

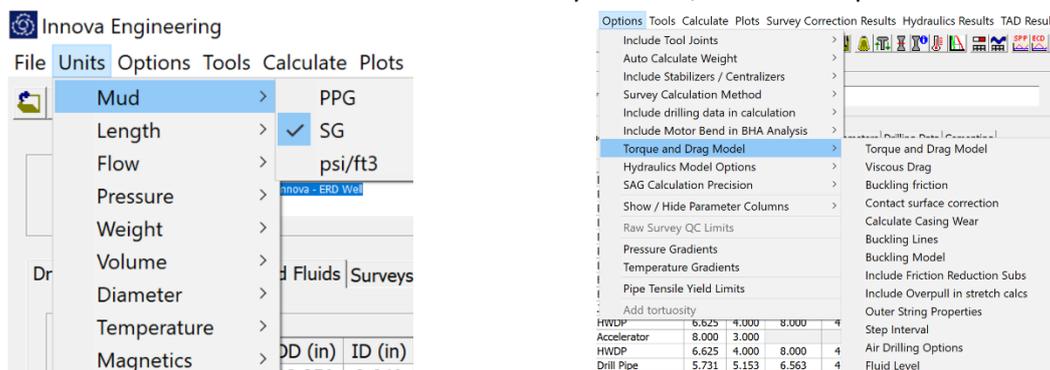
1.0 - Torque & Drag Module - Quick Start Guide

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 of the units are correctly selected, based on requirements



- **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**.
- **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. 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**.

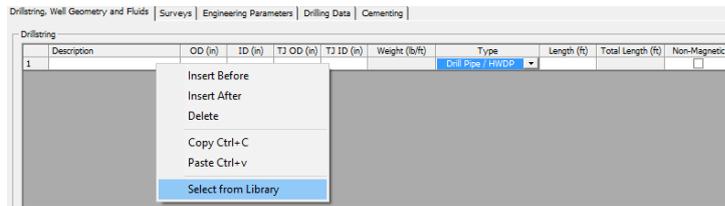
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- **Include Overpull In Stretch Calcs:** Stretch calculations will take into consideration the overpull entered in the Engineering Parameters tab. Default is **No**.
 - **Outer String Properties:** Required input for Liner Expansion calculations.
 - **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. 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.
 - **Pipe Tensile Yield Limits:** Allows the user to enter a pipe size and yield limit in to 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

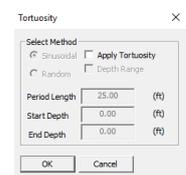
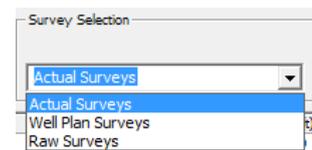
- **Drill String:** Input the assembly as accurately as possible including the drill pipe to surface (note, for the last component e.g. DP to surface, the user does not have to input the exact length as the program will do this automatically based on the calculation depth. Inputting a value of 10 is 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.



- **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 details 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

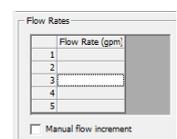
Surveys Tab

- **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.

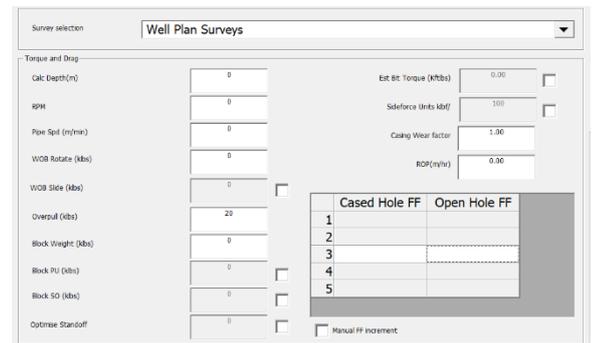


The **Engineering Parameters** Tab, is where the user can select the parameters they want to run the torque & Drag calculation.

- **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 in to 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 calculation. If the automatic range is selected, the flow rate entered in line 3 will be used.



- **Calc Depth** – This is the depth the calculation will stop at 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 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.



