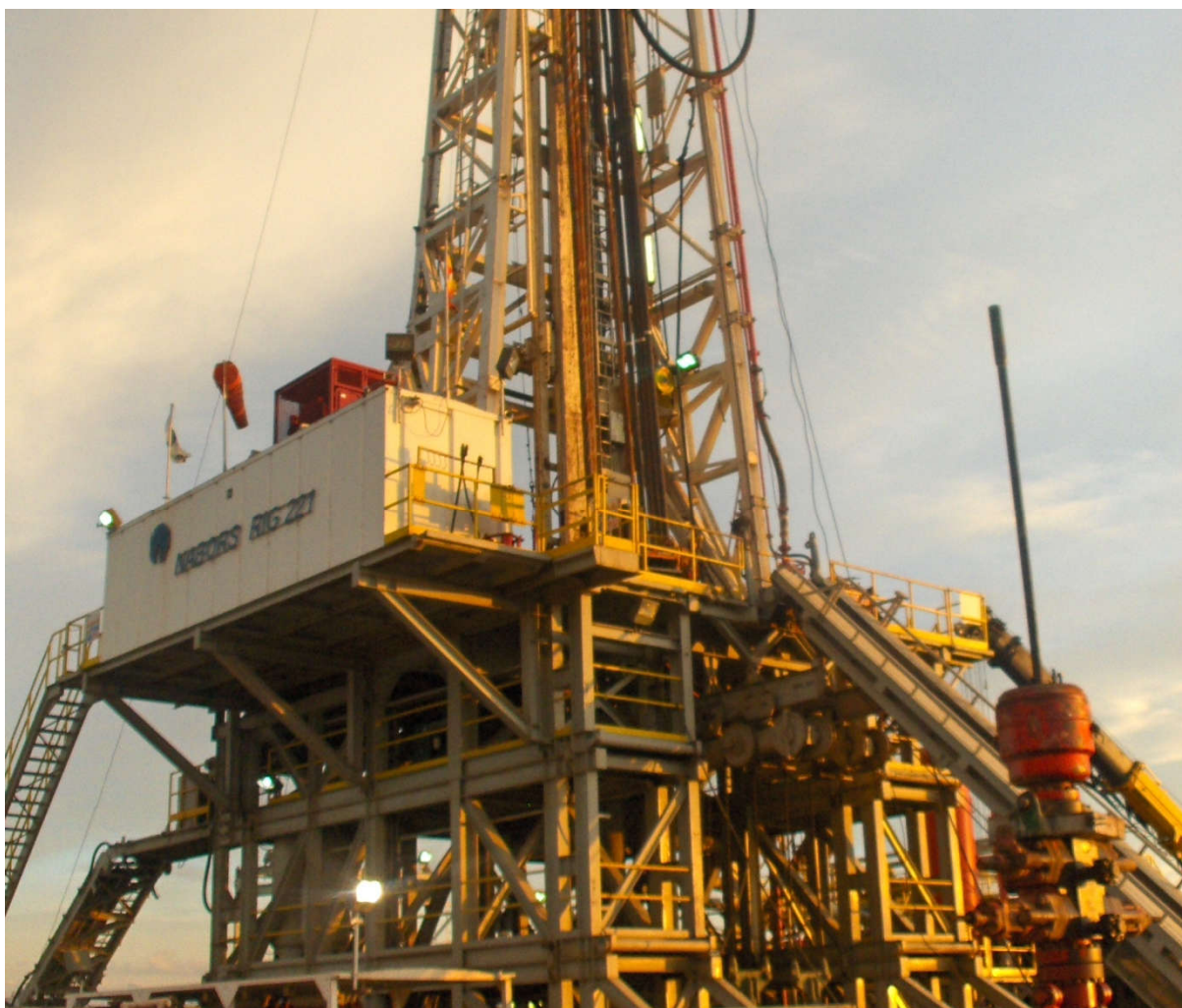




INNOVA
Drilling & Intervention

Torque & Drag Quick Start Guide

Rev 1.4

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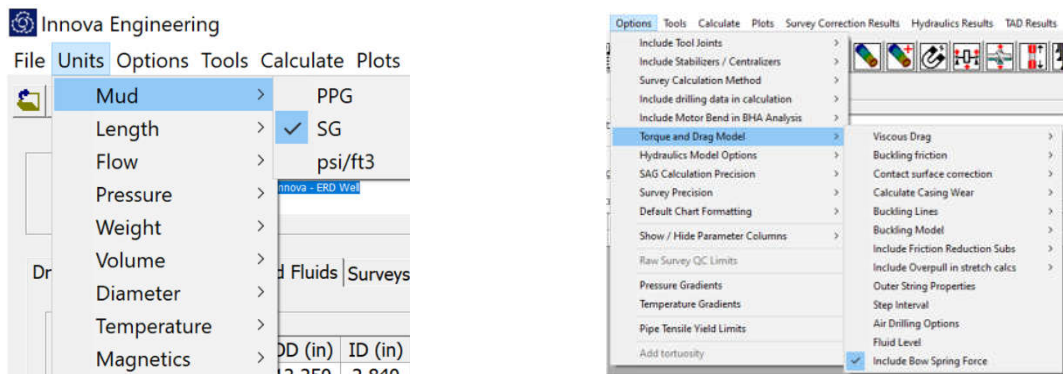
1.0 - Torque & Drag Module - Quick Start Guide

