

User Manual of T&D

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Foreword

The booklet applies to the current version of the T&D spreadsheet.

The program was tested on Windows XP with SP3, 32 bits with Office 2013 and Windows 8, 64 bits, with Office 2016, English versions. All the rights for this version are reserved by Marius Tulceanu.

Naming convention and definitions

Axial Zero Stress – it is the point in the string at which the axial stress equals zero.

Buttons and menu items are marked by square brackets “[]”.

Branch is a section of the hole. It may start from surface (wellhead) or it may start deeper, as child of a parent branch.

Effective Force – it is the hook load measured during drilling, and tripping pipe. It is an axial, continuous force. The buckling forces are calculated using the effective forces. The effective force changes the sign in the *neutral point*.

Neutral Point – it is the location in the string below which the buoyed weight equals the WOB. This is the point above which buckling cannot occur and below which buckling may occur.

Program forms and fields are marked with angle brackets “< >”, like <Well Header>.

True Axial Force – it is the axial force used in mechanics. It is calculated by subtracting the buckling stability force from the *effective force*. At the depths where the OD or ID of the tubular changes (different pipe), the true force value shows a horizontal jump. Axial stresses in tubulars always are determined by the axial true forces. The true force changes the sign in the *axial zero stress*.

Tubular catalog is a file delivered with the program, where the technical data about casing and drill string elements is stored. The file can be found on disk as T&D Catalog.tub and it is actually a MSAccess database. At the first loading of the T&D program into Excel, the user is asked to locate (browse) the path to the catalog. The file may be moved in any location, at any time. However, the user will have to provide the program the new location. This is done by pressing [[Parameters](#)] menu button, and on the shown form by pressing [Select Catalog].

Well file or case file it is a physical file on disk, having a name given by the user (usually the name of the well) and the extension “.cas”.

Abbreviations

PUW – Pick Up Weight, it is the effective force while moving the drillstring upward.

SOW – Slack Off Weight, it is the effective force while moving the drillstring downward.

FRW – Free Rotating Weight, it is the effective force while rotating the drillstring above bottom of the hole.

WOB – Weight On Bit, it is the effective force placed on bit.

BSMF - Bending Stress Magnification Factor

Menus

[Load Case]

It is the main input operation. By picking up this menu item, the user will be allowed to browse the disk for the desired well file (having the extension “.cas”, being actually an unlocked MS Access database), and select the name of the file to load.

[Save case]

This menu item is used to save the well data, in an *already existing* “.cas” file. The user will select the case file and then the branch corresponding to the loaded wellpath. T&D will save the current data from the spreadsheet, including the deviation, by *overwriting* the existing data in the targeted case file.

[Save as New case]

This button is used create an empty “.cas” file. The user will have to provide a name and select a path for the file to be created. The newly created file is a MSAccess database. Once the new case file it was created, the user has the possibility to save (*overwrite*) data in this file, by selecting the menu item [Save Case].

[Set Units]

Allows the user to select the input and the output of the measuring units, individually.

The terms “input” refers to the units used for the data that will be filled in by the user, or for the data that will be loaded from file, and displayed in the input fields. It does not refer to the units of the data stored in the case file.

There is a default configuration of the measuring units saved in the tubular catalog.

However, the user can customize the units individually, by choosing every unit from its combo-box.

By checking the option in the left side-down, the user would allow the saving of the unit preferences as default, which will be saved in the catalog.

By checking the right side-down box, the user would be spared to select the output units too, in the case he wants these to be the same as the input units. By checking the box, the user will override the settings in the right-side panel when he would press <Apply>.

If the user choses to press <Cancel>, no unit will be changed.

Note:

- 1) Some of input units are not changeable as they have important meaning in the existing standards. For example, a steel graded G105 would mean the minimum Yield Stress is 105 thousand psi, while 723,949,515.78 Pa means nothing at all. Same remark for the linear pipe weight: 19.5 ppg in SI would mean 29.02 kg/m and 5 in DP would be 0.127 m.
- 2) It is highly recommended to not modify the units after data was filled in the tables as the data will not be converted backward, in order to avoid losing of precision in the case the conversion factors are rational numbers!