The screenshot shows the 'Well Plan Surveys' software interface. It includes input fields for parameters like Calc Depth (m), RPM, Pipe Spd (m/min), WOB Rotate (kbs), WOB Slide (kbs), Overpull (kbs), Block Weight (kbs), Block PU (kbs), Block SO (kbs), Optimise Standoff, Est Bit Torque (kftbs), Sideforce Units (kft), Casing Wear factor, and ROP (m/hr). There is also a table for Casing Wear Factor selection with columns for Cased Hole FF and Open Hole FF, and rows numbered 1 to 5. A 'Manual FF increment' checkbox is also visible.

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

- **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.

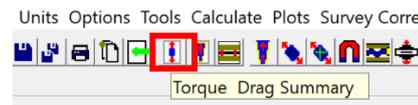


Additionally, the option is available to only calculate the torque and drag snapshot data. To do this, select either the icon displayed below, or select **Calculate – Torque and Drag Snapshot**. This option reduces the calculation time, however will not calculate the full standard torque and drag data.

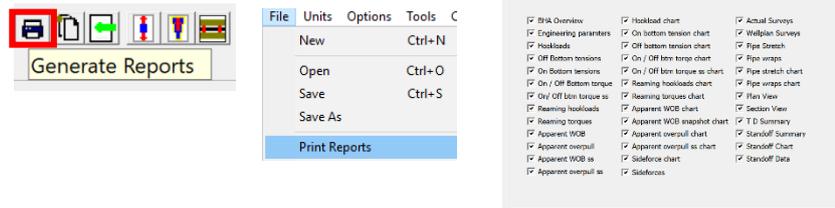


1.4 - Output

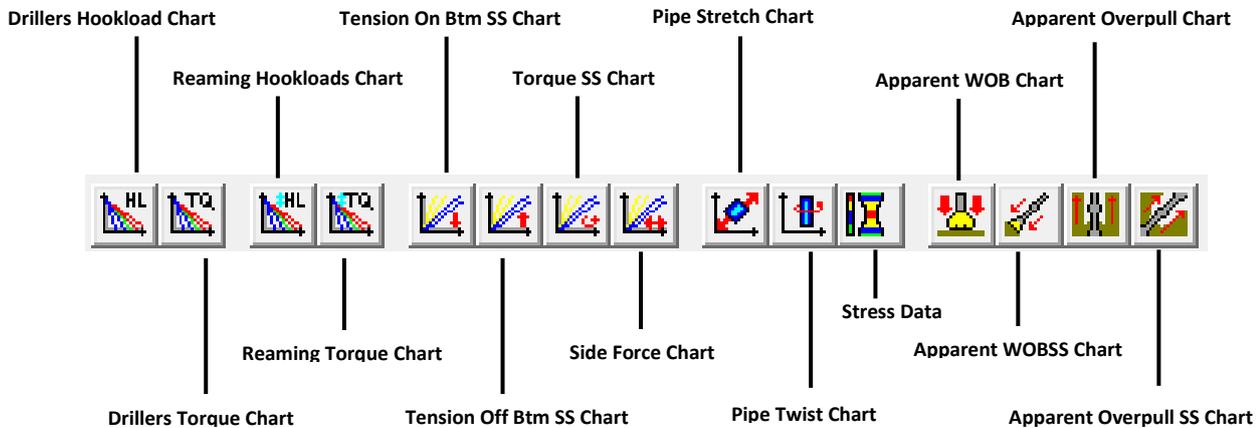
Once the calculation has been run, the Torque and Drag summary report can be viewed by selecting the icon from the toolbar at the top of the screen. This contains an overview of the main values associated with the calculation and can be saved as a pdf.



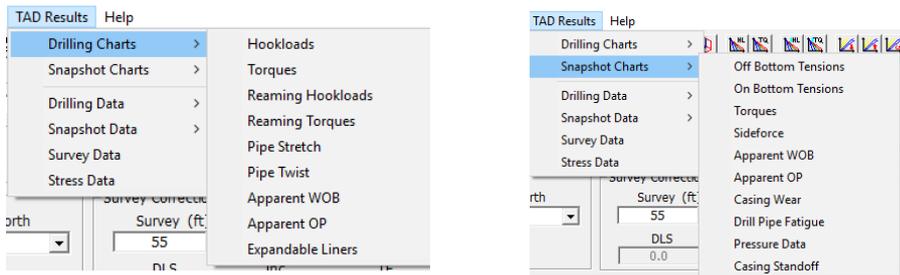
If required, a more detailed report can be generated by selecting "File" - "Print Reports", or selecting the icon on the toolbar (highlighted above). The required data can be selected and a report can be generated either as excel or pdf. Note that when excel is selected the chart selection will be greyed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

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

The Drillers Hookload Chart, displays the slack-off (SO), rotating off bottom, pick-up (PU), reaming out and reaming in weights seen at surface for any given depth in the section. A PU, SO, reaming out and reaming in line will be displayed for each set of friction factors which have been modelled.

There will only ever be one rotating off bottom line as this is not affected by different friction factors.

The Min wt to Hel buckle (Trip In) line is while rotating.

1.5.2 - Drillers Torque Chart

The Drillers Torque Chart displays the On and Off bottom Torques seen at surface for any given depth in the section. On and Off bottom Torque lines will be displayed for each set of friction factors which have been modelled.

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

The Pipe Twist Chart displays the calculated number of wraps expected in the pipe while rotating off bottom for any given depth in the section. There will be a line displayed for each friction factor which has been modelled.

1.5.8 - Apparent WOB Chart

This plot shows the Apparent WOB (Sliding) you need to see at surface (at each depth) in order to Actually have the selected WOB. There will be a line displayed for each friction factor which has been modelled.

1.5.9 - Apparent OP Chart

This plot shows the Apparent Overpull you need to see at surface (at each depth) in order to Actually have the selected OP. There will be a line displayed for each friction factor which has been modelled.

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

The following lines are displayed on this plot:

- Pick Up (one line for each FF modelled)
- Slack Off (one line for each FF modelled)
- Rotating Off Bottom
- Sinusoidal Buckling (Tripping In)
- Helical Buckling (Tripping In)
- Tensile Limit (Plotted from the value input in Component Details for each individual BHA component. If no values were input, then no curve will display on the chart)

Buckling will occur if the slack off line crosses either of the buckling lines.

1.6.2 - Tension On Bottom SS Chart

The following lines are displayed on this plot:

- Pick Up (one line for each FF modelled)
- Sliding (one line for each FF modelled)
- Rotating On Bottom
- Sinusoidal Buckling (Tripping In)
- Helical Buckling (Tripping In)
- Tensile Limit (Plotted from the value input in Component Details for each individual BHA component. If no values were input, then no curve will display on the chart)

Buckling will occur if the Sliding or the Rotating ON Bottom lines crosses either of the buckling lines.

1.6.3 - Torque SS Chart

The following lines are displayed on this plot:

- On Bottom Torque (one line for each FF modelled)
- Off Bottom Torque (one line for each FF modelled)

- Torsional Limit (Plotted from the value input in Component Details for each individual BHA component. If no values were input, then no curve will display on the chart)

The torque snapshot chart displays 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.

1.6.4 - Sideforce SS Chart

The following lines are displayed on this plot:

- SF Pick Up (one line for each FF modelled)
- SF Slack Off (one line for each FF modelled)
- SF Rotating (one line for each FF modelled)

The Sideforce snapshot Chart displays the sideforce at each point in the string (for a given depth) from the bit all the way to surface.

1.6.5 - Apparent WOB SS Chart

This snapshot plot shows the Apparent WOB (Sliding) you will see at surface (for any one specific depth, which is displayed in the chart title) vs the Actual WOB.

1.6.6 - Apparent OP SS Chart

This snapshot plot shows the Apparent Overpull you will see at surface (for any one specific depth, which is displayed in the chart title) vs the Actual Overpull.

1.6.7 - Casing Wear SS Chart

The Casing Wear Snapshot Chart displays the predicted casing wear at each point in the string (for a given depth) from the bit all the way to surface. This 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.

The following lines are displayed on this plot:

- **Casing Wear Rotating:** This is the predicted wear on the casing when the string has 0 ROP.
- **Casing Wear SO:** This is the predicted casing wear calculated using the reaming slack off (one line for each FF modelled).

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 very long.