The Delta Azi Plot shows the difference in azimuth between the MSA and RAW azimuth and the SCC and RAW azimuth.

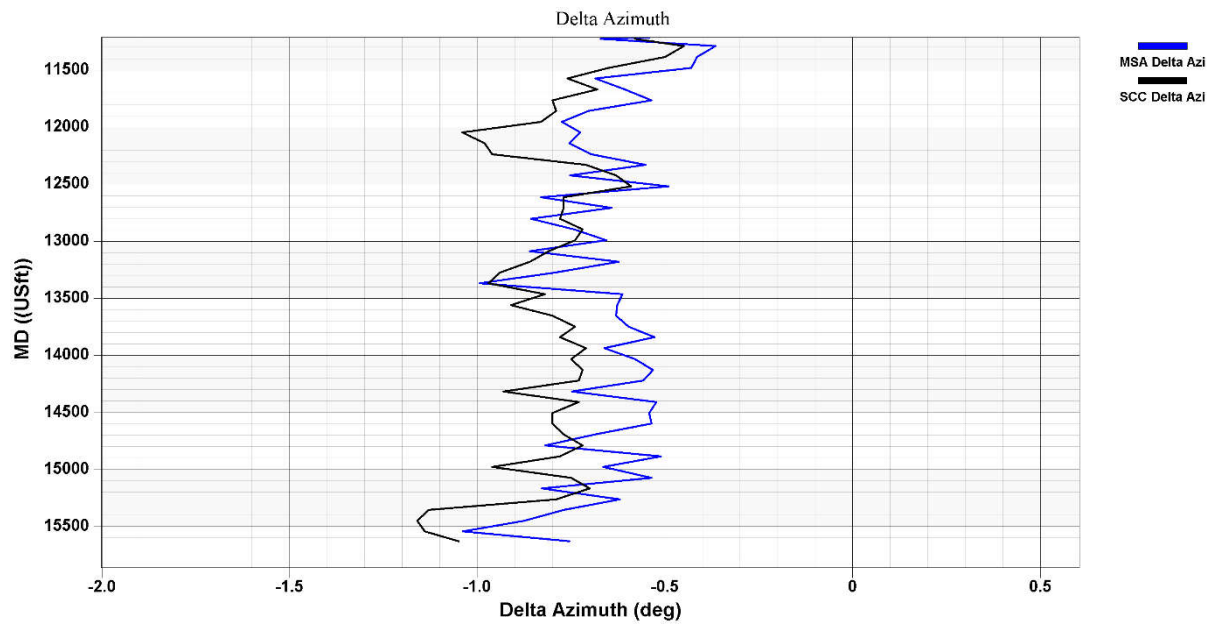


Figure 51: Delta Azi Plot

Delta Dip Plot: The Delta Dip Plot shows the difference in the dip between the MSA and RAW dip and the SCC and RAW dip.

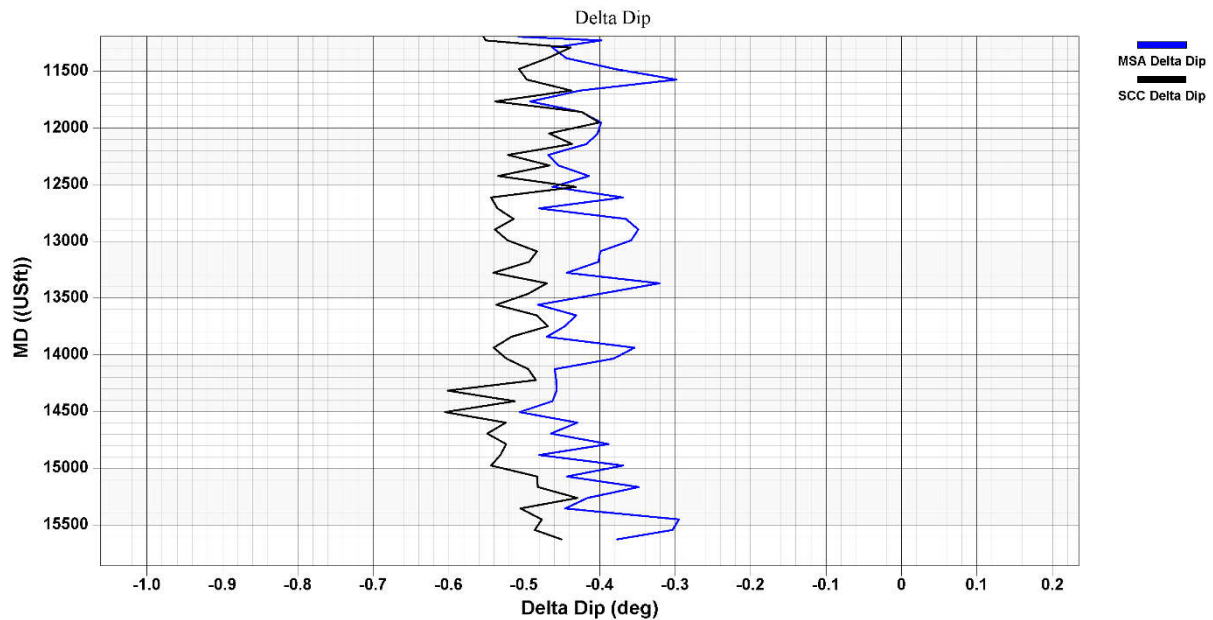


Figure 52: Delta Dip Plot

Delta HL Plot: The Delta HL Plot shows the difference in the HL between the MSA and RAW dip and the SCC and RAW dip.

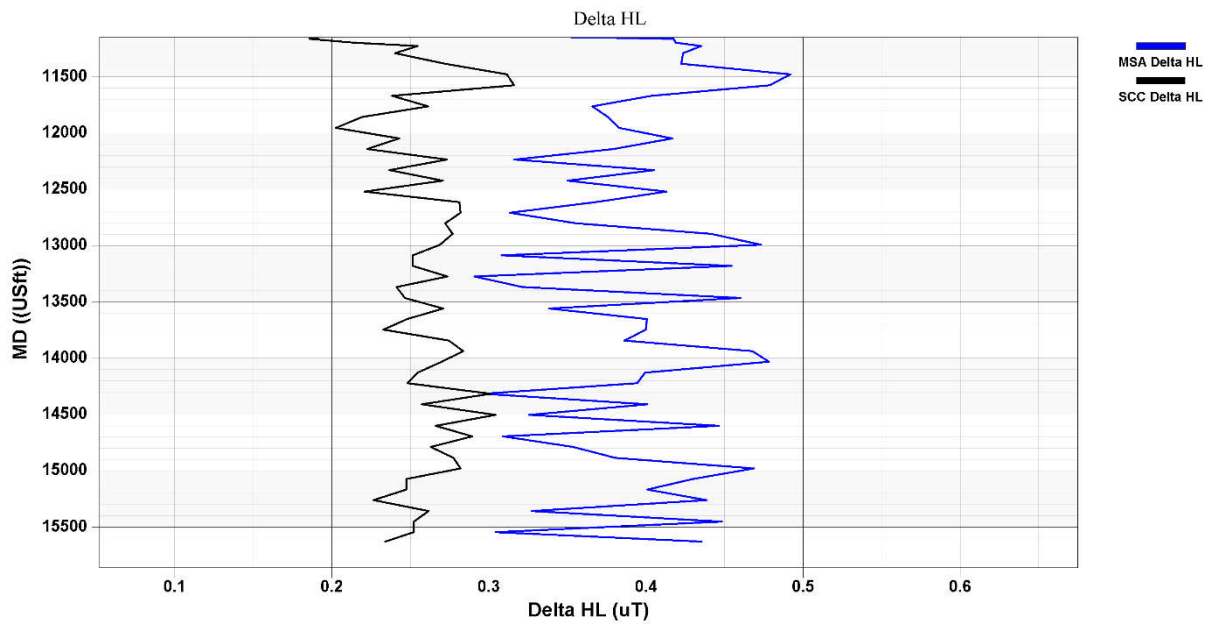


Figure 53: Delta HL Plot

Corrected vs Uncorrected Surveys – Plan View Plot: This plot shows the difference between the corrected and uncorrected surveys in the plan view.

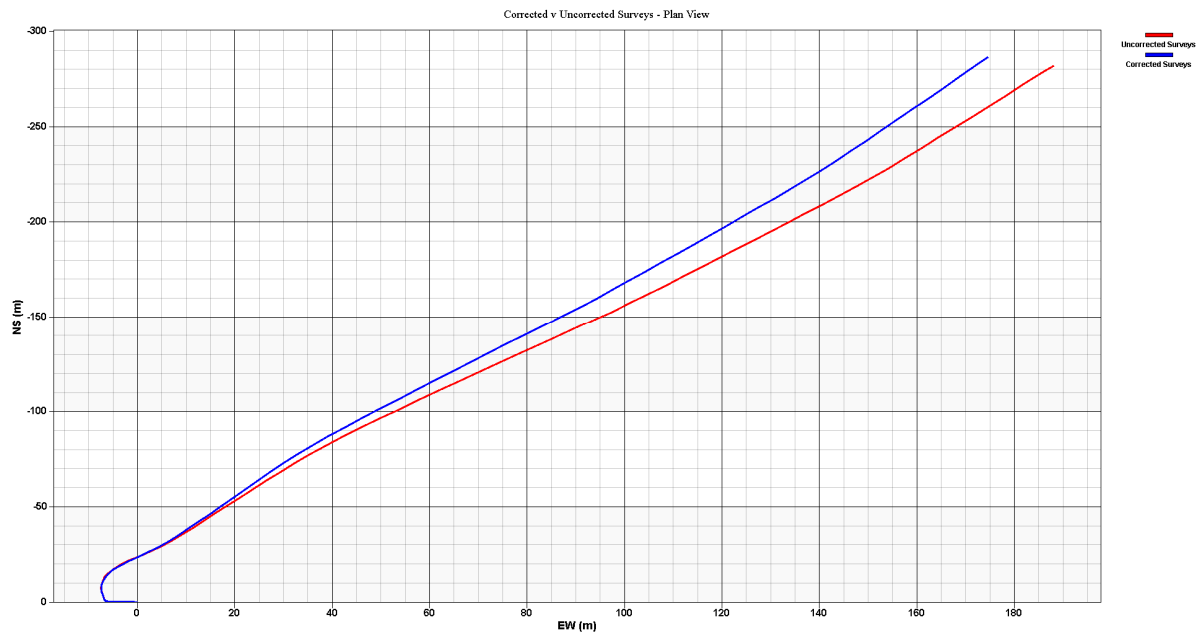


Figure 54: Corrected vs Uncorrected Surveys – Plan View Plot

Corrected vs Uncorrected Surveys – Section View Plot: This plot shows the difference between the corrected and uncorrected surveys in the section view.

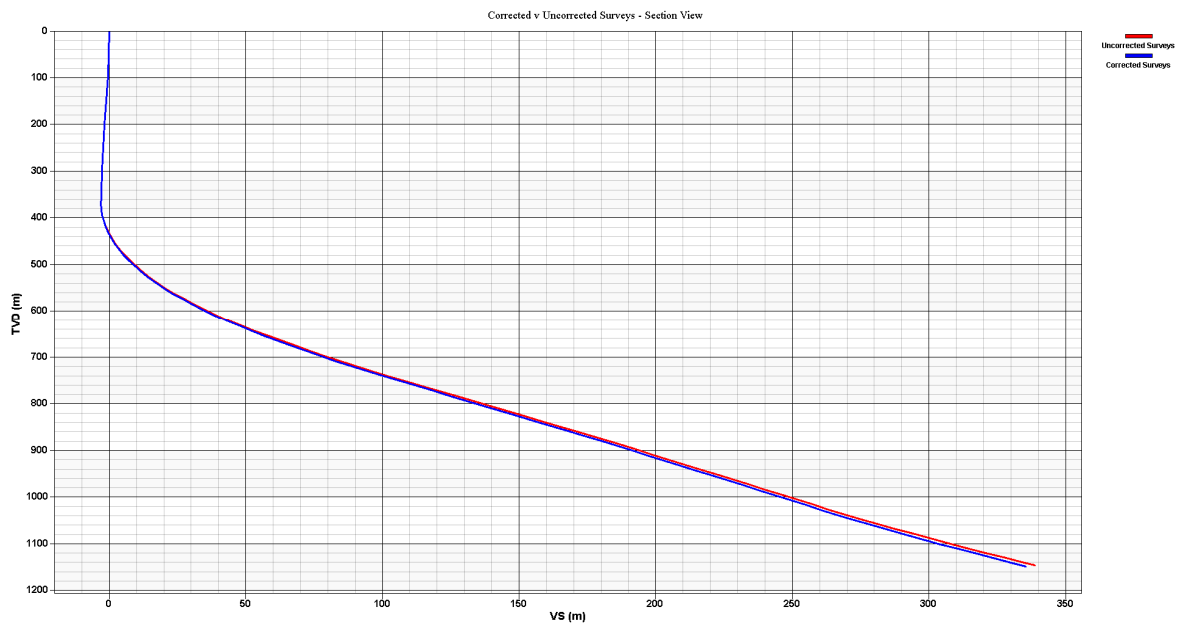


Figure 55: Corrected vs Uncorrected Surveys – Section View Plot

GT Plot: The GT Plot shows the measured GT values against the value entered in the magnetics section.

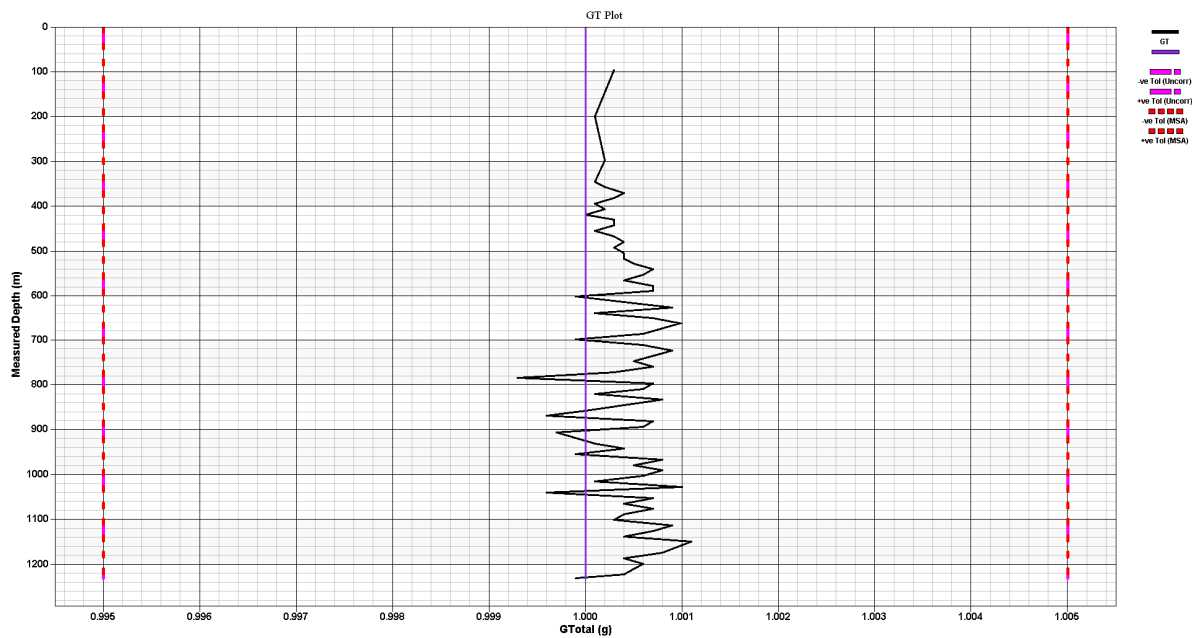


Figure 56: GT Plot

Show Labels on Scatter: Selecting this option, displays labels on the BH BV Scatter plot.

Report Options: Allows the user to select which plots to include in the reports.

4.5.11 – Casing Design

This function is not currently supported but will be in a future release.

4.5.12 – Create Tally / BHA Sheet

This section allows the user to enter multiple BHAs, a Liner Tally, a Work String Tally and an Inner String Tally, and then create an output report which contains the details, including graphics.

Tally / BHA data

File Tools

Job Details

Company	Date	Setting Depth	0.00	Tag Depth	0.0	Problem Int.	0.000	KB	0.0
Lease Name	Rep	Btm of Problem	0.0	LS Collar Below	0.0	US Collar Below	0.0	KB Correction	0.0
Well Number	County / State	Top of Problem	0.0	LS Collar Above	0.0	US Collar Above	0.0	Corrected KB	0.000

BHA | Liner Tally | Work String Tally | Inner String Tally

Select BHA

BHA #1 Length Crossovers 0.0

Component Type	Description	Connection Up	Connection Dn	Torque(Nm)	OD(mm)	ID(mm)	Fish Neck OD(mm)	Fish Neck Length(m)	Length(m)	Total Length(m)
1										

Import BHA Apply Close

Figure 57: Tally / BHA data Dialogue

The user can import the BHA directly from the Drill String section on the main screen by selecting the Import BHA radio button at the bottom right of the screen. The only things which need to be input manually are the Component Type, Fish Neck OD and Fish Neck Length.

4.5.13 – Jar Placement

This opens the Jar Placement Dialog.

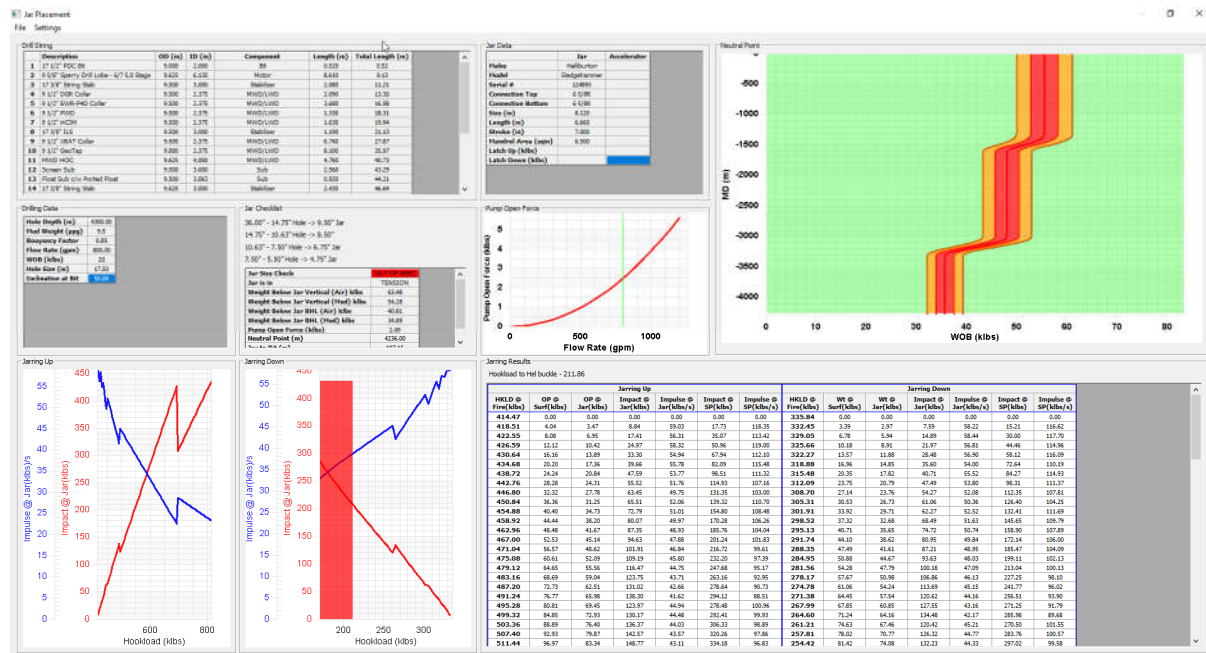


Figure 58: Jar Placement Dialogue

The Jar Placement dialog displays all the information and results relevant to the jar placement module.

Drill String

Description	OD (in)	ID (in)	Component	Length (m)	Total Length (m)
14 17 3/8" String Stab	9.625	3.000	Stabilizer	2.430	46.64
15 3 x 9 1/2" Drill Collars	9.500	3.000	Drill Collar	28.330	74.97
16 X/O	9.500	3.000	Sub	1.240	76.21
17 Churchill Catcher Sub	8.250	2.690	Sub	3.640	79.85
18 Churchill Circ Sub	8.250	2.710	Sub	1.960	81.81
19 2 x 8 1/4" Drill Collars	8.250	2.813	Drill Collar	18.680	100.49
20 8" Sledgehammer Jar	8.120	2.750	Jar	6.660	107.15
21 3 x 8 1/4" Drill Collars	8.250	2.813	Drill Collar	28.150	135.30
22 X/O	8.250	3.000	X/O	1.140	136.44
23 9 x 5 1/2" HWDP	5.500	3.250	Drill Pipe / HWDP	84.520	220.96
24 8 Wenzel Hydraulic Jar Accelerator	8.0000	3.0000	Accelerator	6.660	227.62
25 9 x 5 1/2" HWDP	5.500	3.250	Drill Pipe / HWDP	84.520	312.14
26 5 1/2" Drill Pipe to surface	5.500	4.776	Drill Pipe / HWDP	4054.000	4366.14
27 Bit			Bit		

Figure 59: Drill String Section

Non-editable display of the drill string entered in the Drill String section of the main UI. Jars are highlighted in green and accelerators in orange.

Jar Data

Jar Data		
	Jar	Accelerator
Make	Halliburton	Wenzel
Model	Sledgehammer	Hydraulic Jar Accelerator
Serial #	124893	
Connection Top	6 5/8R	
Connection Bottom	6 5/8R	
Size (in)	8.120	8.0000
Length (m)	6.660	6.660
Stroke (in)	7.000	8
Mandrel Area (sqin)	6.500	
Latch Up (klbs)		
Latch Down (klbs)		

Figure 60: Jar Data Section

Non-editable display of the jar and accelerator component details entered in the Drill String section of the main UI. Only **Stroke** and **Mandrel Area** affect the jar placement results. All other cells are for reference only.

- **Stroke:** This is the free stroke length and is used in the impact and impulse calculations.
- **Mandrel Area:** Is used in the pump open force calculation.

Drilling Data

Drilling Data	
Hole Depth (m)	4300.00
Mud Weight (ppg)	9.5
Bouyancy Factor	0.85
Flow Rate (gpm)	800.00
WOB (klbs)	0
Hole Size (in)	17.50
Inclination at Bit	50.00

Figure 61: Drilling Data Section

Non-editable display of drilling data used in the jar placement calculations.

- **Hole Depth:** Value taken from the deepest MD entered in the Well Geometry section of the main UI. Dictates the deepest depth that the neutral point calculation is run.
- **Mud Weight:** Value from the Fluid Properties, Mud Weight cell. Used in the buoyancy factor calculation.
- **Bouyancy Factor:** Calculated using the below formula.

$$BF = 1 - (MW/k)$$

Where BF is buoyancy factor, MW is mud weight and k is a (mud weight unit dependant) constant. Buoyancy factor is used in the neutral point and jarring results calculations.

- **Flow Rate:** Value from the Engineering Parameters tab. If manual flow increment is selected, the first flow rate entered will be used in the calculation. If the automatic range is selected, the flow rate entered in line 3 will be used. Used in the pump open force calculation.
- **WOB:** Value from Torque and Drag sections WOB Rotate cell. Used in the neutral point calculation.

- **Hole Size:** Value from Well Geometry, Open Hole, ID cell. Used in the **Jar Size Check** and **Jarring Results** calculations.
- **Inclination at Bit:** Interpolated inclination from the survey listing at the **Hole Depth**. Used in the **Weight Below Jar BHL (Air)/(Mud)** calculation.

Jar Checklist

Jar Checklist	
14 3/4" Hole Size or Larger -> 9 1/2" Jar	
10 5/8" - 14 3/4" Hole -> 8" Jar	
7 1/2" - 10 5/8" Hole -> 6 3/4" Jar	
5 1/2" - 7 1/2" Hole -> 4 3/4" Jar	
Jar Size Check	FAIL
Jar is in	TENSION
Weight Below Jar Vertical (Air) klbs	63.48
Weight Below Jar Vertical (Mud) klbs	54.28
Weight Below Jar BHL (Air) klbs	40.81
Weight Below Jar BHL (Mud) klbs	34.89
Pump Open Force (klbs)	0.00
Neutral Point (m)	4300.00
Jar to Bit (m)	107.15

Figure 62: Jar Checklist

Non-editable display of calculated data.

- **Jar Size Check:** A pass or fail check based upon the jar size and the hole size. This is to confirm that the correct OD jar has been chosen for the given hole size. Note that a Fail in this cell has **NO** effect on the jarring calculations, which will be run regardless. All this cell does is highlights to the user if the size of the jar selected is suitable for the hole size based on a checklist which can be fully edited by the user. This is a warning and no more.
- **Jar is in:** **TENSION** or **COMPRESSION**. Based upon the input data, this cell shows whether the jar is currently in tension or compression.
- **Weight Below Jar Vertical (Air):** The weight below the jar in a vertical well in the absence of a drilling fluid. Calculated by the sum of the component weights (input in the Drill String section of the main UI) beneath the jar.
- **Weight Below Jar Vertical (Mud):** The weight below the jar in a vertical well, taking in to account the buoyancy effect of the drilling fluid. Calculated by multiplying the Weight Below Jar Vertical (Air) by the buoyancy factor.
- **Weight Below Jar BHL (Air):** The weight below the jar at the bottom hole location (the bit depth) in the absence of a drilling fluid. Calculated by multiplying the Weight Below Jar Vertical (Air) by the cosine of the Inclination at Bit.
- **Weight Below Jar BHL (Mud):** The weight below the jar at the bottom hole location (the bit depth), taking in to account the buoyancy effect of the drilling fluid. Calculated by multiplying the Weight Below Jar Vertical (Mud) by the cosine of the Inclination at Bit.
- **Pump Open Force:** The force generated by the flow of drilling fluid through the BHA that acts to open the jar. Calculated by the bit pressure loss multiplied by the Mandrel Area.
- **Neutral Point:** The MD of the point in the drill string that transitions from compression to tension based upon the input data. This is directly affected by the WOB.
- **Jar to Bit:** The distance from the top of the jar to the face of the bit.
- **Accelerator to Bit:** The distance from the top of the accelerator to the face of the bit.

Pump Open Force Chart

The pump open force chart displays the pump open force versus the flow rate. The green vertical line depicts the currently selected flow rate.

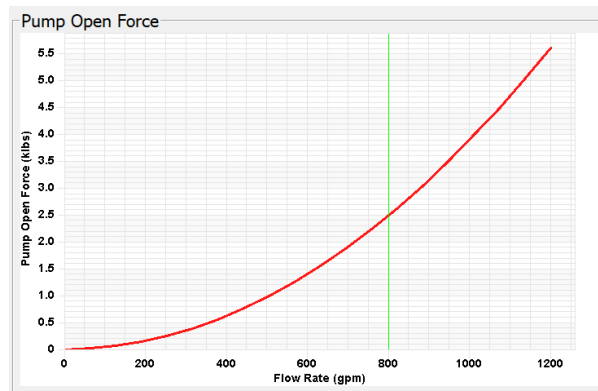


Figure 63: Pump Open Force Chart

Neutral Point Road Map

The neutral point chart is a neutral point road map, which shows the WOB to avoid at every depth along the well path. The centre of the red area represents the neutral point. The red section represents a $\pm 5\%$ safety margin, and the orange area represents a $\pm 10\%$ safety margin. This gives the personnel on the job a WOB range to avoid for any given MD along the entire well path. Note that the 5% and 10% margins are the default values, but these can be changed based on user requirements via the **settings menu**.

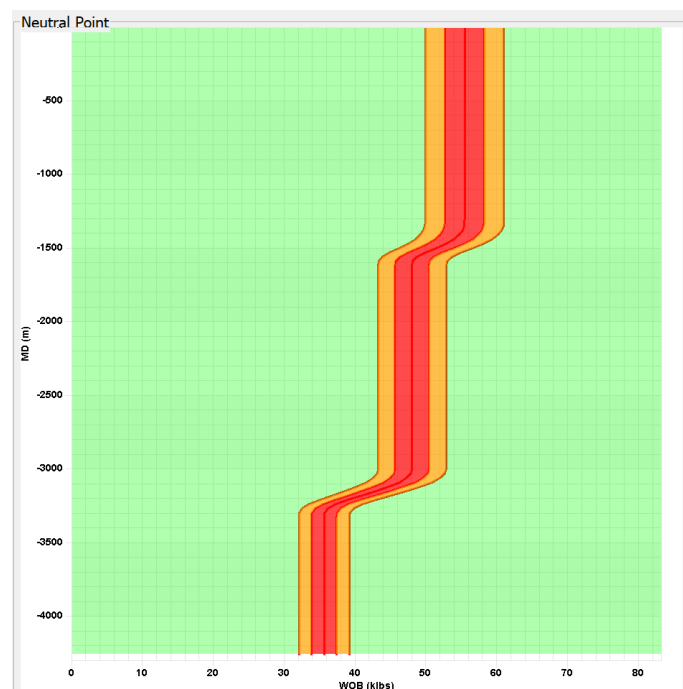


Figure 64: Neutral Point Road Map

Jarring Up Chart

The jarring up chart displays the calculated jarring up impulse and impact at the jar, versus hook load.