[Catalog]

The usefulness of the Catalog is that the user can store the data of the pipe and tools used in T&D simulation. The data can then be retrieved for any new simulation, either using the combo boxes of the main sheet (“Input”), or by looking for a specific element in the catalog and then pressing [SELECT BHA ELEMENT]. This button will place the element on the Input sheet, on the line containing the cursor.

The Catalog form may be opened by pressing [Catalog]. When opening the form, the names of the tables are loaded in the list called BHA Elements.

By clicking on one of the items of the list, a table name is selected and the cursor of the database is automatically positioned on the first record. Therefore, the fields of the table are shown, and the values of the fields for the first record are loaded, starting with the first field, which is a unique number of the record in the table.

A scroll bar is showing at all time the position of the cursor within the selected table, and the number of records (lines) of the table. The scroll bar can be used to navigate the table records, in both directions.

At any time, the user can modify the any of the fields, except the first field, which is managed by the database itself.

CATALOG

Record 854 of 854

BHA Elements

- Accelerator
- Bit
- Casing
- Centralizer
- Completion
- Drill Collar
- Drill Pipe
- Hevi-Wate DP
- Jar
- MWD
- Packer
- PDM
- Pipe Protector
- RSS
- Stabilizer
- Sub
- Tubing

Field

Value

SEARCH FOR

id_Rec	854	ConnID	8.858	[in]	
theSize	9 5/8	[in]	ConnLength	13.9	[in]
Name	Vam Top	MULoss	5.589	[in]	
NomWeight	47	[ppf]	ConnStrength	1086	[klb]
Weight	46.2	[ppf]	ConnComp	652	[klb]
AvWeight		[ppf]	ConnBend	30	[°/100ft]
ConnTop	Vam Top B	ConnBurst	6870	[psi]	
ConnBot	Vam Top P	ConnCollapse	4760	[psi]	
BodyOD	9.625	[in]	CriticalSection	13.572	[in ²]
Thick	0.472	[in]	LoadOnFace	630	[klb]
BodyID	8.681	[in]	MaxMUTorque	17400	[lb·ft]
Yield	80000	[psi]	MUTorque	15900	[lb·ft]
Collapse	4754	[psi]	MinMUTorque	14400	[lb·ft]
Burst	6865	[psi]	ConnTorsYield		[lb·ft]
Strength	1086	[klb]	Mat	CS	
Capacity	0.07321	[bbl/ft]	Young	3E+07	[psi]
CloseDispl	0.08999	[bbl/ft]	Poisson	0.3	
Drift	8.525	[in]	Density	490	[lb/ft ³]
SpecialDrift	NO	[yes/no]			
ConnOD	10.396	[in]			

CREATE NEW RECORD

SAVE CURRENT RECORD

DELETE CURRENT RECORD

CLEAR FIELDS

SELECTT BHA ELEMENT

CALCULATE API DATA

If the user wants to save the modifications within the same record (row), he only has to press [SAVE CURRENT RECORD].

If the user wants to save the modifications as a new record (row), he has to press first the button [CREATE NEW RECORD] and then to press [SAVE CURRENT RECORD].

The cursor in the database is moved automatically to the affected record (the modified, or the new one). This way of adding new records was thought in order to easily add new records alike another existing record, by modifying only a few fields. However, the user may opt to press [CLEAR FIELDS] button to input new data in all fields.

By pressing [DELETE CURRENT RECORD] the current record is deleted without any warning. Beware that if you started modifying the fields of a record, but you did not press any saving button, the current record was not changed.

The form allows the user to search within a table, for a value of a specific field, by pressing [SEARCH FOR]. If there is such a value assigned to the specified field, the cursor of the table will move on the found field and the full record will be shown. From this point, the user can search further for a similar value by pressing again [SEARCH FOR]. If the search (forward only) will not find a new record with the selected criteria, the cursor will not move.

The user can only modify existing records and add new records in tables, but he cannot add fields, or tables, as such feature would not be useful without linking the fields or the tables to the T&D software by lines of code, of which the author reserves all the rights.

[CALCULATE API DATA]. This button is enabled when the BHA element is a casing or a tubing. By pressing it, the API formulae will be used to calculate the resistance of the pipe. The calculated fields have a yellowish background while the required input fields have an orange color.