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

1.1 - Setup

In the options menu, there are selections that affect the way the torque and drag calculation is run and these should be double checked.

- **Units:** Ensure that all units are correctly selected, based on requirements. **Note: If air drilling is being modelled, SFCM must be selected as the Flow units to activate air drilling mode.**



- **Include Tool Joints:** Select whether the OD and ID of the tool joint is included in the calculations. Default is **Yes**.
- **Include Stabilizers / Centralizers:** Enables or disables drill string stabilisers or casing centralisers. Default is **Yes**.
- **Include Drilling Data in Calculation:** 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**.
- **Torque & Drag Model:** Select the T&D setup you would like to run.
 - **Viscous Drag:** Refers to the drag caused by pulling the string through the mud. This only affects **pick-up** weights. Default is **No**.
 - **Buckling Friction:** The additional friction added if the pipe is helically buckled and being pushed through the well. Only applies to **slack-off** 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.

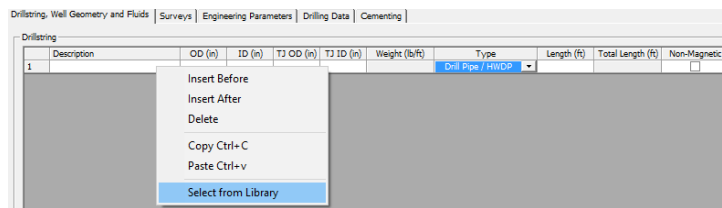
- **Standard (Loading Model):** Sinusoidal limit x 2.1
 - **Include Friction Reduction Subs:** Friction reduction inputs are available in the DP & HWDP component details. This option determines whether these inputs are used in the calculation. Default is **Yes**.
 - **Include Overpull In Stretch Calcs:** Stretch calculations will take into consideration the overpull entered in the Engineering Parameters tab. Default is **No**.
 - **Outer String Properties:** Required input for Liner Expansion calculations.
 - **Step Interval:** Determines the interval between calculated points. Default is **10** i.e. outputs are generated every 10 meters or feet. This will be apparent when viewing the data tables.
 - **Air Drilling Options:** To be used when the section is air drilled. User enters the expected standpipe pressure here for the given flow rate. This will calculate the additional string weight caused by drilling on air. **Note: If air drilling is being modelled this must be selected.**
 - **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.
- **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.*

1.2 - Required Inputs

To run Torque & Drag, the following inputs are required.

Drill string, Well Geometry & Fluids Tab

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

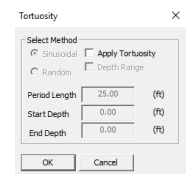
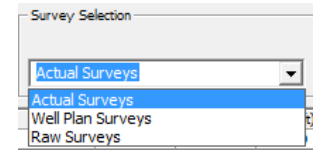


Input the dimensions of the drill sting components into the Drill String grid:

- **Description:** A description of the component entered, this is only used in the generation of reports and plays no part in any of the calculations.
- **OD:** The outer diameter of the component in inches.
- **ID:** The inside diameter of the component in inches.
- **TJ OD:** If the component has a tool joint (such as drill pipe) enter the OD in inches into this column. If the "Include TJ in calculations" menu option is turned off this column will be disabled.
- **TJ ID:** If the component has a tool joint (such as drill pipe) enter the ID in inches into this column. If the "Include TJ in calculations" menu option is turned off this column will be disabled.
- **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.
- **Length:** The length of the component in the system units.
- **Component:** Select the component type from the drop-down list. The type of component that is selected will determine the properties displayed in the lower components grid.
- **Bit TFA:** The bit TFA is required to calculate the pressure drop below the bit, which is used in the buoyancy calculations and in the buckling calculations. This is selected in the component grid section when the bit is selected.
- **Well Geometry:** Input casing, liner and open hole details including depths and ID's. For Open hole, the ID is the OD of the bit.
- **Mud Weight:** This is required for buoyancy and viscous drag calculations

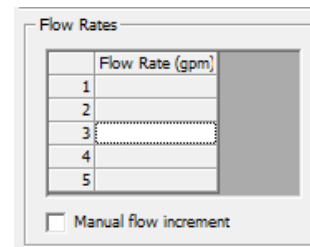
Surveys Tab

- **Survey Selection:** T&D calculations can be run against surveys and well plans. Data can be input as measured depth, inclination and azimuth in both Actual Surveys or Well Plan Surveys and the program will generate the rest of the numbers using whichever survey calculation method you have selected (Minimum Curvature Default). T&D cannot be run against surveys input the RAW surveys section. Either enter the plan or surveys manually, import them or copy and paste the data directly into the cells.
- **Tortuosity:** For portions of a plan which are vertical, it is possible to add tortuosity, to better simulate down hole conditions as a drilled well will never be exactly vertical.



The **Engineering Parameters** Tab is where the user can select the parameters they want to run the Torque & Drag calculation.

- **Survey Selection:** The user can select either **Well Plan Surveys** or **Actual Surveys**. There is also an option to select **Composite Listing**, which splices the actual surveys into the well plan surveys to create a composite listing.
- **Flow rate:** If manual flow increment is selected, the first flow rate entered will be used in the T&D calculation. If the manual flow increment is not selected, the flow rate entered in line 3 will be used.



- **Calc Depth** – This is the depth the calculation will stop at and 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 Rotate** – The weight on bit while on bottom rotary drilling. Used for creating the Apparent WOB & Apparent WOB Snapshot Charts.
- **WOB Slide** – The weight on bit while on bottom 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.
- **Est 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 (e.g. 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 set to 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
	Pipe protector started with rusted casing	4.1
Rotating Drill Pipe protector	Pipe protector with average casing interior	2.1
	Pipe protector after polishing casing	0.06

- **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 period 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. 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.

1.3 - Running the Calculation

Once the user has completed all the required inputs the calculation can be run. To do this, select either the icon displayed below, or select **Calculate - Torque and Drag**. This will calculate all the torque and drag and the torque and drag snapshot data.

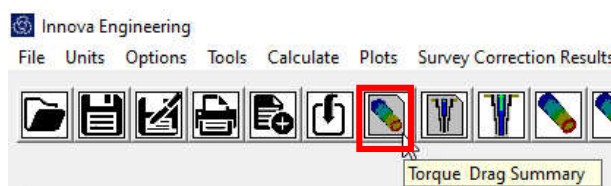


Additionally, the option is available to only calculate the torque and drag snapshot data. To do this, select either the icon displayed below, or select **Calculate – Torque and Drag Snapshot**. This option reduces the calculation time; however, will not calculate the full standard torque and drag data.

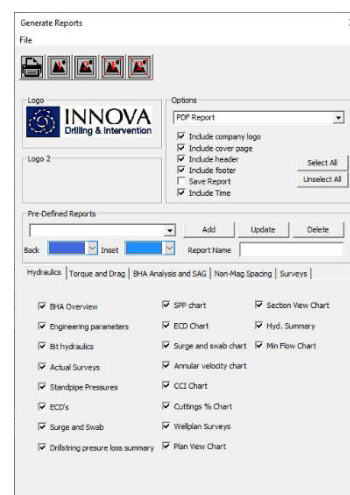
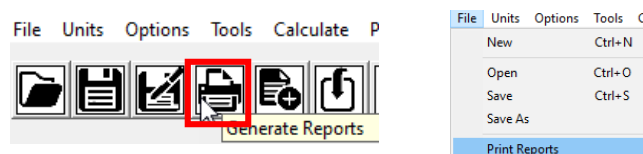


1.4 - Output

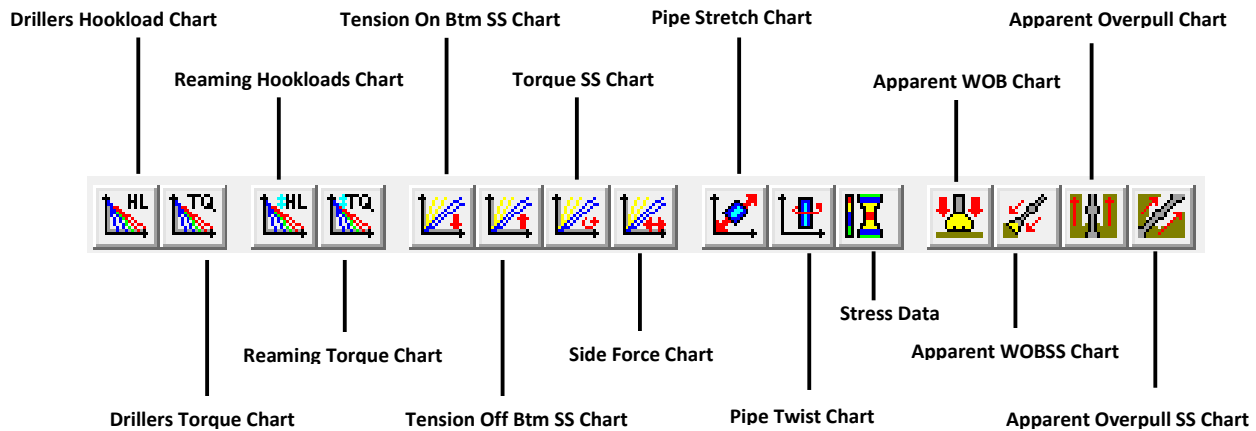
Once the calculation has been run, the Torque and Drag summary report can be viewed by selecting the icon from the toolbar at the top of the screen. This contains an overview of the main values associated with the calculation and can be saved as a pdf.



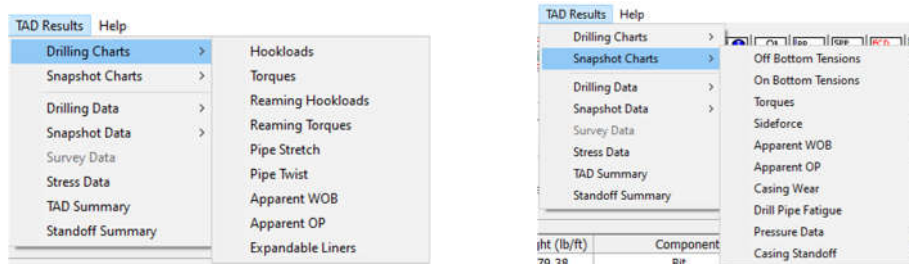
If required, a more detailed report can be generated by selecting **"File" - "Print Reports"** or selecting the icon on the toolbar (highlighted above). The required data can be selected, and a report can be generated either as excel or pdf. Note that when excel is selected the chart selection will be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



Some of the torque and drag results are available to view by selecting the toolbars along the top. This is a quick way to access some of the more commonly used plots.



All the torque and Drag plots and data are available to view by selecting the TAD results at the top of the screen. The Data options mirror the charts and display the numerical data used to generate the charts.



Survey Data: Only available to select when on the survey tab. This gives a breakdown of the survey data every 10 meters or feet and includes any tortuosity which has been applied.

Stress Data: Gives the user access to the stress data associated with different operations i.e. Rotating off bottom, Sliding etc. Charts for this data can be generated directly from here.

TAD Summary: This option prints a report that includes a Torque & Drag Summary Report, Drillers Hookload Chart and Drillers Torque Chart.

Standoff Summary: This option prints a report that includes a Centralizer spacing summary, Drill String summary, Centralizer Stand-off results, Standoff chart, Side Forces / Centralizer Forces chart and Hookload chart.

1.5 - Drilling Charts

The drilling charts represent the calculated (theoretical) values that the driller would expect to see on his gauges as the well is being drilled. Therefore, at each depth, the numbers displayed on the charts and the drilling data tables can be directly compared with values recorded from the drillers gauges as the well is being drilled.

1.5.1 - Drillers 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, apart from 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.

1.5.2 - Drillers 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.

1.5.3 - Reaming Hookloads Chart

The Reaming Hookload Chart displays the PU & SO weights seen at surface for any given depth in the section, based on a specific string RPM and pipe speed. If either rpm or pipe speed is modelled as zero, the reaming Hookloads will match the drillers Hookloads. A Reaming PU and SO line will be displayed for each set of friction factors which have been modelled.

1.5.4 - Reaming Torque Chart

The Reaming Torque Chart displays the PU & SO torques seen at surface for any given depth in the section, based on a specific string RPM and pipe speed. With a pipe speed of zero, both of these lines will mirror the off bottom torque line in the Drillers Torque Chart. PU & SO Torque lines will be displayed for each set of friction factors which have been modelled.

1.5.6 - Pipe Stretch Chart

The Pipe Stretch Chart displays the calculated amount of pipe stretch expected while picking up for any given depth in the section. There will be a line displayed for each friction factor which has been modelled.

1.5.7 - 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.

1.5.8 - 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.

1.5.9 - 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.

1.6 - Snapshot Charts

The snapshot charts represent the theoretically calculated values that you would expect at each point in an assembly when the assembly is at a given depth. For example, when looking at the torque snapshot chart, it will display the torque at each point in the string (for a given depth) from the bit all the way to surface. The surface values will match those of the drilling charts at the depth in question.

1.6.1 - Tension Off Bottom SS 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.

1.6.2 - Tension On Bottom SS 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.

1.6.3 - Torque SS 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.

1.6.4 – Side force SS 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.

1.6.5 - Apparent WOB SS 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.

1.6.6 - Apparent OP SS 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.

1.6.7 - Casing Wear SS 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 into 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.

1.6.8 - Drill Pipe Fatigue SS 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.

1.6.9 – Pressure Data SS 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.