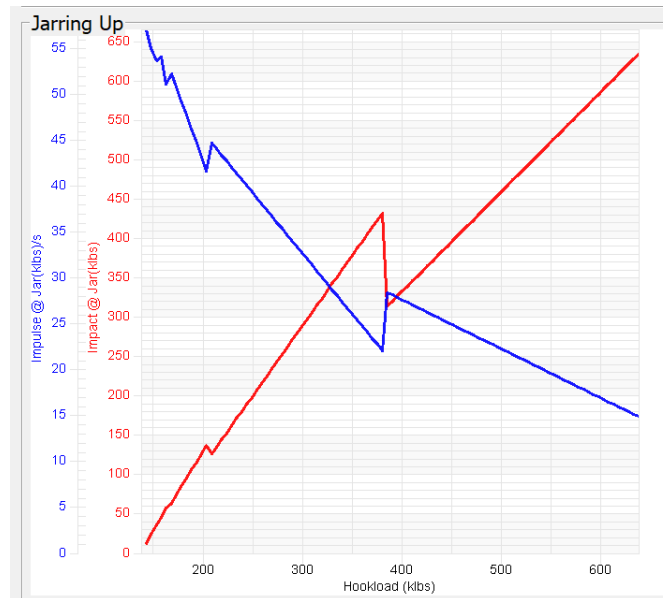


Figure 65: Jarring Up Chart

Jarring Down Chart

The jarring down chart displays the calculated jarring down impulse and impact at the jar, versus hook load. The area shaded in red indicates the hook load range in which the string is modelled as being helically buckled. The buckling will occur at some point in the drill string above the jar and simply indicates that it may not be possible to transmit the required weight to cock / fire the jar. This range is indicated in the jarring results table by lines highlighted in Orange.



Figure 66: Jarring Down Chart

Jarring Results Table

Jarring Results													
Hookload to Hel buckle - 77.87													
Jarring Up							Jarring Down						
HKLD @ Fire(klbs)	OP @ Surf(klbs)	OP @ Jar(klbs)	Impact @ Jar(klbs)	Impulse @ Jar(klbs/s)	Impact @ SP(klbs)	Impulse @ SP(klbs/s)	HKLD @ Fire(klbs)	Wt @ Surf(klbs)	Wt @ Jar(klbs)	Impact @ Jar(klbs)	Impulse @ Jar(klbs/s)	Impact @ SP(klbs)	Impulse @ SP(klbs/s)
137.85	0.00	0.00	0.00	0.00	0.00	0.00	137.85	1.39	1.39	3.58	58.97	7.15	117.96
142.90	5.05	5.05	12.79	57.14	50.40	111.38	136.46	2.78	2.78	7.12	59.09	14.26	118.37
147.95	10.10	10.10	24.91	55.04	50.40	111.38	135.07	4.18	4.18	10.58	59.64	21.24	119.78
153.00	15.15	15.15	36.32	53.71	74.11	109.59	133.68	5.57	5.57	13.96	59.23	28.12	119.29
158.05	20.20	20.20	46.14	54.14	95.51	112.08	132.28	6.96	6.96	17.45	56.28	35.15	113.35
163.11	25.25	25.25	57.67	51.22	119.39	106.03	130.89	8.35	8.35	20.60	57.64	41.69	116.64
168.16	30.30	30.30	63.52	52.34	135.08	111.31	129.50	9.75	9.75	24.03	55.56	48.63	112.44
173.21	35.35	35.35	74.11	50.82	157.59	108.08	128.11	11.14	11.14	26.70	57.62	54.48	117.57
178.26	40.40	40.40	84.69	49.31	180.10	104.85	126.71	12.53	12.53	30.04	56.27	61.30	114.80
183.31	45.45	45.45	95.28	47.79	202.62	101.63	125.32	13.92	13.92	33.38	54.91	68.11	112.03
188.36	50.51	50.51	105.86	46.27	225.13	98.40	123.93	15.32	15.32	36.72	53.55	74.92	109.26
193.41	55.56	55.56	116.45	44.75	247.64	95.17	122.54	16.71	16.71	38.16	56.16	79.00	116.26
198.46	60.61	60.61	127.04	43.24	270.16	91.95	121.14	18.10	18.10	41.34	55.36	85.58	114.59
203.51	65.66	65.66	137.62	41.72	292.67	88.72	119.75	19.49	19.49	44.52	54.55	92.17	112.93
208.56	70.71	70.71	148.21	40.20	315.18	85.50	118.36	20.89	20.89	47.70	53.74	98.75	111.26
213.61	75.76	75.76	158.80	38.68	337.69	82.27	116.97	22.28	22.28	50.88	52.94	105.33	109.59
218.66	80.81	80.81	169.39	37.16	360.20	79.04	115.57	23.67	23.67	54.06	52.13	111.92	107.92
223.71	85.86	85.86	179.98	35.64	382.71	75.81	114.18	25.06	25.06	57.24	51.33	118.50	106.25
228.76	90.91	90.91	190.57	34.12	405.22	72.58	112.79	26.46	26.46	60.42	50.52	125.08	104.58
233.81	95.96	95.96	201.16	32.60	427.73	69.35	111.40	27.85	27.85	63.60	49.71	131.67	102.91
238.86	101.01	101.01	211.75	31.08	450.24	66.12	110.00	29.24	29.24	66.78	48.91	138.25	101.25
243.91	106.06	106.06	222.34	29.56	472.75	62.89	108.61	30.63	30.63	64.21	52.24	136.55	111.10
248.96	111.11	111.11	232.93	28.04	495.26	59.66	107.22	32.03	32.03	67.13	51.82	142.76	110.21
254.01	116.16	116.16	243.52	26.52	517.77	56.43	105.83	33.42	33.42	70.05	51.41	148.97	109.32
259.06	121.21	121.21	254.11	25.00	540.28	53.20	104.43	34.81	34.81	72.97	50.99	155.17	108.43
264.12	126.26	126.26	264.70	23.48	562.79	50.07	103.04	36.20	36.20	75.89	50.57	161.38	107.54
269.17	131.31	131.31	274.79	21.96	585.30	46.84	101.65	37.60	37.60	78.81	50.15	167.59	106.65
274.22	136.36	136.36	284.31	20.44	607.81	43.61	100.26	38.99	38.99	81.72	49.73	173.80	105.76

Figure 67: Jarring Results Table

The jarring results table showing the results of the jarring calculations. These results are the source of the data that is plotted in the **Jarring Up** and **Jarring Down** charts. Note, that in the jarring down section of the results table, any lines which are highlighted in orange, indicate the hook load range in which the string is modelled as being **helically** buckled. The buckling will occur at some point in the drill string above the jar and simply indicates that it may not be possible to transmit the required weight to cock / fire the jar. This range is represented in the jarring down chart by the red shaded area.

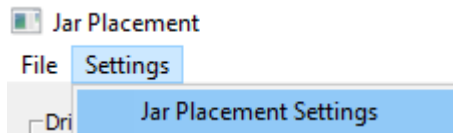
- **HKLD @ Fire:** The surface hook load used to fire the jar This takes in to account the string weight and pick up forces which need to be overcome before the jar starts to have overpull applied. The calculation assumes **CHFF 0.15** and **OHFF 0.25**.
- **OP @ Surf:** The overpull registered at surface for a given hook load.
- **OP @ Jar:** The overpull at the jar for a given hook load. This takes in to account the effects of drag.
- **Wt @ Surf:** The weight registered at surface for a given hook load.
- **Wt @ Jar:** The weight at the jar for a given hook load. This takes in to account the effects of drag.
- **Impact @ Jar:** The impact at the jar resulting from the jar firing when the associated hook load is registered at surface. Calculated utilising the length of the drill collars above the jar, the stroke length of the jar, the overpull/weight applied and the drag in the hole.
- **Impulse @ Jar:** The impulse at the jar resulting from the jar firing when the associated hook load is registered at surface. Calculated as the integral of impact force with respect to time.
- **Impact @ SP:** The impact at the stuck point (the bit) resulting from the jar firing when the associated hook load is registered at surface. Calculated utilising the length of the drill collars above the jar, the stroke length of the jar, the overpull/weight applied, the drag in the hole and the distance between the jar and the stuck point.
- **Impulse @ SP:** The impulse at the stuck point (the bit) resulting from the jar firing when the associated hook load is registered at surface. Calculated as the integral of impact force with respect to time.

Export Charts

Additionally, the user can export any of the charts individually using the right click context menu and selecting **Export Dialog**.

Settings Menu

The settings Menu gives the user access to the Jar Placement Settings dialog.



The Jar Placement Settings dialog is where the user can adjust the jar check size and neutral point chart safety factors.

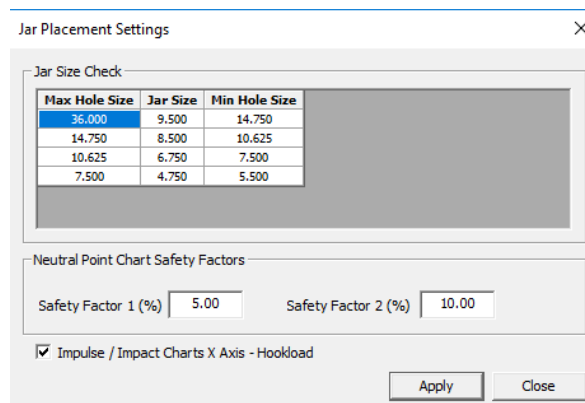


Figure 70: Jar Placement Settings Dialog

Jar Check Size: The user can enter the jar sizes and the relevant minimum and maximum hole sizes the jars are suitable to be run in. This information will be displayed on the main Jar Placement dialog in the jar checklist section. These sizes will also be used by the program for the **Jar Size Check**, where the user will be informed if the jar they have entered into the drill string is suitable, based on the hole size selected.

Neutral Point Safety Factors: The safety factors entered here are represented on the neutral point chart on the main Jar Placement dialog.

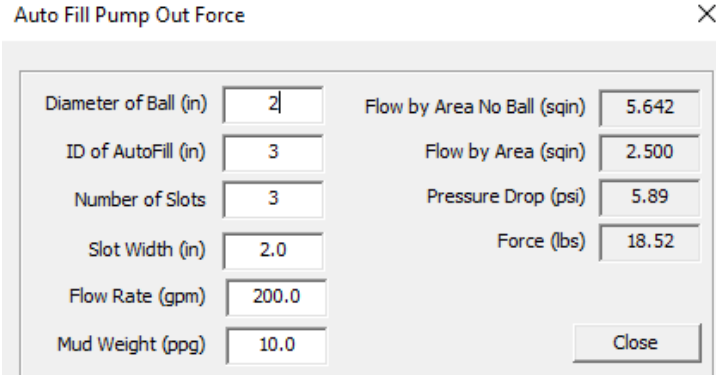
- Safety factor 1 is represented by the red highlighted area
- Safety factor 2 is the orange area displayed on either side of the neutral point line.

The default values are 5% and 10% respectively but can be changed here, as per the user's requirements.

Impulse/Impact Charts X Axis Hookload: When checked, the X axis of the Jarring Up and Down charts will represent the Hookload at surface. If unchecked, the X axis will represent the relevant Overpull (Jarring Up) and Slack Off (Jarring Down) values.

4.5.14 – Auto Fill Pump Out Force

The Auto Fill Pump Out Force tool, allows the user to calculate the flow rate required in order to generate enough force to pump out a casing shoe auto fill device.



The dialog box titled "Auto Fill Pump Out Force" contains the following fields and values:

Diameter of Ball (in)	2	Flow by Area No Ball (sqin)	5.642
ID of AutoFill (in)	3	Flow by Area (sqin)	2.500
Number of Slots	3	Pressure Drop (psi)	5.89
Slot Width (in)	2.0	Force (lbs)	18.52
Flow Rate (gpm)	200.0		
Mud Weight (ppg)	10.0		
		Close	

Figure 71: Auto Fill Pump Out Force Dialog

Diameter of Ball: The diameter of the ball being dropped in the string

ID of Autofill: The internal diameter of the Autofill

Number of Slots: The number of slots in the autofill

Slot Width: The width of the slots in the autofill

Flow Rate: The flow rate at which the force will be calculated

Mud Weight: Mud weight

Flow By Area No Ball: Flow by area in the autofill when there is no ball

Flow by Area: Flow by area in the autofill when the ball has been seated

Pressure Drop: The pressure drop generate by the restriction created by the ball

Force: The force created by the pressure drop

4.5.15 – Packer Setting Analysis

In a deviated well, when weight is slacked off (SO) at surface, depending on the well trajectory, the BHA, the mud and the friction in the hole, this weight is not always transmitted all the way down the string. This dialog allows the user to calculate the slack off weight required at surface to achieve a given slack off at a certain point in the string. The calculation will be run against the actual surveys in the surveys tab. If no surveys are entered, then the calculation will use the Well Plan.

Packer Setting Analysis

Packer Setting Weight (kibs) String Depth (UsFt)
Packer Distance From Btm (UsFt)

Results

	CH 0.20, OH 0.25	CH 0.25, OH 0.30
Hookload (kibs)	639.48	630.33
SO Weight (kibs)	40.34	41.45

Well Schematic

Calculate Close

Figure 72: Packer Setting Analysis Dialog

Packer Setting Weight: The Slack Off (SO) weight required to set the packer.

Packer Distance from Btm: The distance of the packer from the bottom of the drill string. For this calculation, Engineering uses the drill string entered in the drill string tab.

String Depth: The string depth entered in the T&D section of the Engineering Parameters tab, this is the depth at which the calculation will be run.

Results: This section will display an output for each of the friction factors entered in the Engineering Parameters Tab.

- **Hookload:** The hookload expected at surface when the relevant slack off weight is applied.
- **SO Weight:** The slack off (SO) weight actually required at surface to achieve the Packer Setting Weight entered, based on the packers position in the string, which is determined by the value entered in the Packer Distance from Btm cell.

Well Schematic: The Well Schematic is generated using the information entered in the Well Geometry and the Drill String sections of the main user interface.

4.5.16 – Pass Through Dogleg

The pass through dogleg dialog allows the user to calculate the maximum dogleg a certain length of tool can pass through before binding on the ID of the wellbore. It also shows the maximum length of tool which can pass through a given dogleg.

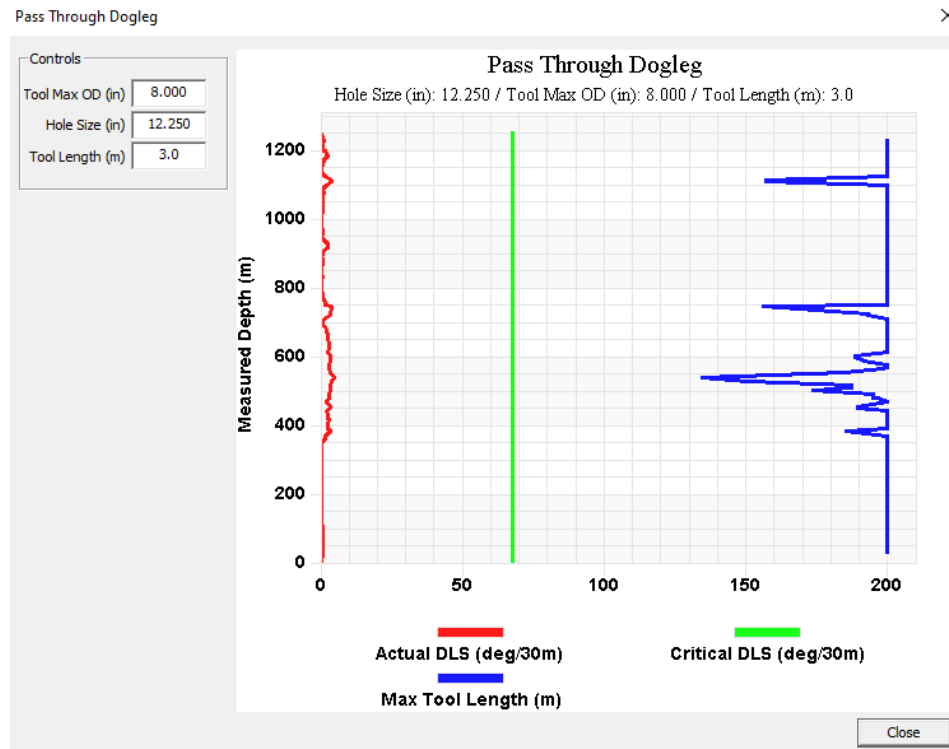


Figure 73: Pass Through Dogleg Dialog

Controls

- **Tool Max OD:** The maximum outside diameter of the tool being run
- **Hole Size:** The size of the hole the tool is being run in.
- **Tool Length:** The length of the tool being run.

Chart

- **Actual DLS:** The doglegs taken from the **Actual Surveys** entered in the surveys tab. If no actual surveys have been entered the program will use the doglegs from the Well Plan. Note that doglegs from the RAW survey are not displayed on this chart; if no actual surveys or well plan data is available, the actual DLS will display as zero.
- **Max Tool Length:** The maximum tool length which can pass through the actual dogleg at the given depth
- **Critical DLS:** The maximum dogleg the tool for a specified length can pass through

4.5.17 – Mud / Buoyancy Factor Calcs

The Mud / Buoyancy calculation dialog allows the user to quickly calculate the buoyancy factor for single and multiple fluids along with the hydrostatic pressure.

Figure 74: Mud Calculation Dialog

Single Fluid Buoyancy Factor

User enters the mud weight and the Buoyancy Factor is automatically calculated.

$$\text{Buoyancy Factor (BF)} = (65.5 - \text{MW (ppg)}) \div 65.5$$

Multi Fluid Buoyancy Factor

User enters the OD and ID of the string along with the External and Internal Fluid weight and the Buoyancy Factor is automatically calculated.

$$\text{Buoyancy Factor (BF)} = \frac{A_o \left(1 - \frac{\rho_o}{\rho_s}\right) - A_i \left(1 - \frac{\rho_i}{\rho_s}\right)}{A_o - A_i}$$

Hydrostatic Pressure

User enters the mud weight and the TVD and the Hydrostatic Pressure is automatically calculated.

$$P \text{ (psi)} = \text{MW (ppg)} \times \text{TVD (ft)} \times 0.052$$

4.6 – Calculate Menu

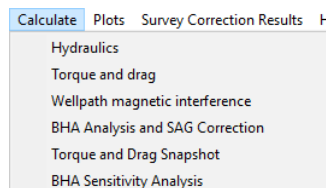


Figure 75: Calculate Menu

This menu allows the various module calculations to be performed. Depending on the license purchased not all options may be available. Note that **“Torque and Drag Snapshot”** will only run the calculation for the snapshot charts. This can be used to cut down calculation time when playing about with different pipe configurations in long extended reach wells where buckling is present.

4.6.1 – Wellpath Magnetic Interference

This option allows the user to check the current BHA configuration to see if there is adequate non-magnetic spacing above and below the sensor. The calculation uses the BHA entered in the drill string tab and will run against whichever survey selection (Actual Surveys, Well Plan, Raw Surveys) is being displayed in the Surveys tab at the time.

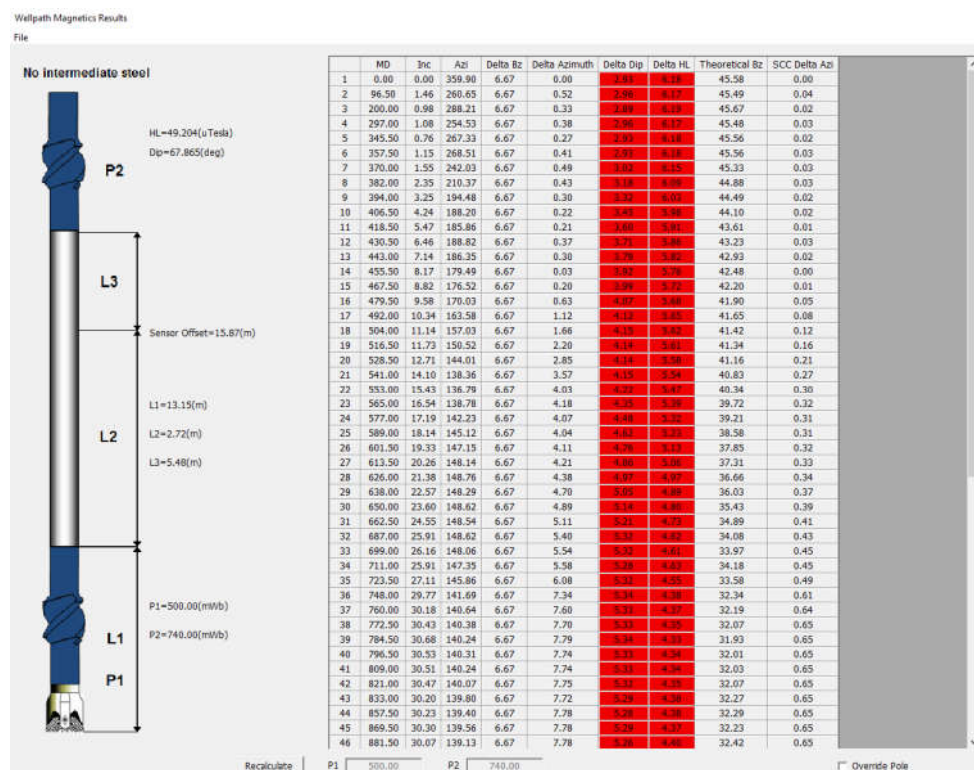


Figure 76: Wellpath Magnetics Results Dialogue

- **Azimuth:** The azimuth displayed is referenced to **Magnetic North** and will therefore look different when compared to the azimuth that was entered in the plan (which could be

referenced to Grid or True North). The correction applied to the input azimuth is automatic and is based on the Geomagnetic data that you have entered in the Raw Survey Data Section.

- **Delta Bz:** The expected error between the **Theoretical Bz** and the Measured Bz (from MWD) for raw, uncorrected surveys.
- **Delta Azimuth:** The expected error in the raw uncorrected azimuth reading, <0.25 degrees is considered acceptable
- **Delta Dip:** The expected error between the calculated dip (from the geo-mag data) and the actual measured value (from MWD). This will be highlighted in red if the value is greater than the tolerance entered in the QC Limits dialog (see **Options** menu).
- **Delta HL:** The expected error between the calculated magnetic field strength (from the geo-mag data) and the actual measured value (from MWD). This will be highlighted in red if the value is greater than the tolerance entered in the QC Limits dialog (see **Options** menu).
- **Theoretical Bz:** The theoretical magnetic field strength expected in the Z axis with no interference.
- **SCC Delta Azi:** The expected error in the SCC corrected azimuth, <0.5 degrees is considered acceptable. This is affected by the Latitude entered in the Raw Survey Data section.

The **P1** and **P2** pole strength values are automatically selected based on the component type and size above and below the non mag components in the string. These can be overridden by the user if necessary, by checking the **override pole** box at the bottom right of the dialog and alternative values can then be entered by the user.

The whole output can be saved to pdf by selecting **File – Export to PDF**.

The data table can be exported to Excel by selecting **File - Export**.

These results can be used to make an informed decision as to whether there is a requirement to run the SCC algorithm, add additional non-mag or do nothing. Company policy will dictate what error values are considered acceptable.

4.6.2 – BHA Analysis and SAG Correction

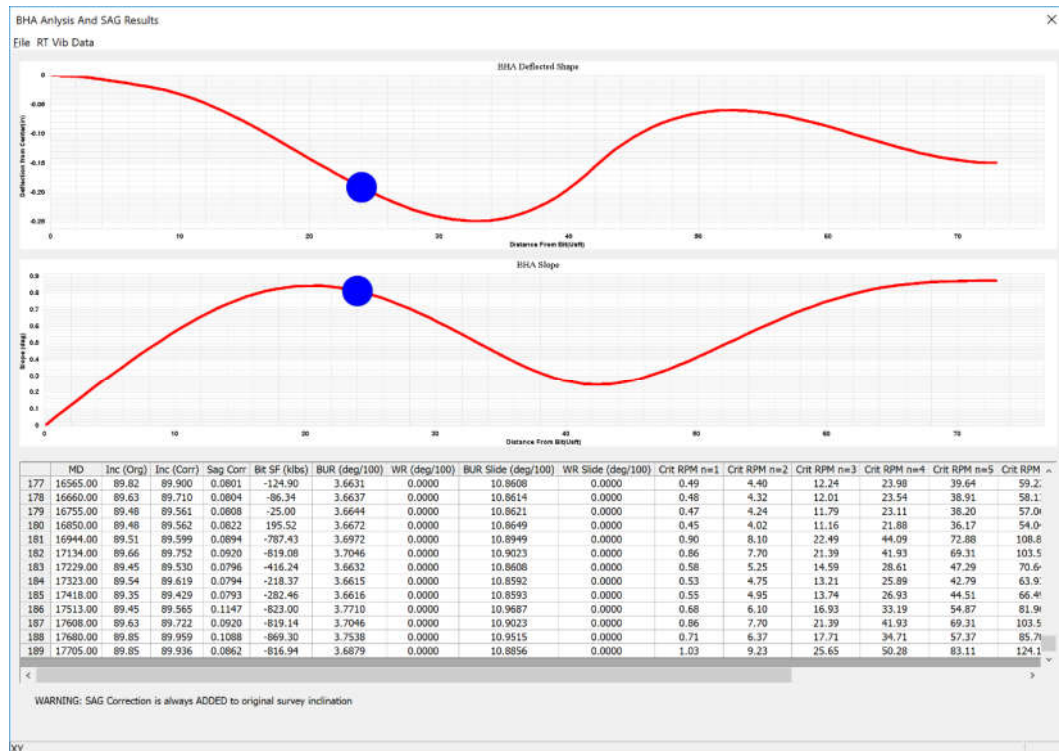


Figure 77: SAG Results

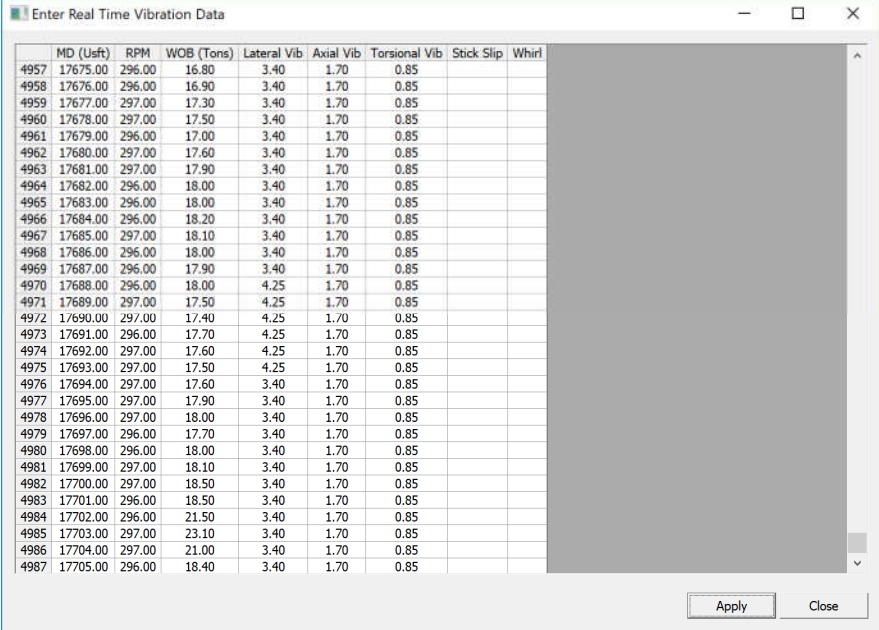
The results of the BHA Analysis and SAG calculation are displayed in this output. For details regarding how to select the parameters that the BHA Analysis and SAG calculation is run with see section [7.4 – Survey Corrections](#)

- **Deflected Shape:** Shows the deflected shape of the BHA. The blue dot represents the sensor position. Note that the displayed plot always represents the **final station**.
- **BHA Slope:** Shows the slope of the BHA and relates to the correction. The blue dot represents the sensor position. The displayed plot always represents the final station.
- **MD:** Measured Depth of Station.
- **Inc (Org):** The uncorrected inclination.
- **Inc (Corr):** The SAG corrected inclination.
- **Sag (Corr):** The SAG correction to be applied to the uncorrected inclination.

$$\text{Inc (Org)} + \text{Sag (Corr)} = \text{Inc (Corr)}$$
- **Bit SF:** Sideforce at the bit.
- **BUR:** Predicted Rotary Build Rate.
- **WR:** Predicted Rotary Walk Rate.
- **BUR (Slide):** Predicted Build Rate Sliding. If the motor has a 0° bend, this column will not display.
- **WR (Slide):** Predicted Walk Rate Sliding. If the motor has a 0° bend, this column will not display.
- **Crit RPM:** The theoretical RPM that excites the natural frequency of the drill string. These RPM's should be avoided when rotating.