[Parameters]

This menu item would open a form that would allow the user to fill in the *mandatory data* for the fluid that fills the well (WBM, SOBM, brine), the *mandatory parameters of the simulation* and to set some options. Most of the fields are self-explanatory.

If the user choses to check any of the boxes for Drilling, Tripping, and Backreaming, he has to fill in all the data required for the respective operation. Failing to do that, would trigger an error.

This form allows the input of one up to six fluid densities inside the pipe and in annulus.

The calculations of T&D are carried out from bottom to surface, by dividing the well length and the drillstring into short segments. <Step> is setting the maximum length of such segment. If the a drillstring element is shorter than Step, the value used as Step for this element is its actual length.

In order to enter the rheologic parameters for each of the fluids placed in the well, just click the checkbox placed in the right side of each mud interval.

In the newly opened form, the user can either fill the Fann data and then press [Calculate Parameters], or he can select the rheologic model to be used, and then to input the rheological parameters.

Pipe - Fluid 1 Rheology

Base type:

Temperature: [°F]

Gel 10min: [lbf/100ft²]

Data Source:
 Known
 Read at Fann

Delete data

Rheologic model:
 Newtonian
 Binghamian
 Power Law
 Yield Power Law 0.99941

Calculate Parameters

FANN Data

Shear rate [RPM]	Shear Stress [lbf/100ft ²]
3	8.54
6	10.67
100	34.14
200	49.08
300	61.89
600	98.16

Rheological Parameters:
 Y.P. lbf/100ft²
 Index K Pa·sⁿ
 Index n

Save same data for annulus

Save data

Once the [Save data] was pressed, the user can check the fit of the model in the sheet “RheoGraph”.

By clicking on the Pumps ON check box, the following form will be opened:

Pump Data

Nozzles:
 x /32" in
 x /32" in
 x /32" in
 x /32" in
 x /32" in

Flow Rate: [gpm]

Max Pressure: [psi]

Include TJ pressure losses

TFA: [in²]

Nozzle coefficient:

Cancel **Apply**

Surface Pressure Drop

x $\left(\frac{300}{\text{Flow Rate}}\right)^2$ x = [psi]

$$P_1 \cdot \left(\frac{Q_2}{Q_1}\right)^2 \cdot \frac{MW_2}{MW_1} = P_2$$

The surface pressure drop can be estimated based on the shown formula or it can be filled in directly by the user.

<Apply tortuosity> is useful to simulate a quasi-real deviation data for the planned wellpaths that are smooth by design, having only constant DLS (zero or not). The action is performed on the deviation data loaded into the spreadsheet, and not on the data stored in the case file. However, if the user will press the [Save Case] menu item, the tortured data will be saved in the case file, overwriting the untortured deviation in the case file.

If the tubular catalog was moved in another location on disk, the user can use the <Select catalog> button to browse the new path to the catalog.

Sheave friction correction

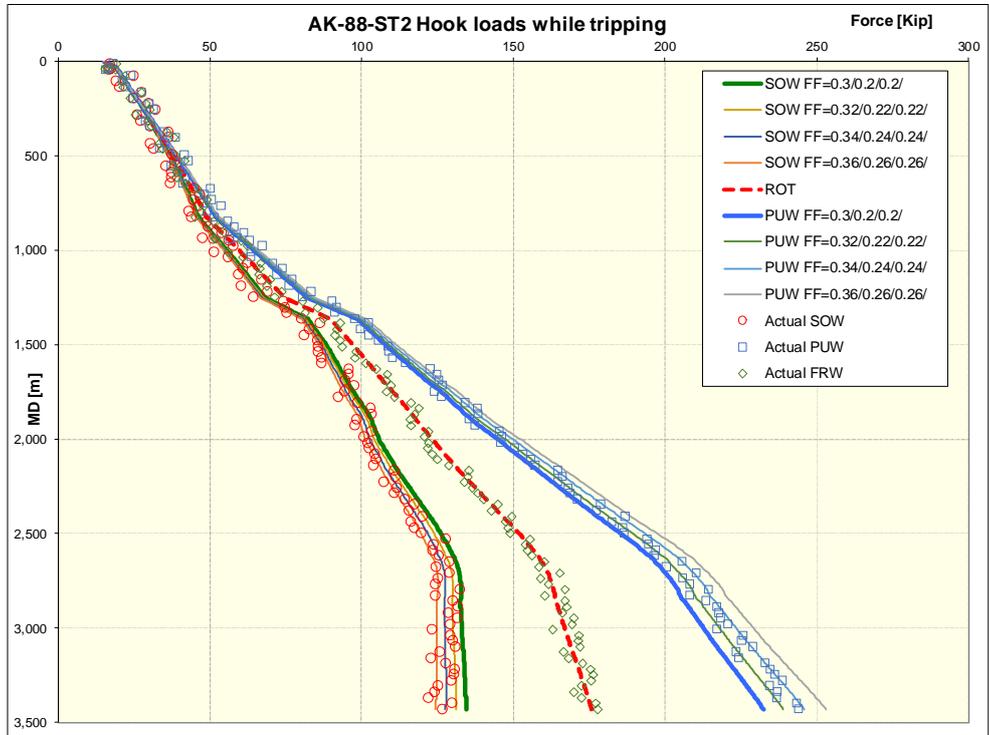
No of lines:

Efficiency:

Apply **Load Data**

By filling in the Number of lines of the Traveling Block and the Efficiency of the sheaves of this assembly, and by pressing <Apply>, the program will correct the loaded data for PUW and SOW (the “actual” data) for sheave friction. The correction is done for the displayed data, and not for the data stored in the ASCII file. By pressing <Apply>, the data will be written/updated into the spreadsheet. However, it will not be saved in the case file.

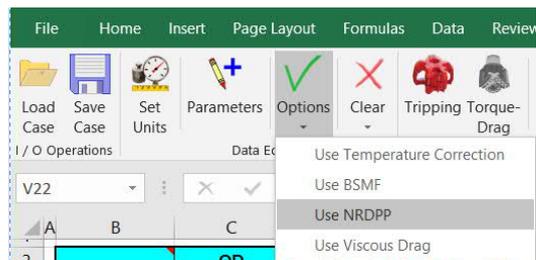
<Load Data> allows the user to load an ASCII file (with Space or Tab separated values of MD, SOW, PUW and FRW, to be loaded and displayed on the “Graphs” sheet, as in the hereafter image. This feature allows two things: to calibrate the friction factors of the T&D model for a specific well, and to check for potential hole issues (tight hole, hole cleaning, big DL, etc):



Press <Cancel> if you want to discard the changes.

[Options]

In this menu, the user can select additional features of the T&D model, like Bending Stress Magnification Factor and Viscous Drag. The Temperature Correction for the fluids in well it is not yet implemented.



[Clear]

The menu item would only delete data from the spreadsheet or from the entire workbook. **It does not delete data from the well file on disk.**

[Tripping]

It is one of the two calculation modules. This would calculate the Pick Up Weight, Slack Off Weight, and the FRW of the drillstring while tripping in. It also calculates the torque while tripping.

[Torque-drag]

It is the main calculation module as it populates most of the sheets and charts with output data and it is providing the most information.

[Centralization/Add NRDPP]

This feature allows a further step to optimize a drillstring design by using of Non-Rotating Drill Pipe Protectors (NRDPP) or similar devices, in order to reduce the torque, drag and the lateral force that may harm the casing and the wellbore.

The 'Standoff Devices' dialog box contains a table titled 'Placement of standoff devices'. The table has the following columns: Measured from bit (From [m], To [m]), No / Joints (No [pc], Joints [pc]), Friction Factors (Force [-], Torque [-]), Name [-], Outside Diameter (Sleeve [in], Effective [in]), Weight [lb], Type (checkbox Rigid), and Bow type centralizer forces (Start [lb], Run [lb], Restore [lb]).