File: Gives the user the option to export the BHA Deflected Shape and BHA Slope charts by selecting **Export to PDF** and the option to export the results data in .txt, xls or xlsx format by selecting **Export**. The user can also exit the BHA Analysis and SAG Results dialog by selecting **Exit**.

RT Vib Data: Selecting **Real Time Vibration Data** will open the **Enter Real Time Vibration Data** dialog. The user can input real time vibration data into this dialog, which will be plotted against RPM and Vibration on the **Critical RPM Chart**.



	MD (Usft)	RPM	WOB (Tons)	Lateral Vib	Axial Vib	Torsional Vib	Stick Slip	Whirl
4957	17675.00	296.00	16.80	3.40	1.70	0.85		
4958	17676.00	296.00	16.90	3.40	1.70	0.85		
4959	17677.00	297.00	17.30	3.40	1.70	0.85		
4960	17678.00	297.00	17.50	3.40	1.70	0.85		
4961	17679.00	296.00	17.00	3.40	1.70	0.85		
4962	17680.00	297.00	17.60	3.40	1.70	0.85		
4963	17681.00	297.00	17.90	3.40	1.70	0.85		
4964	17682.00	296.00	18.00	3.40	1.70	0.85		
4965	17683.00	296.00	18.00	3.40	1.70	0.85		
4966	17684.00	296.00	18.20	3.40	1.70	0.85		
4967	17685.00	297.00	18.10	3.40	1.70	0.85		
4968	17686.00	296.00	18.00	3.40	1.70	0.85		
4969	17687.00	296.00	17.90	3.40	1.70	0.85		
4970	17688.00	296.00	18.00	4.25	1.70	0.85		
4971	17689.00	297.00	17.50	4.25	1.70	0.85		
4972	17690.00	297.00	17.40	4.25	1.70	0.85		
4973	17691.00	296.00	17.70	4.25	1.70	0.85		
4974	17692.00	297.00	17.60	4.25	1.70	0.85		
4975	17693.00	297.00	17.50	4.25	1.70	0.85		
4976	17694.00	297.00	17.60	3.40	1.70	0.85		
4977	17695.00	297.00	17.90	3.40	1.70	0.85		
4978	17696.00	297.00	18.00	3.40	1.70	0.85		
4979	17697.00	296.00	17.70	3.40	1.70	0.85		
4980	17698.00	296.00	18.00	3.40	1.70	0.85		
4981	17699.00	297.00	18.10	3.40	1.70	0.85		
4982	17700.00	297.00	18.50	3.40	1.70	0.85		
4983	17701.00	296.00	18.50	3.40	1.70	0.85		
4984	17702.00	296.00	21.50	3.40	1.70	0.85		
4985	17703.00	297.00	23.10	3.40	1.70	0.85		
4986	17704.00	297.00	21.00	3.40	1.70	0.85		
4987	17705.00	296.00	18.40	3.40	1.70	0.85		

Figure 78: Enter Real Time Vibration Data Dialog

View Critical RPM Chart: Selecting this will open the **Critical RPM Chart**. This chart displays all of the user input real time vibration data against RPM. Additionally, the chart displays the critical RPM values (vertical red lines) calculated for the last point in the **BHA Analysis and SAG Results**. This allows the user to compare real world vibration data vs modelled predictions.

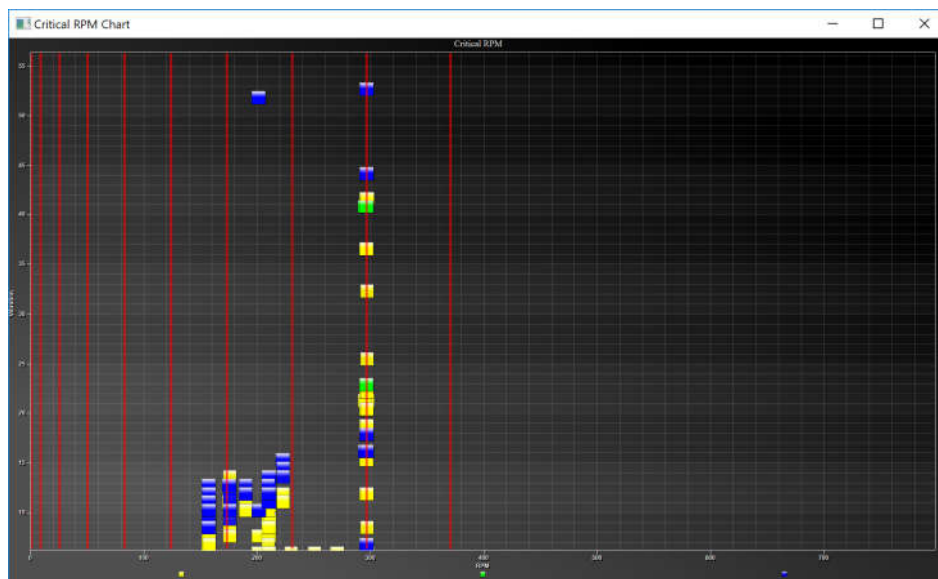


Figure 79: Critical RPM Chart

4.6.3 – BHA Sensitivity Analysis

Figure 80: BHA Sensitivity Analysis Dialogue

Selecting BHA Sensitivity Analysis from the Calculate Menu opens the BHA Sensitivity Analysis Dialogue. The BHA from the main drill string section is used.

Select Parameters is the input section for the calculation. An unlimited number of lines can be added to this section allowing the user to analyse a range of different scenarios.

Parameter: The user can then select one of 6 parameters to run the analysis on.

- **Inclination:** Select a range of inclinations.
- **Dogleg Severity:** Select a range of doglegs. This effectively mimics the curvature of the hole.
- **Motor Bend:** Select a range of motor bend settings.
- **Hole Size:** Select a range of hole sizes. This allows the user to model the effect of varying degrees of hole washout on the assembly trend. Note that the hole size must be the same size as the bit or larger. Any value entered which is smaller than the bit and the calculation will not run.
- **Top Stabiliser Size:** Select a range of top stabiliser sizes. This option looks at the BHA for the stabiliser which is furthest from the bit and effectively overrides the Stab OD value in the component details section.
- **WOB:** Select a range of WOB values.

Start Value: First value in the range

Stop Value: Final value in the range

Step Value: Step size to be used in the calculation between the start and stop values

Toolface: The Toolface used in the analysis. This affects the BUR & WR Sliding

Inclination: The Inclination used for the analysis. This will be greyed out when inclination is selected in the parameters column

DLS: The dogleg used for the analysis. This will be greyed out when DLS is selected in the parameters column

Motor Bend: The Motor Bend used for the analysis. This will be greyed out when motor bend is selected in the parameters column

Hole Size: The Hole Size used for the analysis. This will be greyed out when hole size is selected in the parameters column

Top Stab Size: The Top Stab Size used for the analysis. This will be greyed out when top stab size is selected in the parameters column

WOB: The WOB used for the analysis. This will be greyed out when WOB is selected in the parameters column

Results: This is where all the results are displayed. If more than one line has been calculated the user can scroll through the results for each line from the dropdown menu. Results can be exported as excel or text files. The user can choose to export one single set of results, or checking the **Export All Lines** box will create a report which includes all results.

Parameter Column: This column will change depending on the parameter selected for the calculation, and will contain the start value and the stop value along with all of the relevant step values in between.

BUR ROT: The calculated rotary build rate.

BUR Slide: The calculated build rate when sliding. With a toolface of zero, this value will represent the theoretical maximum motor yield for the selected bend.

Toolface: The toolface used in the calculation

WR Rot: The calculated rotary walk rate. This is directly affected by the Bit Formation Index, which is input in the Bit component details section on the drill string tab.

WR Slide: The calculated walk rate when sliding. This is directly affected by the selected toolface.

Show Charts: This radio button will plot the values displayed in the selected table.

Calculate Menu: Runs the calculations.

4.7 – Plots Menu

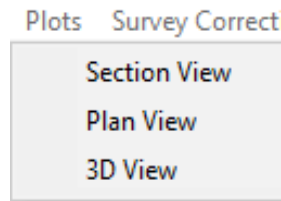


Figure 81: Plots Menu

Allows the user to plot either the section, plan or 3D view for the surveys entered. All surveys can be viewed from the one plot and turned on or off as the user desires.

4.8 – Survey Correction Results Menu

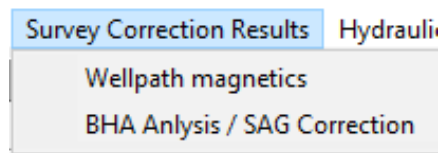


Figure 82: Survey Correction Results Menu

This menu allows the user to view the results from either the well path [magnetic interference calculation](#) or the survey [SAG correction](#), by selecting the appropriate option.

It is important to note here that in order to view the results, the calculations must have first been run via either the Calculate menu or the shortcuts on the toolbar. If the user selects either of these options and the calculations have not been run, they will get the following error message.

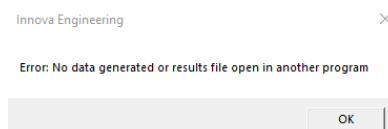


Figure 83: Error Dialog

4.9 – Hydraulics Results Menu

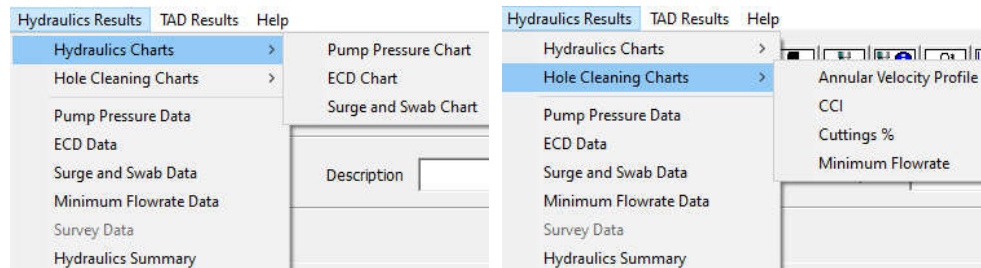


Figure 84: Hydraulics Results Menu

Allows the user to select and view the results from the hydraulics module in either tabular or graphical form. It is important to note here that in order to view the results, the hydraulics calculation must have first been run via either the Calculate menu or the shortcut on the toolbar. If the user selects any of these options and the calculations have not been run, they will get an error message.

4.9.1 – Hydraulics Charts

There are 3 standard hydraulics charts available. These are all drilling charts, which display the values expected at surface when the assembly is at any given depth.

4.9.1.1 - 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.

4.9.1.2 - 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.

4.9.1.3 - Surge and 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.

4.9.2 – Hole Cleaning Charts

There are 4 plots within the hydraulics module dedicated to hole cleaning.

4.9.2.1 - 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 various different flow rates.

4.9.2.2 - Carrying Capacity Index (CCI) 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 various different flow rates.

4.9.2.3 - 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.

4.9.2.4 - Minimum Flowrate 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.

4.9.3 – Pump Pressure Data

This option opens a data table, which contains all the data used to plot the Pump Pressure Chart.

4.9.4 – ECD Data

This option opens a data table, which contains all the data used to plot the ECD Chart.

4.9.5 – Surge and Swab data

This option opens a data table, which contains all the data used to plot the Surge and Swab Chart.

4.9.6 – Minimum Flowrate Data

This option opens a data table, which contains all the data used to plot the Minimum Flowrate Chart.

4.9.7 – Survey Data

This option opens the survey data table, which displays either the Actual Surveys or the Well Plan surveys. The survey displayed is based on the selection made in the Engineering Parameters Tab.

- This option will be greyed out and unavailable to select unless the user is in the surveys tab and has either the Actual Surveys or Well plan Surveys selected.
- If any tortuosity has been added to the survey or plan, this will be included in the survey data table.

4.9.8 – Hydraulics Summary

This option prints off the Hydraulics Summary, which includes:

- Hydraulics Summary Report
- Pump Pressure Chart
- ECD Chart

4.10 – Torque and Drag Results Menu

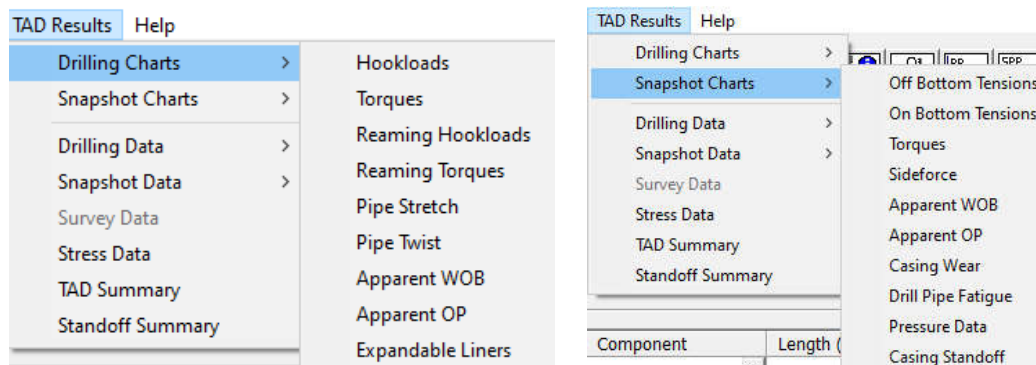


Figure 85: Torque and Drag Results

Allows the user to select and view the results from the torque and drag module in either tabular or graphical form. It is important to note here that in order to view the results, the torque and drag calculation must have first been run via either the Calculate menu or the shortcut on the toolbar. If the user selects any of these options and the calculations have not been run, they will get an error message.

4.10.1 – Drilling Charts

Drilling charts display the values expected at surface when the assembly is at any given depth.

4.10.1.1 – Hookload Chart

This chart displays the calculated hookload values for tripping in, Rotating off Bottom and tripping out. It also includes the Reaming In and Out hookloads.

For each operation, there will be a line represented for each set of friction factors entered in the Engineering Parameters tab, with the exception of the Rotating off Bottom line, of which there will only ever be one.

The minimum weight to helically buckle (trip In) will also be displayed on this chart. Any tripping in line which crosses this limit will start to experience buckling in the string. At this point it may be difficult to effectively transfer weight down hole and the string may need to be rotated in order to get to bottom. From the chart, you can tell the string depth and hookload when the buckling will occur, but you will not be able to determine where in the string the buckling is occurring.

4.10.1.2 – Torque Chart

This chart displays the On and Off Bottom torques. For each operation, there will be a line represented for each set of friction factors entered in the Engineering Parameters tab.

4.10.1.3 – Reaming Hookload Chart

This chart is the same as the hookload chart, with the exception that it only displays the Reaming In and Reaming Out hookloads.

4.10.1.4 – Reaming Torque Chart

This chart is the same as the Torque chart, with the exception that it is the reaming torques which are plotted. These torques are calculated based on the RPM and Pipe Speed values entered in the torque and drag section of the Engineering Parameters tab.

4.10.1.5 – Pipe Stretch Chart

This chart displays the amount of pipe elongation the user would see when picking up, for each of the friction factors entered in the Engineering Parameters tab.

4.10.1.6 – Pipe Twist Chart

This chart displays the number of completed revolutions that the rotary table must be turned in order to turn the bit. A line will be represented for each of the friction factors entered in the Engineering Parameters tab.

4.10.1.7 – Apparent WOB Chart

This chart displays the apparent weight on bit (WOB) required at any given depth to achieve a user defined Actual WOB. The actual WOB value used is the WOB value entered in the torque and drag section of the Engineering Parameters tab.

To read the chart the user should select the measured depth of interest and note the apparent WOB for each of the friction factors at that depth. These are the WOB values the user will need to register at surface in order to achieve the desired actual WOB down hole at the bit. Note that if no WOB value is entered in the torque and drag section of the Engineering Parameters tab, then this will model as a vertical line.

4.10.1.8 – Apparent OP Chart

This chart displays the apparent Overpull (OP) required at any given depth to achieve a user defined Actual OP. The actual OP value used is the OP value entered in the torque and drag section of the Engineering Parameters tab.

To read the chart the user should select the measured depth of interest and note the apparent OP for each of the friction factors at that depth. These are the OP values the user will need to register at surface in order to achieve the desired actual OP down hole at the bit. Note that if no overpull value is entered in the torque and drag section of the Engineering Parameters tab, then this will model as a vertical line.

4.10.2 – Snapshot Charts

Snapshot charts display the values at each point in the string when the assembly is at a specific depth. Unlike drilling charts which can be used over the entire depth range of the well, snapshot charts are only relevant to one specific depth.

4.10.2.1 – Off Bottom Tension Chart

This chart displays the effective tension at all points in the string when the string is at a specific depth. This depth is displayed at the top of the chart and is the calc depth entered in the torque and drag section of the Engineering Parameters tab.

The chart displays the following lines:

- **Rotating off Bottom**
- **Sinusoidal Buckling** – Any load line which crosses this buckling line will be representative of Sinusoidal buckling. The depth at which the line crosses will also represent the component in the string which is experiencing the buckling.
- **Helical Buckling** – Any load line which crosses this buckling line will be representative of Helical buckling. The depth at which the line crosses will also represent the component in the string which is experiencing the buckling.
- **PU** – A Pickup line will be represented for each of the entered friction factors.
- **SO** – A Slack Off line will be represented for each of the entered friction factors.
- **Tensile Limit** – The tensile limit will be displayed based on the tensile limits entered in the component details section for each individual component.
- **String Tension with Overpull** – This line is generated based on the overpull entered in the torque and drag section of the Engineering Parameters tab.

4.10.2.2 – On Bottom Tension Chart

This chart displays the effective tension at all points in the string when the string is at a specific depth with a specific WOB. The depth and WOB are displayed at the top of the chart with these values having been entered in the torque and drag section of the Engineering Parameters tab.

The chart displays the following lines:

- **Rotating off Bottom**
- **Sinusoidal Buckling** – Any load line which crosses this buckling line will be representative of Sinusoidal buckling. The depth at which the line crosses will also represent the component in the string which is experiencing the buckling.
- **Helical Buckling** – Any load line which crosses this buckling line will be representative of Helical buckling. The depth at which the line crosses will also represent the component in the string which is experiencing the buckling.
- **PU** – A Pickup line will be represented for each of the entered friction factors.
- **Sliding** – A Sliding line will be represented for each of the entered friction factors.
- **Tensile Limit** – The tensile limit will be displayed based on the tensile limits entered in the component details section for each individual component.

4.10.2.3 – Torque Chart

This chart displays the torque at all points in the string when the string is at a specific depth. This depth is displayed at the top of the chart and is the calc depth entered in the torque and drag section of the Engineering Parameters tab. For each operation, there will be a line represented for each set of friction factors entered.

4.10.2.4 – Side force Chart

This chart displays the side force at all points in the string when the string is at a specific depth. This depth is displayed at the top of the chart and is the calc depth entered in the torque and drag section of the Engineering Parameters tab.

The chart displays the rotating side force along with the pickup and slack off side forces for each set of friction factors entered.

4.10.2.5 – Apparent WOB Chart

This chart plots the actual WOB against the apparent WOB when the string is at a specific depth. This depth is displayed at the top of the chart and is the calc depth entered in the torque and drag section of the Engineering Parameters tab.

To use this chart, the user should select the actual WOB they require downhole, and the corresponding apparent WOB is the weight that will be required at surface to achieve this.

4.10.2.6 – Apparent OP Chart

This chart plots the actual overpull against the apparent overpull when the string is at a specific depth. This depth is displayed at the top of the chart and is the calc depth entered in the torque and drag section of the Engineering Parameters tab.

To use this chart, the user should select the actual overpull they require downhole, and the corresponding apparent overpull is the overpull that will be required at surface to achieve this.

4.10.2.7 – Casing Wear Chart

This chart shows the predicted cumulative wear at each point in the casing when the assembly is at a specific depth. This depth is displayed at the top of the chart and is the calc depth entered in the torque and drag section of the Engineering Parameters tab.

The casing wear is expressed as depth in either inches or mm depending on what units are selected for Diameter. The depth of wear indicates depth of the groove which will be worn in to the side of the casing over a period of time.

- **Casing Wear Rotating:** This is the predicted wear on the casing when the string has 0 ROP. This calculation uses the rotating side force.
- **Casing Wear SO:** This is the predicted casing wear calculated using the reaming slack off. This calculation uses the slack off side force.

4.10.2.8 – Drill Pipe Fatigue Chart

Drill string fatigue will only occur while rotating and only while rotating over a dogleg. The more tension within the pipe the more likely it is to get fatigued. There is a critical value of dogleg where fatigue failure becomes an issue.

The Drill Pipe Fatigue Chart, is a snapshot chart which displays the actual dogleg and the critical dogleg at every point in the string for a given depth. If the actual dogleg is greater than the critical dogleg then fatigue failure is a potential issue.

The critical dogleg curve is generated based on the free rotating weight of the drilling assembly. One point to note is that back reaming will increase the tension and therefore reduce the critical rotating dogleg; however, this has not been included in the chart because back reaming operations do not generally last too long.

4.10.2.9 – Pressure Data Chart

This chart shows the Internal and External pressure at each point in the string for a given flowrate, when the assembly is at a specific depth. This depth is displayed at the top of the chart and is the calc depth entered in the torque and drag section of the Engineering Parameters tab.

In the flow rate section, if manual flow increment is selected, the first flow rate entered will be used for generating the outputs for this chart. If the automatic range is selected, the flow rate entered in line 3 will be used.

4.10.2.10 – Casing Standoff Chart

The casing standoff chart is a snapshot chart which provides outputs for each point in the string from surface to the calculated depth.

Without Optimised Standoff

If Optimise Standoff has **NOT** been selected when the torque and drag calculation is run, the standoff chart will include the following:

- **Inc:** Inclination
- **Cent OD:** Centralizer Outside Diameter
- **Deflection Mid Joint:** Deflection of the casing between 2 centralizers.
- **Deflection Centralizer:** Deflection of casing at the centralizer.
- **Standoff Mid Joint:** This is calculated as follows
 - $(1 - (\text{Deflection Mid Joint} / ((\text{Hole ID} - \text{Casing OD})/2))) * 100$. It is effectively the percentage deflection from well bore centre. If the casing is centralised perfectly the standoff is 100%
- **Standoff Centralizer:** The Percentage Standoff at the Centralizer. This is calculated as follows
 - $(1 - (\text{Deflection Centralizer} / ((\text{Hole ID} - \text{Casing OD})/2))) * 100$
- **Cent Spacing:** The centralizer spacing as entered by the user in the component details section of the drill string editor (This line will NOT be present if Optimise Standoff is selected in the Torque and Drag section of the Engineering Parameters tab on the main user interface).
- **Restoring Force:** The restoring force of the bow spring centralizer which has been entered in the component details section of the drill string tab.
- **Running Force:** The running force of the bow spring centralizer which has been entered in the component details section of the drill string tab.
- **Side Force:** The side force exerted on the casing.

With Optimised Standoff

If Optimise Standoff has been selected, when the torque and drag calculation is run, the standoff chart will have the addition of an **Optimum Spacing** line, and the Centralizer Spacing line becomes the **Recommended Spacing** line.

- **Rec Spacing:** Recommended Spacing, calculated based on the Optimise standoff value (This line will NOT be present if Optimise Standoff is not selected)
- **Opt Spacing:** This is the optimum spacing which applies the maximum step value to the Recommended Spacing (This line will NOT be present if Optimise Standoff is not selected).

All the other lines described in the above (**Without Optimised Standoff**) section, are also available to be displayed in this chart if required.

4.10.3 – Drilling Data

This section has the same options available as there are in the above Drilling Charts option, only instead of opening the charts, this option will open the data table, which contains all the data used to plot the charts.

4.10.4 – Snapshot Data

This section has the same options available as there are in the above Snapshot Charts option, only instead of opening the charts, this option will open the data table, which contains all of the data used to plot the charts.

4.10.5 – Survey Data

This option opens the survey data table, which displays either the Actual Surveys or the Well Plan surveys. The survey displayed is based on the selection made in the Engineering Parameters Tab.

- This option will be greyed out and unavailable to select unless the user is in the surveys tab and has either the Actual Surveys or Well plan Surveys selected.
- If any tortuosity has been added to the survey or plan, this will be included in the survey data table.

4.10.6 – Stress Data

This table displays the stress data at all points in the drill string, when the string is at a specific depth, and covers the following operations:

- Rotating Off Bottom
- Rotating On Bottom
- Sliding
- Picking Up
- Slacking Off
- Reaming Pickup
- Reaming Slackoff

Stress Data X

Select Operation
Rotating Off Bottom View Chart Export Data

Stress Data

Depth(m)	Hoop Stress(psi)	Radial Stress(psi)	Torsional Stress(psi)	Shear Stress(psi)	Axial Stress(psi)	Buckling Stress(psi)	Bending Stress(psi)	Von Mises Stress(psi)	Component
0	8321	-1497	1939	0	23738	0	0	15872	5 X-95 IEU(19.5lb/ft) Drill Pipe
10.00	8208	-1497	1939	26	16949	0	495	11436	5 X-95 IEU(19.5lb/ft) Drill Pipe
20.00	8167	-1512	1930	26	16838	0	495	11378	5 X-95 IEU(19.5lb/ft) Drill Pipe
30.00	8126	-1526	1921	25	16728	0	495	11318	5 X-95 IEU(19.5lb/ft) Drill Pipe
40.00	8086	-1541	1912	25	16618	0	495	11258	5 X-95 IEU(19.5lb/ft) Drill Pipe
50.00	8045	-1556	1894	25	16508	0	495	11197	5 X-95 IEU(19.5lb/ft) Drill Pipe
60.00	8004	-1571	1885	24	16398	0	495	11137	5 X-95 IEU(19.5lb/ft) Drill Pipe
70.00	7963	-1586	1876	24	16288	0	495	11077	5 X-95 IEU(19.5lb/ft) Drill Pipe
80.00	7922	-1601	1876	24	16178	0	495	11018	5 X-95 IEU(19.5lb/ft) Drill Pipe
90.00	7881	-1615	1867	23	16068	0	495	10959	5 X-95 IEU(19.5lb/ft) Drill Pipe
100.00	7839	-1630	1858	11	15731	0	267	10782	5 X-95 IEU(19.5lb/ft) Drill Pipe
110.00	7798	-1645	1858	13	15602	0	248	10714	5 X-95 IEU(19.5lb/ft) Drill Pipe
120.00	7756	-1660	1858	13	15491	0	248	10656	5 X-95 IEU(19.5lb/ft) Drill Pipe
130.00	7714	-1675	1849	13	15383	0	248	10597	5 X-95 IEU(19.5lb/ft) Drill Pipe
140.00	7673	-1689	1849	12	15273	0	248	10539	5 X-95 IEU(19.5lb/ft) Drill Pipe
150.00	7631	-1704	1840	12	15163	0	248	10480	5 X-95 IEU(19.5lb/ft) Drill Pipe
160.00	7589	-1719	1840	12	15054	0	248	10423	5 X-95 IEU(19.5lb/ft) Drill Pipe
170.00	7548	-1734	1840	12	14944	0	248	10365	5 X-95 IEU(19.5lb/ft) Drill Pipe
180.00	7506	-1749	1831	12	14834	0	248	10305	5 X-95 IEU(19.5lb/ft) Drill Pipe
190.00	7465	-1764	1831	12	14726	0	248	10248	5 X-95 IEU(19.5lb/ft) Drill Pipe
200.00	7423	-1778	1831	11	14616	0	248	10191	5 X-95 IEU(19.5lb/ft) Drill Pipe
210.00	7381	-1793	1822	9	14467	0	210	10112	5 X-95 IEU(19.5lb/ft) Drill Pipe
220.00	7340	-1808	1822	9	14357	0	210	10054	5 X-95 IEU(19.5lb/ft) Drill Pipe
230.00	7298	-1823	1822	9	14249	0	210	9997	5 X-95 IEU(19.5lb/ft) Drill Pipe
240.00	7257	-1838	1822	9	14139	0	210	9940	5 X-95 IEU(19.5lb/ft) Drill Pipe
250.00	7215	-1852	1813	9	14029	0	210	9880	5 X-95 IEU(19.5lb/ft) Drill Pipe
260.00	7173	-1867	1813	9	13920	0	210	9824	5 X-95 IEU(19.5lb/ft) Drill Pipe
270.00	7132	-1882	1813	9	13810	0	210	9766	5 X-95 IEU(19.5lb/ft) Drill Pipe
280.00	7090	-1897	1813	8	13700	0	210	9709	5 X-95 IEU(19.5lb/ft) Drill Pipe
290.00	7049	-1912	1804	8	13592	0	210	9651	5 X-95 IEU(19.5lb/ft) Drill Pipe
300.00	7007	-1926	1804	4	13467	0	95	9536	5 X-95 IEU(19.5lb/ft) Drill Pipe
310.00	6965	-1941	1804	12	13429	0	267	9564	5 X-95 IEU(19.5lb/ft) Drill Pipe
320.00	6924	-1956	1804	12	13319	0	267	9507	5 X-95 IEU(19.5lb/ft) Drill Pipe
330.00	6882	-1971	1795	12	13210	0	267	9449	5 X-95 IEU(19.5lb/ft) Drill Pipe
340.00	6841	-1986	1795	11	13100	0	267	9392	5 X-95 IEU(19.5lb/ft) Drill Pipe

OK Cancel

Figure 86: Stress Data Dialog

The following stresses are included in the output:

- **Hoop Stress** due to internal and external pressure
- **Radial Stress** due to internal and external pressure
- **Torsional Stress** from twist
- **Shear Stress** from contact
- **Axial Stress** due to hydrostatic and mechanical loading
- **Buckling Stress** due to buckling
- **Bending Stress** approximated from wellbore curvature
- **Von Mises Stress** – Tri-axial combination of the component stresses

Once the user has selected the relevant operation from the dropdown menu, they can select the View Chart option, which opens a stress data chart with all of the data from the table plotted.

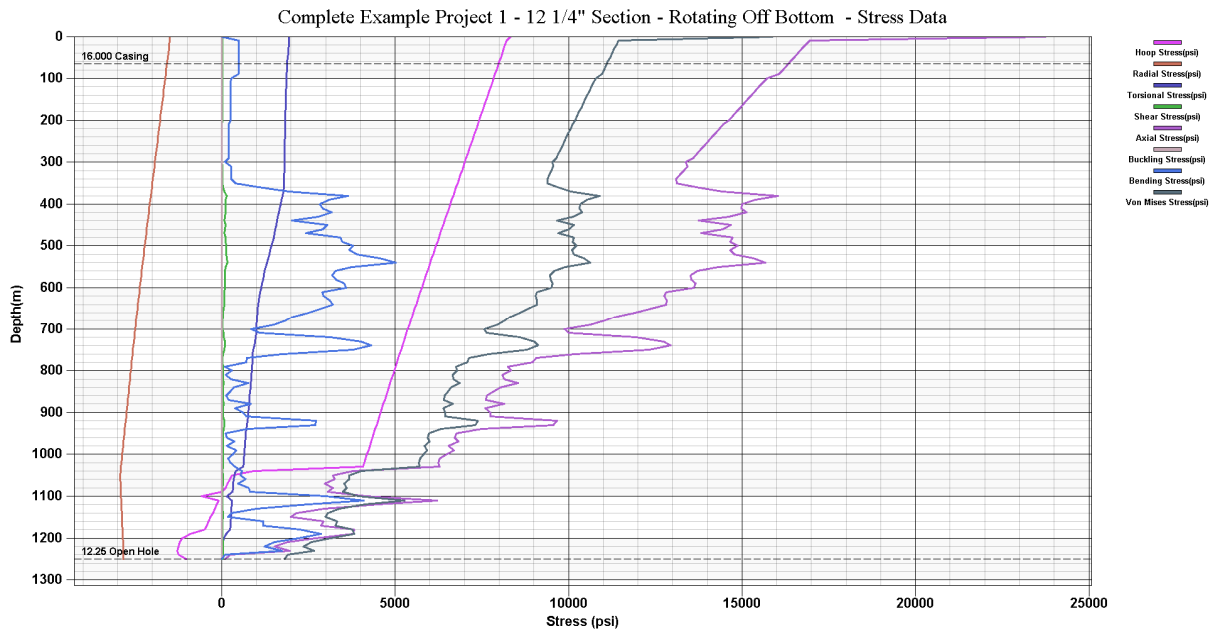


Figure 87: Stress Data Chart

4.10.7 – TAD Summary

This option prints off the Torque and Drag Summary, which includes:

- Torque and Drag Summary Report
- Drillers Hookload Chart
- Drillers Torque Chart

4.10.8 – Standoff summary

This option prints off the standoff summary report, which includes:

- Centralizer spacing summary
- Drill string summary
- Centralizer stand-off results
- Standoff chart
- Side forces / centralizer forces chart
- Hookload chart

4.11 – Help Menu

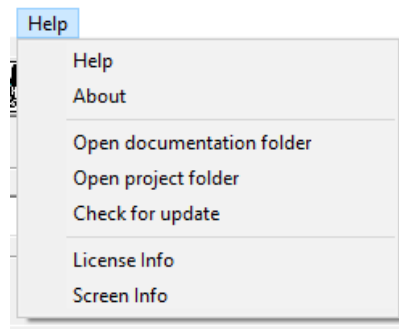


Figure 88: Help Menu

Access the interactive help file, software version information and the current license information. See appendix for detailed information about program licensing. The user can also access screen resolution information from here.

Help: Opens the Innova Engineering help file.

About: Displays program version information.

Open documentation folder: Opens the Manuals folder in the Innova Engineering directory. The Manuals folder contains this manual as well as several example guides on the following subjects:

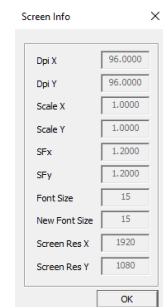
- BHA Analysis
- Hydraulics
- Magnetic Interference
- Riserless Hydraulics
- Short Collar Correction
- Survey Importing
- Torque and Drag

Open project folder: Opens the folder containing the currently opened Engineering project.

Check for update: Opens the Innova website where update versions of the software can be downloaded (<https://www.innova-drilling.com/drilling-software/download-free-demo/>)

License Info: Opens the License Details dialog. See **Appendix A – Software Licensing**.

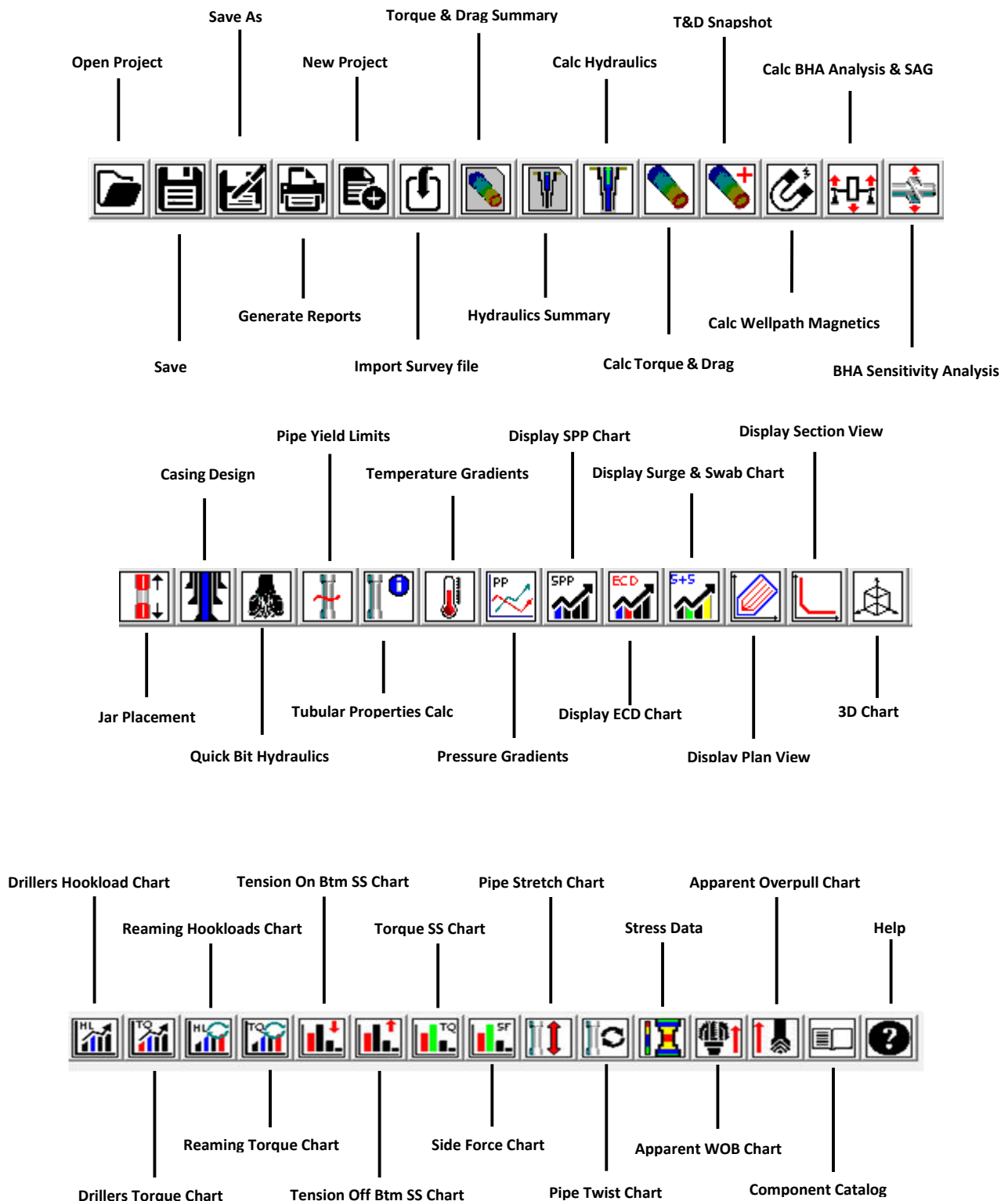
Screen Info: Displays information regarding the screen being used to view Innova Engineering.



5.0 – Toolbars

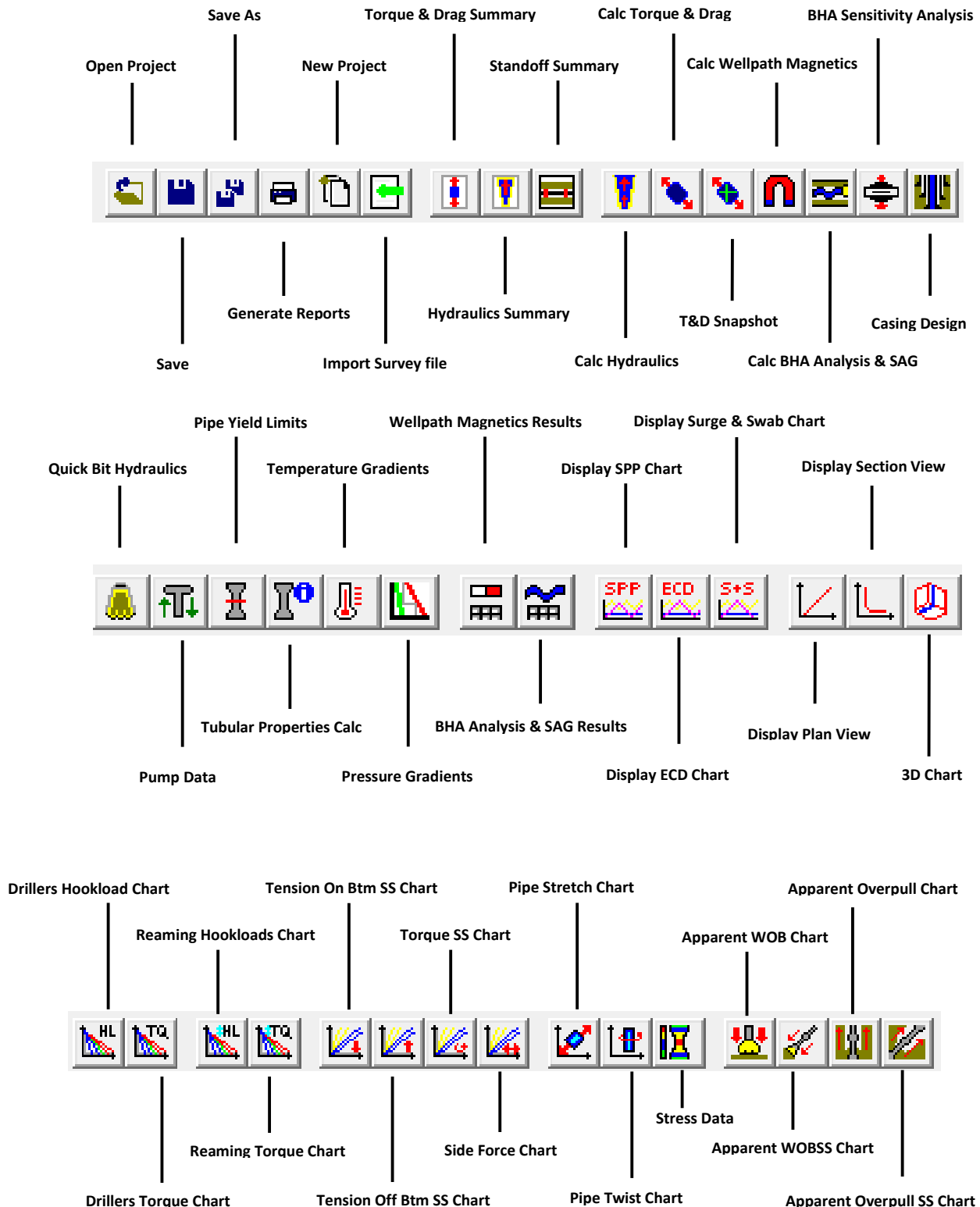
5.1 – High Resolution Toolbar

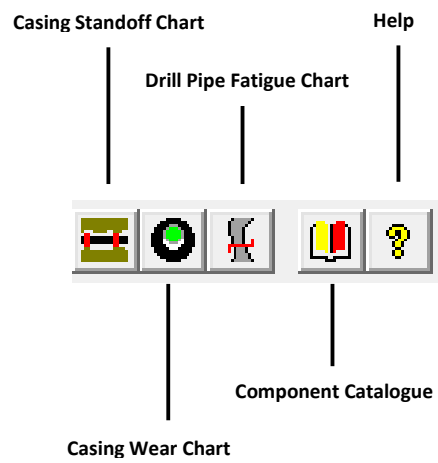
The main tool bar allows a quick alternative method to access functions and options available in the menus. The following toolbar icons will be displayed when using a high resolution screen.



5.2 – Standard Resolution Toolbar

The main tool bar allows a quick alternative method to access functions and options available in the menus. The following toolbar icons will be displayed when using a standard resolution screen.





6.0 – Drill String, Well Geometry and Fluids Tab

Project Name: Description: 16" Hole Section - RSS BHA

Drill String, Well Geometry and Fluids | Surveys | Engineering Parameters | Drilling Data | Cementing |

Drill String

Description	OD (in)	ID (in)	TJ OD (in)	TJ ID (in)	Weight (lb/ft)	Component	Length (m)	Total Length (m)	Non-Magnetic
1 PDC Bit	8.500	3.000			168.79	Bit	0.400	0.40	☐
2 Powerdrive Orbit 900	8.000	3.000			146.77	RSS	4.330	4.73	☐
3 15 7/8" NM Stabilizer	8.000	3.000			146.77	Stabilizer	1.790	6.52	☒
4 ARC 9	8.000	3.000			146.77	MWD/LWD	5.900	12.42	☒
5 Telescope	8.000	3.000			146.77	MWD/LWD	8.520	20.94	☒
6 NM Pony DC	8.000	3.000			146.77	Drill Collar	3.040	23.98	☒
7 15 1/4" String Stabilizer	8.000	3.000			146.77	Stabilizer	2.330	26.31	☒
8 CSIMDC	8.000	3.000			146.77	Drill Collar	9.440	35.75	☒
9 Downhole filter sub	8.000	3.000			146.77	Sub	2.200	37.95	☐
10 Downhole filter sub	8.000	3.000			146.77	Sub	2.320	40.27	☐
11 X/O	8.000	3.000			146.77	X/O	1.260	41.53	☐
12 6 5/8" (72ppf) HWDP	6.997	4.631	8.000	5.000	72.000	Drill Pipe / HWDP	29.224	70.75	☐
13 X/O	8.000	3.000			146.77	X/O	0.810	71.56	☐
14 Hydraulic Jar	8.000	3.000			146.77	Jar	10.000	81.56	☐
15 X/O	8.000	3.000			146.77	X/O	0.890	82.45	☐
16 6 5/8" (72ppf) HWDP	6.997	4.631	8.000	5.000	72.000	Drill Pipe / HWDP	29.220	111.67	☐
17 X/O	8.000	3.000			146.77	X/O	0.810	112.48	☐
18 Accelerator	8.000	3.000			146.77	Accelerator	10.410	122.89	☐
19 X/O	8.000	3.000			146.77	X/O	0.890	123.78	☐
20 6 5/8" (72ppf) HWDP	6.997	4.631	8.000	5.000	72.000	Drill Pipe / HWDP	38.960	162.74	☐
21 6 5/8" DP S-135 XT65 (27.7ppf)	6.741	5.836	8.000	5.000	27.700	Drill Pipe / HWDP	1280.176	1442.92	☐
22									☐

Component Details: BHA Weight (Buoyed) 43.45 kbs (Vertical), Weight Below Jar (Buoyed) 21.78 kbs (Vertical) 20 ☒ Last BHA Item

SN	
Gauge OD (in)	
TFA (in)	2.0279
Connection Top	
Bit Formation Index (0-1)	
Bit Type	PDC
Tensile Yield (kbs)	
Torsional Yield (ft-lbs)	

Insert Before Insert After Move Up Move Down Delete

Well Geometry

Type	MD (m)	TVD (m)	ID (in)	OD (in)
1 Casing	1301.00	1065.980	17.660	28.000
2 Open Hole	4200.00	1626.538	16.000	16.000
3				

Insert Before Insert After Delete

Fluid properties

Mud Weight (sg) 1.45

Add Fluid PV 40

Fluid Library YP 28

☐ Calculate N and K

600	117
300	73
200	57
100	40
6	17
3	16
N	0.667
K	1.059

Cuttings Details

Density (sg) 2.6 ☐

Diameter (in) 0.125 ☐

Thickness (in) 0.125 ☐

Additional Fluids

Vol (bbls)	Density (sg)
1	

☐ Enable

Figure 89: Drill string, Well Geometry and Fluids Tab

6.1 – Project Name and Description

Project Name: Description:

Figure 90: Project name & description

The project name and the project description can be entered in the edit boxes at the top of the main dialog. These are used in Chart titles and on the Reports

6.2 – Drill string & component grid

Drill String

	Description	OD (in)	ID (in)	TJ OD (in)	TJ ID (in)	Weight (lb/ft)	Component	Length (m)	Total Length (m)	Non-Magnetic
1	PDC Bit	8.500	3.000			168.79	Bit	0.400	0.40	☐
2	Powerdrive Orbit 900	8.000	3.000			146.77	RSS	4.330	4.73	☐
3	15 7/8" NM Stabiliser	8.000	3.000			146.77	Stabilizer	1.790	6.52	☒
4	ARC 9	8.000	3.000			146.77	MWD/LWD	5.900	12.42	☒
5	Telescope	8.000	3.000			146.77	MWD/LWD	8.520	20.94	☒
6	NM Pony DC	8.000	3.000			146.77	Drill Collar	3.040	23.98	☒
7	15 1/4" String Stabiliser	8.000	3.000			146.77	Stabilizer	2.330	26.31	☒
8	CSNMDC	8.000	3.000			146.77	Drill Collar	9.440	35.75	☒
9	Downhole filter sub	8.000	3.000			146.77	Sub	2.200	37.95	☐
10	Downhole filter sub	8.000	3.000			146.77	Sub	2.320	40.27	☐
11	X/O	8.000	3.000			146.77	X/O	1.260	41.53	☐
12	6 5/8" (72ppf) HWDP	6.997	4.631	8.000	5.000	72.000	Drill Pipe / HWDP	29.224	70.75	☐
13	X/O	8.000	3.000			146.77	X/O	0.810	71.56	☐
14	Hydraulic Jar	8.000	3.000			146.77	Jar	10.000	81.56	☐
15	X/O	8.000	3.000			146.77	X/O	0.890	82.45	☐
16	6 5/8" (72ppf) HWDP	6.997	4.631	8.000	5.000	72.000	Drill Pipe / HWDP	29.220	111.67	☐
17	X/O	8.000	3.000			146.77	X/O	0.810	112.48	☐
18	Accelerator	8.000	3.000			146.77	Accelerator	10.410	122.89	☐
19	X/O	8.000	3.000			146.77	X/O	0.890	123.78	☐
20	6 5/8" (72ppf) HWDP	6.997	4.631	8.000	5.000	72.000	Drill Pipe / HWDP	38.960	162.74	☐
21	6 5/8" DP S-135 XT65 (27.7ppf)	6.741	5.836	8.000	5.000	27.700	Drill Pipe / HWDP	1280.176	1442.92	☐
22										☐

Component Details BHA Weight (Buoyed) 43.45 kbs (Vertical), Weight Below Jar (Buoyed) 21.76 kbs (Vertical) 20 ☒ Last BHA Item

Connection Top	
Connection Bottom	
Friction Reduction Sub %	
Class	
Tensile Yield (kbs)	
Torsional Yield (kftlbs)	
Burst (psi)	
Collapse (psi)	
Material	
Internal Fluid Wt	

Insert Before Insert After Move Up Move Down Delete

Figure 91: Drill string grid

This grid allows the user to enter the details of the drill string, which is used in all calculation modules. Different types of assembly can be modelled, and data entry is identical for each.

New lines can be added to the grid by clicking on the insert above and below buttons at the bottom of the grid or by pressing the space bar. The insert functions can also be accessed from the context menu by right clicking on the grid. Components can also be moved up and down unless the component is the bit. Rows can be deleted by clicking the delete button or by pressing the backspace key. Multiple rows can be deleted by highlighting multiple rows and pressing the delete button.

Data can be copied and pasted into the grid by using the standard copy and paste methods from the clipboard.

The length of the last component does not have to be specified exactly and the program adjusts its length depending on the calculation depth. If for instance the last item in the BHA is drill pipe just enter 9.9 for its length regardless of the actual length.

The following describes what the various columns in the grid do.

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 in to 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 in to this column. If the “Include TJ in calculations” menu option is turned off this column will be disabled.

Weight: This is the weight per unit length of the component, this is either calculated automatically based on the OD / ID of the component or can be entered manually by the user if the “Auto Calculate Weight” option is turned off. This is used for torque and drag calculations as well as SAG calculations.

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. The following is a list of the components available, and a description of their properties can be viewed in [Appendix E – Component Details](#).

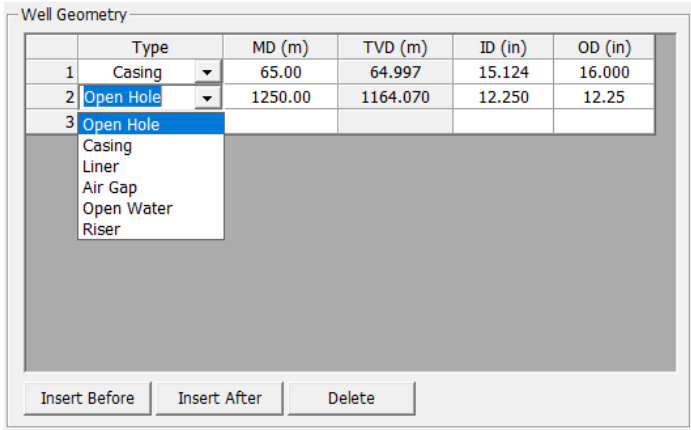
- Bit
- Hole Opener / Under Reamer
- Circ Sub
- Cross Over (X/O)
- RSS – Rotary Steerable system
- MWD / LWD
- Motor
- Turbine
- Stabiliser
- Drill Collar
- Drill Pipe / HWDP
- Jar
- Accelerator
- Sub
- Liner
- Casing / Tubing
- Agitator
- Reamer

Length: The length of the component in the system units

Total lengths: The cumulative length of the drill string components up to that point. This is automatically calculated.

Non-Magnetic: Is the component steel of non-mag material. This is used for the magnetic interference calculations.

6.3 – Well Geometry



	Type	MD (m)	TVD (m)	ID (in)	OD (in)
1	Casing	65.00	64.997	15.124	16.000
2	Open Hole	1250.00	1164.070	12.250	12.25
3	Open Hole				

Insert Before Insert After Delete

Figure 92: Well geometry

This section allows the user to define the well construction. The section type is selected from the combo box in the type column and the depth is entered in the MD column. The TVD is interpolated from the actual survey listing and if the depth cannot be found the well plan listing is searched. If no survey data has been entered the cell will remain blank. The TVD is not used in any of the calculations and is just displayed for reference.

The ID of the section in inches is entered in the ID column, and the OD is entered in the OD column. ID and OD's must get progressively smaller and MDs must get progressively deeper. When Open Hole is selected, the OD cell will automatically populate with the same value entered in the ID cell.

Rows can be inserted using the buttons or the context menu. Backspace and the spacebar keys delete and insert rows respectively. A list of the hole section types can be found below.

- **Open Hole** – This must always be the last item in the geometry list
- **Casing** – Casing can be positioned below a riser, open water, or an air gap but must be above a liner or open hole. Multiple casing sections can be added to represent a tapered casing string.
- **Liner** – Must be positioned below casing and above open hole
- **Air Gap** – Must be the first item entered and if this is detected, riserless drilling mode is enabled. The next item must be open water
- **Open Water** – Must be below air gap and the second item, used for riserless drilling mode
- **Riser** – must be the first item entered

6.4 – Fluid Properties

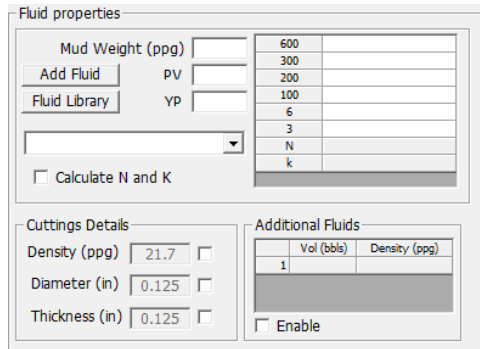


Figure 93: Fluid Properties

This section of the main tab allows all the mud properties to be specified. The mud properties are used for all calculation modules.

- **Mud weight** – Mud density in the units specified
- **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
- **Cuttings Density** – The density of the cuttings in the mud units specified, used in the hole cleaning calculations of the hydraulics module. **Default is 21.7ppg**
- **Cuttings Diameter** – Diameter of the cuttings in inches used for the hole cleaning calculations in the hydraulics module. **Default is 0.125 inches**
- **Cuttings Thickness** – Thickness of the cuttings in inches used for the hole cleaning calculations in the hydraulics module. **Default is 0.125 inches**
- **Mud Rheology** – The Fann dial readings of the drilling fluid, used for all hydraulics models except Bingham Plastic. Included in the rheology section are the N and k values, which represent the **Flow Index (N)** and the **Consistency Index (k)**. These cells are populated automatically based on the input PV & YP values. If no PV & YP values are input, the 600 & 300 values are used to generate the values in these cells.
- **Additional fluids** – Allows the user to simulate pumping pills and sweeps. Enter the volume and the density of the fluid and this will be included in the hydraulics calculation. The program effectively calculates a new mud weight for running the calculations based on the additional fluid being added to the system. Multiple fluids can be entered. The cementing module provides more detailed outputs for users interested in modelling pills and sweeps.
- **Add Fluid** – This radio button adds the populated fluid properties data into a “New Fluid” line in the Fluid Library. When selected, this will open the Fluid Library dialogue and the user can then rename the fluid appropriately and where required add additional information.

- **Calculate N & K** – Allows the user to manually enter the N & k values. This overrides any PV, YP and Rheology data entered.
- **Fluid Library** – This radio button opens the fluid library

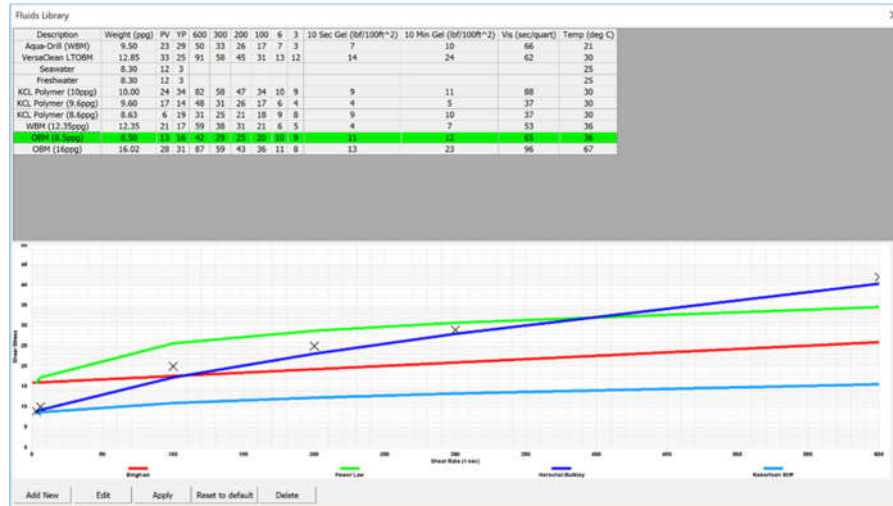


Figure 94: Fluid Library

The fluid library comes with the above fluids as part of the install. These basic fluids can be edited or deleted and there is no limit to the number of new fluids which can be added. Any fluid from the library can be assigned by selecting it from the drop-down menu in the fluid properties dialogue.

New fluids are saved to a file located in the Engineering folder called **Def_fluids.txt**. It should be noted that this file will be overwritten if the program is reinstalled for any reason, so if the user has a large fluids library, this should be backed up before removing and reinstalling the software.

- **10 Sec Gel** – 10 Sec Gel strength of the fluid. Not used in any calculations.
- **10 Min Gel** – 10 minute Gel strength of the fluid. Not used in any calculations.
- **Vis** – Viscosity of the fluid. Not used in any calculations.
- **Temp** – Temperature of the fluid. Not used in any calculations.
- **Add New** – Creates a blank row allowing the user to add a new fluid
- **Edit** – Allows the user to edit which ever fluid they have selected
- **Apply** – Saves any changes made
- **Reset to Default** – Resets the Library back to its default values. This will delete any new fluids added since the initial install.
- **Delete** – Deletes whichever fluid is selected
- **Shear Stress vs Shear Rate Chart** – This chart plots the selected fluids 3, 6, 100, 200, 300 and 600 rpm viscometer readings and presents it alongside the Bingham, Power Law, Herschel

Bulkley and Robertson Stiff model lines. This can be used as a guide for selecting the best hydraulic model for a specific fluid.

6.5 – Well Schematic

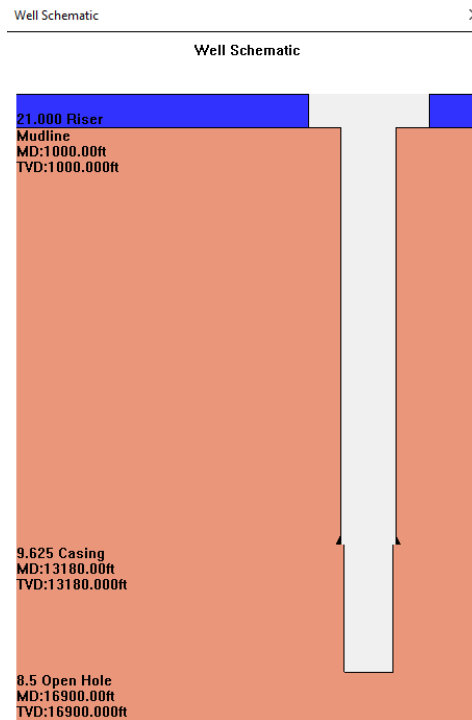


Figure 95: Well Schematic

The well Schematic gives a visual representation of information populated in the Well Geometry section of the main tab. If the user is viewing the program on a large enough screen, this schematic can be found at the right-hand side regardless of which tab is being viewed.

If the program is being viewed on a smaller screen e.g. on a laptop, to maximise space, the schematic will be hidden. It can be viewed at any time though by selecting **Tools – Well Schematic** from the top menu.

7.0 – Surveys Tab

The Surveys Tab interface includes several sections for data entry and calculation:

- Vertical Section:** Fields for Azi (0.00), Origin NS (0.00), and Origin EW (0.00).
- Raw Survey Data:** Fields for Latitude (0.00), HL Ref (0.0), Dip Ref (0.0), North Ref (Grid), TAC (0.450), Grid Conv (-0.45), Dec (0.0), and Inclination to Use (SAG Corrected Inc).
- Survey Corrections:** Fields for Survey Offset (ft) (38.00), Inc Start (0.0), Inc Stop (90.0), Inc Step (2.0), and Calc Type (Single).
- Survey Selection:** A dropdown menu set to 'Well Plan'.
- Data Table:** A table with 11 columns: MD (ft), Inc, Azi, TVD (ft), NS (ft), EW (ft), VS (ft), TF deg, DLS deg/100, BR deg/100, TR deg/100, and CL. It contains 7 rows of data.
- Buttons:** Insert Before, Insert After, Delete, Tortuosity, Calculated Survey Data, and MSA.

	MD (ft)	Inc	Azi	TVD (ft)	NS (ft)	EW (ft)	VS (ft)	TF deg	DLS deg/100	BR deg/100	TR deg/100	CL
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
2	1292.00	0.00	0.00	1292.00	0.00	0.00	-0.00	0.00	0.0000	0.0000	0.0000	1292.00
3	1500.00	30.00	0.00	1490.63	53.22	0.00	53.22	0.00	14.4231	14.4231	0.0000	208.00
4	3000.00	30.00	0.00	2789.66	803.22	0.00	803.22	0.00	0.0000	0.0000	0.0000	1500.00
5	3200.00	50.00	0.00	2942.10	931.13	0.00	931.13	0.00	10.0000	10.0000	0.0000	200.00
6	5800.00	50.00	0.00	4613.34	2922.84	0.00	2922.84	0.00	0.0000	0.0000	0.0000	2600.00
7												

Figure 96: Surveys Tab

7.1 – Vertical section

The Vertical Section details panel contains three input fields:

- Azi:** 0.00
- Origin NS:** 0.00
- Origin EW:** 0.00

Figure 97: Vertical section details

This part of the tab allows the user to specify how the vertical section is calculated. The vertical section is displayed on the Section View Plot, so changing these parameters will change how the surveys are displayed. Parameters in this section have no effect on any calculation module.

- **Vertical Section azimuth** – The azimuth of the vertical section in degrees
- **Origin NS** – The origin NS where the vertical section is calculated from in local co-ordinates. This value is usually zero if the vertical section is calculated from the well head location.
- **Origin EW** - The origin EW where the vertical section is calculated from in local co-ordinates. This value is usually zero if the vertical section is calculated from the well head location.

7.2 – Survey Selection

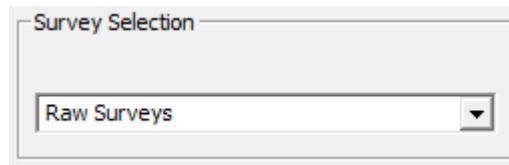


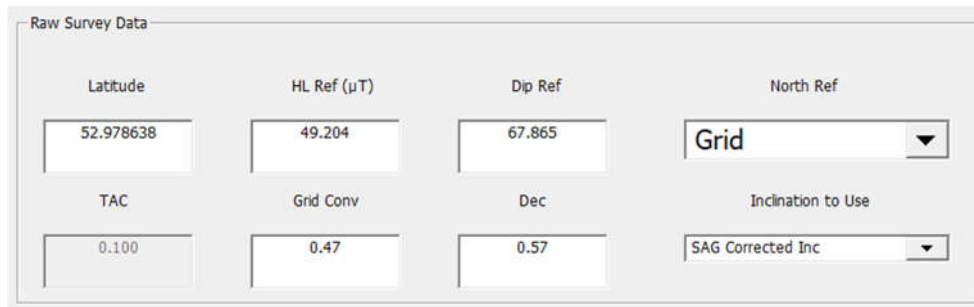
Figure 98: Survey Selection

This section defines which surveys are being displayed in the survey grid. There are three options

- **Actual surveys** – Usually surveys taken while drilling
- **Well Plan** – Plan or surveys used when the well was in the planning stage
- **Raw surveys** – Raw MWD surveys, this page is used for survey corrections such as MSA, SCC and SAG

Note that when modelling a well where only one survey listing or plan is present, it does not matter if the surveys are entered in well plan or actual.

7.3 – Raw Survey Data



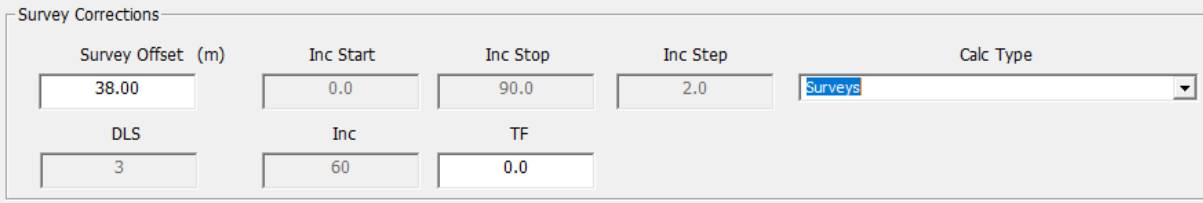
The screenshot shows a software window titled "Raw Survey Data". It contains eight input fields arranged in two rows of four. The first row fields are: "Latitude" (value: 52.978638), "HL Ref (μT)" (value: 49.204), "Dip Ref" (value: 67.865), and "North Ref" (a dropdown menu showing "Grid"). The second row fields are: "TAC" (value: 0.100), "Grid Conv" (value: 0.47), "Dec" (value: 0.57), and "Inclination to Use" (a dropdown menu showing "SAG Corrected Inc").

Figure 99: Raw survey details

The data in this section is used for the Short Collar Correction (SCC) and Multi-Station Analysis (MSA) modules and the well path magnetics calculations. The data in this section only affects surveys in the raw survey grid.

- **Latitude** - Required to calculate the SCC Delta Azi in the Magnetic Spacing Calculator
- **HL Ref** – The reference magnetic field strength in micro Tesla (μT). This is used for the SCC, MSA and magnetic spacing calculations. This value is usually obtained from the well planning department and a program such as IGRF, BGGM or HDGM.
- **Dip Ref** – The reference magnetic dip angle. This is used for the SCC, MSA and magnetic spacing calculations. This value is obtained from the well planning department and a program such as IGRF, BGGM or HDGM.
- **TAC** – Total Applied Correction. This is the correction applied to raw survey azimuths and is calculated automatically, depending on the north reference and the value of grid convergence and magnetic declination.
- **Grid** – Grid Convergence. This value comes from a well planning package and is the angle between True North and Grid North from True North. Note this is the inverse of Grid correction. The two should not be confused.
- **Dec** – Magnetic declination. This is angle from True North to Magnetic North from True North and is used to calculate the TAC and the magnetic azimuth for magnetic interference calculations. This comes from a package such as IGRF or BGGM.
- **North** – The north reference the surveys are referenced to. Either true or grid.
- **Inclination to use** – This is the inclination used by the program to calculate the TVD, NS, EW, VS, TF, DLS, BR & TR values. The user can choose between Sag Corrected and Raw. This option only affects the raw surveys.

7.4 – Survey Corrections



Survey Offset (m)	Inc Start	Inc Stop	Inc Step	Calc Type	DLS	Inc	TF
38.00	0.0	90.0	2.0	Surveys	3	60	0.0

Figure 100: Survey corrections

This section defines parameters for the SAG correction module and the well path magnetic interference module.

- **Offset** – The distance from the bit to the MWD directional sensor. This is used for well path magnetic interference calculations and SAG calculations.
- **Inc Start** – If inclination range is specified in the Calc. type combo this is the 1st inclination value to be calculated.
- **Inc Stop** – If inclination range is specified in the Calc. type combo this is the last inclination value to be calculated.
- **Inc Step** – This is the step value used for the inclination range calculation
- **DLS** – The hole curvature used for single and inclination range calculations
- **Inc** – The inclination use for single calculation
- **Calc Type** –
 - **Single** – Calculates SAG & BHA Analysis for a single inclination
 - **Inc Range** – Calculates SAG & BHA Analysis for a range of surveys specified by inc start, stop and step
 - **Surveys** – Calculates SAG & BHA Analysis for the survey grid selected, curvature is derived from the surveys themselves. If the raw survey grid is selected the corrected inclinations will be displayed in the grid as well as the delta inc.

7.5 – Main Survey Grid

	MD (Usft)	GX	GY	GZ	HX	HY	HZ	Inc	Azi	Inc SAG	Azi SCC	HL SCC	Dip SCC	HL	GT	Dip	HSTF	Delta Inc	Delta Azi	TVD (Usft)	NS (Us ^
1	8292.00							4.754	97.89									0.000		8290.37	107.3
2	8380.00	82.830000	174.620000	-981.450000	1602.130000	26161.190000	9338.520000	11.09	119.87	11.136	119.83	48.2498	60.9674	48.3698	1.0001	61.0620	115.2384	0.066	-0.0296	8377.50	102.6
3	8380.00	191.600000	0.000000	-982.620000	19439.220000	20416.260000	9353.940000	11.03	120.38	11.030	120.45	48.2800	60.9152	48.4091	1.0011	61.0179	180.0000	0.000	-0.0653	8377.50	102.6
4	8380.00	52.730000	-185.160000	-982.620000	24987.410000	3027.950000	9390.560000	11.09	120.09	11.090	120.17	48.2757	60.9227	48.4326	1.0013	61.0501	254.1041	0.000	-0.0788	8377.50	102.6
5	8380.00	-22.270000	-191.020000	-982.620000	18001.830000	1661.380000	9399.720000	11.07	120.31	11.070	120.40	48.2591	60.9512	48.4316	1.0013	61.0954	276.6498	0.000	-0.0897	8377.50	102.6
6	8474.00	-235.550000	-31.640000	-972.660000	6770.430000	13762.510000	9877.870000	13.73	116.00	13.730	116.14	48.3397	60.8146	48.5530	1.0013	60.9939	352.3496	0.000	-0.1353	8469.30	93.14
7	8474.00	-237.300000	-15.820000	-972.660000	8294.800000	2622.680000	9887.020000	13.74	115.88	13.740	116.03	48.3496	60.7981	48.5663	1.0013	60.9763	356.1859	0.000	-0.1461	8469.30	93.14
8	8474.00	-208.590000	113.670000	-972.660000	7532.620000	9324.650000	9891.600000	13.72	115.80	13.720	115.94	48.3429	60.8092	48.5546	1.0012	60.9795	28.5879	0.000	-0.1427	8469.30	93.14
9	8474.00	105.470000	213.280000	-972.070000	0320.440000	27999.610000	9900.760000	13.75	115.86	13.750	116.01	48.2910	60.8969	48.5198	1.0008	61.0895	116.3131	0.000	-0.1476	8469.30	93.14
10	8567.00	-127.150000	-321.090000	-939.840000	13140.310000	7772.520000	7550.350000	20.18	107.61	20.242	107.86	48.2786	60.9179	48.5181	1.0013	61.1187	291.6033	0.062	-0.2528	8558.22	83.31
11	8567.00	-97.850000	-331.050000	-939.840000	15584.800000	6467.900000	7550.350000	20.17	107.58	20.170	107.83	48.2771	60.9205	48.5125	1.0012	61.1126	286.4663	0.000	-0.2472	8558.22	83.31
12	8567.00	-238.480000	-248.440000	-939.840000	1636.530000	10715.940000	7554.930000	20.12	107.79	20.120	108.05	48.2945	60.8913	48.5440	1.0009	61.0942	313.8282	0.000	-0.2564	8558.22	83.31
13	8567.00	-217.970000	268.360000	-939.840000	10704.970000	1899.720000	7536.620000	20.20	107.12	20.200	107.31	48.3546	60.7895	48.5325	1.0014	60.9358	50.9155	0.000	-0.1902	8558.22	83.31
14	9332.00	329.300000	-942.770000	-63.280000	35941.860000	11983.950000	1660.030000	86.37	86.02	86.472	87.65	48.2773	60.9803	48.3374	1.0006	60.9526	250.7462	0.102	-1.6328	8992.75	56.5
15	9427.00	-996.680000	-59.770000	-63.870000	10556.190000	16005.550000	1930.110000	86.34	85.46	86.340	89.61	48.2847	60.8273	48.4293	1.0005	60.7858	356.5881	0.000	-4.1549	8998.79	58.8
16	9522.00	978.520000	-198.050000	-68.550000	45788.510000	14607.240000	5981.180000	86.07	85.53	86.070	87.06	48.2678	60.9308	48.3299	1.0007	60.9023	191.4420	0.000	-1.5285	9005.08	61.5
17	9616.00	993.750000	-93.750000	-70.310000	43975.740000	19377.140000	5259.700000	85.97	85.28	85.970	87.20	48.2629	60.9058	48.3426	1.0006	60.8680	185.3893	0.000	-1.9193	9011.60	66.2
18	9711.00	906.450000	-417.190000	-78.520000	47917.140000	3726.200000	5406.190000	85.50	85.77	85.500	88.05	48.2690	60.9407	48.3649	1.0009	60.9126	204.7141	0.000	-2.2773	9018.67	70.2
19	9805.00	981.450000	153.520000	-123.050000	37516.590000	29603.580000	7077.030000	82.94	86.24	82.940	86.95	48.2688	60.8560	48.3110	1.0010	60.8567	171.1097	0.000	-0.7111	9028.14	74.2
20	9900.00	-650.390000	752.340000	-116.600000	15065.230000	16154.480000	5958.010000	83.31	85.89	83.310	87.65	48.2764	60.7838	48.3762	1.0013	60.7783	49.1569	0.000	-1.7629	9039.51	78.7
21	9995.00	-429.490000	-898.830000	-96.090000	2996.110000	17955.320000	3900.570000	84.49	86.38	84.490	90.22	48.2428	61.0105	48.4098	1.0008	61.0246	295.5400	0.000	-3.8406	9049.60	80.4
22	10089.00	513.870000	-853.120000	-92.580000	41709.770000	15844.510000	5419.920000	84.69	87.19	84.690	89.14	48.2659	60.9326	48.3494	1.0002	60.9536	238.9377	0.000	-1.9508	9056.47	81.0
23	10184.00	558.980000	-822.660000	-107.230000	42881.670000	1450.810000	5285.100000	83.85	86.58	83.850	88.37	48.2673	60.9486	48.3578	1.0004	60.9527	235.8047	0.000	-1.7894	9067.95	83.0
24	10278.00	-505.080000	858.400000	-93.750000	15311.240000	24119.570000	5918.880000	84.62	86.10	84.620	88.44	48.2813	60.7565	48.3904	1.0004	60.7490	59.5276	0.000	-2.3441	9077.39	85.6
25	10373.00	-164.060000	-983.790000	-77.340000	16111.240000	15295.720000	5140.690000	85.57	86.29	85.570	88.23	48.2717	61.0443	48.3498	1.0004	61.0306	279.4677	0.000	-1.9385	9085.52	88.4

Figure 101: Main survey grid

The main survey grid is where all the actual survey data is entered. The survey grid has the same grid controls as all other grids in Innova engineering, with insert delete and copy and paste functions. Surveys can be entered in a number of ways:

- Manually typing in each survey line by line
- Importing surveys from an existing file using the survey import tool
- Copy and pasting data from the clipboard

Depending on the survey selection the survey grid will display different information. If raw surveys are selected and a valid **Ref HL** and **Ref Dip** are entered the short collar correction algorithm will automatically run and update every time a change is made to the grid or ref HL and Dip. Surveys which fall out with the QC limits specified will be highlighted in red.

7.5.1 - Tortuosity

Tortuosity

Select Method

☒ Sinusoidal
 ☐ Random

☐ Apply Tortuosity
 ☐ Depth Range

Period Length

25.00

(ft)

Start Depth

0.00

(ft)

End Depth

0.00

(ft)

OK

Cancel

Figure 102: Tortuosity

This option is only available for Actual and Well Plan surveys and cannot be used with raw surveys. In some situations, it may be necessary to add tortuosity to a well plan or survey to better simulate real life conditions. Well plans which contain purely vertical sections are a typical example of this.

Tortuosity can be applied to the whole wellbore or to one specific section.

- **Apply Tortuosity** – Select this box to enable the tortuosity options
- **Sinusoidal** – Tortuosity will be applied in the form of a sine wave. The inclination and azimuth vary by an amount equal to: $A \sin(2\pi * (MD/T))$. The maximum dogleg variation is $4A/T$
- **Random** – The inclination and azimuth vary independently in the range $\pm A$ every depth interval T . The maximum dogleg variation is $2A/T$.
- **Depth Range** – Select this box to enable the Depth Range options. If this is not selected, tortuosity will be applied to the whole survey or plan.
- **Period Length** – The length of one cycle of the curve.
- **Start Depth** – First depth at which Tortuosity will be applied.
- **End Depth** – Last depth at which Tortuosity will be applied.

7.5.2 – Calculated Survey Data

Results

File

MD (ft)	Inc	Azi	TVD (ft)	NS (ft)	EW (ft)	VS (ft)	TF deg	DLS deg/100	BR deg/100	TR deg/100	CL
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	10.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
20.00	0.00	0.00	20.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
30.00	0.00	0.00	30.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
40.00	0.00	0.00	40.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
50.00	0.00	0.00	50.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
60.00	0.00	0.00	60.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
70.00	0.00	0.00	70.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
80.00	0.00	0.00	80.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
90.00	0.00	0.00	90.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
100.00	0.00	0.00	100.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
110.00	0.00	0.00	110.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
120.00	0.00	0.00	120.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
130.00	0.00	0.00	130.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
140.00	0.00	0.00	140.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
150.00	0.00	0.00	150.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00
160.00	0.00	0.00	160.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	10.00

Figure 103: Calculated Survey Data

This option is only available for Actual and Well Plan surveys and cannot be used with raw surveys. This section gives a breakdown of the selected surveys every 10ft or meters, and is a representation of the survey data used in the calculations. If tortuosity has been added to the selected survey, then it will be included in this listing.

7.5.3 – MSA

This radio button opens the Multi-Station Analysis dialogue. This is discussed in more detail in [Section 4.5.10 – Multi Station Analysis](#).

8.0 – Engineering Parameters Tab

Figure 104: Engineering Parameters Tab

8.1 – Hydraulics module parameters

Figure 105: Hydraulics module parameters

This section allows the parameters for the hydraulics module to be specified.

- **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 common references from the combo box:
 - **Bit** – Bit depth
 - **Shoe** –Shoe depth, taken from the well geometry dialogue in the drill string tab
 - **Bottom Hole** – Bottom hole depth, taken from the well geometry dialogue in the drill string tab
 - 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 (Dirty) 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 to better match the model with MWD PWD data.
- **SW Den** – Sea water density, which is used for riserless drilling calculations. Default is 8.55ppg.
- **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 at which the calculation will be run and the depth at which snap shot calculations will be performed. This depth must be within the range of the surveys for a directional well.

8.2 – Flow Rates

Flow Rates	
	Flow Rate (gpm)
1	50.00
2	75.00
3	100.00
4	125.00
5	150.00

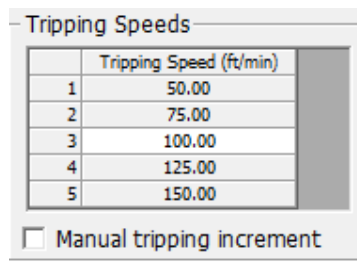
☐ Manual flow increment

Figure 106: Flow rates grid

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.

For torque and drag calculations, if a flow rate has been entered, Engineering will use this in the calculations. If manual flow increment is selected, the first flow rate entered will be used in the T&D calculations. If the automatic range is selected, the flow rate entered in line 3 will be used.

8.3 - Tripping speeds



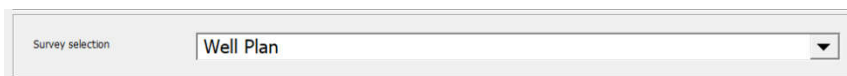
	Tripping Speed (ft/min)
1	50.00
2	75.00
3	100.00
4	125.00
5	150.00

☐ Manual tripping increment

Figure 107: Tripping speeds grid

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.

8.4 – Survey Selection



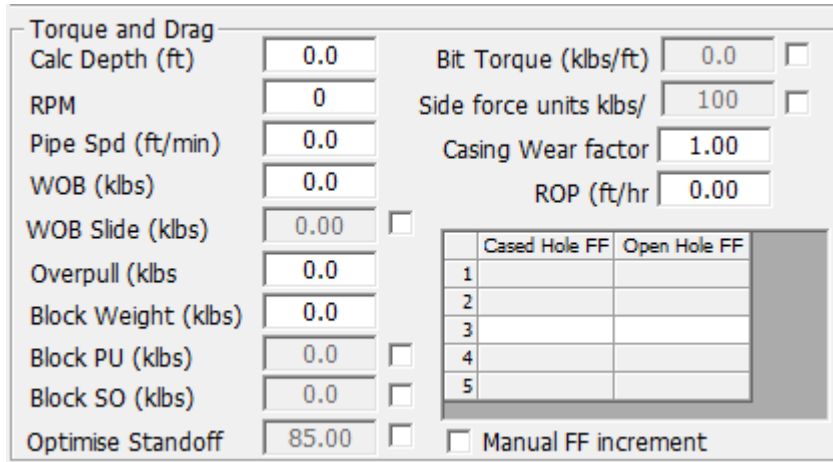
Survey selection: Well Plan

Figure 108: Survey selection combo

The survey selection box is used for both the hydraulics and torque and drag module. It allows the user to select which survey listing is to be used for the calculation.

- **Actual surveys** – Use actual survey grid
- **Well Plan** – Use well plan grid
- **Composite** – Splice the actual surveys into the well plan surveys to create a composite listing. The surveys will be used from surface, and the plan will tie-onto the last survey station.

8.5 – Torque and Drag parameters



Torque and Drag																			
Calc Depth (ft)	0.0																		
RPM	0																		
Pipe Spd (ft/min)	0.0																		
WOB (klbs)	0.0																		
WOB Slide (klbs)	0.00 ☐																		
Overpull (klbs)	0.0																		
Block Weight (klbs)	0.0																		
Block PU (klbs)	0.0 ☐																		
Block SO (klbs)	0.0 ☐																		
Optimise Standoff	85.00 ☐																		
Bit Torque (klbs/ft)	0.0 ☐																		
Side force units klbs/	100 ☐																		
Casing Wear factor	1.00																		
ROP (ft/hr)	0.00																		
<table border="1"> <thead> <tr> <th></th> <th>Cased Hole FF</th> <th>Open Hole FF</th> </tr> </thead> <tbody> <tr><td>1</td><td></td><td></td></tr> <tr><td>2</td><td></td><td></td></tr> <tr><td>3</td><td></td><td></td></tr> <tr><td>4</td><td></td><td></td></tr> <tr><td>5</td><td></td><td></td></tr> </tbody> </table>			Cased Hole FF	Open Hole FF	1			2			3			4			5		
	Cased Hole FF	Open Hole FF																	
1																			
2																			
3																			
4																			
5																			
☐ Manual FF increment																			

Figure 109: Torque and drag module parameters

This section allows the parameters of the torque and drag model to be defined:

- **Calc Depth** – This is the depth at which the calculation will be run and also the depth the snapshot graphs and tables will display
- **RPM** – Rotational speed of the drill string, used to calculate reaming torques and hook loads
- **Pipe speed** – The speed the pipe is moving up and down in depth units / min. Used to calculate reaming hook loads and torques. It is also used to calculate the viscous drag if selected
- **WOB** – The weight on bit while Rotary drilling
- **WOB Slide**– The weight on bit while Slide drilling. If the check box is not selected, this will auto populate with the value in the WOB cell.
- **Overpull** - The overpull applied to the assembly when pulling out of hole. Used for creating the Apparent Overpull & Apparent Overpull Snapshot Charts
- **Block weight** – The weight of the travelling block
- **Block PU** – If the weight of the travelling block is different to the block weight while picking up, enter it here. Click the check box to enable
- **Block SO** - If the weight of the travelling block is different to the block weight while slacking off, enter it here. Click the check box to enable
- **Optimise Standoff** – Used in the casing standoff calculation. This will override the centralizer spacing selected in casing component details, and output the spacing required to achieve the desired standoff.

- **Bit Torque** – The estimated torque generated by the bit. This is calculated from the WOB and the bit OD (taken from the drill string), however it can be over-ridden with a user defined value by clicking the check box.
- **Side force units** – Specifies the unit length of the calculated side force. It should be noted that if you are using side force to predict casing wear, the default units should be over ridden to side force / per tool joint (ie. 30ft or 10m).
- **Casing Wear Factor** – Casing wear factor, defined as the ratio of friction factor to specific energy, E-10psi-1. The table below should be used as guide for casing wear factor selection. Default is 1.

	Selections	Wear Factor (E-10 psi ⁻¹)
Mud type	Water or Water based, Steel tool joint	0.5 to .40
	Oil based mud, Steel tool joint	0.3 to 5
Tool joint material	Smooth tungsten carbide	8.5
	Very rough tungsten carbide	1625
	Other proprietary casing-friendly hardbanding	1 to 6
Rotating Drill Pipe protector	Pipe protector started with rusted casing	4.1
	Pipe protector with average casing interior	2.1
	Pipe protector after polishing casing	0.06

Figure 110: Casing Wear Factor Selection

- **ROP** – The rate of penetration in feet or meters / hour. The ROP is used to calculate the casing wear. This is done by taking the depth of the last casing or liner and subtracting it from the calculation depth. This value is then divided by the ROP to give the time over which casing wear is calculated.
- **Friction factor grid** – The friction factors for cased hole and open hole. By default, the enable manual increment box is disabled. If this is the case, enter a friction factor for the cased hole and open hole in the middle cells of each column and values above and below will automatically be calculated ($\pm 25\%$ & $\pm 50\%$) in order to perform a sensitivity analysis. If you wish to override this feature, click the check box and enter as many friction factors as required. This can also be used to perform a single friction factor calculation.

8.6 – Hydraulics Results

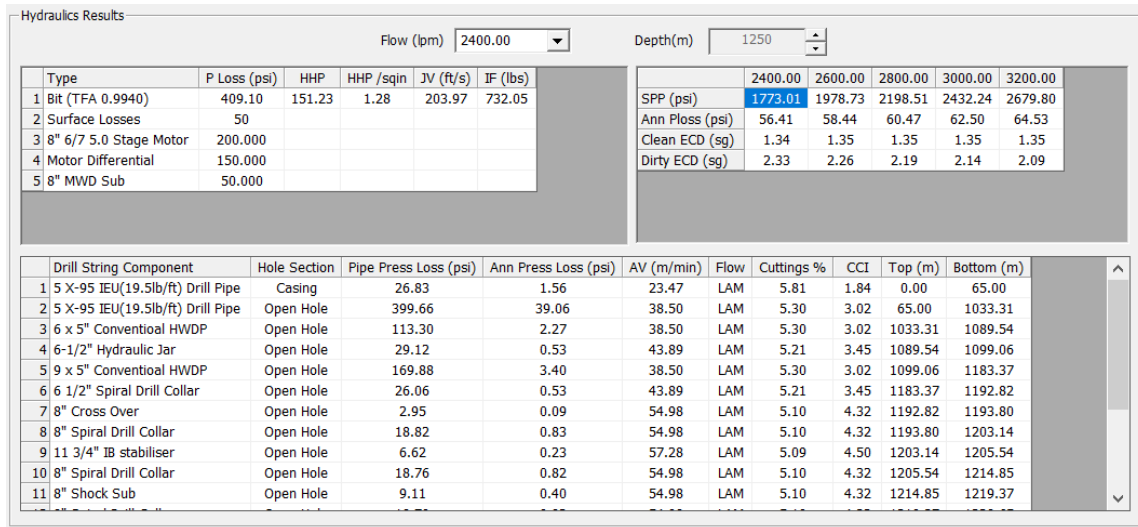


Figure 111: Hydraulics results section

This section displays the results from the hydraulics module once the hydraulics have been calculated. The grid in the top left displays the pressure loss for the bit and any other pressure losses from specific tools in the drill string such as MWD and motors. The grid at the top right displays a summary of the stand pipe pressures, annular pressure loss and ECD's for all the flow rates selected.

The bottom grid gives an overview of the pressure losses and flow regime in each pipe section and each hole section. The results for different flow rates can be viewed by selecting them from the "Flow" combo box at the top of the section. The overview grid results can be viewed for different depths by clicking on the spin button to the right of the flow combo box.

8.7 – Torque and Drag Results

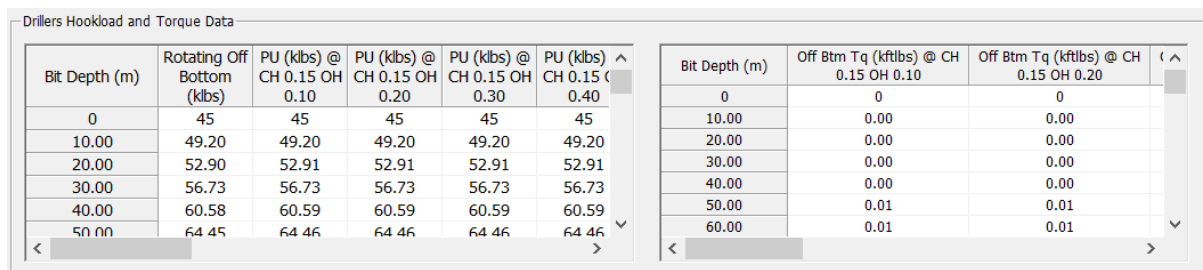


Figure 112: Torque and drag results section

A summary of the torque and drag results are displayed in the grids once the torque and drag has been calculated. Only hook loads and torques are displayed. Full results can be obtained by viewing the data tables from the TAD results menu.

9.0 – Drilling Data Tab

Drill String, Well Geometry and Fluids | Surveys | Engineering Parameters | Drilling Data | Cementing

	MD (m)	WOB (kba)	Flow Rate (gpm)	RPM	On Btm Tq (kftlbs)	Off Btm Tq (kftlbs)	On Btm Pressure (psi)	Off Btm Pressure (psi)	ECD (ppg)	MW (ppg)	PV	YP	600	300	200	100	6	3	ROP (in/hr)	Pumps On PU Wt (kba)
1																				

<

Insert Before

Insert After

Delete

>

Figure 113: Drilling Data Tab

Drilling parameters collected from the well site can be entered into this grid. These values can be used when running the calculations by selecting **“Include Drilling Data in Calculation”** from the Options menu.

Columns not in use can be hidden via the options menu and data entered can also be overlaid with modelled data by clicking on add additional series button while viewing the relevant chart.

10.0 – Cementing Tab

The screenshot displays the 'Volumes' section of the software. It includes several tables and input fields:

- Capacities & Displacements Table:**

Description	Capacity bbls/ft	Tot Capacity bbls	Displacement bbls/ft	Tot Displacement bbls	Ann. Cap. bbls/ft	Riser 18.750"	Casing 12.800"	Open Hole 12
1 9.625 Casing (47lb/ft)	0.0732	219.6000	0.0168	50.4000	0.2515	0.0692	0.0558	
2 5 S-135 IEU(19.5lb/ft) Drill Pipe	0.0169	33.8000	0.0094	18.8000	0.3151	0.1328	0.1194	
Totals		253.4000		69.2000				
- Annular Capacities Table:**

Description	Capacity bbls/ft	Tot Capacity bbls	Annular Volume bbls	String Capacity bbls	Steel Displacement bbls
1 Riser 18.750"	0.3415	683.0000	630.2805	33.8675	18.8955
2 Casing 12.800"	0.1592	238.8000	103.7488	109.8112	25.1810
3 Open Hole 12.250"	0.1458	218.7000	83.6728	109.8112	25.1810
Totals		1140.5000	817.7022	253.4899	69.2574
- Input Fields:**
 - String Depth (ft): 5000
 - Displacement Type: Open Ended
 - Flow Rate (gpm): 50
 - Pump Output (bbl/stk): 0.101
 - Stroke Rate (SPM): 11.79
 - Hydraulics Model: Bingham
- Time Table:**

	Time (min)	Strokes
Top down	212.93	2510.46
Bottoms Up	686.87	8098.20
Full Circulation	899.80	10608.66
- Cement Volumes Table:**

Description	Top (ft)	Bottom (ft)	Excess (%)	Volume (bbls)
1 Spacer	2000	2000	0	13.93
2 Lead Cement	2000	4800	0	63.27
3 Tail Cement	4800	5000	0	11.16
4				
- Pumping Schedule Table:**

Description	Vol. (bbls)	Strokes	Time (min)	Wt. (gpm)	Pump Rate (bbls/min)	600	300	200	100	6	3	PV
1 Spacer	13.93	136	1	8.000	10.000							15.000
2 Lead Cement	93.27	923	9	16.500	10.000							30.000
3 Tail Cement	15.65	154	1	16.000	10.000							30.000
4 Displacement Fluid	248.91	2464	24	9.5	10.000							20.000
- Cement Job Calculation Table:**

Description	OD (in)	ID (in)	Length (ft)	Cap. (bbls/ft)	Total Cap. (bbls)
1 3 1/2" String	3.5	2.5	200	0.086725	17.345
- Shoe Track Capacity (bbls):**
 - Shoe -> Float Dist (ft): 30
 - Shoe Track Capacity (bbls): 2.20
 - ☐ Cementing with inner string
 -

Figure 114: Cementing Tab

10.1 – Volumes

This section displays the various volumes, capacities and displacements of the drill string and the annulus.

The top of this section details the different capacities of the drill string components. These components are taken directly from the drill string entered in the drill string tab, and the capacities are automatically calculated based on the dimensions (OD & ID) associated with these components. The annular capacities are detailed for the components, based on each of the lines entered in the Well Geometry section of the drill string tab. **NOTE:** A String Depth **MUST** be entered for this section to display correctly.

The screenshot displays the 'Volumes' section of the software. It includes several tables and input fields:

- Capacities & Displacements Table:**

Description	Capacity bbls/ft	Tot Capacity bbls	Displacement bbls/ft	Tot Displacement bbls	Ann. Cap. bbls/ft	Riser 18.750"	Casing 12.800"	Open Hole 12
1 9.625 Casing (47lb/ft)	0.0732	219.6000	0.0168	50.4000	0.2515	0.0692	0.0558	
2 5 S-135 IEU(19.5lb/ft) Drill Pipe	0.0169	33.8000	0.0094	18.8000	0.3151	0.1328	0.1194	
Totals		253.4000		69.2000				
- Annular Capacities Table:**

Description	Capacity bbls/ft	Tot Capacity bbls	Annular Volume bbls	String Capacity bbls	Steel Displacement bbls
1 Riser 18.750"	0.3415	683.0000	630.2805	33.8675	18.8955
2 Casing 12.800"	0.1592	238.8000	103.7488	109.8112	25.1810
3 Open Hole 12.250"	0.1458	218.7000	83.6728	109.8112	25.1810
Totals		1140.5000	817.7022	253.4899	69.2574
- Input Fields:**
 - String Depth (ft): 5000
 - Displacement Type: Open Ended
 - Flow Rate (gpm): 50
 - Pump Output (bbl/stk): 0.101
 - Stroke Rate (SPM): 11.79
 - Hydraulics Model: Bingham
- Time Table:**

	Time (min)	Strokes
Top down	212.93	2510.46
Bottoms Up	686.87	8098.20
Full Circulation	899.80	10608.66

Figure 115: Volumes

The middle part of this section shows the various capacities, volumes and displacements for the well.
NOTE: A String Depth **MUST** be entered for this section to display correctly.

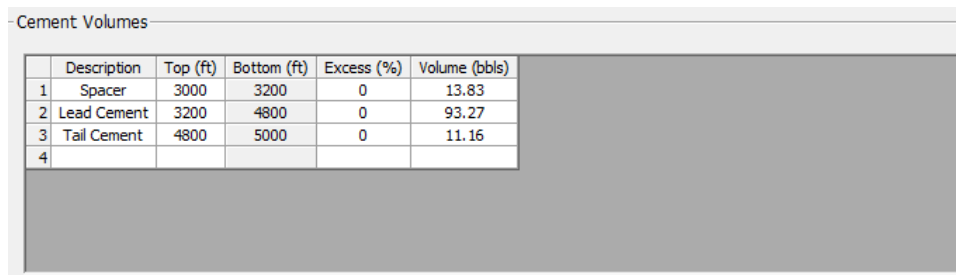
The lower part of this section is the most important as the inputs here affect the entire cementing calculations.

- **String Depth:** Depth of the string when performing the cement job. The calculation will not run without a value entered here.
- **Displacement Type:** Select **Open Ended** or **Close Ended**. This affects the Displacement and Total Displacement calculated values.
- **Flow Rate:** Flow rate of cement job. This is used to calculate the **Top Down, Bottoms Up** and **Full Circulation** values. This input is not required to run the cementing calculation, as the pump rate for this is entered in the pumping schedule section.
- **Pump Output:** Volume pumped per stroke. Pump efficiency should be factored into this input i.e. if the book output is 0.1bbl/stroke and the pump is 95% efficient, then output should be entered as 0.095bbl/stroke. This input is essential as it is required for calculating the number of strokes in the Pumping Schedule section.
- **Stroke Rate:** This cell auto calculates based on the values entered for flow rate and pump output.
- **Hydraulics Model:** Select from **Bingham, Power Law, Herschel Bulkley** or **Robertson Stiff**. This affects the calculated Annular Pressure, Pump Pressure and ECD values in the Cementing Results dialog.

10.2 - Cement Volumes

This section allows the user to quickly calculate the volumes required for the cementing operation.

Row 1 should contain the first fluid to be pumped and the user can enter the required top, and the bottom will be automatically populated. The top and bottom depths of the fluid represent where they will be in the Annulus at the end of the cementing operations. The user can then enter as many additional lines as required. It should be noted that the bottom depth of the fluid in the last row will always be equal to the **String Depth** value input in the Volumes section.



	Description	Top (ft)	Bottom (ft)	Excess (%)	Volume (bbls)
1	Spacer	3000	3200	0	13.83
2	Lead Cement	3200	4800	0	93.27
3	Tail Cement	4800	5000	0	11.16
4					

Figure 116: Cement Volumes

The user can also enter the desired excess and the volume column will update automatically to reflect this excess percentage.

10.3 - Pumping Schedule

Once the Cement Volumes and Cement Job Calculation sections have been input, the user can select **Create**, which will populate the Pumping Schedule table, with the description and calculated volumes from the Cement Volumes section. Note that this also takes into account the data input in the **Cement Job Calculation** section. It is also possible to complete this section manually.

If the **Include Spacer** box is checked and then **Create** is selected, row one of the table will be created for a spacer, but the volume cell will need to be populated manually by the user. If the user has included a spacer in the cement volumes section, then the include spacer box should not be checked.

The **Use Rheometer Readings** check box toggles the Pumping Schedule table between PV, YP and 600 – 3 rpm dial reading inputs.

The user should fill in the Description, Volume, Wt, Pump Rate, and rheology values for each row. These inputs affect the calculated Annular Pressure, Pump Pressure and ECD values in the Cementing Results dialog.

Pumping Schedule

	Description	Vol. (bbls)	Strokes	Time (min)	Wt. (ppg)	Pump Rate (bbls/min)	600	300	200	100	6	3	PV
1	Spacer	13.83	136	1	8.000	10.000							15.000
2	Lead Cement	93.27	923	9	16.500	10.000							30.000
3	Tail Cement	15.65	154	1	16.000	10.000							30.000
4	Displacement Fluid	248.91	2464	24	9.5	10.000							20.000

< >

Create ☐ Include Spacer ☒ Use Rheometer Readings

Figure 117: Pumping Schedule

10.4 - Cement Job Calculation

For conventional cement jobs the user should enter the **Shoe – Float Distance**. The shoe track capacity will be automatically calculated.

If cementing with a stinger, the user should check the **Cementing with inner string** box and enter the **Description, OD, ID and Length** of the stinger string. The capacity and total capacity of the inner string will be automatically calculated.

Cement Job Calculation

	Description	OD (in)	ID (in)	Length (ft)	Cap. (bbls/ft)	Total Cap. (bbls)
1	3 1/2" Stinger	3.5	2.5	3180	0.0060715	19.30736

Shoe -> Float Dist (ft) Shoe Track Capacity (bbls)

30 2.20 ☐ Cementing with inner string **Calculate**

Figure 118: Cement Job Calculation

Once the cementing tab has been completed, selecting Calculate, opens the **Cementing Results** Dialog.

10.5 – Cementing Results

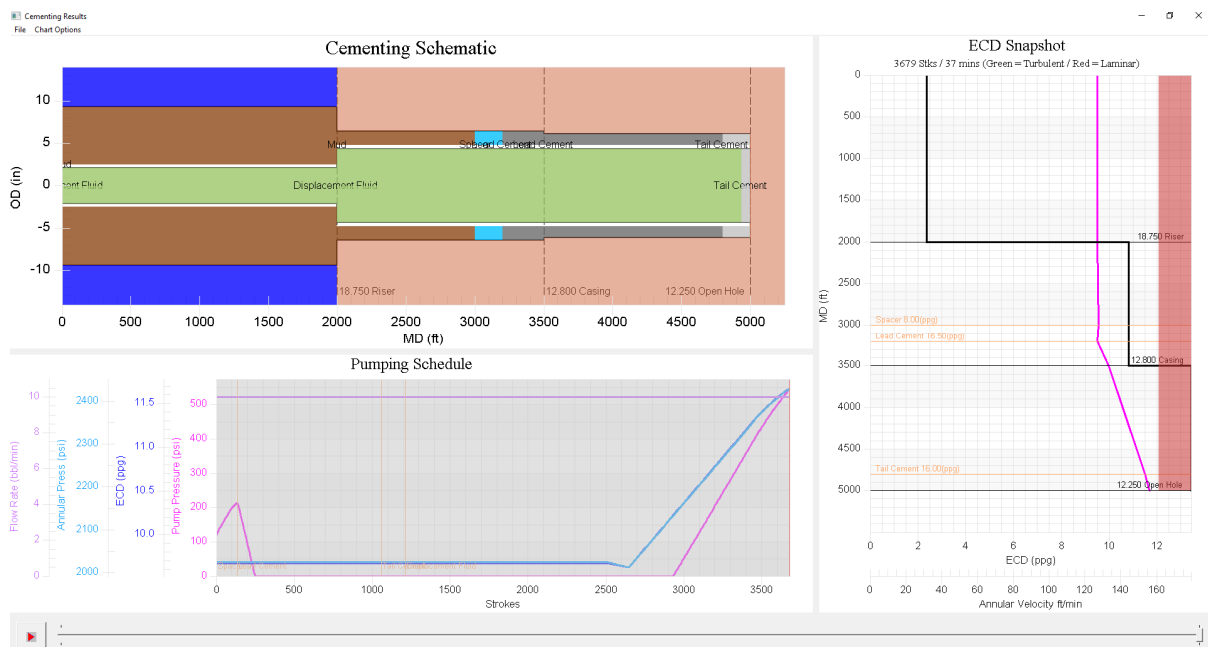


Figure 119: Cementing Results Dialog

The Cementing Results dialog displays all the information and results relevant to the cementing module. By utilising the scroll bar at the bottom of the dialog the user can view the three charts at different stages of the cement job.

10.5.1 – Cementing Schematic

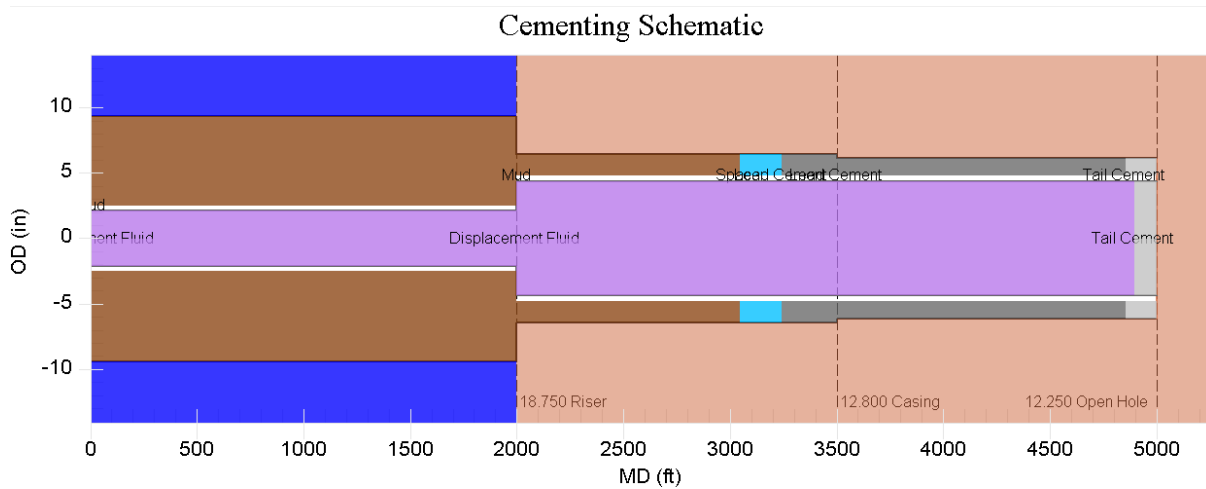


Figure 120: Cementing Schematic

This is a visual representation of the well geometry, string and fluids at a given stage in the cement job, dictated by the position selected on the scroll bar. The values used to generate this schematic (MD, Component OD & ID's and well geometry OD & ID's) are taken from the values entered in the **Drill String, Well Geometry and Fluids Tab**. The fluid labels can be toggled on or off by selecting **Chart Options** and checking or unchecking **Show Schematic Fluid Labels**.

- Changes in well geometry are marked by a label and dashed line.
- Areas out with the fluid flow path are white.
- Sea water is dark blue
- Drilling mud is brown.
- Spacer is light blue.
- Lead cement is dark grey.
- Tail cement is light grey.
- Displacement fluid is a variable colour.

10.5.2 – Pumping Schedule

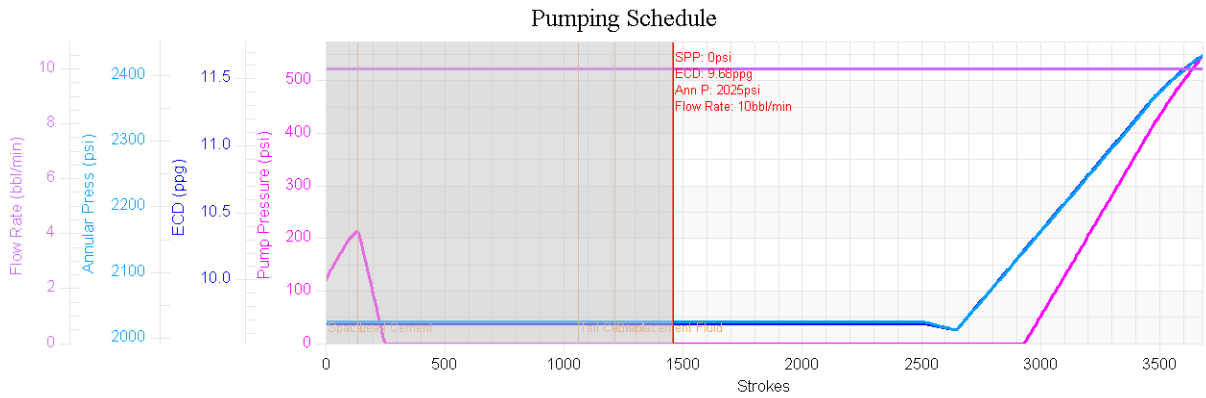


Figure 121: Pumping Schedule Chart

The Pumping Schedule chart depicts:

- The annular pressure at the string depth entered in the volumes section
- The equivalent circulating density (ECD) at the string depth entered in the volumes section
- The pump pressure at surface at a given stage in the cement job
- The Flow Rate

All the above outputs are dictated by the position selected on the scroll bar.

The X-axis can be toggled to display either Elapsed Time or Strokes by selecting **Chart Options** and checking or unchecking **X Axis – Strokes**.

10.5.3 – Cementing Results Dialog Scroll Bar

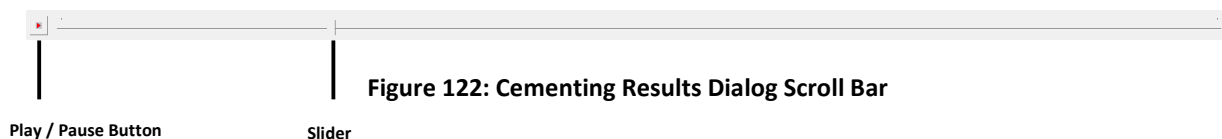


Figure 122: Cementing Results Dialog Scroll Bar

The position of the slider on the scroll bar dictates the stage of the cement job depicted on the Cementing Schematic, Pumping Schedule and ECD Snapshot. The user can click the play button for the slider to commence movement at a specific speed. This speed can be adjusted using the + and – keys to speed up and slow down the slider progression respectively. The user can then select the pause button to stop the slider at any point. The slider can also be manually dragged to any point in the scroll bar by the user.

10.5.4 – ECD Snapshot

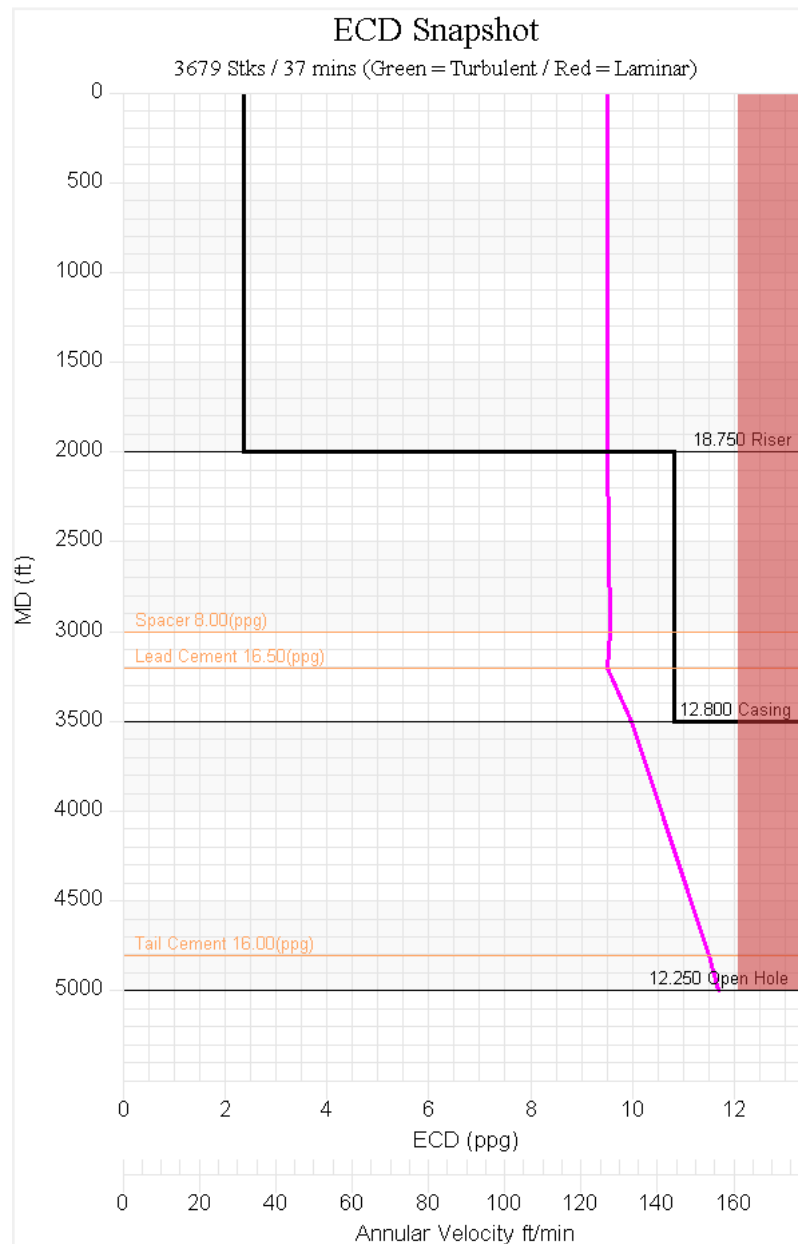


Figure 123: Cementing ECD Snapshot Chart

The ECD Snapshot chart depicts the equivalent circulating density and the annular velocity, across all depths from surface to the string depth, at a given stage in the cement job, dictated by the position selected on the scroll bar.

The right-hand side of the chart shows the flow regime across all depths from surface to the string depth, at a given stage in the cement job, dictated by the position selected on the scroll bar. Red is Laminar Flow and Green is Turbulent.

Additionally, markers display the respective depths of the top of the various fluids in the annulus and any changes in the well geometry.

10.5.5 – Cementing File Menu

Within the Cementing Results dialog, the user can output the following via the **file** menu:

- PDF Cementing Report
- Excel Cementing Report
- Export Data

10.5.5.1 - PDF Cementing Report

File > Print PDF Report. This generates a report which can be saved to pdf format.