From [m]	To [m]	No [pc]	Joints [pc]	Force [-]	Torque [-]	Name [-]	Sleeve [in]	Effective [in]	Weight [lb]	Type	Start [lb]	Run [lb]	Restore [lb]
1550	2550	2	1	0.05	0.07	QAZ	8	7	5	<input type="checkbox"/> Rigid	150	107	378
2700	3000	1	2	0.05	0.07	QWER	8.1	7.1	5.1	<input checked="" type="checkbox"/> Rigid	145	146	147
3100	3200	2	3	0.06	0.08	HT-350	5.5	5	2	<input checked="" type="checkbox"/> Rigid			
										<input type="checkbox"/> Rigid			
										<input type="checkbox"/> Rigid			

Buttons: Apply, Cancel

By clicking [Apply], the data is finally ready to be used in calculation or to be saved in the .cas file.

While some of the new data has to be filled in manually, the characteristics of the devices can be selected by clicking on the field <Name>, which will open a selection form. The user can browse the existing NRDPP and select the one suitable for the string interval.

The 'NRDPP' selection dialog box displays the following fields:

- id_Rec: 8
- Manufacturer: WWT
- Name: S-550
- DPSIZE: 5 1/2 [in]
- CollarOD: 7 [in]
- SleeveOD: 7.75 [in]
- SleeveLength: 0.83 [ft]
- OverallLength: 1.66 [ft]
- LoadRating: 2000 [lb]
- TempRating: 230 [°C]
- Weight: 2 [lb/ft]
- Mat: AL
- isRigid: YES

On the right, there is a list of 'NRDPP Centralizers' with 'TRS' selected. Below the list is a vertical scrollbar showing 'Record 8' and 'of 18'. A 'SELECT' button is at the bottom.

Press [Select] to update the selected NRDPP features on the above form.

Even if the data of standoff devices is saved in the case, the user has the option to either use it in T&D calculation, or not, by selecting the menu option <Use NRDPP>:

Sheets

Input sheet

This is the main data sheet. It comprises the wellbore description as well as the description of the elements of the string.

The wellbore table:



Type	OD [in]	ID [in]	Weight [lb/ft]	Top [m]	Bottom [m]	Friction factors	
						Drag	Torque
Open hole		12 1/4		2269.00	4140.00	0.30	0.3
Casing	13 3/8	12.41	68.00	0.00	2269.00	0.25	0.25

The fields marked in red shall not be filled by the user.

It is filled starting from the lowest section, as it is flagging the comment. For casing, the user should select either the ID, or the nominal weight.

The section type shall be picked from the available types, while the casing data may be either picked up from the tubular catalog, or filled in manually.

The program will fill automatically the bottom of each interval, once the first line was filled by the user.

The user may want to split one section, in order to use different friction factors (FF). For example, if the FF for the open hole to a certain depth was 0.25, and because of a big dogleg, or similar (semi)permanent restriction, at that depth, the open hole friction factor suddenly increased to 0.35, the user may do the split, and then to calibrate, by trial and error, the second friction factor for the section below the restriction (for example 0.25 in the upper section and 0.4 in the lower section). There is the possibility of using different FF for drag and for torque.

The drillstring table:

This table shall be also filled starting with the lowermost element of the string. The types of the elements are standardized, and they are picked up from the tubular catalog. The rest of the fields may be also picked up from the catalog, or may be filled in by hand. The length of the element may be also read from the database (if it is a specific tool, like a jar).

It is recommended to select each element of the string, from the combo boxes, one after another, till the full line is completed. The reason is, the selection of the data for the next field, is narrowed after each step.

However, if the user missed a field, he has just to go back to the previous field and restart the selection.

Another method to fill in the string elements is to move the cursor on the first field of the next line, open the <Catalog>, search for the tubular needed and then press [SELECT BHA ELEMENT].

Type	Name	Size [in]	Nom Weight [lb/ft]	Length [m]	Body		Mtr	Grade (YS) [psi]	Class	Tool Joint / Stabilizer blades				TJ sep [m]
					OD [in]	ID [in]				Connection		OD [in]	ID [in]	
										Top	Bottom			
BIT	KGR50	6	80.00	0.20	6.000					3 1/2 Reg P				
PDM	4 3/4-5/6-8.3	4 3/4	42.91	8.00	4.750	2.000	CS	110000		3 1/2 IF B	3 1/2 IF B			9.1
Stabilizer	IBS	4 3/4	40.00	0.35	4.750	2.250	CS	110000		3 1/2 Reg B	3 1/2 Reg P	5.750	2.190	1.0
Hevi-Wate DP	GP - Spiral	3 1/2	25.00	3.10	3.500	2.250	CS	55000		NC 38 B	NC 38 P	4.750	2.188	6.1
MWD	MWD	4 3/4	50.00	18.70	4.750	1.920	SS	110000		NC 38 B	NC 38 B			9.1
Hevi-Wate DP	GP	3 1/2	25.00	9.30	3.500	2.063	CS	55000		NC 38 B	NC 38 P	4.750	2.125	6.1
Drill Pipe	Drill Pipe	3 1/2	14.69	785.70	3.500	2.764	CS	135000	P	3 1/2 IF B	3 1/2 IF P	4.812	2.125	9.1
Hevi-Wate DP	GP	3 1/2	23.20	111.95	3.500	2.250	CS	55000		NC 38 B	NC 38 P	4.750	2.313	6.1
Jar	Griffith-Vector	4 3/4	46.78	3.81	4.750	2.000	CS	110000		3 1/2 IF B	3 1/2 IF P			6.1
Hevi-Wate DP	GP	3 1/2	23.20	307.89	3.500	2.250	CS	55000		NC 38 B	NC 38 P	4.750	2.313	6.1
Hevi-Wate DP	SMFI	5	49.70	113.00	5.000	3.000	CS	55000		NC 50 B	NC 50 P	6.500	3.000	6.1
Drill Pipe	Drill Pipe	5	19.50	2066.83	5.000	4.280	CS	135000	P	5 XH B	5 XH P	6.312	2.750	8.8

from BOTTOM to TOP

CS for Carbon Steel
SS for Stainless Steel
AL for Aluminium
TI for Titanium
BY DEFAULT: CS

Yield strength

BY DEFAULT: P
REQUIRED ONLY FOR DRILL PIPES

Distance between tool joints or between tool joint and upset for HWDP
REQUIRED ONLY WHEN USE BSMF CALCULATION (RECOMMENDED)

Although the manual filling in of the data (or manual pasting) it is not advisable, the user is allowed to do it.

If the user filled in a value that is not find in the tubular database (for example 32 ppf for the “Hevi-Wate DP” and “GP – Spiral” and “3 1/2” that are only 24.88 ppf and 27.05 ppf, like below), the rest of the fields on the line will have to be filled manually, by the user.

Type	Name	Size [in]	Nom Weight [lb/ft]	Length [m]	Body		Mtr	Grade (YS) [psi]	Class	Tool Joint / Stabilizer blades				TJ sep [m]
					OD [in]	ID [in]				Connection		OD [in]	ID [in]	
										Top	Bottom			
BIT	KGR50	6	80.00	0.20	6.000					3 1/2 Reg P				
PDM	4 3/4-5/6-8.3	4 3/4	42.91	8.00	4.750	2.000	CS	110000		3 1/2 IF B	3 1/2 IF B			9.1
Stabilizer	IBS	4 3/4	40.00	0.35	4.750	2.250	CS	110000		3 1/2 Reg B	3 1/2 Reg P	5.750	2.190	1.0
Hevi-Wate DP	GP - Spiral	3 1/2	32											
			24.88											
			27.05											

The body OD and ID of the elements, are filled in automatically by the program, with the corresponding data from the tubular catalog. However, the user may fill in different data.

The program proposes automatically a length of the section, as difference between the bottom of the first segment in the casing table (Well Depth), and the sum of the previous elements selected in the drillstring table. However, any value should be filled in by the user, if it is not correct.

Notes:

- 1) The total length of the string shall not exceed the depth of the well, which shall not exceed the depth of the last deviation point.
- 2) The program checks if the OD of the elements (TJ, or body - if slick) would not exceed the ID of the wellbore sections.
- 3) The body OD field refers to the slick part of the element, without any upset.
- 4) If the OD and ID of the Tool Joint are missing, it is assumed they are the same as the OD and ID of the body.
- 5) The Tool Joints separation length it is not mandatory. However, if they are not filled in, the program will disable the calculation of BSMF. If filled in, the TJ separation length shall not exceed the length of the individual element (DP, Jar, HWDP, DC, MWD, crossover, etc).