Cementing Report

Innova Engineering - Cementing Report															
Project: Innova Cementing Riser					Description: 13 3/8" Casing Run										
Casing String															
#	Description	OD (in)	ID (in)	I/D (in)	Weight (lb/ft)	Length (ft)	Total Length (ft)								
1	8.625 Casing (4750/ft)	8.625	8.381	8.625	8.881	47	3000.000	3000.00							
2	8.5-135 (IDU)(19.5lb/ft) Drill Pipe	8	4.375	6.625	3.5	22.81	2000.000	5000.00							
Casing String Volumes															
		Capacities & Displacements					Ann. Cap. bbls/ft								
		Capacity	Tot. Capacity	Displacement	Tot. Displacement		Riser 18.750"	Casing 12.800"	Open Hole 12.250"						
		(bbl/ft)	(bbl)	(bbl/ft)	(bbl)										
1	8.625 Casing (4750/ft)	0.0732	219.8008	0.0148	50.4008		0.2818	0.0882	0.0008						
2	8.5-135 (IDU)(19.5lb/ft) Drill Pipe	0.0168	33.8000	0.0094	19.8000		0.3101	0.1328	0.1194						
Totals			253.6008		69.2008										
Well Geometry															
#	Type	MD (ft)	TVL (ft)	OD (in)	ID (in)										
1	Riser	2000.00	1923.840	20.000	18.750										
2	Casing	3500.00	3154.808	13.375	12.800										
3	Open Hole	5000.00	4099.118	12.250	12.250										
Well Volumes															
#	Description	Capacity bbls/ft	Tot Capacity bbls	Annular Volume bbls	String Capacity bbls	Steel Displacement bbls									
1	Riser 18.750"	0.5415	983.0000	630.2805	23.8875	16.8885									
2	Casing 12.800"	0.1982	256.8000	103.7488	108.8112	25.1810									
3	Open Hole 12.250"	0.1480	219.7000	87.6725	108.8112	25.1810									
Totals			1145.5000	817.7022	205.4999	68.2504									
Cementing Parameters															
Cap. Depth	Displacement	Circ Flow Rate	Pump Output	Circ Sbk Rate	Hyd. Model	Float Depth	Shoe Track Cap.	Inner String							
5000	Open Ended	50	0.121	11.79	Singham	4875.00	2.30	Yes							
Circulation Times															
		Time (min)	Strokes												
Top down		212.35	2513.45												
Bottoms Up		486.07	5830.20												
Full Circulation		598.30	7095.66												
Cementing Volumes															
Description	Top (ft)	Bottom (ft)	Excess (%)	Volume (bbls)											
1 Spacer	3000	3200	0	13.83											
2 Lead Cement	3200	4000	0	83.27											
3 Tail Cement	4000	5000	0	11.16											
4															
Pumping Schedule															
Description	Vol. (bbls)	Strokes	Time (min)	Wt. (ppg)	Pump Rate (bbls/min)	000	300	200	100	0					
1 Spacer	13.83	136	1	6.300	10.000				15.000	15.000					
2 Lead Cement	83.27	823	9	16.500	10.000				30.000	15.000					
3 Tail Cement	11.16	132	1	16.000	10.000				30.000	15.000					
4 Displacement Fluid	30.18	296	3	9.5	10.000				30.000	10.000					
Inner String															
Description	OD (in)	ID (in)	Length (ft)	Cap. (bbls/ft)	Total Cap. (bbls)										
1 3 1/2" Stinger	3.5	2.5	4875.00	0.0060715	30.17534										
Well Schematic															
Cementing Schematic															

Figure 124: Cementing PDF Report Layout

The report includes all the relevant data used in the cementing calculation and the charts displayed within the Cementing Results dialog, as they appeared when the report was created.

10.5.5.2 - Excel Cementing Report

File > Print Excel Report. This generates a report which can be saved to excel format.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Project Innova Cementing Riser															
Description 13 3/8" Casing Run															
Casing String															
#	Description	OD (in)	ID (in)	TJ OD (in)	TJ ID (in)	Weight (lb/ft)	Length (ft)	Total Length (ft)							
1	9.625 Casing (47lb/ft)	9.625	8.661	9.625	8.661	47	3000	3000							
2	5.5-135 EU(19.5lb/ft) Drill Pipe	5	4.276	6.625	3.5	22.61	2000	5000							
Casing String Volumes															
Description	Capacity (bbl/ft)	Capacities & Displacements		Displacement (bbl/ft)	Tot. Displacement (bbl)	Ann. Cap. bbls/ft Riser 18.750"	Casing 12.800"	Open Hole 12.250"							
1	9.625 Casing (47lb/ft)	0.0732		0.0188	50.4	0.2515	0.0092	0.0558							
2	5.5-135 EU(19.5lb/ft) Drill Pipe	0.0109		0.0094	18.8	0.3151	0.1328	0.1194							
Totals			253.4		69.2										
Well Geometry															
#	Type	MD (ft)	TVD (ft)	OD (in)	ID (in)										
1	Riser	2000	1923.643	20	18.75										
2	Casing	3000	3144.939	18.875	12.8										
3	Open Hole	5000	4099.118	12.25	12.25										
Well Volumes															
#	Description	Capacity bbls/ft	Tot Capacity bbls	Annular Volume bbls	String Capacity bbls	Steel Displacement bbls									
1	Riser 18.750"	0.3415	683	630.2805	31.8675	18.8955									
2	Casing 12.800"	0.1592	238.8	103.7488	109.8112	25.181									
3	Open Hole 12.250"	0.1458	218.7	83.6728	109.8112	25.181									
Totals			1140.5	817.7022	253.4899	69.2574									
Cementing Parameters															
Csg. Depth (ft)	Displacement	Circ Flow Rate (gpm)	Pump Output (bbl/stk)	Circ Stk Rate (stk/min)	Hyd. Model	Float Depth (ft)	Shoe Track Cap. (bbl)	Inner String							
5000	Open Ended	50	0.101	11.79	Bingham	4970	2.2	Yes							
Circulation Times															
	Time (min)	Strokes													
Top down	212.93	2510.46													
Bottoms up	686.87	8098.2													
Full Circulation	899.8	10608.66													
Cementing Volumes															
Description	Top (ft)	Bottom (ft)	Excess (%)	Volume (bbls)											
1	Spacer	3000	0	13.83											
2	Lead Cement	3200	0	93.27											
3	Tail Cement	4800	0	30.18											
4			0	11.16											
Pumping Schedule															
Description	Vol. (bbls)	Strokes	Time (min)	Wt. (ppg)	Pump Rate (bbls/min)	600	300	200	100	6	3	PV	YP		
1	Spacer	13.83	136	1	8	10						15	15		
2	Lead Cement	93.27	923	9	16.5	10						30	15		
3	Tail Cement	30.18	132	1	16	10						30	15		
4	Displacement Fluid	30.18	298	3	9.5	10						20	10		
Inner String															
Description	OD (in)	ID (in)	Length (ft)	Cap. (bbls/ft)	Total Cap. (bbls)										
1	3 1/2" Stinger	3.5	2.5	4970	0.0000715	30.17534									
Cementing Report															
Well Schematic															
Pumping Schedule															
ECD Snapshot															

Figure 125: Cementing Excel Report Layout

The report includes all the relevant data used in the cementing calculation and the charts displayed within the Cementing Results dialog, as they appeared when the report was created. These charts are allocated their own sheet within the excel document.

10.5.5.3 – Export Data

This option allows the user to export the data used to generate the Pumping Schedule and ECD Snapshot Charts.

10.5.6 – Chart Options

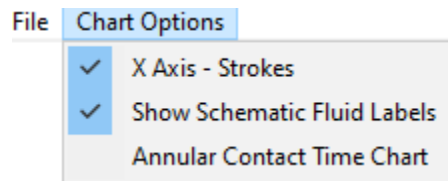


Figure 126: Cementing Chart Options Menu

X-Axis – Strokes – This option allows the user to switch between **Strokes** and **Elapsed Time** as the units for the X-axis of the Pumping Schedule Chart in the Cementing Results dialog.

Show Schematic Fluid Labels – This option allows the user to turn the fluid labels on and off in the Cementing Schematic section of the Cementing Results dialog.

Annular Contact Time Chart – This option opens the Annular Contact Time Chart. This chart shows the length of time any of the individual fluids in the pumping schedule are in contact with the annulus at any given depth.

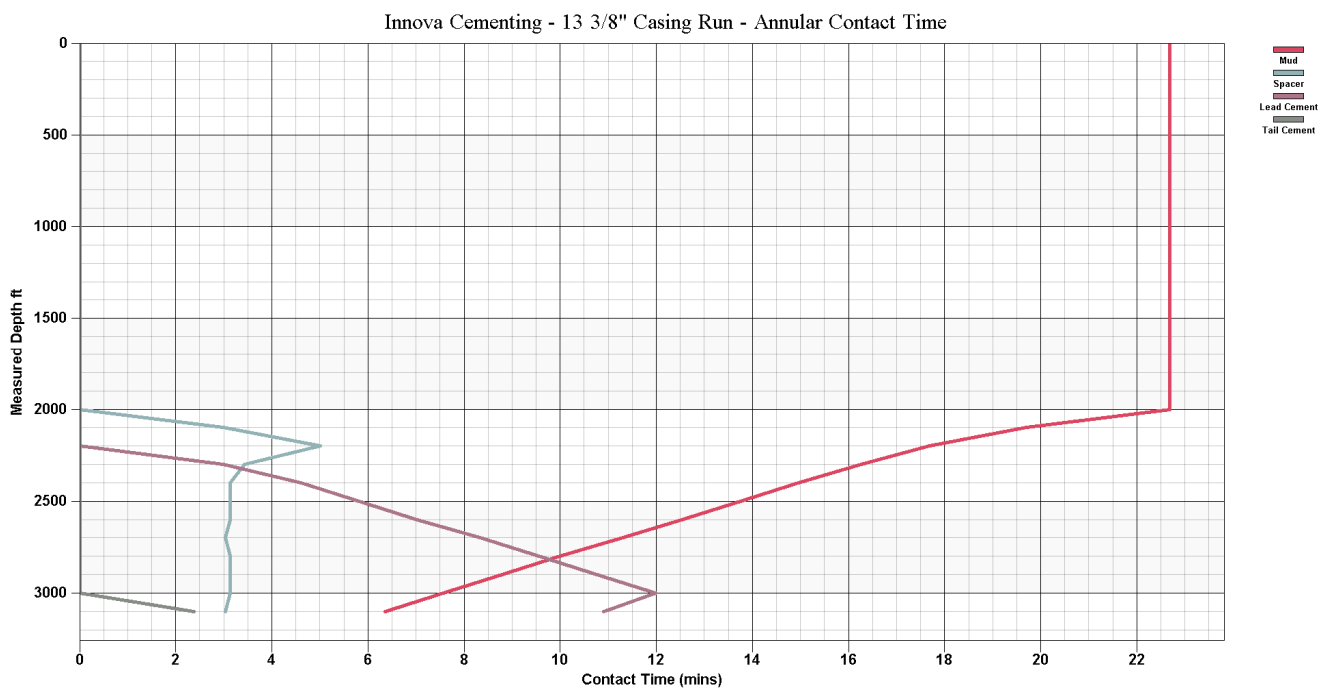


Figure 127: Annular Contact Time Chart

11.0 – Chart Results

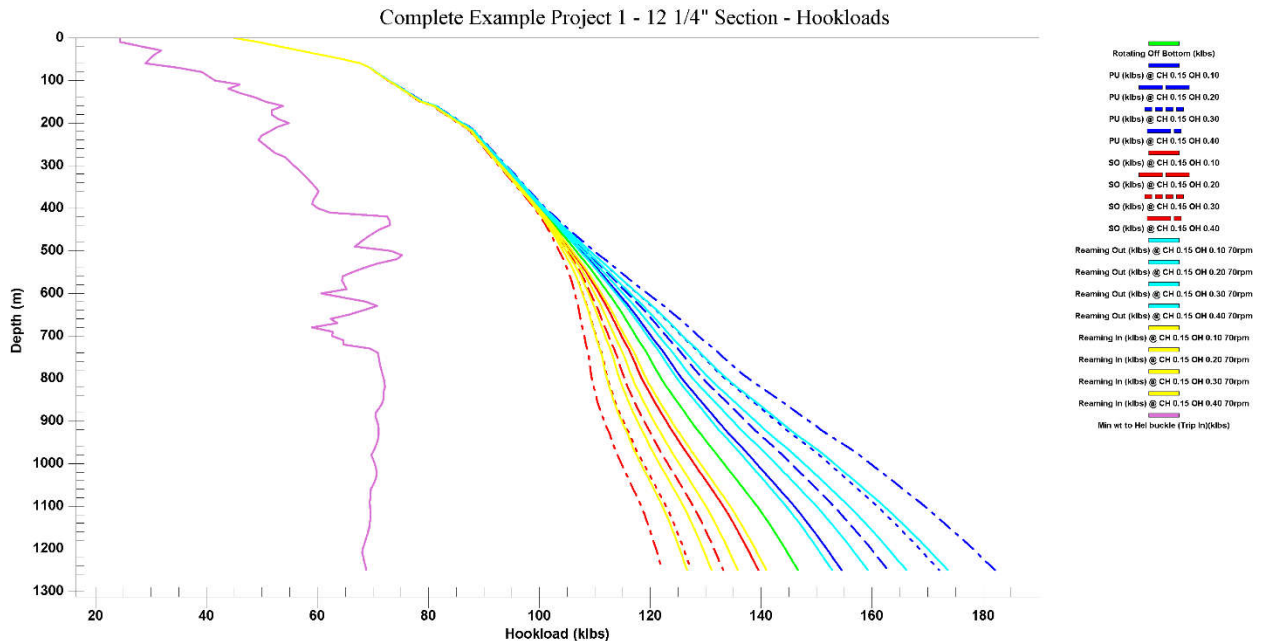


Figure 128: Chart results

Innova Engineering comes with a chart viewer which has the same user interface regardless of what type of chart is being viewed. The functions for the chart can be accessed from the context menu (by right clicking on the chart area), from the edit menu or by clicking on the relevant tool bar button.

The visual style of the chart is saved when the chart is closed.

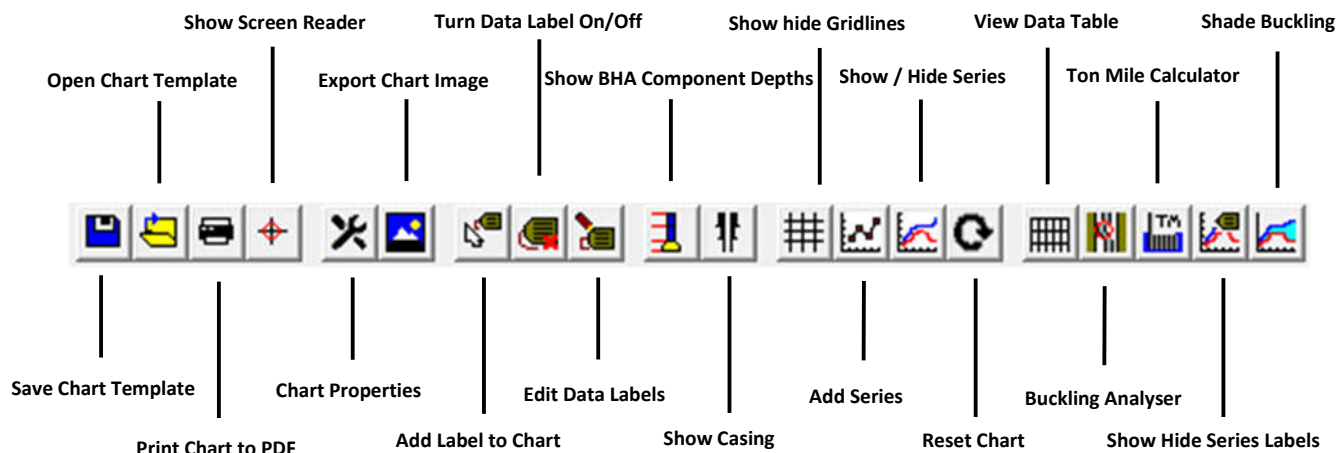


Figure 129: Chart toolbar

The chart functions are described below:

Save Template – Save the visual Style of the chart to a **.ctf** file which can be used as a template for charts in other projects.

Open Template – Open a **.ctf** file and load the charts visual style to that of the template.

PDF Chart – Print the chart to a PDF file with header and footer

Screen Reader – Displays the current chart co-ordinates of the mouse cursor in a small table at the top right of the chart

Screen Reader			
Pump Pressure (psi)	4744.57		
Depth (m)	2110.27		

Figure 130: Screen Reader

Chart Properties – Brings up the chart properties dialog which allows all aspects of the chart to be customized.

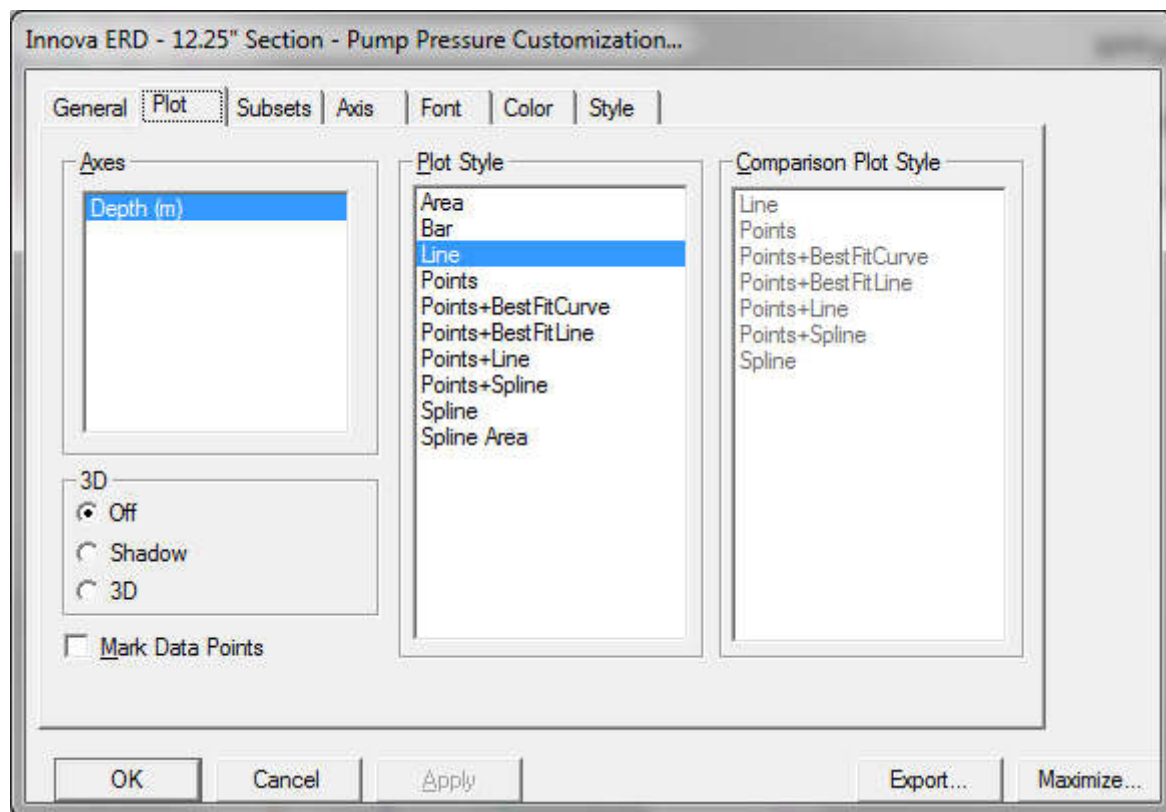


Figure 131: Chart customization dialog

Export Chart – Brings up a dialog which allows the user to export the chart to a file or the clip board.

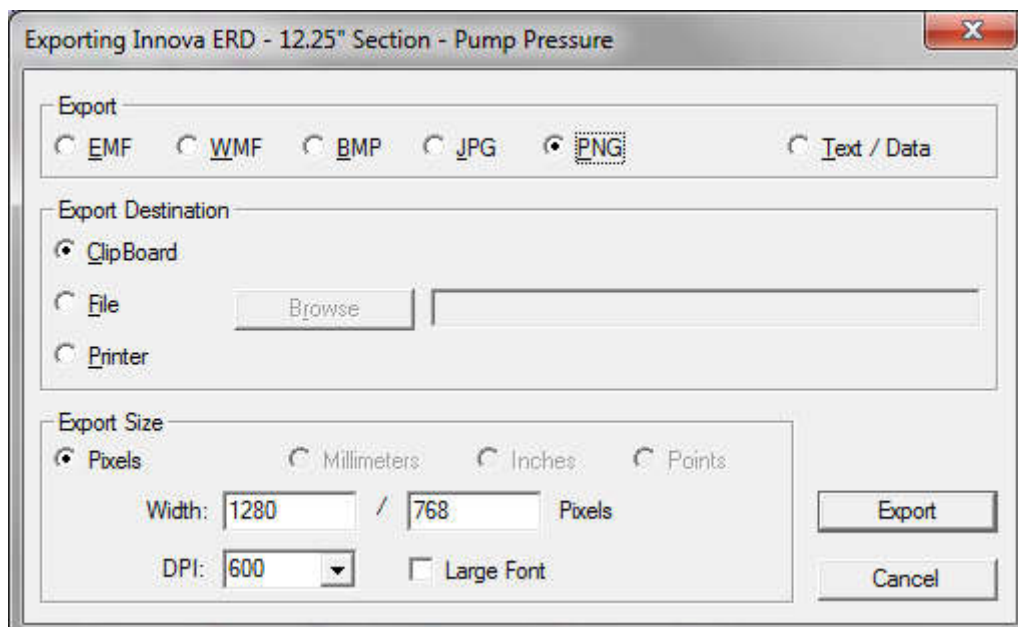


Figure 132: Export Dialog

Add Label to Chart – If this option is selected, when the chart area is clicked a label will be added at the cursor point. The text for the label should be entered in the dialog which appears.

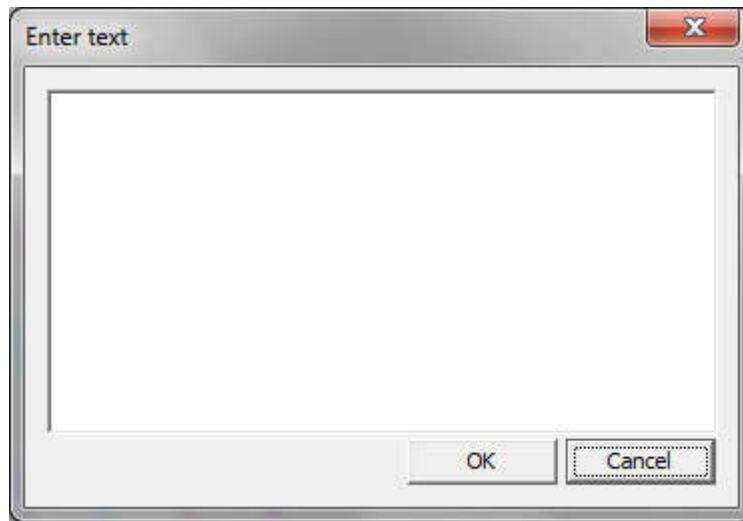


Figure 133: Add data label

Labels On / Off – Show / Hide data labels and tether lines on chart

Edit Data Labels – Brings up the edit data labels dialog, which allows the user to set the co-ordinates of the label as well as the text and the label style and size. If tether lines are enabled and a label is dragged a tether line will also be drawn. Both ends of the tether line can be moved as desired by dragging with the mouse. The colour of the labels can also be set using the colour picker.

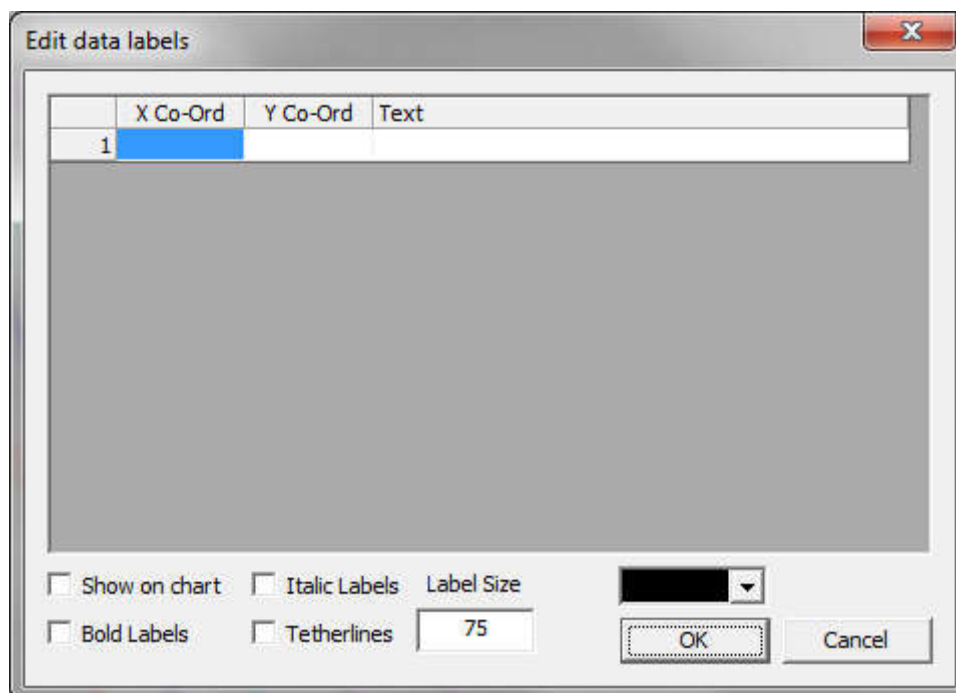


Figure 134: Label Properties

Display BHA: If a snapshot chart is selected this option allows the user to display the BHA on the chart.

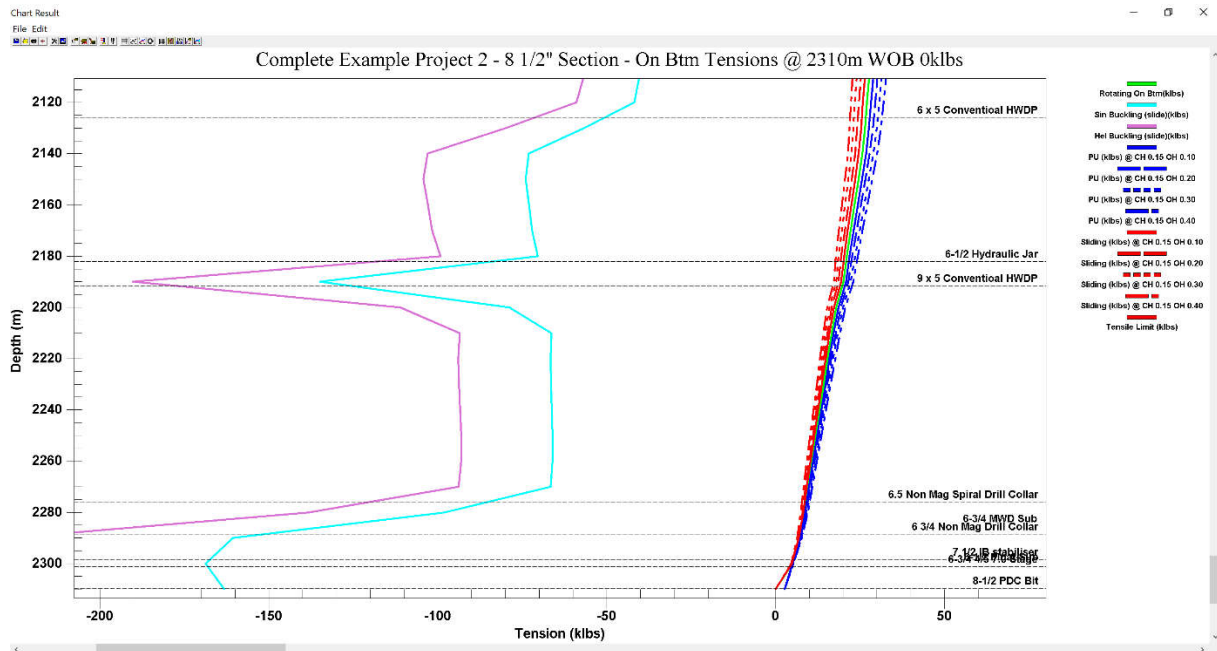
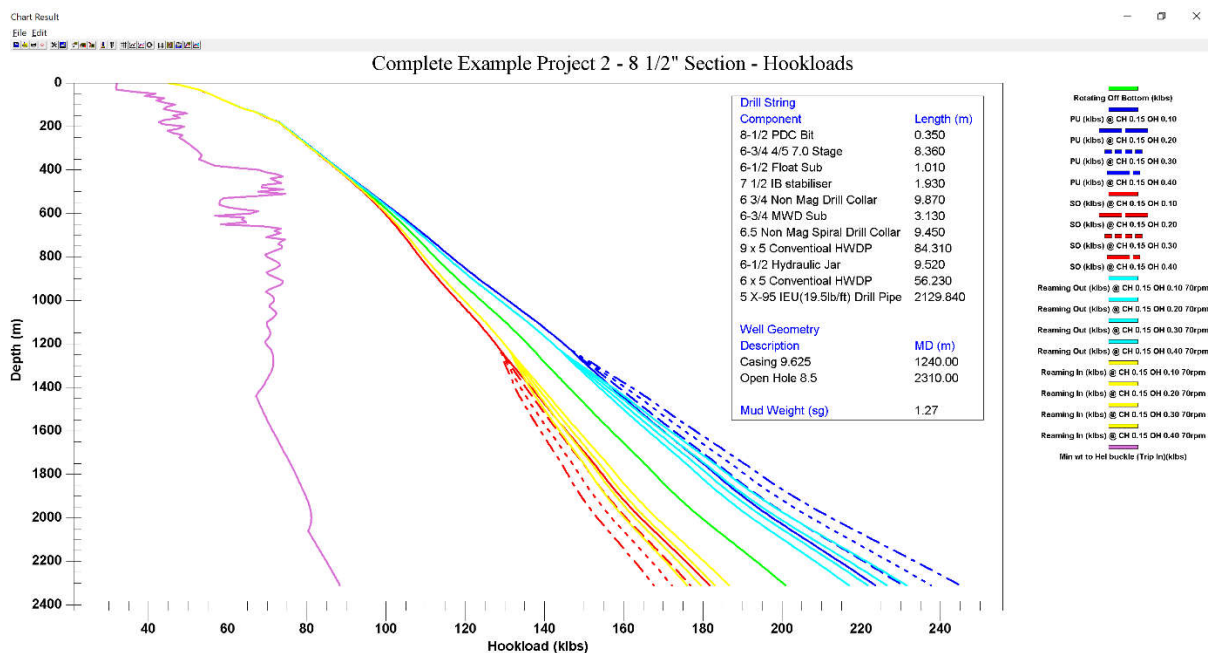


Figure 135: Show BHA on Snapshot Chart

If a drillers view is selected the BHA and hole geometry are displayed as a table



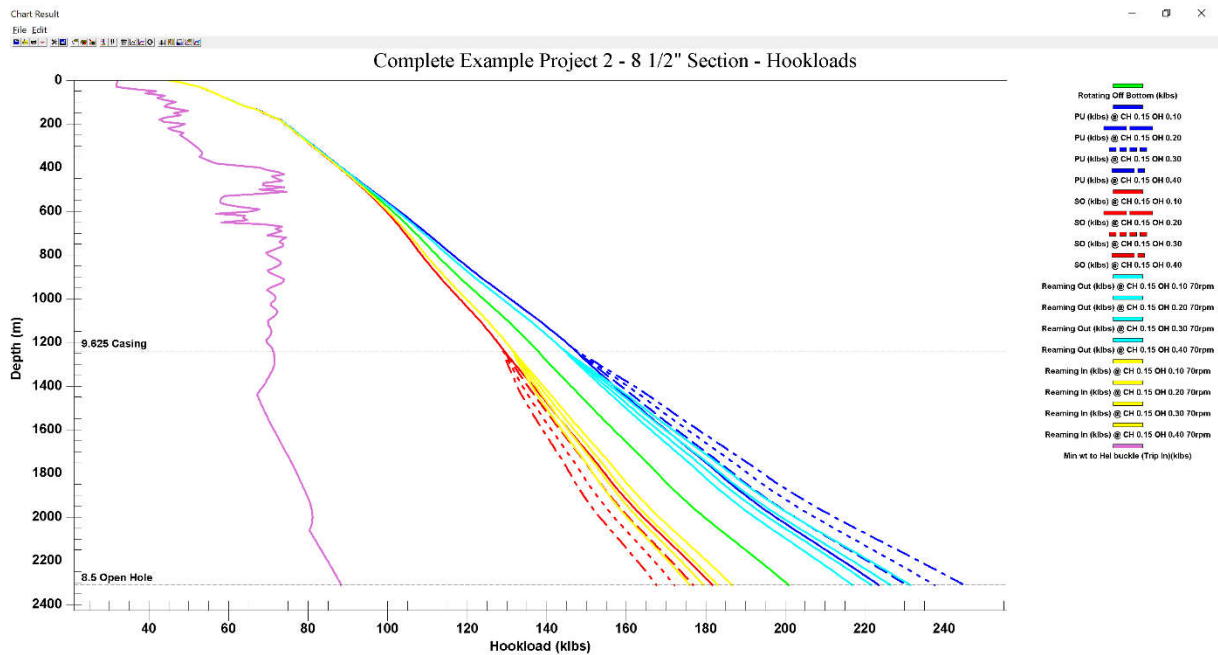


Figure 137: Show Casing on plots

Show Hide Gridlines: Turns Gridlines on and off on the plot.

Add additional series: Brings up the “add additional series” dialog. This is where the drilling data can be plotted as well as the pipe yield data, and pump liner limits.

Figure 138: Add additional series dialog

Click on the series which you wish to add and click on the arrow button to move it in to the displayed list box. Do the opposite to remove a series.

Show / Hide Series: Brings up a dialog which allows the user to define which chart series are currently visible.

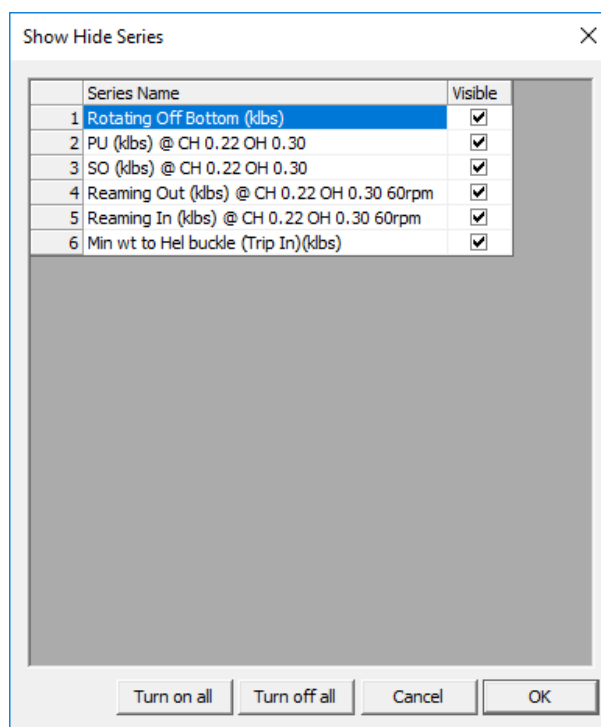


Figure 139: Series show / hide

Reset Chart: Returns the chart to its original state. This will remove all user defined formatting.

View Data Table: Brings up the data the chart is created with in a tabular format

Buckling Analyser: This option is only available when in the “*Tension On Bottom*” and “*Tension Off Bottom*” snapshot charts. This shows values for rotating on bottom and sliding (tension on bottom chart) and rotating off bottom and slacking off (tension off bottom chart).

Buckling Analyser							
	Rotating On Btm	Sliding @ CH 0.15 OH 0.10	Sliding @ CH 0.15 OH 0.20	Sliding @ CH 0.15 OH 0.30	Sliding @ CH 0.15 OH 0.40	Tensile Limit	
HEL Buckle Length (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SBN Buckle Length (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEL Index	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SBN Index	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Depth (m)	1250	1250	1250	1250	1250	1250	1250
WOB (klbs)	0	0	0	0	0	0	0

Figure 140: Buckling Analyser

- **Helical Buckling Length:** The cumulative amount of helical buckling in the string.
- **Sinusoidal Buckling Length:** The cumulative amount of sinusoidal buckling in the string.
- **HEL Index:** The Helical Index is a unitless value which represents the amount of Helical Buckling for any specific operation. The higher this value, the more helical buckling is present.
- **SIN Index:** The Sinusoidal Index is a unitless value which represents the amount of Sinusoidal Buckling for any specific operation. The higher this value, the more sinusoidal buckling is present.
- **Depth:** The bit depth for the snapshot calculation.
- **WOB:** The weight on bit used for the calculation.

Ton Mile Calculator: This option is only available when in the “*Drillers Hookloads Chart*”.

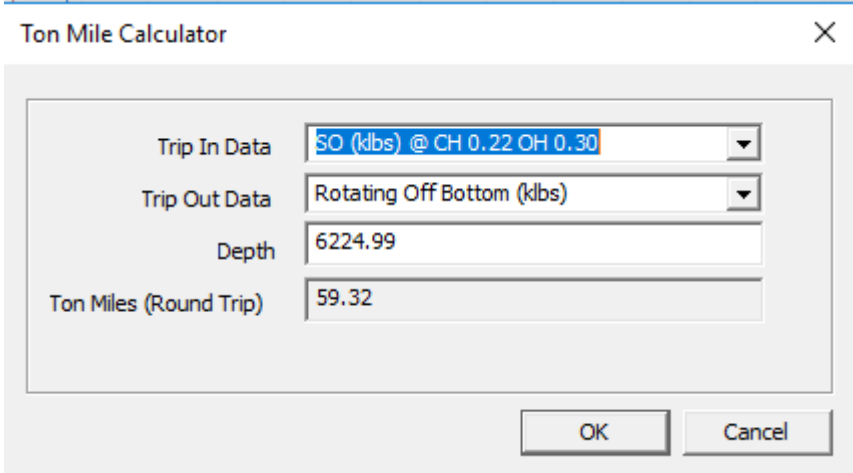


Figure 141: Ton Mile Calculator

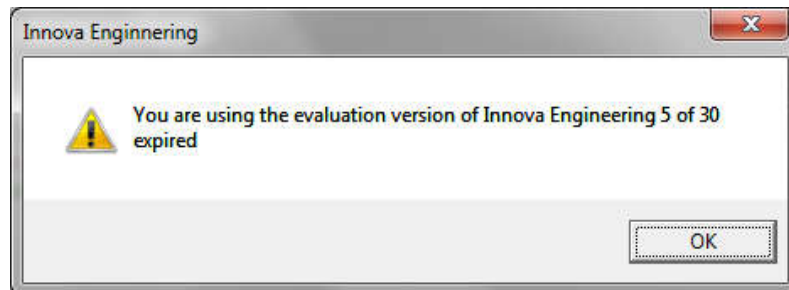
- **Trip In Data:** Option to choose from Rotating off Bottom, or any of the Slack of weights
- **Trip Out Data:** Option to choose from Rotating off Bottom, or any of the pick-up weights
- **Depth:** The depth at which the calculation is run.
- **Ton Miles (Round Trip):** The calculated Ton Miles to get from Surface to the selected depth, and then back to surface again.

Show Hide Series Labels: This option toggles the series labels on and off, the default being off.

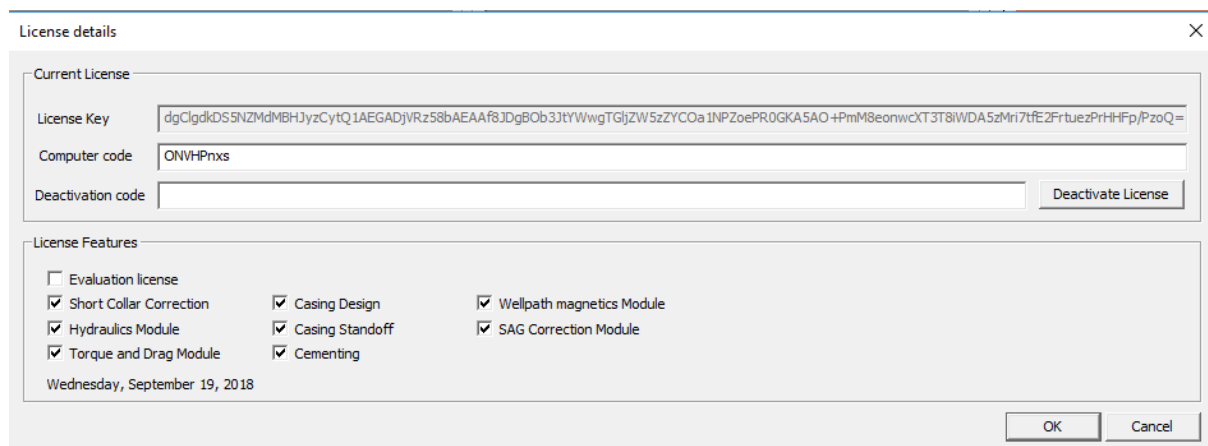
Shade Buckling: Will apply a block of colour to fill the graph to the left of the buckling lines.

Appendix A – Software Licensing

Innova Engineering is by default shipped with a 2-day trial license, which enables all software features. If using a trial copy, each time Innova Engineering is run, the following dialog will be displayed detailing how many days are remaining on the trial period.



After this period has expired a full license must be purchased. Each software license is issued for a specific PC and to do this a computer code must be provided to Innova, so the license can be issued. If your trial period has not expired open Innova engineering and click on the **help menu-> License info** option to display the license info dialog.



If your trial copy of Innova engineering has expired or your license is invalid, the computer code will be displayed the next time you attempt to open the program. The code can be copied to the clipboard by highlighting the code and pressing Ctrl + C. This can then be pasted in to a text document or email.

Send the computer code to sales@innova-drilling.com and you will receive your license in the form of a **ENG_LICENSE.txt** file. Place this file in the same directory as InnovaEngineering.exe. usually **C:\Program Files (x86)\Innova Drilling & Intervention\Innova Engineering**. And run the software. To check to see which features of Innova engineering are currently enabled open the license info dialog from the help menu and see which check boxes are checked. If you have a paid license, the expiry date will be displayed at the bottom left of the screen.

License Deactivation

If you wish to deactivate a license (to move it to another machine), click on the deactivate license button in the license info dialog. Note the deactivation code and send a copy along with the computer code of the new PC to sales@inova-drilling.com. Once the deactivation code has been verified a license for the new machine will be issued.

Appendix B – Nomenclature

MD	Measured Depth
TVD	True Vertical Depth
INC	Inclination
AZI	Azimuth
TD	Total Depth
OD	Outside Diameter
ID	Inside Diameter
TJ	Tool Joint
HWDP	Heavy Weight Drill Pipe
DP	Drill Pipe
OH	Open Hole
CH	Cased Hole
BHP	Bottom Hole Pressure
P/U	Pick Up
S/O	Slack Off
ROB	Rotating On Bottom
FF	Friction Factor

Appendix C – Axial and Cross Axial Magnetic Correction

Axial correction or Short Collar Correction (SCC) is used with magnetic survey tools when there is insufficient non-magnetic material above or below the sensor. A magnetic survey tool has magnetometers measuring the Earth's magnetic field in three axes, X, Y and Z. The Z axis is assumed to be aligned in the along hole direction of the drill string. The sensor must be surrounded by non-magnetic material which shields the X and Y magnetometers from magnetic interference. In normal drilling operations usually enough non-magnetic material above and below the sensor is incorporated to magnetically isolate it from the steel components within the drill string.

This however is not always possible, resulting in magnetic interference in the Z axis magnetometer. This can be corrected by using a mathematical algorithm. This algorithm assumes that the value for the X and Y axis magnetometers are correct and using values for dip angle and HL for the surface location, the Z axis magnetometer can be corrected. There are, however limits to when this correction can be used, and these are listed below.

Inclination Range (Deg)	Azimuth Range (Deg)	Limitations
0-60	0-360	No Limitations
60-90	0-60, 120-240, 300-360	No Limitations
60-90	60-70, 110-120, 240-250, 290-300	See Note (1)
60-90	70-110, 250-290	See Note (2)

- **Note 1** – If **possible, SCC should NOT be used** and the BHA should be correctly spaced with non-magnetic tubulars as required.
- **Note 2** – **SCC must NOT be used if the well path is known to be within these parameters.** Again, the BHA should be correctly spaced with non-magnetic tubulars as required.
- If the above parameters are encountered, then the SCC algorithm will not function correctly and erratic corrected data will be seen. It is therefore necessary to discuss beforehand with the Directional Driller / Company Representative as to an agreeable plan of action if the above criteria are expected to be encountered during drilling.

Appendix D – Pole Strengths

Component	Size	Pole Strength (mWb)	Component	Size	Pole Strength (mWb)
Motor	3 1/8"	250	Drill Collar	6 3/4"	610
Motor	3 3/4"	290	Drill Collar	7 1/2"	670
Motor	4 3/4"	320	Drill Collar	8	740
Motor	6 3/4"	415	Drill Collar	9 1/2"	850
Motor	8"	480	Sub	3 1/8"	290
Motor	9 1/2"	590	Sub	3 3/4"	320
Motor	11 1/4"	620	Sub	4 3/4"	380
Stabilizer	5"	320	Sub	6 3/4"	415
Stabilizer	6"	340	Sub	8"	480
Stabilizer	10"	400	Sub	9 1/2"	590
Stabilizer	12 1/4"	500	Sub	11 1/4"	620
Stabilizer	15"	680	Drill Pipe	3"	300
Stabilizer	16"	700	Drill Pipe	3 1/2"	350
Stabilizer	17 1/2"	700	Drill Pipe	4"	400
Stabilizer	20"	780	Drill Pipe	5"	450
Stabilizer	25"	800	Drill Pipe	6"	500
Stabilizer	26"	800	Turbine	-	900
Stabilizer	26"	900	Jar	-	450
Stabilizer	42"	1000	Accelerator		450
Drill Collar	4 3/4"	450			

Appendix E – Component Details

In the Drill String, Well Geometry and Fluids Tab, when a component is selected from the dropdown menu the user can assign various component details. The type of component that is selected will determine the properties displayed in the lower components grid. The following is a list of the components and a description of their properties which can be viewed in the **Component Details** box at the bottom of the tab.

E1 - Bit

- **SN:** Serial number plays no part in any calculations
- **Gauge OD:** Gauge OD plays no part in any calculations.
- **TFA:** Click on the cell to bring up the jets dialog. The details of the bit jets and / or the TFA can be entered by typing in the jet details in to the grid or the fixed TFA in to the edit box.

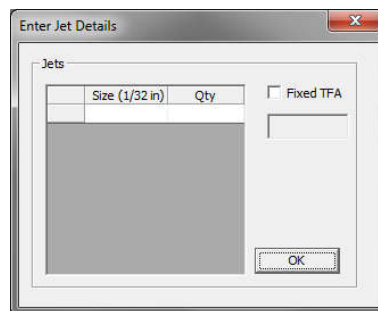


Figure 143: Jet details

- **Connection top:** plays no part in any calculation
- **Bit Formation Index (0-1):** Models the tendency of the bit to walk. 0 will model no walk, while 1 models a very aggressive bit with high walk tendencies. Used in BHA analysis calculations. For tri-cone bits, a BFI range of 0 to 0.3 is typical, while for more aggressive PDC bits 0.2 to 0.5 (or higher) can be modelled.
 - **Build Up Rate (BUR) = $DLS * \cos(BFI)$**
 - **Walk Rate (WR) = $DLS * \sin(BFI)$**
- **Bit Type:** Drop down menu (PDC or Tricone) - plays no part in any calculation
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected

Note: If a bit is selected it must always be the first component and cannot be moved from the first row.

E2 - Hole Opener / Under Reamer

- **Same properties as a bit** –see above

E3 - Circ Sub

- **Same properties as Bit**, excluding the Bit Formation Index and Bit Type – see above.

E4 - Cross Over (X/O)

- **SN:** Serial Number plays no part in any calculation
- **Connection Top:** Plays no part in any calculation
- **Connection Bottom:** Plays no part in any calculation
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected

E5 - RSS – Rotary Steerable system

- **SN:** Serial number plays no part in any calculation
- **Stab OD:** if the tool has a stabiliser enter its OD, used for SAG calculations and hydraulics
- **Stab blade length (in):** if the tool has a stabiliser enter its blade length in inches, used for SAG calculations and hydraulics
- **Stab distance from bottom:** If the tool has a stabiliser enter the distance from the bottom of the tool to the start of the stabiliser blade section. Enter in the depth units selected from the units menu. Used for SAG calculations
- **Connection top:** not used in any calculation
- **Connection bottom:** not used in any calculation
- **Pressure drop:** enter the pressure drop across the tool if any, used in hydraulics and T&D calculations
- **Stab blade width:** If the tool has a stabiliser enter its blade width in inches, used for hydraulics calculations
- **No of Blades:** The number of blades on the stabiliser. Not used in any calculation
- **Max Dogleg Capability:** The theoretical maximum dls capability of the tool. This is used in the BHA analysis BUR calculation.

- **Deflection / Force Setting:** This is used in the BHA analysis BUR calculation. This will give an effective BUR based on the max dogleg capability entered above.
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected

E6 - MWD / LWD

- Same properties as **RSS**, excluding the max dogleg capability and deflection / force setting.

E7 - Motor

- **SN:** Serial number plays no part in any calculation
- **Stab OD:** if the tool has a stabiliser enter its OD, used for SAG calculations and hydraulics
- **Stab blade length (in):** if the tool has a stabiliser enter its blade length in inches, used for SAG calculations and hydraulics
- **Stab distance from bottom:** If the tool has a stabiliser enter the distance from the bottom of the tool to the start of the stabiliser blade section. Enter in the depth units selected from the units menu. Used for SAG calculations
- **Connection top:** not used in any calculation
- **Connection bottom:** not used in any calculation
- **Pressure drop:** enter the pressure drop across the tool if any, used in hydraulics and T&D calculations
- **Stab blade width:** If the tool has a stabiliser enter its blade width in inches, used for hydraulics calculations
- **No of Blades:** The number of blades on the stabiliser. Not used in any calculation
- **Bend Angle:** The bend setting on the motor. Used to calculate the theoretical maximum dls capability of the tool. This is used in the BHA analysis BUR calculation.
- **Bit to Bend:** This is used in the BHA analysis BUR calculation. This will give an effective BUR based on the bend angle entered above.
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected

- **Differential Pressure:** The expected differential pressure to be run across the motor. Used in hydraulics and T&D calculations.

E8 - Turbine

- Same properties as **Motor**, excluding the differential pressure

E9 - Stabiliser

- **SN:** Serial number plays no part in any calculation
- **Stab OD:** OD of the stabiliser blades, used for SAG calculations and hydraulics
- **Stab blade length (in):** Blade length in inches, used for SAG calculations and hydraulics
- **Stab distance from bottom:** Distance from the bottom of the tool to the start of the stabiliser blade section. Enter in the depth units selected from the units menu. Used for SAG calculations
- **Connection top:** not used in any calculation
- **Connection bottom:** not used in any calculation
- **Stab Blade Width:** Blade width in inches, used for hydraulics calculations
- **No of Blades:** The number of blades on the stabiliser. Not used in any calculation
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected

E10 - Drill Collar

- Same properties as a **X/O**

E11 - Drill Pipe / HWDP

- **Connection top:** not used in any calculation
- **Connection bottom:** not used in any calculation
- **Friction reduction Sub %:** If friction reduction subs are run in this interval then enter the % reduction in torque and drag (from manufacturers spec). Note if torque reduction subs are only run over a set interval the drill pipe must be entered in separate sections and the section with the friction reduction subs specified.

- **Class:** Choose from the dropdown menu in the cell – New, Premium, Class 1 & Class 2 – This adjusts the wall thickness for T&D calculations and has an effect on hookloads and buckling calculations
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected
- **Burst:** The Burst pressure of the pipe in psi.
- **Collapse:** The collapse pressure of the pipe in psi.
- **Material:** Steel or Aluminium, chosen from a dropdown menu. This selection changes the Youngs Modulus of the pipe and effects buckling.
- **Internal Fluid Weight:** This is the weight of fluid inside the pipe, and is used for floating casing. If no value is entered the program assumes the pipe is filled with mud as per the fluid properties. If zero is entered, the program assumes there is NO fluid. If the fluid inside is a different weight from the mud weight in the fluid properties, enter the weight in ppg.
- **SN:** Serial number plays no part in any calculation

E12 - Jar

- **SN:** Serial Number plays no part in any calculation
- **Connection Top:** Plays no part in any calculation
- **Connection Bottom:** Plays no part in any calculation
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected
- **Latch Up:** The latch up setting for Mechanical or Hydro-mechanical Jars – Plays no part in any calculation
- **Latch Down:** The latch down setting for Mechanical or Hydro-mechanical Jars – Plays no part in any calculation
- **Impulse:** The change in momentum during the impact phase, measured by the area under the load versus time curve – Plays no part in any calculation
- **Pump Open Area:** Pump open Area of the jar. This is used in the pump open force calculations in the jar placement module.

- **Stroke Length:** Free Stroke Length of the jar. Used in the Impact and Impulse calculations in the jar placement module.
- **Make:** Jar make. Appears in the jar placement report.
- **Model:** Jar model. Appears in the jar placement report.

E13 - Accelerator

- **SN:** Serial Number plays no part in any calculation
- **Connection Top:** Plays no part in any calculation
- **Connection Bottom:** Plays no part in any calculation
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected
- **Stroke Length:** Free Stroke Length of the accelerator. Used in the Impact and Impulse calculations in the jar placement module.
- **Make:** Accelerator make. Appears in the jar placement report.
- **Model:** Accelerator model. Appears in the jar placement report.

E14 - Sub

- **SN:** Serial Number plays no part in any calculation
- **Has float:** YES / NO not used in any calculation
- **Connection Top:** Plays no part in any calculation
- **Connection Bottom:** Plays no part in any calculation
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected

E15 - Liner

- **Connection Top:** Plays no part in any calculation
- **Connection Bottom:** Plays no part in any calculation

- **Float TFA:** enter the TFA of the float or shoe, this is used for surge and swab calculations. Clicking on the cell brings up the jets dialog. This is used for hydraulics Calculations.
- **Centraliser Spacing:** number of centralisers over the interval – note if centralisers are only run across a certain interval then the liner should be entered as separate sections in the string. This is used for hydraulics, torque and drag and casing standoff calculations
- **Centraliser OD:** the OD of the centralisers, if bow spring type simply enter the ID of the hole. This is used for hydraulics, torque and drag and casing standoff calculations
- **Centraliser length:** the length of a centraliser blade which contacts the wellbore in inches. This is used for hydraulics Calculations.
- **Centraliser blade width:** width of 1 blade of the centraliser in inches. This is used for hydraulics Calculations.
- **Centraliser blade count:** number of blades on centraliser. This is used for hydraulics Calculations.
- **Internal Fluid Weight:** This is the weight of fluid inside the liner and is used for floating casing. If no value is entered the program assumes the pipe is filled with mud as per the fluid properties. If zero is entered, the program assumes there is NO fluid. If the fluid inside is a different weight from the mud weight in the fluid properties, enter the weight in ppg. This is used for T&D Calculations.
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected. Plays no part in any calculation
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected. Plays no part in any calculation
- **Burst:** The Burst pressure of the pipe in psi. Plays no part in any calculation
- **Collapse:** The collapse pressure of the pipe in psi. Plays no part in any calculation
- **Bowspring Restoring Force:** The Force exerted by a centralizer against the casing to keep it away from the wellbore wall. This input is used in the standoff calculation to determine how much the bow spring centralizer has deformed for a given side force. The centralizer will never compress more than the body OD. The higher the side force the more deformation of the centralizer. If nothing is entered for the restoring force it is assumed that the centralizer is rigid.
- **Centralizer Body OD:** The OD of the body of the centralizer. This is used for hydraulics Calculations.
- **Friction Reduction %:** % reduction in torque and drag (from manufacturers spec), based on the type of centralizer which is being used. This is used for T&D Calculations.

- **Running Force:** The maximum force required to insert a centralizer into a specified wellbore diameter. This input is not used in the standoff calculation but is used for T&D. The running force will be applied to the hookload and torque values and will increase / decrease with the well bore size. The smaller the ID of the wellbore the more running force will be added and vice versa.
- **Centralizer Type:** The user can manually enter the centralizer type and make / model here. This is not used in any calculations.

E16 - Casing / Tubing

- Same properties as **liner**

E17 - Agitator

- **SN:** Serial Number plays no part in any calculation
- **Connection Top:** Plays no part in any calculation
- **Connection Bottom:** Plays no part in any calculation
- **Reduction in Slack Off FF:** The percentage reduction in the slack off friction factor because of the agitator's inclusion in the string. This is factored into the T&D calculations for Tripping In, Slide Drilling and Rotating on Bottom operations.
- **Make:** Plays no part in any calculation
- **Model:** Plays no part in any calculation
- **Pressure Drop:** enter the pressure drop across the tool if any, used in hydraulics and T&D calculations
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected

E18 - Reamer

- **SN:** Serial Number plays no part in any calculation
- **Reamer Arm OD:** OD of the Reamer Arm, used for SAG calculations and hydraulics
- **Arm Length:** Arm length in inches, used for SAG calculations and hydraulics
- **Reamer Arm Distance from Bottom:** Distance from the bottom of the tool to the start of the Reamer Arm section. Enter in the depth units selected from the units menu. Used for SAG calculations

- **Connection Top:** Plays no part in any calculation
- **Connection Bottom:** Plays no part in any calculation
- **Arm Width:** Arm width in inches, used for hydraulics calculations
- **No of Arms:** The number of arms on the reamer. Not used in any calculation
- **Tensile Yield:** The tensile yield of the component. This value is displayed on the charts if selected
- **Torsional Yield:** The torsional yield of the component. This value can be displayed on the charts if selected