6) The user should pay attention at the measuring units he selected, especially for lengths.

Deviation sheet

The deviation sheet is used by the program to display the trajectory loaded from the case file. If there is no deviation data in the case file, the user must paste a deviation (Measured Depth, Inclination and Azimuth) before attempting to do any calculation. The top line shall be the shallowest depth (usually MD=0). The Measured Depth shall use the measuring unit selected for lengths.

When loaded from file, the program calculates the trajectory automatically and displays a lateral view and a horizontal view, without any features.

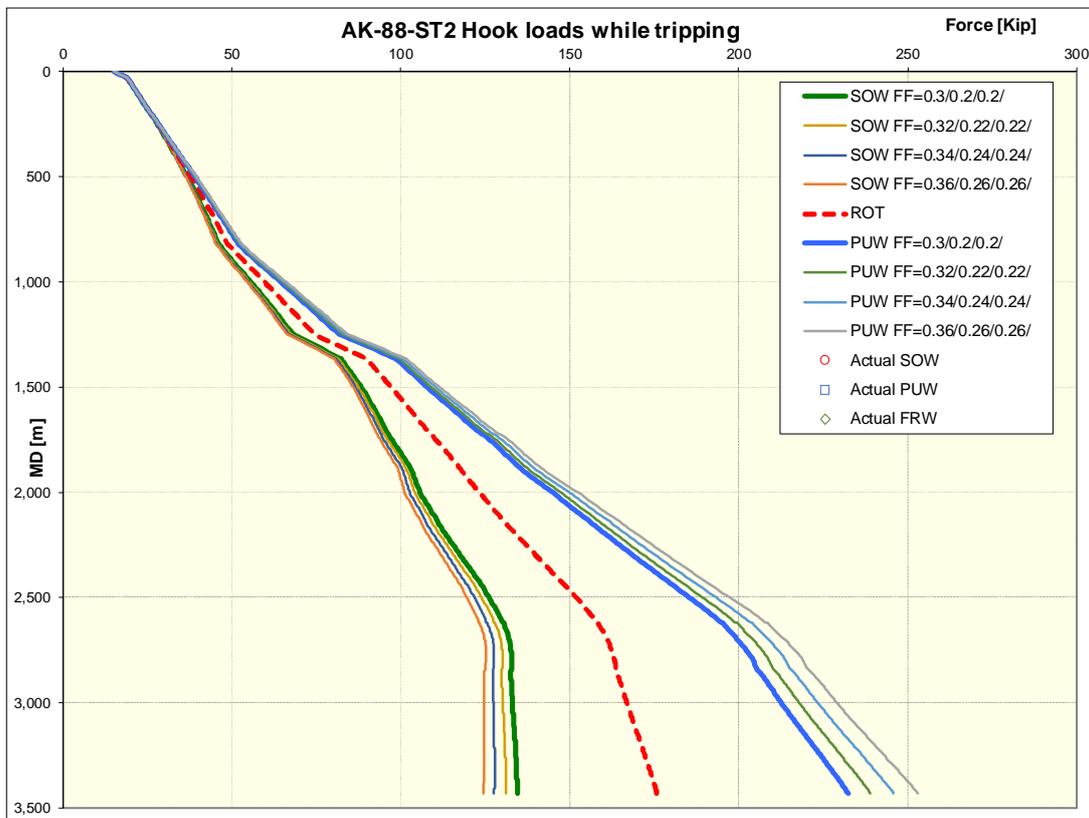
Result sheet

On this sheet it is printed the output of the module of the menu [Tripping]. The program converts first the results in the units selected by the user.

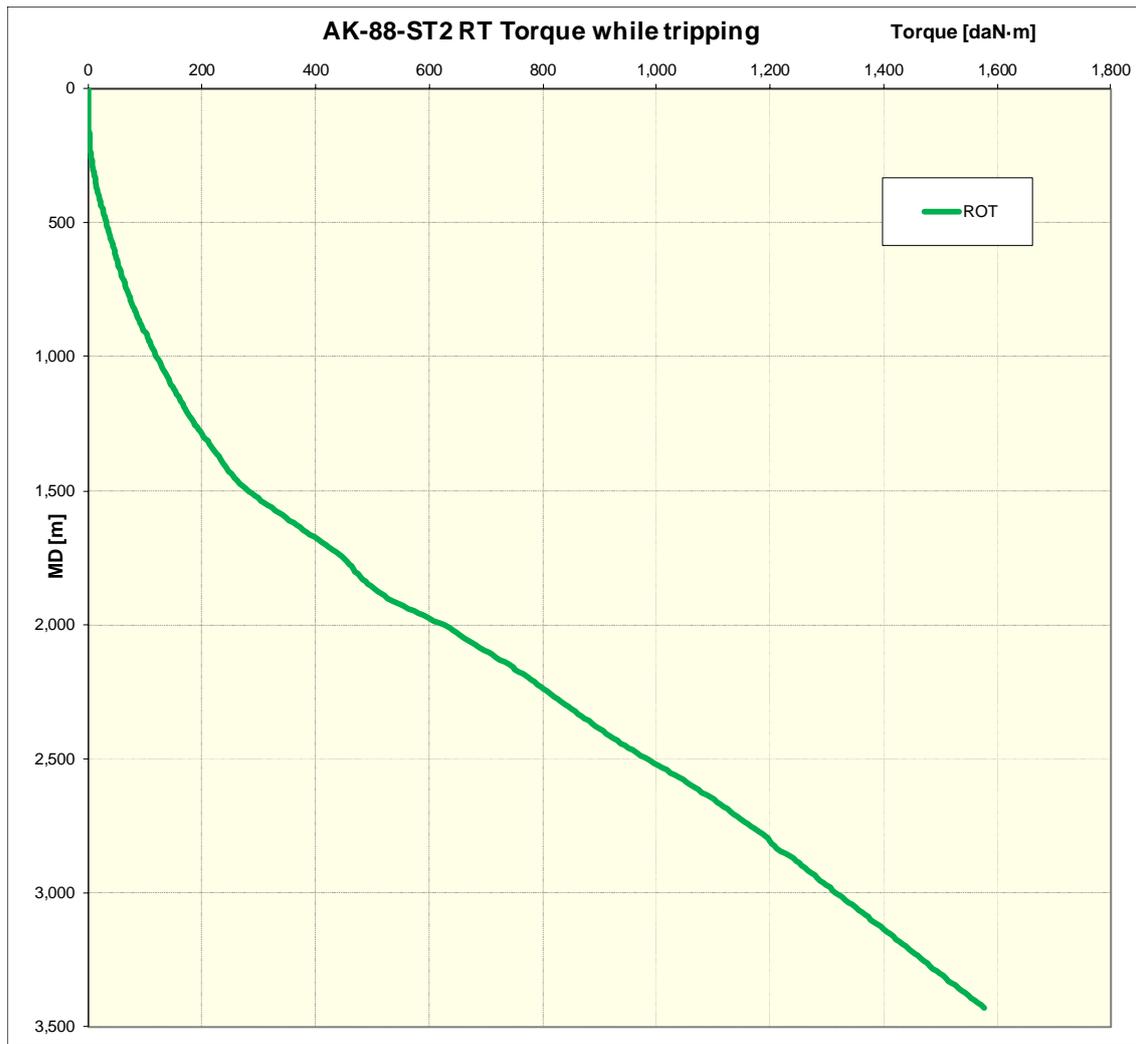
Graphs sheet

Is displaying on two charts the data printed on sheet Result.

The PUW, SOW and FRW are displayed on the leftmost chart, for a range of friction factors:



The Free Rotating Torque (FRW) at different bit depths along the hole, it is displayed on the rightmost chart:



Summary sheet

It displays two tables. The first one is the table with the input of the string. However, the linear weights of the elements shown here are the actual ones, which were used in the calculation, and not the nominal weights.

The second table is the summary of the output for the forces, torque, neutral points and zero axial points for each operation.

The other sheets

The rest of the sheets are used to display the rest of the output data, tabular and graphic:

