MEDCO
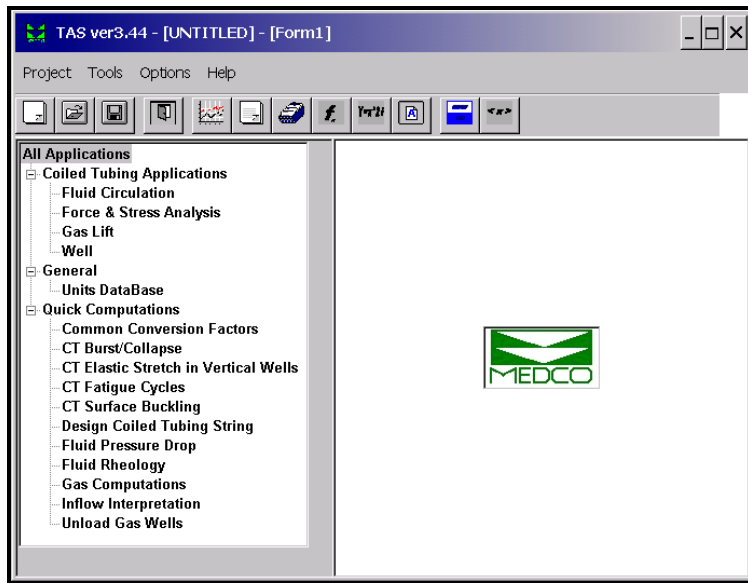## Modelling Engineering & Development Company Limited

Tubing Analysis System

TAS

Version 3.xx

User Manual

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Overview

Tubing Analysis System, *TAS*, is a simulation program comprising *Force & Stress Analysis*, *Fluid Circulation*, and *Gas Lift Analysis* modules. In all modules, the well profile is required. Hence, the program has an essential module which handles the well profile. The computations of the well profile are automatic whenever any of the other modules' computations are performed.

In addition, the program has several *quick computations* included. The quick computations are to help users perform simple tasks quickly and without the need to refer to tables or formulae.

A large database of many oil and gas industry equipment is also included. The database is aimed at easing the data entry in the program and is also available for general reference.

The simulations are based on mathematical algorithms from public domain libraries which are generally accepted in the oil and gas industry as valid algorithms. The algorithms will equally apply to many different applications in the oil and gas industry. For example, force & stress analysis algorithms were derived for well tubulars, such as drill pipe and casings, while the applications include coiled tubing and wireline too. Similarly, the fluid circulation module can be used for coiled tubing, drill pipe, under-balanced drilling, and many other fluid circulation applications.

Installation

TAS can be installed on any IBM compatible PC with Windows™ 32-bit platform as an operating system. The PC must have a USB port. The USB port is only needed for the security activation key (dongle).

Installation Instructions

- Installation files are normally zipped together.
- All the files are self-extracting. When a file is opened, the user will be prompted to confirm the path to which the files will be extracted. For example, the self-extracting files will unzip to "C:\Medco Applications Setup Files\TAS".
- Once the main file has been unzipped (i.e. files extracted), use Windows Explorer to open the folder to which the files were extracted. (for Windows explorer, right-click on START then select EXPLORE).
- Within the folder, there may be more self-extracting files that should be unzipped within the same folder and they will automatically unzip to "C:\Medco Applications Setup Files\TAS\disk1\" and "C:\Medco Applications Setup Files\TAS\disk2\" and so forth, depending on the number of disks associated with the program version being installed.
- After having unzipped all the sub-files, locate the program "setup.exe" within "C:\Medco Applications Setup Files\TAS\" or "C:\Medco Applications Setup Files\TAS\disk1\" and double-click to run.
- Follow the setup instructions.
- IMPORTANT If you do not remove a previously installed version of TAS, then you may receive a message warning you that "SETUP is about to replace a pre-existing file", and you will be given the option to Cancel Setup – you should reply NO – you will then get another message asking "Are you sure you want to continue?" to which you should reply YES. If you remove a previous installation then you will lose any changes you made to the settings. It is suggested that you do not remove a previous installation.

Instructions to Activate your Copy

- If using a hardware security activation key (dongle), then you need to install a driver for the dongle. The driver can be installed using the steps described in the section: see Security Activation Key – Dongle.
- For demo versions only, click here to download the *CopyControl* installation program. Setup *CopyControl* in the same manner as per the installation instructions above then run CopyCtrl (from START > PROGRAMS > CopyCtrl), obtain a serial number and send an email to support@medcotas.com indicating which application is being activated and your company affiliation.

DataBase Components

These components are required and must be installed prior to running TAS. They are automatically available on the computer if using Windows XP, otherwise they must be installed. Once installed, there is no need to re-install them for version updates unless specifically stated.

- DCOM95 for Windows 95 only Must be installed first.
- ActiveX Data Object(mdac_typ) Must be installed for all Windows 32-bit platforms (including Windows 95). If you have *Microsoft Access* installed then you do not need to perform this task.

See also
Security Activation Key (Dongle)

Activation Key (Dongle)

This key should be connected to a USB port of the computer. The Activation Key will not affect the normal operation of the computer. TAS will not run if the Activation Key has not been installed.

If using WINDOWS 2000, NT, or XP and you experience problems with the activation key, then download the following file and unzip then run SetupSysDriver (will be installed in "C:\Program Files\Rainbow Technologies\Sentinel System Driver") ftp://anonftp.rainbow.com/support/SSD5411-32bit.exe.

Your activation key will hold information on your company-ID and user-ID. It also holds information on additional modules acquired by the company/user.

Note that while you can install TAS on as many computers as you may wish, you will not be able to use any copies without the activation key.

Security Activation Key – Dongle

User Reference Manual

This reference manual describes how to enter/edit input data, perform computations and obtain graphical and tabular outputs. The program's front-end uses conventional windows interface. This means that the program can be used with or without a mouse.

The user can move from one object to another using the TAB key. The movement takes place through a sequence pre-defined in the program. To move back, use SHIFT + TAB. Once the desired object receives focus, the user may then perform the following action, depending on the object type:

Object Type	Action	Result
Menu option	Press Enter	Activates the menu option or displays the sub-menu
Command button	Press Enter	Activates the command
Options	Press Right/Left arrow key	Changes selected option to the next/previous in the list of options
	Press Enter	Select the current option with focus on
Check box	Press SpaceBar	Changes values, checked or unchecked
Grid	Press Up/Down arrow keys	Scrolls Up/Down one row
	Press Right/Left arrow keys	Scrolls Right/Left one column
	Press Enter	Makes the selected row the current row for editing

General Windows Controls

Menus and sub-menus can be accessed using the mouse by pointing at the desired Menu_Option and clicking the left button of the mouse once. Alternatively, pressing the ALT key, when the blank worksheet only is on display, will highlight the first Menu_Option. The user may then use either the arrow keys or the underlined letter of the desired Menu_Option to select.
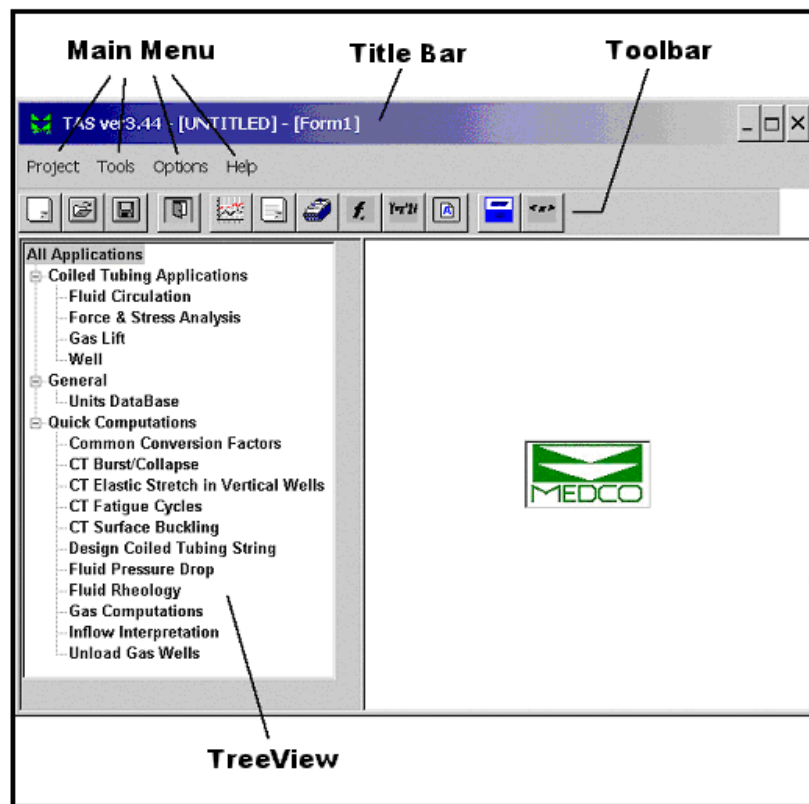
TAS Main Window

Text Box

A text box is used to enter a value which can be either *text* or a *number*. A text box is the simplest form of data entry field. Use of the various keyboard keys is permitted and functions such as copy, cut, and paste are also permitted.
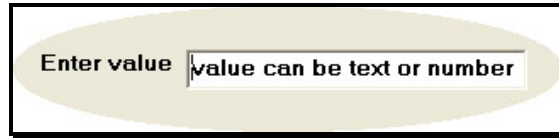
Text box

Command Buttons

These can be activated by clicking the mouse left button or by using the ALT + Underlined letter of the command button.

Command Button

Option Controls

These are used to allow the user to choose **one** out of several options. Option controls are found in frames that define the objective of the options. Only one option will be active at any one time and will be indicated by a solid circle inside a hollow circle. All other options will be inactive and have hollow circles.

To select an option, point at the desired option using the mouse and click the left button once. Alternatively, use the ALT + Underlined letter of the option.
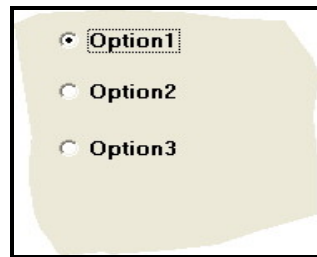
Option controls

Check Boxes

Check boxes are boolean variables that can have values of True or False. To change the value of a check box, use the mouse to point at the check box and click the left button once, alternatively, use the ALT + Underlined letter of the check box title.
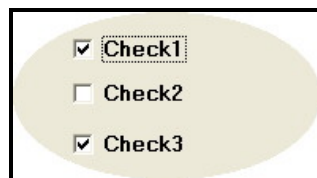
Check boxes

Grid Control

A grid control is different from a text box. Normally, the grid does not allow the user to write directly to any of the cells in the grid. However, a special procedure has been implemented in TAS to allow direct entries to the grid cells. The procedure uses a floating text box that moves to the grid cell receiving focus. Once a keyboard entry is made, the text box will automatically be activated and all the actions permitted in an ordinary text box will be also permitted. If you want to extend the width of the column simply press, hold and move left button of the mouse until you get the right width, then release.

In addition, there is a pop-up menu that can normally be accessed by pointing at a cell in the grid and right-click. The pop-up menu consists of 2 items:
- Insert Row: Used to insert a row above the current active row.
- Delete Row: Deletes the current active row. If this is the only row in the grid, then this action will only clear the contents of the current row.

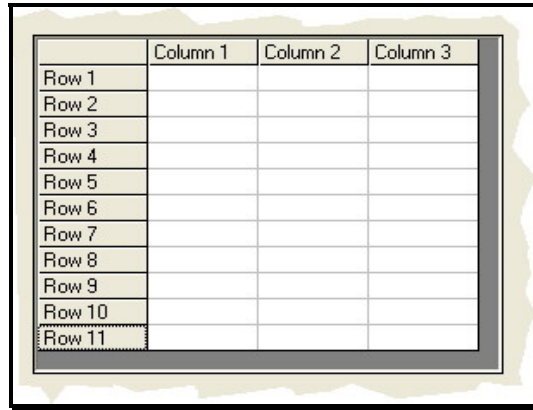|	Column 1	Column 2	Column 3
Row 1			
Row 2			
Row 3			
Row 4			
Row 5			
Row 6			
Row 7			
Row 8			
Row 9			
Row 10			
Row 11			

Grid control

Combo Box

A combo box contains a list of options where only one option can be selected. To see the list of options, the user needs to click on the small downwards pointing arrow on the right-hand-side of the combo box. If using the keyboard only then the up/down arrow keys can be used to go through the list but will not show all the options simultaneously.

Combo box

Edit Input Data

In general, the input data windows have command buttons and a unit's frame as well as various other controls that differ for different data groups. These controls are described below:

O.K.	<< Back	Next >>	Cancel
New	Open File	Save File	Save File As..

Units
- ⦿ API English   ○ Metric   ○ User Defined   Convert Units
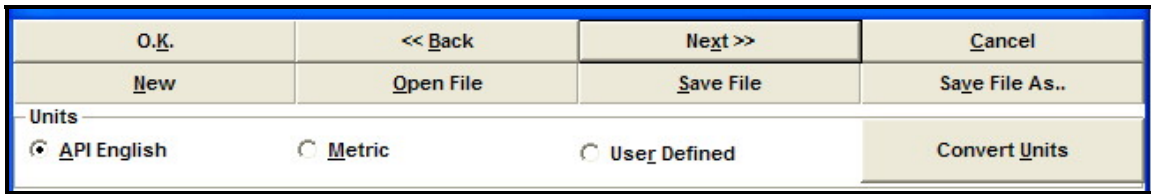
Edit window

Command Buttons

- **OK**: This is used to commit the data entry and close the window. The data in the program memory will be updated with the current values once this button is pressed.
- **<< BACK**: This button is equivalent to the OK button. In addition, it will display the previous "edit window". If the current window is the first in the sequence of "edit windows" then this button will not be available.
- **NEXT >>:** This is equivalent to the OK button. In addition, it will display the next "edit window". If the current window is the last in the sequence of "edit windows" then this button will not be available.
- **CANCEL**: Using this button will result in cancelling all the changes made in the current "edit window" and closing the window. The data in the program memory will revert back to the original data that was in memory before entering the "edit window".
- **NEW**: Will clear the current values in the current "edit window" and in the program memory and prepare to take new values.
- **OPEN FILE**: This is used to open and load data from a file. The data in this case is only relating to the current edit window. Note that by opening a file, you will not be able to CANCEL the changes made to the data in the program memory.
- **SAVE FILE**: Using this button will save the current values in the current file and will also commit the changes made in the current edit window to the program memory.
- **SAVE FILE AS..**: Using this button will save the current values in a file, to be specified by the user, and will also commit the changes made in the current edit window to the program memory.

The following list shows the order of the edit windows that is used in TAS.

1	**Header Information**
2	**Coiled Tubing Data**
3	**Job Data**
4	**Bottom Hole Assembly**
5	**Survey Data**
6	**Completion Data**
7	**Mud and Fluid in CT Data**
8	**Production Data**
9	**Fluid Data**
10	**Reservoir Data**
11	**Sand Data**
12	**Gas Lift Valves**

Units

There are three units systems implemented in TAS. The first conforms to the API English standards, the second conforms to the API Metric standards, while the third can be defined by the user and can use a mixture of various units systems and non-standard units. (see User Defined Units).

Selecting one of the above options merely tells TAS that the units used in this edit window are of the current option type. To actually convert the current values from one units system to another, the "Convert Units" button should be used.

Graphs
The following options and command buttons are available on all graphs.

Units Option
The graph can be viewed and/or printed either in API English, Metric, or User Defined units.

Alternative Graph List Box
There are three types of graphs that the user can display and/or print. The graph that will be shown will be that of your choice in MAIN MENU > OPTIONS. The other graphs would still be available by using this list box.

The exception is with graphs displaying vertical axis parameters that do not share common units, for example, weights and stresses. In this case only two graph types will be available to the user, both are with the logo option.
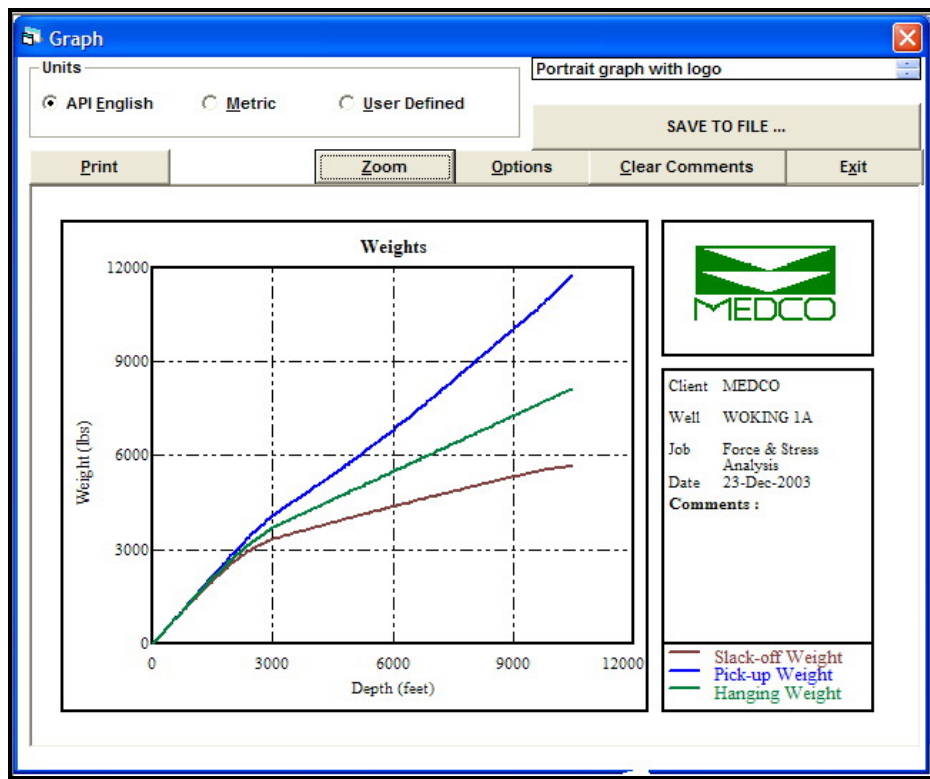
Landscape graph with logo
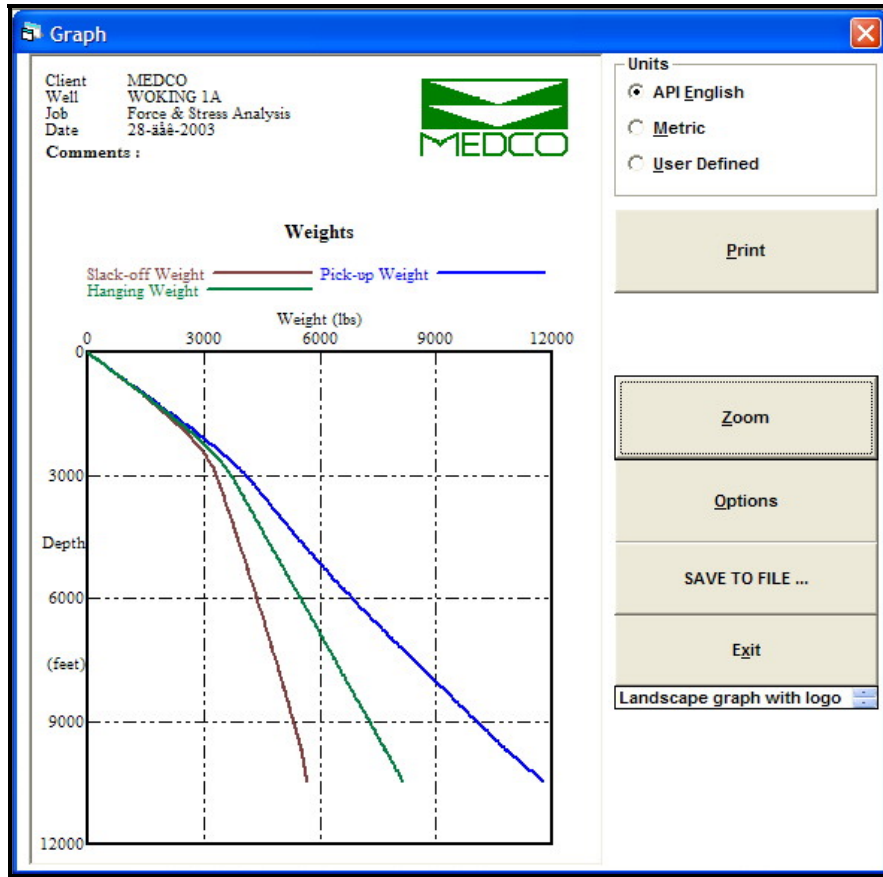
Portrait graph with logo

Landscape graph without logo

13
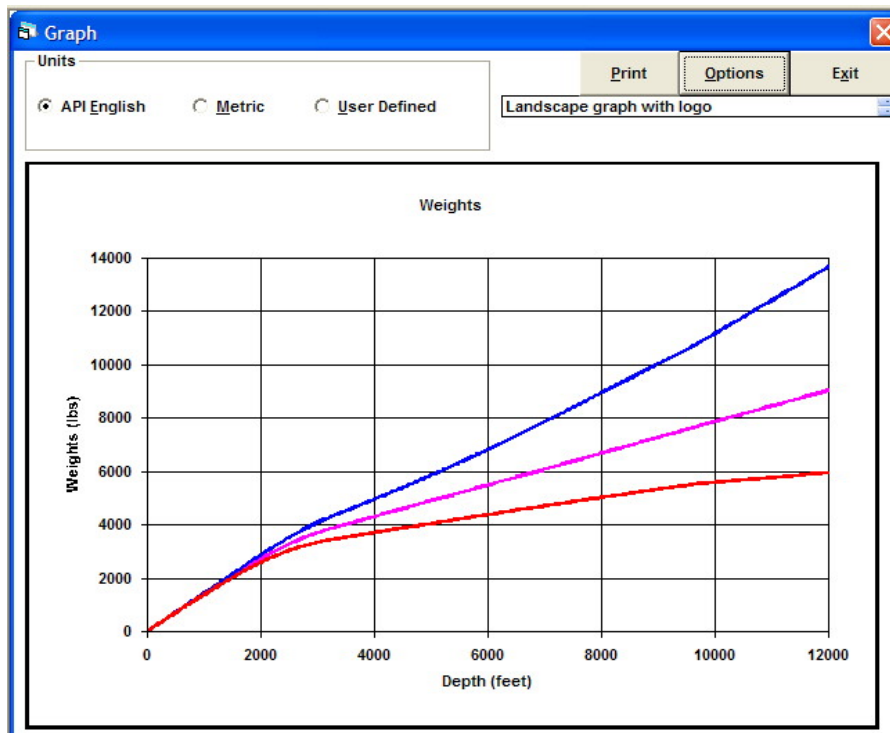
Graphs - continued

Save to file

This button is not available in the "Landscape graph without logo". Use this button to save the current graph to a bitmap file. The file will be available to other applications for inserting.

Print

Use this button to send the graph to print. When using the graphs with the logo and comments, you need to be carefull when selecting font as some printers do not support *True Type fonts*. If this is the case, then select *Graph fonts*.

Full View

This button is not available in the "Landscape graph without logo". The button is initially invisible and remains so until the **Zoom** command has been used. When this button is used the full horizontal scale is restored.

Zoom

This button is not available in the "Landscape graph without logo". It can be used to zoom-in to a portion of the horizontal axis. Once this button is clicked the mouse pointer within the graph will change to a cross. Pressing the mouse left button and holding the button down will define the left-most point then moving the mouse to the right and upon releasing the left button the right-most point is defined. The graph will automatically be re-drawn. Note that the left most and right most points should be selected close enough to reasonable sub-scaling range. To zoom-in the vertical axis set the minimum and maximum scales using the **options**.

Options

This will display a window of various graph options for the user.
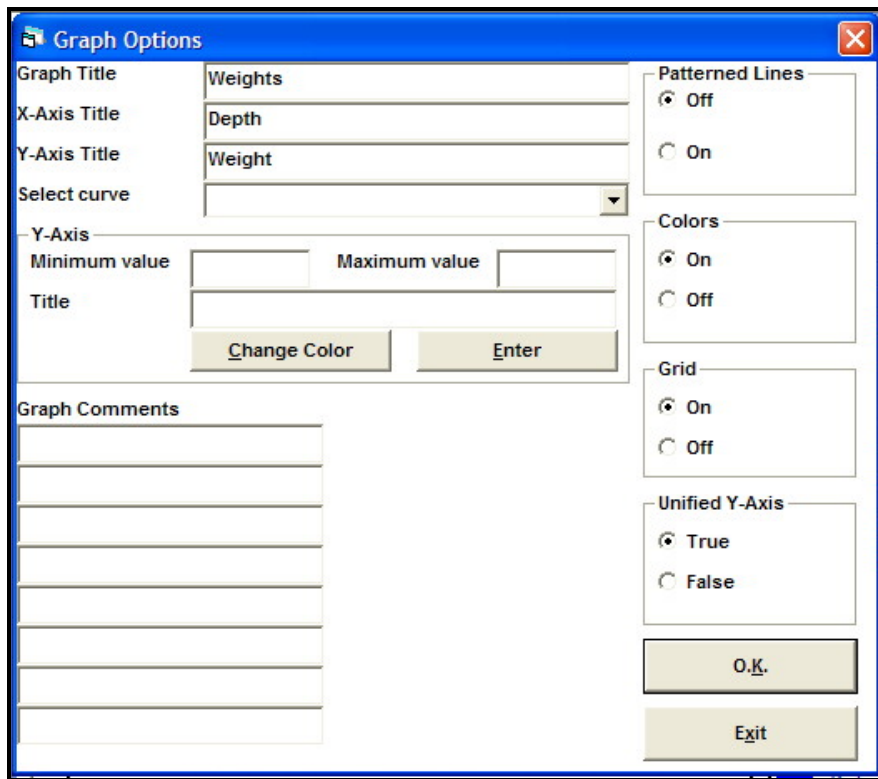
Graph options window

Graph Title

Enter or change the graph title.

X-Axis Title

Enter or change the x-axis title.

Y-Axis Title

Enter or change the y-axis title. This is only available for graphs with a unified Y-axis.

Select Curve

Use this selection box for selecting the curve which you wish to edit. The following parameters are available for editing. Only available in graph type "with logo and comments".

Y-Axis

    Minimum and Maximum Values

    The minimum and maximum values can be entered or changed here. Use these to zoom-in on the y-axis or to enhance the presentation scales.

    When the Unified Y-Axis is used, then changing the scales of the first curve will apply to all the curves on the graph.

    Title

    Used to enter or change the title of the individual curves.

    Change Color

    Can be used to change the default color of the individual curves.

    Enter

    Use this button to confirm that the changes to the selected curve have been completed and get ready for the next curve. Note if there are more than one curve, then the next curve will automatically get selected once this button is clicked.

Patterned Lines

If you do not have a color printer or plotter then use patterned lines with graphs having more than one curve.

Colors

Use this option if you wish to have different curves plotted in different colors. If you print, you must have a color printer or plotter.

Display Grid

Select the option you require.

Unified Y-Axis

This button is not available in the "Landscape graph without logo". This will only appear if all the curves share common units. In this case it is possible to unify the Y-Axis and a legend will appear at the bottom right hand corner.

Note that the Y-Axis title will change to the common words in the individual curves titles from the end. For example, if the curves plotted are "slack-off weight" and "pick-up weight" then the Y-Axis title will become "weight", while if the curves were "pick-up weight" and "maximum pull" then there are no common words and the Y-Axis title will be " ". To avoid the later case,

change the second curve title to "maximum pull weight" such that the word "weight" becomes common. This must be done before unifying the Y-Axis then return to the Graph Options to unify the Y-Axis.

Comments

Only available in one graph type, with logo and comments. There is room to enter up to 12 comments each can have up to 25 characters.

In the fluid circulation module, some readily defined comments can be inserted simply by double clicking the required comment. Note though that the comments will not clear or update themselves should the computations or the values change. It will be up to the user to remove any existing comments.

Clear Comments

The user can insert further comments on the graph area by moving the mouse cursor to any point within the graph area, then right-click to insert the comment. It is not possible to remove a single comment, however, it is possible to remove all the comments in the graph area by using the **Clear Comments** button.
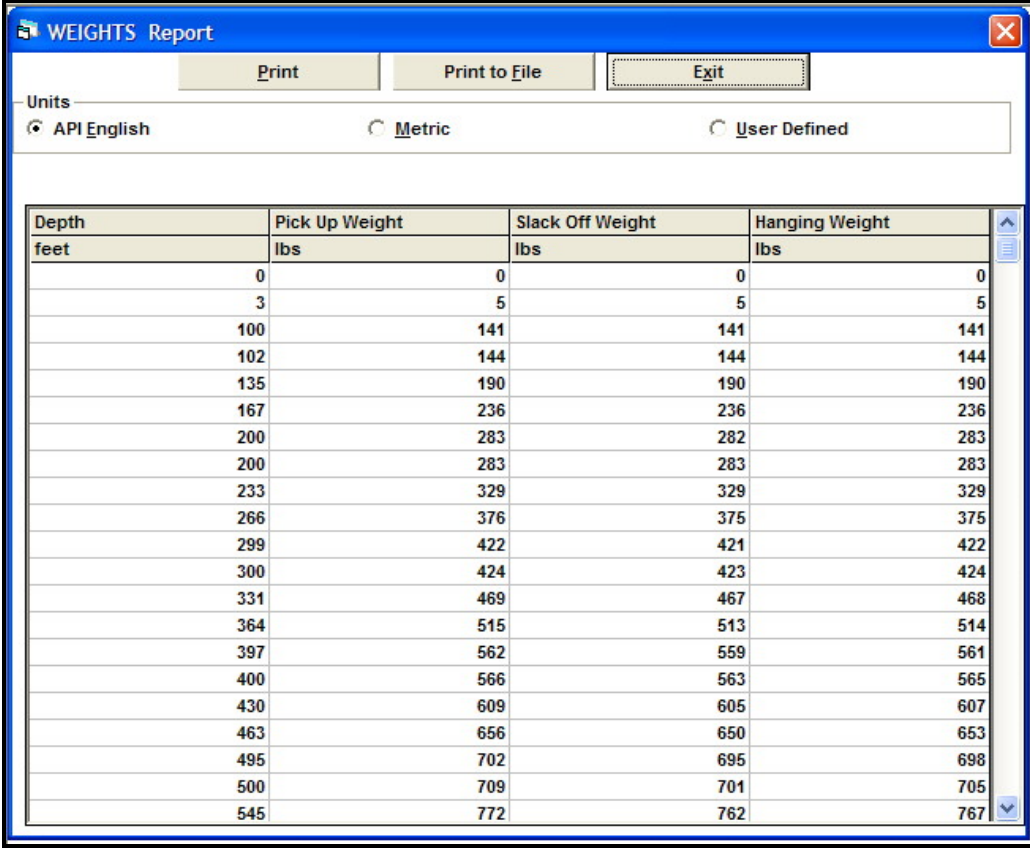
Exit

Use this button to exit the current graph.

Reports

Reports have the following command buttons.

WEIGHTS Report

| Print | Print to File | Exit |

Units
- ⦿ API English
- ○ Metric
- ○ User Defined

Depth	Pick Up Weight	Slack Off Weight	Hanging Weight
feet	lbs	lbs	lbs
0	0	0	0
3	5	5	5
100	141	141	141
102	144	144	144
135	190	190	190
167	236	236	236
200	283	282	283
200	283	283	283
233	329	329	329
266	376	375	375
299	422	421	422
300	424	423	424
331	469	467	468
364	515	513	514
397	562	559	561
400	566	563	565
430	609	605	607
463	656	650	653
495	702	695	698
500	709	701	705
545	772	762	767

Reports

Units Option
Use this option to display the report in *API English*, *Metric* or *User Defined* units.

Print
Use this button to print the report to the on-line printer. *Select-Fonts* form will appear if no fonts have been specified before, otherwise use Main Menu: Tools - Fonts to access this form.

Print to File
Use this command to print the report to a file. The file will be *ASCII format* and *comma delimited*. The file will have the extension ".out" and can be retrieved by any spreadsheet that has an import ASCII formatted file facility.

Exit
Use this button to quit viewing a report.

Main Menu

The main menu is available at all times but will be replaced by module's menu when any of the modules is active. When a module menu replaces the main menu, the main menu toolbar will still be available. The program main menu has the following options:

Project

This menu option is generally for opening, saving and printing project data. The sub-menu options are:

New

Use this option to erase all the input data from the program memory. This option will not affect data already saved in files.

Open

Use this option to open an existing project. All project names have the extension ".mak". Project files hold header data as well as the paths and names of all the data files corresponding to the edit windows.

Save

Use this option to save the project that is currently open. This option will save all data files as well, using the same names and locations. If you want to save the current project using a different name or location choose the next option, *Save As...*

Save As..

Use this option to save and name the active project in a specified location. To save a project with its existing name and location, use the above option, *Save*. This option will automatically create a sub-folder for the project using the same project name (without the extension ".mak"). The sub-folder will be created within the folder chosen for saving. For example, if the project is being saved as "Medco example 1.mak" in the path "C:\Program Files\TAS" then the actual path will become "C:\Program Files\TAS\Medco example 1".

Print All Input Data

Use this option to print all input data report. The default printer will be automatically used.

Print Preview

This option displays all the input data as it would be sent to the printer. The data will be displayed in an image that can be copied and thus becomes available for pasting to other applications such as *Microsoft Word*.

There are two buttons that will appear on the image, the COPY button which can be used to copy the current contents of the image, and CONTINUE/CLOSE button which can be used to advance to next page or in the case of the last page, will close the *Print Preview* image.
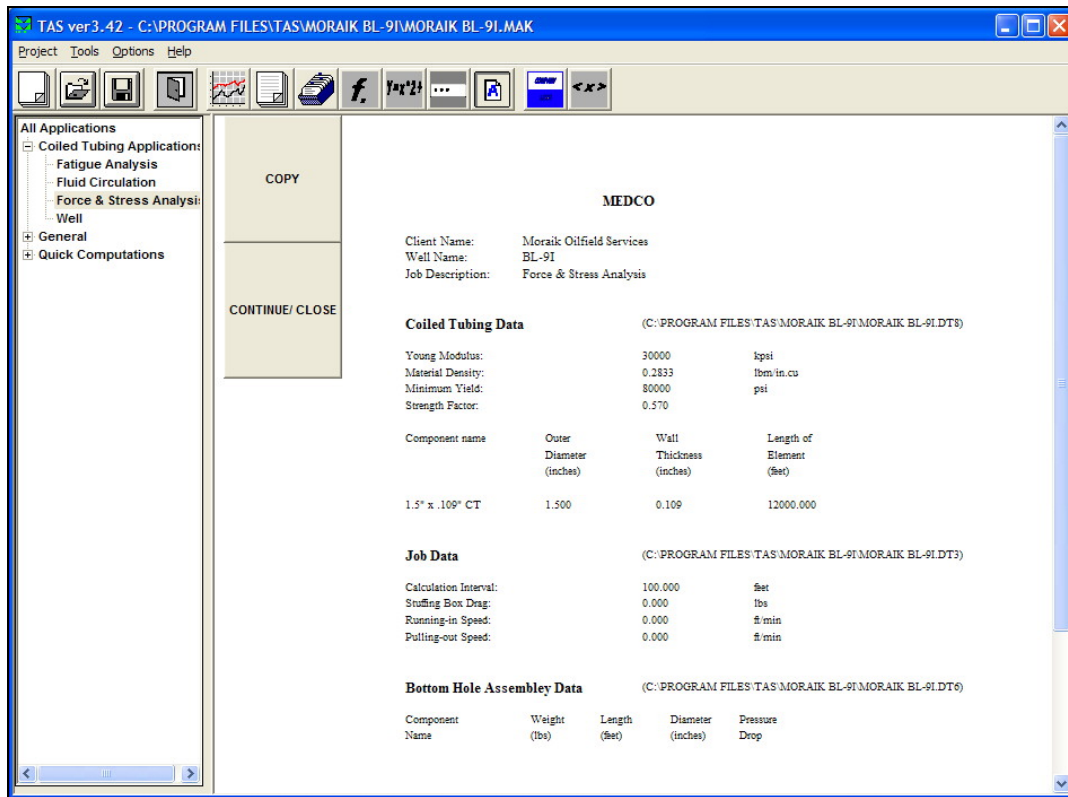
Print Preview

Exit

This option is used to exit TAS.

Last Projects

The last four projects will be displayed for quick access.

Tools

Customise Graph

This is a very useful feature that allows users to create *customised* graphs. Furthermore, you can store the customised settings such that in future you can use this graph of your own design as part of the *Graphs* menu options. These may be accessed by any of the graph buttons or menus within the following modules:

- Well
- Force/Stress
- Fluid

This tool can also be used to create a temporary customised graph, without necessarily saving it.
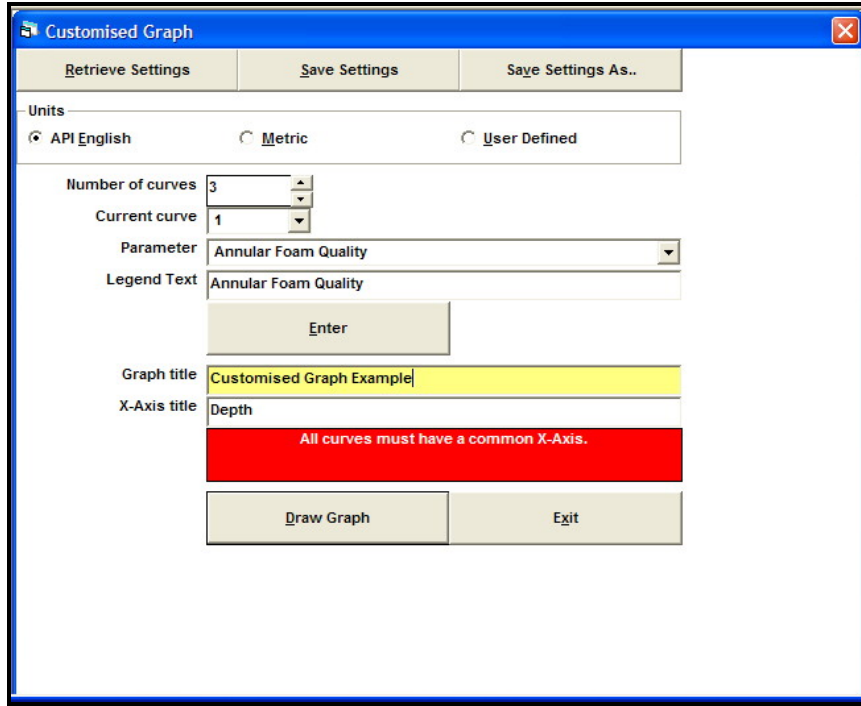
To customise a graph means that you can select any of the computed and/or any of the *user defined* parameters to plot.

Units Option

Select the units you desire for the graph.

Number of Curves

Up to eight curves can be plotted simultaneously. Note that if you intend to plot more than one curve, then they must all have a common x-axis, for example depth.

Customised Graph

Current Curve

Once you have specified the number of curves required, this selection box will have exactly the same number of curves. It is normal that you select curve number 1 then select the parameter that you desire for the curve then number 2 and so forth.

Parameter

This is the parameter you wish to include for the current curve selected. The list includes all the parameters that TAS computes and the user defined parameters. Note that if you select parameters that have not been computed, for example, if you have only carried out *drag computations* and you try to include "annular fluid velocity", then this curve will only produce a line at zero. See **List of Computed Parameters**.

Legend Text

Once the parameter has been selected, by default a legend text will appear. You can change this if you wish. This legend text will only apply to the curve representing the current parameter being added to the graph.

Enter

Use this button to confirm that you have finished entering the related data concerning the current curve. You should now go back to select the remaining parameters for the remaining curves.

Graph Title

This will remain blank unless you enter something in this box.

X-Axis Title

Once the first curve has been selected, this title will be filled automatically. You can change the title if you wish.

Draw Graph

Use this button to draw the graph. If all of your selected curves have a common Y-Axis then all three types of graphs will be available. Otherwise, only two graph types are capable of presenting curves with different Y-Axis scales and units, "graphs with logo".

Retrieve Settings

If you have already created a customised graph setting, then you can use this button to retrieve the settings from the settings file. Note that the settings file does not actually hold the computed data, rather it holds information on the selected parameters only.

Save Settings

Use this button to save settings with same file name as you have opened or previously used to save settings as..

Save Settings As..

If you have just created a customised graph from new and wish to keep the settings for future use, then use this button to name the settings file.

Customise Report

This option is similar to *Customise Graph*. A window for designing a customised report will appear. To design a customised report follow these steps:

Units Option

Select the units you desire for the report.

Number of Columns

Up to 9 columns can be placed in the report.

Column Number

Once you have specified the number of columns required, this selection box will have exactly the same number of columns. It is normal that you select column number 1 then select the parameter that you desire for the column then number 2 and so on.

Parameter

This is the parameter you wish to include for the current column selected. The list includes all the parameters that TAS computes and the user defined parameters. Note that if you select parameters that have not been computed, for example, if you have only carried out *drag computations* and you try to include "annular fluid velocity", then this column will only produce zeros. See **List of Computed Parameters**.

Enter

Use this button to confirm that you have finished entering the related data concerning the current column.

You can select the data that you desire for the header. The header information will be repeated for every page of the report.
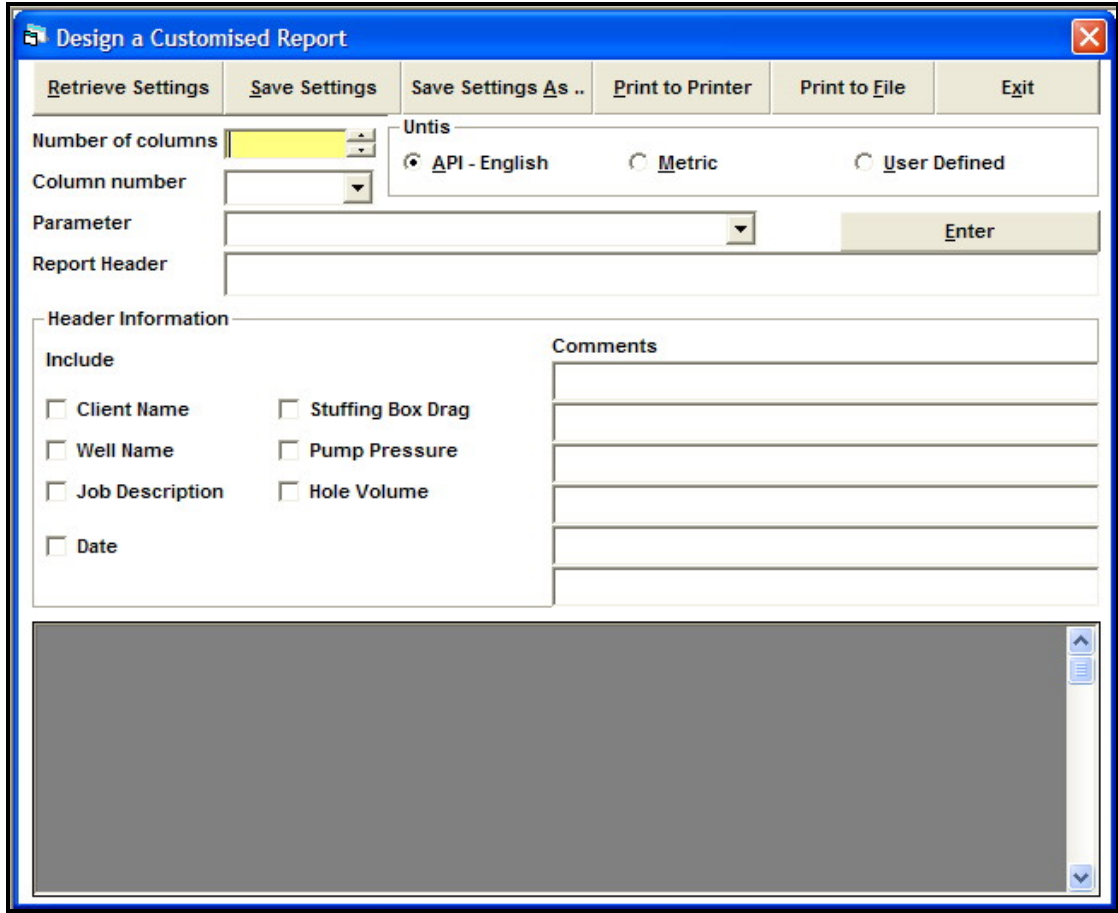
Customised Report

Retrieve Settings

If you have already created a customised report setting then you can use this button to retrieve the settings from the settings file. Note that the settings file does not actually hold the computed data, rather it holds information on the selected parameters only.

Save Settings

Use this button to save settings with same file name as you have opened or previously used to save settings as.

Save Settings As..

If you have just created a customised report from new and wish to keep the settings for future use, then use this button to name the settings file.

Print - To Printer

Prints the report in landscape and uses the default printer for destination.

Print - To File

Prints the report to an *ASCII format* file which has comma delimiters. File extension is "*.rpt*".

Edit DataBase

The Edit Database window is accessed via the Global module either by the button within the Global window or by the menu option at the top of the TAS window.

File

New

Use this option to clear the database from memory and prepare the database editor for opening another database file.

Open

Use this option to open a database file. If a database file is already open then use *File-New* to clear the database editor before opening another file.

Save

If you have changed the contents of the database file, then use this option before leaving the database editor. This option will save to the current opened file.

Save As

Use this option if you do not wish to over-write the database files used by TAS. In practice, this option should not be needed at all.

Exit

Use this option to end your database editing session. You will automatically be prompted to save the database file that you have been editing. If you wish to do so then click the *YES* button otherwise click the *NO* button.

Edit

Update

Use this option to update the contents of the current record being edited. This option is equivalent to using the UPDATE button.

Add

Use this option to add a new record to the current database. The new record will automatically be added as the last record. To re-organise the records in ascending alphabetical order use *Tools-Sort*. This option is equivalent to using the ADD button.

Delete

Use this option to remove the currently selected record from the database. This option is equivalent to using the DELETE button.

Clear

Use this option to clear the data fields and prepare to enter new record data. This option is equivalent to using the CLEAR button.

Tools

Sort

Use this option to sort the records in ascending alphabetical order.

Search

Use this option to search for a particular record. The search field is the description.

Print

Use this option to print the current database file contents.

Units

When retrieving the data of a record into TAS, the data will automatically be converted to the appropriate system of units as for the edit window regardless of the units used in the DataBase Editor for entering the record. You can, therefore, use either units system for entering data in the database.

Only one system of units may be used for a record.

API English
Use this option to set the units of the current record entry to API English. The API English units will be checked if this is the current selection.

Metric
Use this option to set the units of the current record entry to Metric. The Metric units will be checked if this is the current selection.

The database files included in TAS are:

Casing DataBase

Two files are associated with this database. "casings.def" is the structure definition file and "casings.dbs" is the actual database file which stores all the records. Each record in this database file has the following fields:

Description
The description of the record. In TAS, this parameter does not affect computations.

Weight/Length
The weight of the casing per unit length. In TAS, this parameter does not affect computations.

Outer Diameter
The outer diameter of the casing. In TAS, this parameter does not affect computations.

Inner Diameter
The inner diameter of the casing. This is an important parameter and is used by TAS in computations of force analysis and fluid circulation.

Friction Factor
The friction factor anticipated between the surface of this casing and the coiled tubing. This parameter will be used in TAS in force analysis only. Note that the same casing could be re-entered, using the *ADD* button, and a different friction factor could be used. Also, in TAS the user is still able to change the friction factor, if so desired.

Relative Roughness
The relative roughness is the *average size of the surface protrusions compared to the inner diameter of the casing*. This parameter is used in the fluid circulation computations and will only affect the flow in the turbulent regime.

Coiled Tubing DataBase

Two files are associated with this database. "ct.def" is the structure definition file and "ct.dbs" is the actual database file which stores all the records. Each record in this database file has the following fields:

Known Parameter

Two options appear in the list of possible known parameters. The inner diameter or the wall thickness. If you know the inner diameter of the coiled tubing then select inner diameter otherwise select wall thickness.

Description
The description of the record. In TAS, this parameter does not affect computations.

Weight/Length
The weight of the coiled tubing per unit length. In TAS, this parameter does not affect computations. TAS uses the material density of the coiled tubing which is entered in Edit Coiled Tubing Geometry Data.

Outer Diameter
The outer diameter of the coiled tubing. In TAS, this parameter is used in all computations.

Depending on your selection of Known Parameter, you will either get Inner Diameter or Wall Thickness:

> **Inner Diameter**
> The inner diameter of the coiled tubing. Used in all TAS computations.

> **Wall Thickness**
> The wall thickness of the coiled tubing. Using the outer diameter and this parameter, TAS will work out the inner diameter.

Note that TAS will always present the wall thickness to the user in any edit window regardless of the selected known parameter in the database.

Corrosion Factors Database

Two files are associated with this database. "corr_f.def" is the structure definition file and "corr_f.dbs" is the actual database file which stores all the records. Each record in this database file has the following fields:

> **Description**
> The description of the record. In TAS, this parameter does not affect computations.

> **Corrosion Factor**
> The corrosion factor relating to the fluid. This parameter is used in the fatigue computations.

> **Int./Ext. Corrosion**
> The corrosion can either act internally or externally. External corrosion will only affect the portion of the coiled tubing that is actually in the well while internal corrosion will affect the entire length of the coiled tubing.

> Use the full word Internal or External to input in this field.

Down Hole Tools Database

Two files are associated with this database. "dhtools.def" is the structure definition file and "dhtools.dbs" is the actual database file which stores all the records. Each record in this database file has the following fields:

> **Pressure Drop**

Four options are available which include none, constant, compute through nozzles, and table of pressure drop. Using the none or constant options will apply equally to the force analysis and the fluid circulation computations, while the compute through nozzles and table of pressure drop will only apply to the fluid circulation computations. The reason being that the later two require a flow rate to compute a pressure drop while the first two options will apply whether or not a flow rate exists.

Remember also that in the force analysis computations the user has the option of specifying pump-on or hold pressure constant. In the pump-on option the flow rate is assumed minimum while in hold pressure constant the pressure is set at surface then it is re-adjusted according to the hydrostatic fluid pressures both on the inside and the outside of the coiled tubing. In case the inside pressure exceeds the outside pressure plus the pressure drop through the bottom hole assembly leakage of fluids will occur.

Description
The description of the record. In TAS, this parameter does not affect computations.

Weight
The weight of the tool. This parameter will affect the end force on the bottom of the coiled tubing.

Length
The length of the tool. This parameter is used to compute the tool volume and the buoyancy.

Diameter
The outer diameter of the tool. This parameter is used to compute the tool volume and the buoyancy.

Depending on your selection of Pressure Drop, you will get "nothing", "pressure drop", "number of nozzles and nozzle diameter", or "a table of pressure drops at given flow rates":

Pressure Drop - Constant
A constant pressure drop though the tool regardless of flow rates. A typical example would be a sequence valve which is a check valve with a minimum pressure difference to be overcome before the valve would open.

Number of Nozzles - Compute through nozzles
The total number of nozzles. All nozzles will be assumed to have the same diameter.

Nozzle Diameter - Compute through nozzles
The diameter of the nozzle.

Table of Pressure Drops
Three pressure drops at corresponding flow rates are to be supplied. The fluid circulation will use these values to derive a second order polynomial that determines the pressure drop at any flow rate.

Fluids Database

Two files are associated with this database. "fluids.def" is the structure definition file and "fluids.dbs" is the actual database file which stores all the records. Each record in this database file has the following fields:

Rheology Model
Four options are available which include Newtonian, Power-law, Bingham-plastic, and Fann Rheometer readings.

Note that only Newtonian fluids may be used in the mud and fluid in CT data, reservoir data, and production data. Also, in fluid circulation data, using a flow type of foam will also force the user to use a Newtonian fluid.

Description
The description of the record. In TAS, this parameter does not affect computations.

Density
The density of the fluid. This parameter is used in both the force analysis and fluid circulation computations.

Surface Tension
The surface tension of the fluid. This parameter is used in the multi-phase algorithms appicable to the fluid circulation computations.

Surface tension can be measured by placing the fluid in a capillary tube and measuring the height of the fluid column. The surface tension force is supporting the weight of the fluid column, therefore:

$$(\text{surface tension}) \times (2\pi r) = (\text{height of column}) \times (\pi r^2) \times (\text{fluid density})$$

where r is the radius of the capillary tube.

Depending on your selection of Rheology Model, you will get the following:

Viscosity - Newtonian
The fluid viscosity.

Consistency Factor, K - Power-law
The consistency factor, K, of the fluid.

Power Index, n - Power-law
The power index, n, of the fluid.

Yield Point, YP - Bingham-plastic
The yield point, YP, of the fluid.

Plastic Viscosity, PV - Bingham-plastic
The plastic viscosity, PV, of the fluid.

Table of Fann Rheometer Readings
The Fann rheometer readings at the corresponding shear rates, expressed in rpm.

In all the fluid models, the fluid circulation will compute an effective viscosity of the fluid at the computed shear rate.

Welds Stress Concentration Factors Database

Two files are associated with this database. "weld_f.def" is the structure definition file and "weld_f.dbs" is the actual database file which stores all the records. Each record in this database file has the following fields:

Description
The description of the record. In TAS, this parameter does not affect computations.

Weld Factor

This is the weld stress concentration factor. A weld factor of unity means that no stress concentration exists while a weld factor of less than unity means that a stress concentration due to a weld exists. This parameter is used in the fatigue analysis module.

Functions and Algorithms

Here the user can change the algorithms used in multi-phase flow. The available algorithms are as follows:

- Duns and Ros
- Beggs and Brill
- Hagedorn and Brown
- Separate by deviation: With this option, the user can specify one algorithm for vertical to a given angle, then another algorithm from the given angle to horizontal. Again, the three algorithms listed above will be available to choose from in both cases.

By default, *TAS* uses Duns and Ros for vertical wells to 60° then Beggs and Brill from 60° to horizontal. If the user is not familiar with the effects of changing these algorithms, then it is strongly suggested that the default settings are used.
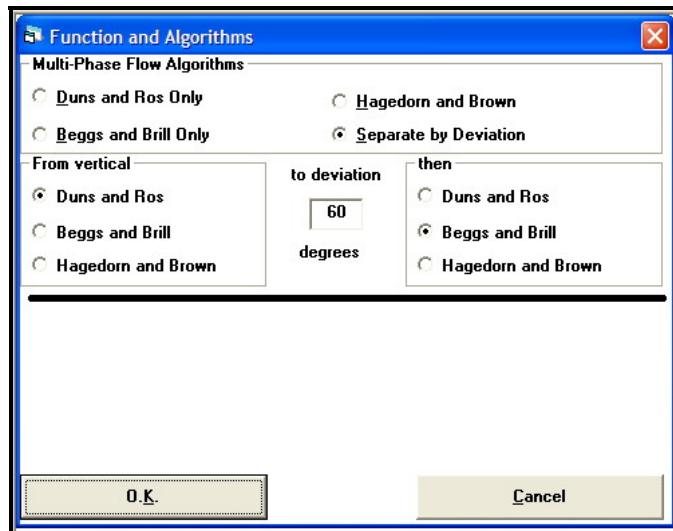
Functions and Algorithms

User Defined Parameters

TAS has a special feature which virtually makes the program "programmable". This feature, allows the user to define new parameters and have *TAS* compute them in the same way that the embedded parameters are computed.

The example used here is the equivalent "Differential Pressure" which has been named as "Example Parameter". The following equation represents the Differential Pressure:

$$P_{diff} = P_i - P_o$$

Where P_{diff} is the differential pressure, P_i is the internal pressure, and P_o is the external pressure. The steps followed to create the "Example Parameter" were:

- On the main menu, select TOOLS > USER DEFINED PARAMETERS
- In the text box for the *New Parameter Name*, enter the name "Example Parameter".
- Select the "CT Fluid Pressure" from the *Select Variable* list.
- Then click inside the space provided for the equation (title "*Equation goes here → Example Parameter =*").
- The "CT Fluid Pressure" parameter is entered in the equation as "x14". This is automatically done by the program.
- Next, select the *minus* operator "-" and again click in the equation box.
- Back to select variable and select "Annular Fluid Pressure".
- The "Annular Fluid Pressure" will be represented by the variable "x15".
- Click on the appropriate units for this parameter in the *Parameter Units* list. In this case, we have selected the units of "Pressure". This will assign pressure units to this new parameter which will also allow converting units from API English to Metric or User Defined.
- Finally, click on the *Add Parameter* button.

User Defined Parameters

To remove an existing parameter that was previously created using this feature, select the parameter from the *Select Existing Parameter* list then click the *Remove Parameter* button.

The list of mathematical operators available are:
- **"Constant number"**, must be typed in the equation box.
- "+ Plus" for addition
- "- minus" for subtraction
- "* times" for multiplication
- "/ divided by" for dividing
- "(left parenthesis"
- ") right parenthesis"
- "^ to the power of" for raising a number or value to the power of
- "sin(" for sine of an angle
- "cos(" for cosine of an angle
- "tan(" for tangent of an angle
- "log(" logarithm base 10
- "ln(" natural logarithm, base *e*
- "exp(" natural *e* to the power of
- "delta" this is the derivative, equivalent to $\dfrac{\partial x}{\partial D}$ where x is a variable and D is depth
- "sum" this the summation, equivalent to $\int x dD$ where x is a variable and D is depth
- "pi = 3.1415926" to insert the physical constant π

Fonts
To change the graph or print fonts, select this menu option.

Options
Owner Copy Options
The following is a list of the options that are used by the program in general:

Owner Name
Insert your company name here.

Default Directory
The path entered here will be the default path for the program to save and retrieve data as well as looking for customised graphs and reports.

Units
Select your preferred units system to be the default for the program.

Use Company Logo in Prints
When printing graphs or reports, *TAS* can either use the *owner name* or the company logo. To change the company logo, use the Change Logo button and locate the company logo.

Note that the company logo should be sized appropriately to give a presentable appearance. If in doubt, use the supplied MEDCO company logo and replace it's contents with your own company logo, keeping all other attributes the same.

Default Graph Option

There are two types of graphs used in *TAS*, a generic *Microsoft* chart and a special MEDCO chart. The Microsoft chart is limited in it's capabilities particularly when plotting multi y-axis charts. The MEDCO chart, on the other hand, can be used with multi y-axis plots, with company logo, and with comments too. Furthermore, the MEDCO chart can also be in Landscape or Portrait format. Thus, the list box will have the following options:

- "Landscape graph with logo" being the MEDCO chart in Landscape format.
- "Portrait graph with logo" being the MEDCO chart in Portrait format.
- "Graph without logo" being the Microsoft chart.

Screen Resolution
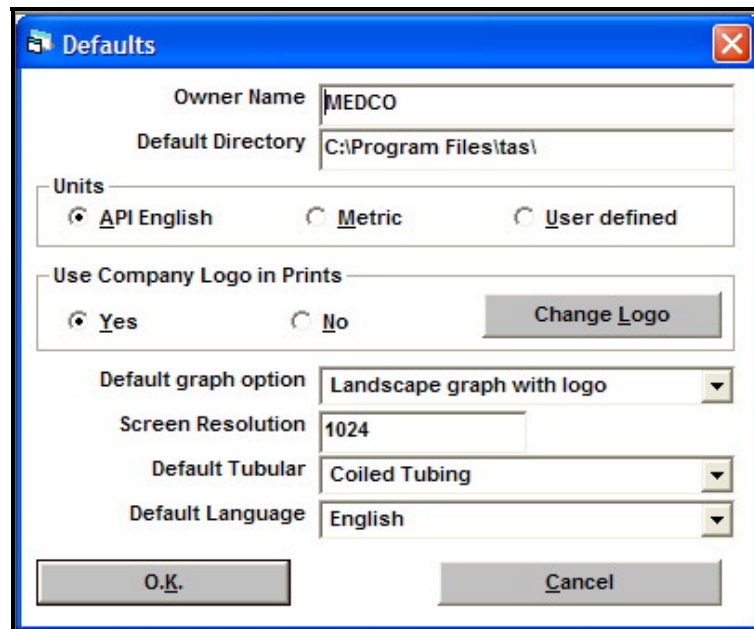
The program will automatically attempt to detect your computer screen resolution. However, should you find that the text on the graphs are not in the appropriate spaces, then this parameter may be fine tuned to remedy the situation. Normally, the program will detect the appropriate screen resolution.

Default Tubular

As *TAS* may be used for coiled tubing or drill pipe applications, this option will determine which is to be the default tubular application. Note though that you will still be able to enter data for other types of tubulars in the program but the main database that will be displayed will be that of the default tubular.

Default Language

If you have acquired a foreign language supported copy of *TAS* then use this option to tell the program which language you wish to operate. By default, the program runs in English.

Owner Copy Options

Minimum Maximum and Default Values

Each parameter used in the program will be restricted to values between the minimum and maximum values entered here. Should the user enter a value outside the range, the program will alert the user, but not stop, and if the user acknowledges that he/she wishes to change the value then the program will automatically replace the value by the default value for that type of parameter.

A *RESET* button is available to reset all the minimum, maximum, and default values to those supplied by MEDCO.

Parameter	Units	Minimum	Maximum	Default
Coiled Tubing Outer Diameter	inches	0.75	4.5	1.5
Coiled Tubing Wall Thickness	inches	0.067	0.204	0.109
Coiled Tubing Length	feet	0	30000	18000
Depth	feet	0	30000	15000
Stuffing Box Drag	lbs	-5000	10000	500
Running-in Speed	ft/min	-200	200	40
Pulling-out Speed	ft/min	-200	200	60
Fluid Density	lbs/gal	0	30	8.33
Tool Length	feet	0	1000	1
Tool Diameter	inches	0	10	1
Tool Weight	lbs	0	10000	5
Pressure	psi	0	30000	0
Liquid Volume	Barrels	0	10	1
Gas Volume	scf	0	10000	500
Liquid/Gas Time	secs	1	100	1
Viscosity	centi-poise	0.001	1000	1
Bingham Plastic Yield Point	lbs/100 sq.ft	0	1000	0
Surface Tension	dynes/cm	0	200	70
Temperature	deg.F	-40	350	50
Casing Size	inches	1	26	7
Friction Factor		0	1	0.2
Production Rate - Liquid	barrels/day	0	30000	0

Minimum, maximum, and default values

Help
To access the program help menu. The program help is the same as this document.

Coiled Tubing Applications

The coiled tubing applications comprise *Fluid Circulation*, *Force & Stress Analysis*, and *Well Profile*. When a module is selected, a sub-window or form will appear and the program main menu will be replaced by the module's own menu. However, the toolbar menus will remain unchanged.

The menu for each of the modules consist of the following:

Edit

For entering/editing the input data. The input data are arranged in categories and these are explained here:

Global Data This category of data applies to all the modules and cosists of:

Header Information

This is the header information and includes the *Client Name*, *Well Name,* and *Job Description*.

Coiled Tubing Geometry

This group of data is used for defining the *elements* that make up the coiled tubing string to be used in the job. Coiled tubing are either *parallel* or *tapered* strings.

A parallel coiled tubing string is made of a single element having a constant diameter and wall thickness throughout the string. A tapered coiled tubing string is made of elements having different wall thicknesses or outer diameters. It is not common to find tapered strings made of different outer diameters, though possible. More common is the use of a constant outer diameter but different wall thicknesses, hence different inner diameters. The program allows the use of either case of tapered strings, except in the Fatigue module, where a constant outer diameter is assumed.

IMPORTANT NOTE
When entering data of a tapered coiled tubing string, care must be taken in entering the elements in the right order. The right order in this case is *FIRST ELEMENT IN THE WELL* to be entered *FIRST*.

The coiled tubing data is therefore made up of four columns and any number of rows. Each row will hold data pertinent to one coiled tubing element.

The columns are used for the *Component Name*, *Length of element***,** *Outer diameter*, and *Wall thickness***.**

You can use the existing coiled tubing database to select the appropriate coiled tubing. The only parameter you still have to enter would be the length.

- **Young Modulus** This parameter will be used in both the force analysis and fatigue computations. While most coiled tubings supplied have a Young Modulus of $30x10^6$ psi, you may enter a different value here, particularly, if you were using TAS to model something else other than coiled tubing, such as cable or drill pipe.
- **Material Density** This parameter will only be used in force analysis computations. The default value is 0.2833 lb_m/in^3. You may enter a different value here, particularly, if you were using TAS to model something else other than coiled tubing, such as cable or drill pipe.
- **Minimum Yield** This is the coiled tubing minimum yield stress. This parameter is used in force analysis and fatigue computations. Currently, there are four known coiled tubing minimum yield values which are 70000, 80000, 90000 and 100000 psi.

Coiled Tubing With Cable

Some coiled tubing strings may contain a cable/wireline. This is normally used for logging highly deviated wells or for performing logging jobs simultaneously as circulating fluids through the coiled tubing. TAS allows the use of coiled tubing strings containing a logging cable.

When **drilling** with coiled tubing, it is often the case that a cable and two capillaries will exist. The cable will be used for transmitting data uphole while the capillaries for steering the bottom hole assembly. Since there is no facility to enter three cables, the user should improvise and use a single cable but re-compute the effective diameter and weight. The proper method for re-computing the effective diameter is to add the cross sectional areas of the capillaries and the cable then work out the diameter of a cable that would have this total area. The weight, on the other hand , is simply the sum of the weights per unit length.

Two parameters pertinent to the cable are required:
- **Cable Diameter** The diameter of the cable. Must be smaller than the minimum coiled tubing inner diameter.
- **Cable Weight** The cable weight per unit length.

Creating a True Tapered Section

A true tapered string can be created by selecting the **True Tapered Section** in the **Select Component.** A new window will pop-up prompting for the starting CT size (the first part of the true tapered string that will go into the well) and the end CT size (the last part of the true tapered string that will go into the well). By default, the true tapered section will have 10 equal lengths with equal wall thickness increments. The number of true tapered sub-sections can be increased or decreased in the pop-up window. The lengths and sizes of the sub-sections can be edited later in the coiled tubing geometry window by direct entry into the grid (i.e. after clicking the O.K. button).

Job Data

- **Calculation Interval:** The calculation interval is the distance between two calculation nodes. The program will automatically include all survey points, completions, and other points of interest as calculation nodes. In addition, calculation nodes will be added every calculation interval if they don't already exist. The maximum distance between two calculation nodes will be no more than the calculation interval.
- **Stuffing Box Drag:** The stuffing box drag or stripper friction needs to be estimated by the user. On the job, the user can actually compute the stuffing box drag by noting the difference in weight readings between pulling-out and running-in, in vertical section of the well, then dividing this difference by two will give the stuffing box drag.
- **Running-in and Pulling-out Speed**: As the program will be computing the fluid drg on the coiled tubing during it's journey in and out of the well.

Bottom Hole Assembly

This group is used for editing data pertinent to the down hole tools being used. Because of the pressure drop parameter described later, the only method for entering this group of data is to select the individual components from the down hole tools database. You should, therefore, make sure that your down hole tools database is comprehensive.

- **Component Name:** A description of the down hole component.
- **Weight:** The weight of the tool.
- **Length:** The length of the tool.
- **Diameter:** The outer diameter of the tool in inches. Must not exceed the minimum casing inner diameter.
- **Pressure Drop:** This is the pressure drop through the down hole tool when fluids are being pumped through. Only the type of pressure drop will appear here.

The remaining categories or data entry forms will be detailed in the relevant modules. The list below shows where to find a particular group.

Survey Data – See Well Profile Module.
Completion Data – See Well Profile Module.

Mud and Fluid in CT – See Force & Stress Analysis Module.
Production Data – See Force & Stress Analysis Module.

Fluid Circulation – See Fluid Circulation Module.
Reservoir Data – See Fluid Circulation Module.
Sand Data – See Fluid Circulation Module.
Gas Lift Valves – See Fluid Circulation Module.

Well Profile Module

Edit Input Data

Suvey Data

This group is used for entering the data pertinent to the well profile.
- **Depth:** The measured depth.
- **Inclination:** The inclination or deviation of the well measured from vertical in degrees.
- **Azimuth:** The azimuth of the well measured from true north in degrees.

Importing data from an ASCII formatted survey

The data for this group may be imported directly from an ASCII formated survey file. The required format is as follows;

    Number_of_survey_stations
    Measured_Depth , Inclination , Azimuth

i.e. the first line will tell TAS how many survey stations there are to follow then the data immediately appears after that. The data should be organised in three columns as shown above with a **comma** separator between the columns. The data can be in either API English, metric, or User Defined units and the appropriate **Units Option** in the edit window should be selected.

Completion Data

The completion data refers to the casing, tubing, or open hole sections that the coiled tubing will be going through during it's journey in and out of the well. That is, this data should refer only to the inner most casing/tubing in the well.

The information here includes the **component name**, **outer diameter**, **inner diameter**, **to depth**, **friction factor**, and **relative roughness**. The **component name** and the **outer diameter** are for presentation purposes only and, therefore, will not cause any errors if not entered.
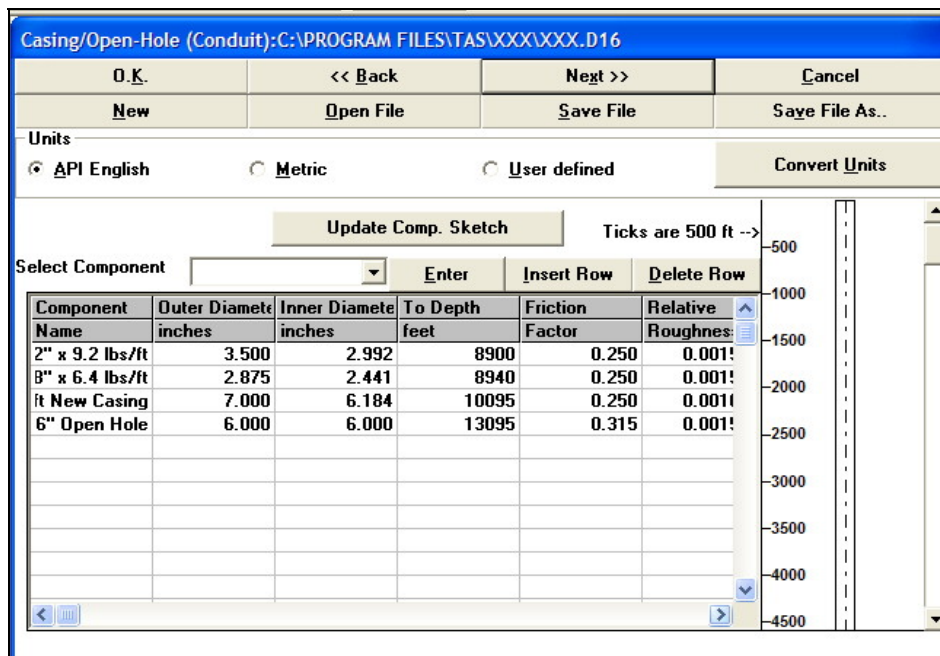- **Inner Diameter:** This is the casing/tubing inner diameter as seen by the coiled tubing. If, for example, the well has a production tubing inside the casing then it is the production string inner diameter that is required and not the casing.

- **To Depth:** The first completion component starts from surface, i.e. it starts *from depth* 0 and it occupies the space down to this parameter, *To Depth*. The next component will automatically start from the **To Depth** value of the current component.
- **Friction Factor:** The friction factor for the current component. The friction factor depends on the nature of the two surfaces that are in contact with each other. Hence, for a scaled part of the well or open hole, the friction factor should be increased to say 0.30 to 0.35 . For a new casing a friction factor of 0.20 can be assumed.

  In open hole, the friction factor will largely depend on the type of formation. For example, in one case study a friction factor of 0.27 was found to be accurate for open hole section in limestone formation.
- **Relative Roughness:** The relative roughness is the average size of the surface protrusions compared to the inner diameter.

You can select components from the casing database or you can enter the data directly into the grid.

Casing/Open-Hole (Conduit):C:\PROGRAM FILES\TAS\XXX\XXX.D16

Component Name	Outer Diameter inches	Inner Diameter inches	To Depth feet	Friction Factor	Relative Roughness
2" x 9.2 lbs/ft	3.500	2.992	8900	0.250	0.001!
3" x 6.4 lbs/ft	2.875	2.441	8940	0.250	0.001!
ft New Casing	7.000	6.184	10095	0.250	0.001(
6" Open Hole	6.000	6.000	13095	0.315	0.001!

Compute Well Profile

No options are available here. The computations will include the well profile and the geometry of the completion. The other modules will use the results of the this computation to identify the calculation nodes. Calculation nodes, along the length of the well, are created when this computation is done and the calculation nodes will include any survey points, any depths at which there is a completion size change, and further calculation nodes will be created at equal intervals determined by the *Calculation Interval* value entered in the *JOB DATA*.

In both, the force & stress analysis and the fluid circulation modules, the computations of this module will be automatically included even if not selected. Thus, if the intention is to carry out a force & stress analysis computation, then there will be no need to perform this computation separately, instead simply use the force & stress analysis *compute* option.

Well Profile Graphs
The graphs include the following:

Well Profile - Looking North
The positive distances represent distance towards the east while negative towards the west.

Well Profile - Looking West
The positive distances represent distance towrds the north while negative towards the south.

Polar Plot - Looking Down
This graph shows the azimuth of the well.

3D Well Profile
This is a 3-dimensional presentation of the well path. At the start, your view point is positioned directly above the well head at a distance pre-set and diplayed in the **distance** box. The view point is facing north, and the **focal point** is the well head. The **tilt** is the angle between the vertical and the line joining the view point to the well head. You can use the **vertical scroll bar** to change the tilt. The **azimuth** is the angle between the horizontal line in the north direction and the line joining the view point to the well head. You can use the **horizontal scroll bar** to change the azimuth. Note also that you can change the focal point to any position you wish.

To include a representation of the completion, select the check box option for **Draw Casing**. Then, to make a more dramatic visual impact, use the **adjust casing size** to exaggerate the casing size.

The well profile will be re-drawn instantaneously as you scroll using either the vertical or the horizontal scroll bar. To print the well profile, use the **print** option when you are satisfied with the view.
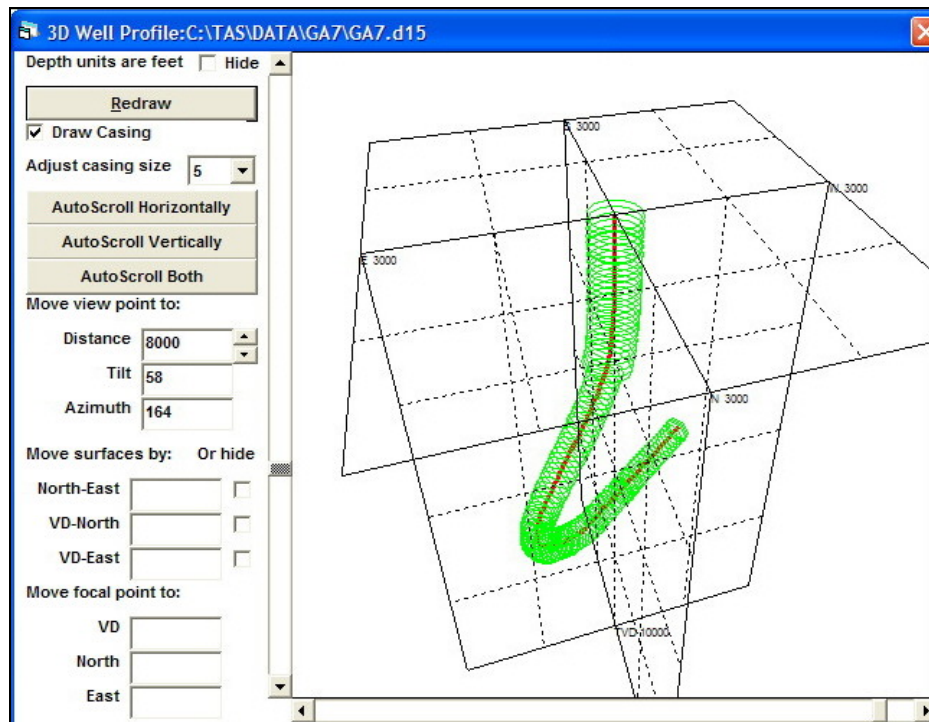
Well Profile Report
The well profile results include **True Vertical Depth**, **Horizontal Distance - East** and **Horizontal Distance - North.**

Force and Stress Analysis Module

Edit Input Data

Mud and Fluid in CT

You can have up to three different fluids in the well and one fluid in the coiled tubing. All the fluids used in this entry window must be Newtonian fluids and if attempts are made to select other than Newtonian fluids from the fluids database then these will not be accepted. The fluids in the well are termed *Bottom Mud*, *Intermediate Mud*, and *Surface Mud*. Each of these fluids as well as the fluid in the coiled tubing will have the following entries;

- **Weight:** This the density of the fluid. TAS allows up to three different fluids in a well.
- **Viscosity:** The fluid viscosity is required if the dynamic simulator is intended to be used.
- **Surface Tension:** The fluid surface tension is required if the dynamic simulator is intended to be used and there is a possibility of multi-phase flow to exist.
- **Top of this fluid at Depth:** Applies to the fluids in the well only. The *bottom mud* will occupy the interval between total depth of the well and this depth. If this parameter is non-zero then input boxes for *intermediate mud* will appear. The intermediate mud will occupy the space between the top of the *bottom mud* and the *intermediate mud's Top of this fluid at Depth*. If the *intermediate mud's Top of this fluid at Depth* is non-zero then the entry boxes for the *surface mud* will appear. There will not be an entry box for the surface mud Top of this fluid at Depth as this will always be to surface.

Production Data

This group is used for editing data pertinent to the well productivity. The production data will affect the Force and Stress Analysis calculations because the produced fluids can exert a drag force on the coiled tubing. The produced fluid drag will resist the running-in of the coiled tubing and will assist in the picking-up. Furthermore, the well head pressure is used in computing the end force on the coiled tubing.

Normal practice of running into wells of high well head pressure is to pump some fluid at a slow rate to enable the descent of the coiled tubing into the well without having to overcome too much of an end force on the

coiled tubing. This means that the pressure inside the coiled tubing must be at least equal to the well head pressure and any hydrostatic pressure if at depth. This assumption is automatically made in the program.

You can select fluids from the fluids database, alternatively enter the following parameters manually;
- **Produced Fluid Density:** The density of the fluid being produced.
- **Produced Fluid Viscosity:** The viscosity of the fluid being produced.
- **Well Head Pressure:** The well head pressure.
- **Flow Rate:** The flow rate of the produced fluid.

Production of gas does not affect the weight calculations significantly. However, care must be taken if productivity is very high and in small casing. To enter gas production then average the gas density and compute the flow rate in terms of units of volume of space rather than standard cubic units. Use *Quick Computations: Gas Computations* to do the conversions.

Compute Force & Stress (Drag computations)
This option initiates the drag computations. Stress analysis is automatically carried out with the Drag computations (they are combined) and will include computations of **tri-axial stress**. The computations will only consider the hydrostatic fluid pressures in computing the **hoop and radial stresses**. An option of using the circulation fluid pressures is available. Note that **bending stress** is automatically included if applicable.

A window appears informing the user of the total depth of the well and the total length of the coiled tubing string. By default, the program assumes a running-in depth equal to the lowest of the two. The user can change the **running-in depth (Compute to Depth)** to any value less than or equal to the lowest of total depth and total length of coiled tubing string. Note that the total depth will be the total well depth less the total bottom hole assembly length.

Several computation options can be activated here;

1. Use Circulation Pressure
This option may be used if you wish to include the effects of fluid circulation on the force and stress analysis computations.

When fluid circulation is taking place, the pressures both inside and outside the coiled tubing will change. Changes in the pressure have two main effects, the **neutral point** may be moved (this defines the point that separates stable and unstable regions of the coiled tubing), and the end force at the bottom of the coiled tubing will change due to changes in the pressure differential across the BHA. The circulation pressure will also affect the radial and hoop stresses.

2. Hang-up Analysis/Set-down Weight

The user has the option of performing a **Hang-up Analysis/Set-Down Weight** computations at the corresponding running-in depth. If the coiled tubing happens to **lock-up** before or at the running-in depth, then the Hang-up/Set-down weight analysis will not be performed.

The hang-up analysis basically means that the program will increment the compressive force at the bottom of the coiled tubing and will actually produce a **Force-In** vs **Force-Out** chart. This process is continued until lock-up is reached. The force-in being the force applied at surface and the force-out being the force transmitted to the bottom of the coiled tubing as a result of applying the force-in.

There are several instances where this type of analysis is useful. When setting a bridge plug, for example, it is often necessary to test the setting by performing a **set-down weight** test, or when **drilling** with coiled tubing the user is interested in finding out how much **weight-on-bit** can be achieved and what should be the weight at surface to obtain that weight-on-bit.

3. WOB at a given Hook Load
This option will compute the **weight-on-bit (WOB)** at a given hook load, i.e. at assuming a constant slack-off weight.

Note here that the computations will only be carried out for the interval where the hook load (or weight), is less than the predicted **slack-off weight** and greater than the **minimum slack-off weight**. The reason being that if the required hook load is greater than the predicted slack-off weight then you cannot push to bring up the weight to the required hook load and if the hook load is below the minimum slack-off weight then lock-up will occur before reaching the required hook load.

4. Slack-off Weight at a given WOB
If you are interested in predicting the slack-off weight with a constant push force applied at the bottom of the coiled tubing, such as a constant WOB, then this option will provide this analysis. Note that if the WOB exceeds the maximum WOB (see **Lower Bound** below) then the computations will stop at the corresponding depth.

5. BH Pull at a given Hook Load
This is similar to WOB at a given Hook Load (3), except that the bottom hole force is a pull and the hook load represents a pick-up weight.

6. Pick-up Weight at a given BH Pull
This is the same as Slack-off Weight at a given WOB (4), except that the bottom hole force is a pull and the predicted weight is for pick-up.

7. Lockup weight (lower bound)
The lower bound is the limit at which the coiled tubing will **lock-up**. This option will create a **minimum slack-off weight** at which the lock-up will occur. Also, this computation will provide the maximum WOB that can be applied. (see description of **lockup** below)

8. Maximum pull (upper bound)
The upper bound option computes the maximum pull available subject to a maximum **safety factor** to be specified by the user. The safety factor in this case is the maximum stress to be applied as a percentage of the minimum yield stress.

Note that when using the **upper bound** option, the **maximum bottom hole pull** will automatically be computed.

9. Switch off pump/pressure constant
You can either run-in the well with the pump ticking over, or shut off the pump and **Hold pressure constant**. If the pump is ticking over then, for the fluids to keep flowing, the pressure inside the coiled tubing will have to be slightly greater than the pressure in the well at the depth of the coiled tubing plus any pressure drop through the bottom hole assembly. Note that in the force analysis computations the pressure drop through the BHA is calculated using zero flow rates.

On holding the pressure constant, the program will assume that the pressure inside the coiled tubing when at surface is equal to the well head pressure plus any pressure drop through the bottom hole assembly. Note that you have the option of changing this pressure to anything lower. Once the coiled tubing is moved into the well, the pump is shut off and the pressure inside the coiled tubing will remain constant at the bottom of the coiled tubing, provided that this pressure does not exceed the well pressure plus the bottom hole assembly pressure drop in which case the pressure at the bottom of the coiled tubing will be re-adjusted. In the mean time the pressure at the pump will inevitably decrease because of the hydrostatic effect.

During the drag analysis computations, the program will automatically look out for lock-up should it occur. If indeed, lock-up is predicted, then a message will be displayed to inform the user and the computations will be terminated at the lock-up depth.

Definition of Lock Up

Lock up is defined as the point at which the coiled tubing ceases to make progress in the well. This would normally happen if the coiled tubing goes into helical buckling and the extra friction due to the buckling is causing more coiled tubing to become buckled rather than moving the end of the coiled tubing further into the well. i.e. additional forces exerted on the upper side of the coiled tubing are not being transmitted to the lower end. This criterion can be translated as the point at which force transmission to the bottom of the coiled tubing diminishes, however, mathematically "diminishes" is arbitrarily defined, i.e. can be described as a ratio of (force out / force in) being less than 1% or 0.5% or so on, while the stress limit is accurately described.

The criterion for lockup is, therefore, defined as the point at which the stresses in the coiled tubing reach the minimum yeild stress multiplied by the safety margin specified as the maximum % of minimum yield. When the coiled tubing goes through sinusoidal and helical buckling, bending stresses are induced and these will tend to increase the overall tri-axial stress. This implies that lockup is the point at which permanent deformation of the coiled tubing takes place.

Graphs of the Force & Stress Analysis Module
The following graphs are available in this in this module.

DragGraph
This graph presents the predicted weight curves. It is a dynamic graph showing the weight predictions when the coiled tubing free end is at the corresponding depth. There are several options here:

Pick Up The weight prediction during pick up. If the **upper bound** option in Compute Drag has been selected then the **maximum pull** curve will automatically appear.

Slack Off The weight prediction during slack off. If the **lower bound** option has been selected in Compute Drag then the **minimum weight** curve will automatically appear.

Hanging The weight prediction while stationary

Combined All the weight prediction on one graph

Tension/Compression
These graphs show the state of tension/compression, a snapshot, of the coiled tubing when the end of the coiled tubing is at the maximum depth.

Pick Up The tension/compression during pick up.

Slack Off The tension/compression during slack off.

Combined The pick up and slack off tension/compression.

Stress
Use this option to view and/or print the **tri-axial stresses**. The curves show the stress when the end of the coiled tubing is at the maximum depth.

Pick Up The stresses during pick up.

Slack Off The stresses during slack off.

Combined The stresses during pick up and slack off.

Hang-up/Set-down Analysis

If the Hang-up/Set-down weight analysis option was selected in Compute Drag & Stress then this graph will be enabled. This graph shows the **force-out** vs **force-in**, where the force-out is the force being transmitted to the bottom end of the coiled tubing while the force-in is the force needed to be applied at surface.

Weight-on-Bit

If the Hang-up/Set-down weight analysis option was selected in Compute Drag & Stress then this graph will be enabled. This graph will present the force-out vs force-in in a different view point being the weight at surface, or **hook load**, vs the **weight-on-bit**. Note that at a weight-on-bit of zero, the Hook Load is equivalent to the predicted slack-off (running-in) weight at the corresponding depth of the hang-up analysis.
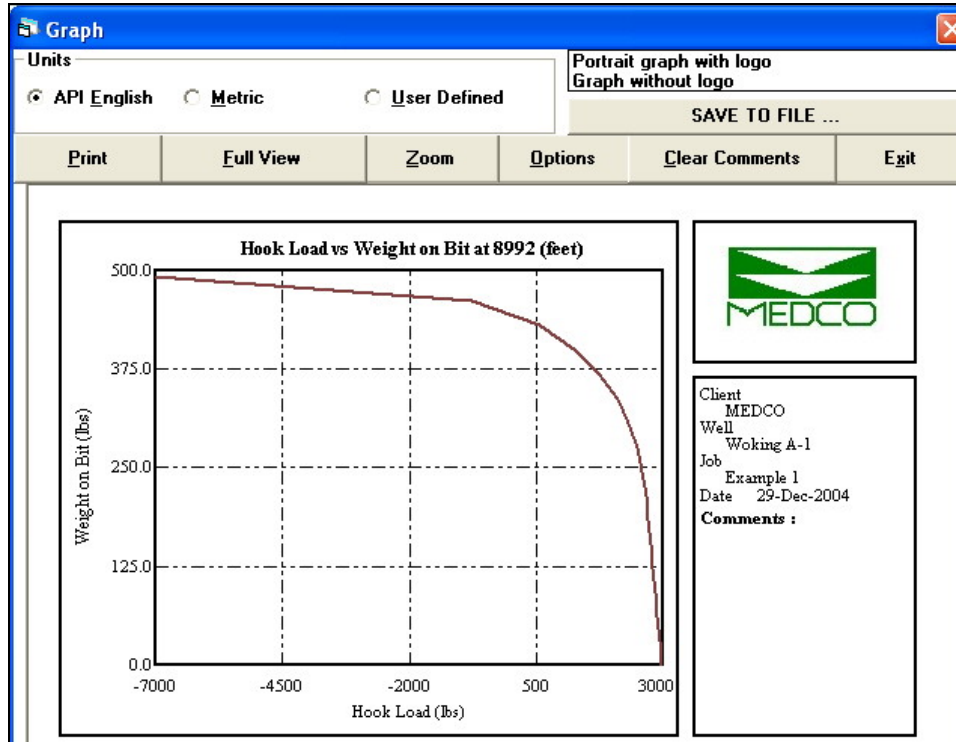
Reports of the Force & Stress Analysis Module

Weights

The outputs include the **Pick-up**, **Slack-off** and **Hanging** weights. These weights represent the predicted weights when the bottom end of the coiled tubing is at the corresponding depth.

Stress

The stresses included are the **Pick-up** and **Slack-off**. The stresses are when the coiled tubing has reached the required depth and these results show the state of stress at that moment.

Hang-up Analysis

This report will only be available if the Hang-up Analysis option has been selected in the Compute Drag. The parameters are the predicted **force-out** vs **force-in** and the corresponding **Hook Load**. Hook Load is the same as weight reading.

Fluid Circulation Module

Edit Input Data

Fluid Circulation

This group is used for editing the data pertinent to the fluid circulation module. Here, the pumped fluids are entered.

- **Flow Type Options:** This option defines the flow type to be used in the fluid circulation model. The program will automatically display the parameters pertinent to the selected flow and liquid types. The *flow type* is only referring to the flow type inside the coiled tubing. The program will account for other flows from different sources in the well such as reservoirs, coiled tubing, and gas lift valves. The options available are:
  - **Single Phase – Liquid:** Liquid only being pumped.
  - **Slug - Alternate Pumping:** Liquids are pumped through the coiled tubing for a period of time then purged by Nitrogen gas. The mixing of the two phases takes place in the annulus.
  - **Slug - Thro' T:** Both the liquid and the gas are pumped through the coiled tubing simultaneously. This means that multi-phase flow will actually exist inside the coiled tubing.
  - **Foam Flow:** Liquid and gas are mixed at surface and pumped through the coiled tubing in the shape of foam, i.e. using a surfactant agent.
  - **Nitrogen - Gas Lift:** Only Nitrogen gas is being pumped through the coiled tubing. The well must have a liquid that needs to be gas lifted. This computation will produce the steady state results when the fluids in the well have been lifted. It should be noted here that this type of computation should be repeated for the various stages of the gas lifting process.
  - **Siphon String:** No pumping is taking place. This option is for evaluating the outflow performance of the well through a siphon string. Siphon strings, also known as velocity strings, are normally used to unload gas wells that are producing some condensate. After the well has been producing and depletion takes place, the reservoir productivity will decline resulting in reduced gas velocity. If the gas velocity in the production string becomes too low to the extent that it is not capable of lifting the condensate droplets then accumulation of the condensate will occur and at some stage the hydrostatic of the condensate in the well will stop the well from flowing. The alternative is to insert a smaller production string which will increase the gas velocity thereby unloading the condensate.

    The production path can be through the coiled tubing, but it can also be through the gap between the coiled tubing and the existing production string. The siphon string option will perform the flow computations for three cases of outflow being the CT Outflow, Annular Outflow, and the Production Tubing Outflow in addition to the Inflow Performance.

    If the *Velcoity String* is only to be partially installed in the well, i.e. does not extend to surface, then the length of the CT string in *Edit - Coiled Tubing Geometry* should represent the length of CT that will be used as a velocity string. In this case the Annular Outflow performance will not be computed.

- **Liquid Type Options:** In all flow types, liquids exist. This option defines the mathematical model to be used to describe the liquid. The options available are:
  - **Newtonian:** This model describes a liquid which behaves according to Newton's definition of viscosity. Newton's definition is that viscosity is the constant of proportionality between the shear stress and the shear rate.

    Other liquids do not behave according to Newton's definition of viscosity, hence the term Non-Newtonian fluid. Instead the fluid viscosity becomes a function of the shear rate. Non-Newtonian fluids can also be described as Generalised Newtonian fluids, where the viscosity function can be reduced to describe a constant viscosity. Newtonian fluids are defined by one parameter, the viscosity.
  - **Power Law:** This model can describe the behaviour of shear thinning and shear thickening fluids. Power law fluids are defined by two parameters, the *consistency factor (K)* and the *power index (n)*.
  - **Bingham Plastic:** This model describes fluids that exhibit behaviour somewhat similar to solids in that they have a minimum yield stress to be overcome before the fluid starts to flow. Bingham plastic fluids are defined by two parameters, the *yield point (YP)* and the *plastic viscosity (PV)*.

- o **Fann Rheometer Readings:** While most fluids rheological behaviour can be sufficiently described using one of the mathematical models above, there are some fluids that cannot be properly approximated by these models. Thus, TAS allows the user to enter a table of Fann Rheometer readings directly. These readings correspond to six given shear rates which cover most of the range of application in the coiled tubing. In the computations, therefore, TAS will use the appropriate viscosity at the corresponding shear rate.
- **Compute Using Fixed**.. Flow rate or pump pressure. The program calculations will always be carried out using fixed flow rates, because the pressure can be readily computed in an explicit formula. If the user selects a fixed pump pressure, then the program will have to assume some flow rate and compute the pump pressure. If the resulting pump pressure does not match that specified by the user, then the program will re-adjust the flow rate and iterate until finding the right flow rate corresponding to the required pump pressure.
- **Liquid Phase Parameters:** The fluids can be selected from the fluids database. Alternatively, the following parameters must be entered manually.
  - o **Density:** If the flow type is gas lift then this parameter refers to the density of the liquid in the well. Otherwise, it is the density of the liquid being pumped.
    According to Liquid Type selected
  - o **Newtonian: Viscosity** The viscosity of the liquid in the well (in gas lift and siphon string flow type options) or the liquid being pumped in all other flow types.
  - o **Power Law: Consistency Factor(K):** The consistency factor of the liquid in the well or the liquid being pumped.
  - o **Power Law: Power Index(n):** The power index of the liquid in the well or the liquid being pumped.
  - o **Bingham Plastic: Plastic Viscosity(PV):** The plastic viscosity of the liquid in the well or the liquid being pumped.
  - o **Bingham Plastic: Yield Point(YP):** The yield point of the liquid in the well or the liquid being pumped.
  - o **Fann Rheometer Readings Table:** Six readings corresponding to 3, 6, 100, 200, 300, and 600 rpm.
  - o **Surface Tension:** The surface tension of the liquid in the well or the liquid being pumped. For water use 70 dynes/cm and for oil use 30 dynes/cm. Required only with Gas Lift and Slug Flow.
  - o **Flow Rate:** The flow rate of liquid being pumped.
- **Gas Phase Parameters**
  - o **Flow Rate:** The flow rate of gas being pumped.
- **Well Conditions**
  - o **Surface Temperature:** Surface or well head flowing temperature.
  - o **Bottom Hole Temperature:** Bottom hole (at total depth) flowing temperature.

- **Circulation Depth:** The depth at which fluid circulation is taking place, i.e. where the depth of the coiled tubing. This parameter is limited to the total depth of the well less the total length of the bottom hole assembly or the total length of the coiled tubing, whichever is the shortest.

Reservoir Data

This group of data relates to the reservoir. The reservoir is treated as a single point source/sink. The following reservoir properties need to be entered:

- **Reservoir Pressure:** The expected static reservoir pressure.
- **Reservoir Depth:** The measured depth of the reservoir, *not true vertical depth*. The TAS program will compute the Ture Vertical Depth of the reservoir.
- **Produced fluids' properties:** Whether it's oil, water, or both, the produced fluid properties needed are;
  - **Fluid Density:** The reservoir fluid density.
  - **Fluid Viscosity:** The reservoir fluid viscosity. Reservoir fluids must be **Newtonian**.
  - **Fluid Surface Tension:** The reservoir fluid surface tension. For oil use 30 dynes/cm, while for water use 70 dynes/cm.
- **Water/Oil Ratio:** The ratio of water volumes to oil volumes produced.
- **Flow Rate:** The reservoir production can either be computed by TAS or entered as fixed flow rates.

You can set the reservoir production either to be **computed** based on the reservoir productivity index or the **Fetkovitch** relationship or the production may be **fixed** regardless of the conditions in the well. If the option is set to computed then you will need to enter the following parameters;

Productivity Index

This parameter can be deduced from the **inflow performance** of the well. If the reservoir is producing liquids then this parameter is in terms of the oil production per pressure difference between the **reservoir pressure** and the **bore hole pressure**, or the bottom hole flowing pressure. If the reservoir is **Gas Only** then the productivity index relates to the gas production.

Fetkovitch Equation

This relationship is a better approximation of the reservoir inflow performance but does requires more information. The reservoir production, Q, is given by the relatioship;

$$Q = C \left(P_{reservoir}^2 - BHFP^2 \right)^n$$

where $P_{reservoir}$ is the static reservoir pressure,
    BHFP   is the bottom hole flowing pressure

The user has to supply the program with the two parameters **C** and **n**.

Gas/Oil Ratio

If the reservoir produces oil, then this parameter can be used to input the gas/oil ratio. This parameter can be left as zero if there is no gas production at all.

Gas Specific Gravity

If the reservoir is producing gas, with or without oil, then the gas specific gravity, relative to air under standard temperature and pressure conditions, must be entered. The program supplies a list of typical natural gas specific gravities commonly found. However, you can enter any number in this input.

Sand/Cuttings Data

This is the data relating to sand or the **cuttings,** when **drilling with coiled tubing,** to be cleaned out.

   Specific Gravity

The sand specific gravity relative to water. Most sand has a specific gravity close to 2.65.

Volume Concentration
A rule of thumb for cleaning out sand is to lift 1 lbf of sand per gallon of water. The water density is 8.33 lbf/gal, therefore, 1 lbm of sand will occupy a space of 1/(8.33x2.65) gallons giving a ratio of approximately 1/22 or 4.5% by volume. Therefore, the user is recommended not to exceed 5% concentration.

Minimum Mesh Size
The mesh size is inversely related to the particle size. Therefore, the minimum mesh size will indicate the maximum particle size.

Gas Lift Valves (Mandrels)

Use this option to include any gas lift mandrels in the well or to simulate a **parasite string** for injecting gas while performing an **under balanced drilling**. Up to six gas lift valves can be included.

Depth The depth of the gas lift valve or the parasite string.
Flow Rate The gas injection rate.

Compute Fluid Circulation

This option will perform the fluid circulation computations. A **fluid circulation module** form will appear giving the user the option of resetting the **relative roughness inside the coiled tubing** and the option to include the effects of **sand** or **cuttings** on the flow. Another option, only available for single phase flow, is to reverse circulate, i.e. the fluids will be pumped down the annulus and up the coiled tubing.

The relative roughness inside the coiled tubing is initially set to the default value for relative roughness or 0.001 which is true for most coiled tubings. However, if a braided cable exists inside the coiled tubing then this figure should be increased. Note that the size of the protrusions in this case will actually be the difference between the cable maximum and minimum diameters.

Another option available here is to **Perform Sensitivity Analysis**. This option may be used to perform several computations using different input values of a single parameter. Up to 10 parameters can be monitored in the sensitivity analysis. The following describes how to perform a sensitivity analysis;

- Tick the check box (Perform Sensitivity Analysis). Once this box is ticked, several controls will appear on the screen.
- Select the parameter you wish to vary. You have the option of changing the known pressure (i.e. what ever was selected in Edit Fluid Data), the liquid flow volume, the gas flow volume, or the circulation depth.
- Specify the range of values to be included.
- Select the number of steps required. By default this will be 10.
- Select the parameters you wish to monitor.

When the computations have been carried out, the parameters that were selected for monitoring will be available for display on the sensitivity analysis graph.

Graphs of the Fluid Circulation Module

Fluid Velocities

The velocities of the fluids being circulated both in the coiled tubing and in the annulus. When multi-phase - alternate pumping is used as the flow type, the fluid velocity in the coiled tubing represents that of the liquid phase.

Fluid Pressures

The pressures of the fluids being circulated both in the coiled tubing and in the annulus. When multi-phase - alternate pumping is used as the flow type, the fluid pressure in the coiled tubing represents that of the liquid phase.
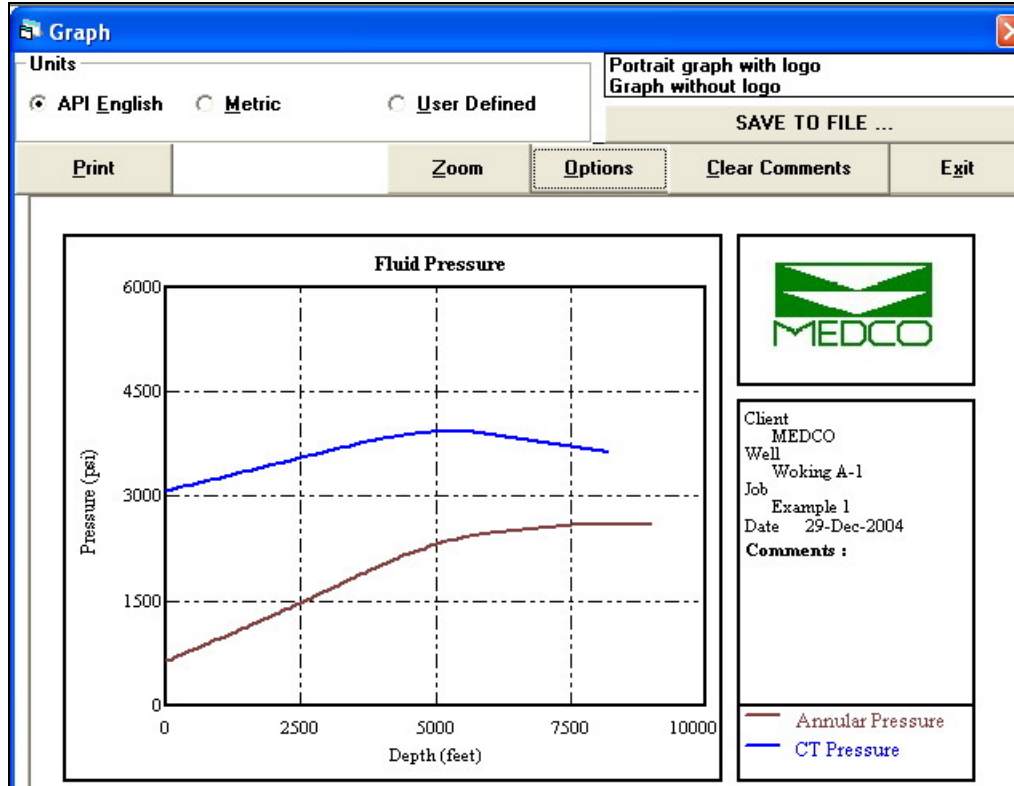
Penetration Rates

If the **Include Sand** option was used in the fluid circulation computations then this graph will be enabled. This graph presents the recommended penetration rates that will correspond to the sand or cuttings volume being lifted, i.e. at the percentage by volume of the liquid state.

Velocity String

This graph shows curves of Bottom Hole Flowing pressure against Flow Rate for the **Inflow Performance** and the **Outflow Performances..** of CT, Annular, and & Production Tubing.

Interpretation The Flow Rate or production rate of interest occurs at the intersection of an Outflow Performance curve with the Inflow Performance curve for a specific region of Outflow Performance curve. This region is the part of the Outflow Performance curve which has positive slope after having gone through a minimum turning point. Where there is no such intersect the well will not be producing for that particular Outflow Performance type.

At most there will be three such intersections and therefore three production rates. Whichever of these is highest gives the ideal production method.
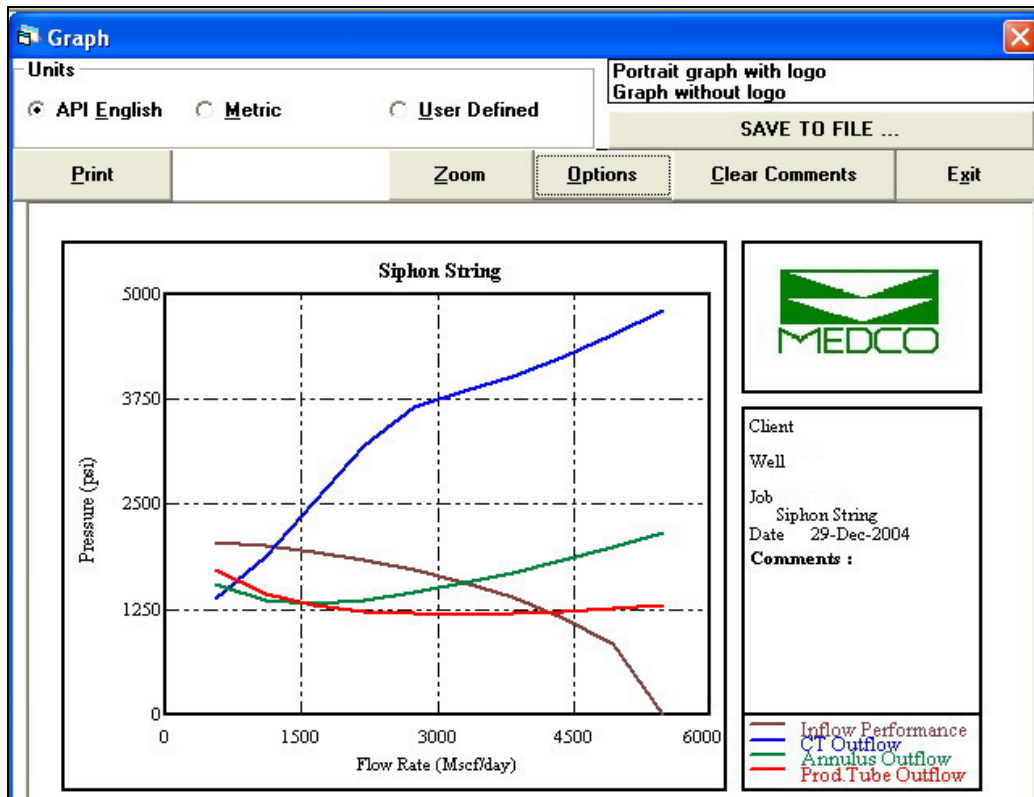
Sensitivity Analysis Graph

If the sensitivity analysis option had been used in the computations, then this graph will be enabled. The user simply has to select the parameters to be included in the graph and they will be plotted versus the variable selected by the user.
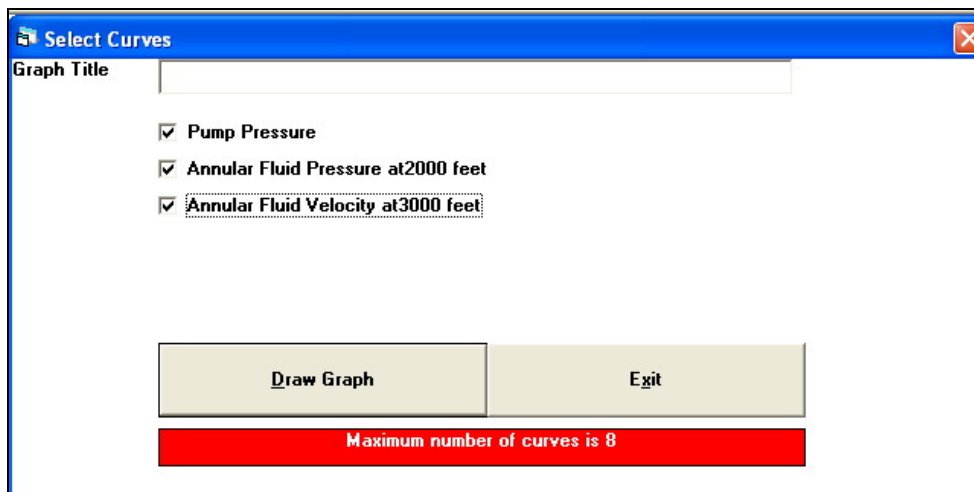
Reports of the Fluid Circulation Module

In multi-phase flows, the report is made up of more than one section, hence two more command buttons exist:

- **Next Page** Use this button to view the next part of the report.
- **Last Page** Use this button to view the previous part of the report.
  Note: When printing, all the fluid circulation reports will automatically go to print.
- **Choke Size Computation Method Options** Currently only two methods are used by the program, that is the **Baker** and the **Gilbert** methods. The Gilbert cannot be used if gas only is flowing through the surface choke, while the Baker method is not reliable for large choke sizes.

Definitions and Notes

- **Pump Pressure** Note that if the flow type is multi-phase flow - alternate pumping then this parameter will represent the pump pressure for the liquid stage.
- **Hole Volume** The volume of the annulus between the circulation depth to surface.
- **Bottoms up Time** The time taken for fluids in the annulus to reach the current depth from the circulation depth.
- **Foam Quality** The ratio of gas volume to total volume of foam.
- **Minimum Required Gas velocity** Used in gas lift. The gas velocity required to achieve a gas lift must be greater than the escape velocity of bubbles. If the gas velocity in the annulus is less than this figure, then the gas will escape in the form of bubbles without reducing the hydrostatic pressure in the annulus, i.e. no gas lift will take place.
- **Choke Size** This is the recommended choke size to use. It is only applicable when the flow has reached steady state. In gas lift, for example, the choke will be fully open at first, gradually reduced to the recommended choke size over the bottoms-up time to surface.

BHA Pressure Drops

When a bottom hole assembly is used, the pressure drops through each of the components will be shown in this report. In addition, if any of the components has nozzles, then the fluid velocities through the nozzles will also be shown here.

Quick Computations

Common Conversion Factors

A table of all the parameter types that are included in the UNITS DATABASE is presented. To convert the physical measurements from one unit system to another:

- select the units used for the known value.
- enter the value.
- select the units to which the value is to be converted.

CT Burst/Collapse Pressures

Use this option to plot the coiled tubing burst and collapse pressures versus load. The input parameters required are:

Outer Diameter The coiled tubing outer diameter.
Wall Thickness The coiled tubing wall thickness.
Minimum Yield Stress This parameter will already have the default minimum yield stress used in the program. You can change this if you wish and it will not affect the program defaults.
% of Minimum Yield The maximum stress shall not exceed % of minimum yield stress multiplied by the **minimum yield stress**.
Ovality The pipe ovality as a percentage. Ovality is defined as the ratio of *difference between maximum and minimum diameters* to *average diameter*.

$$Ovality = \frac{d_{max} - d_{min}}{d_{avg}}$$

Note that collapse pressures can be positive as well as negative. Negative collapse pressures mean that the coiled tubing will be able to withstand a higher pressure on the outside than the pressure inside the coiled tubing, while positive collapse pressure means that the coiled tubing must be pressurised from the inside to prevent collapse. The latter case would normally happen if the loading is close to the maximum load and **necking** is taking place. To prevent necking, or collapse, the tubing must be pressured from the inside.

Ovality will have a negative effect on the coiled tubing collapse pressure, i.e. the maximum collapse pressure is reduced as ovality increases.
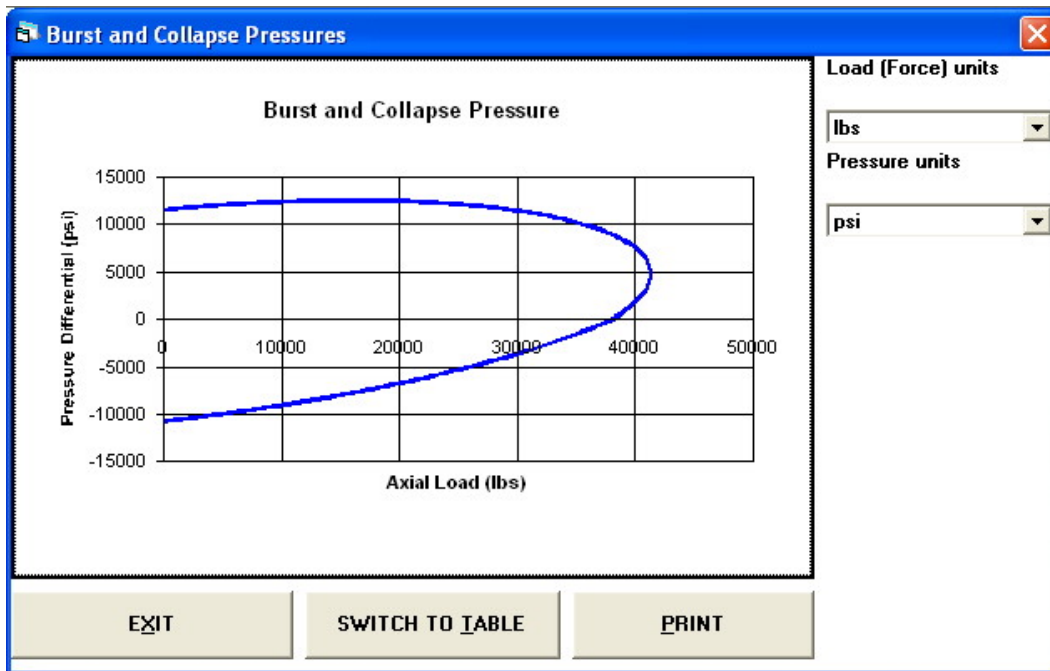
Elastic Stretch in Vertical Wells

This type of computation is used to compute the stretch of the coiled tubing in a vertical well. The computations assume that the pipe has not exceeded the elastic limits. The same type of computation can be used to estimate the stuck point, again only applicable in vertical wells and subject to the stresses remaining within the elastic range.

Elastic Stretch

This computation will also take into effect the thermal expansion of the coiled tubing as this could have a significant effect on the stretch. Thus, the input parameters required will **outer diameter**, **wall thickness**, **Young's modulus**, **current depth**, **current weight**, **weight of BHA**, and **temperatures**.

Stuck Point Calculation

From knowing the amount of stretch that can be achieved subject to a given overpull and constant thermal conditions, the stuck point can be estimated. The parameters needed here are **outer diameter**, **wall thickness**, **Young's modulus**, **stretch** seen at surface at a given overpull, and the **overpull**.

CT Fatigue Cycles

This option computes the number of cycles that a section of coiled tubing can go through before fatigue failure would occur. A **cycle is defined as running-in and out** from the reel and over the gooseneck. The input data required includes;

Outer Diameter The coiled tubing outer diameter.
Wall Thickness The coiled tubing wall thickness.
**Corrosion Factor** Select a corrosion factor from the corrosion database or enter a corrosion factor directly.
Stress Concentration Select a weld stress concentration factor from the weld factors database or enter the factor directly.
Minimum Yield Strength of the coiled tubing.
Reel Diameter The core diameter of the reel.
Gooseneck Radius
Range of Internal Pressure by default this will be 0 to 5000 psi or the equivalent in a different units system.
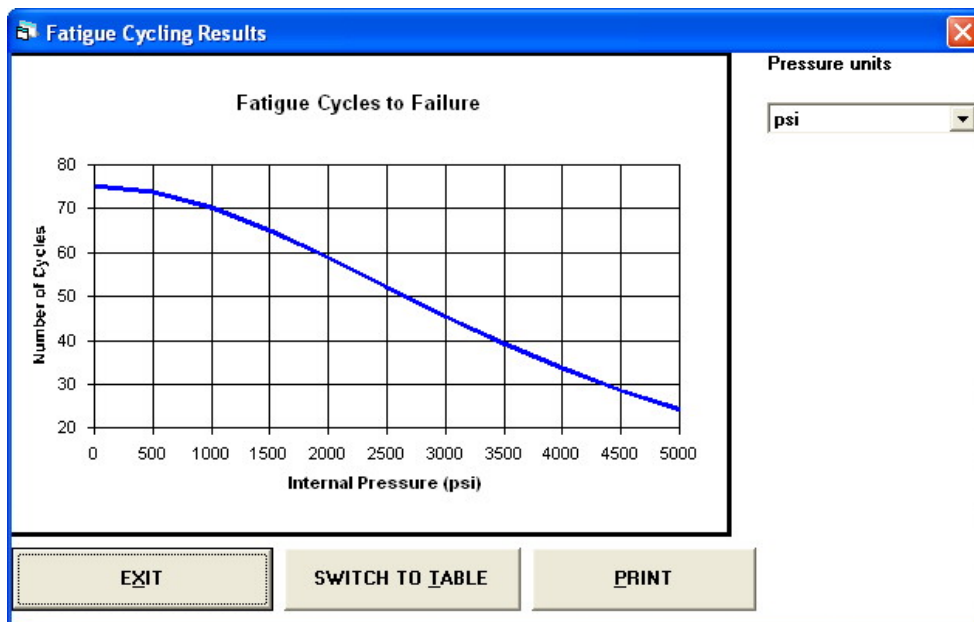
CT Surface Buckling

This computation calculates the maximum compressive force that can be applied to the coiled tubing segment between the lowest chain block and the stripper box. There are three formulae that are included here:

The Secant Formula This formula will include the effects of eccentricity. The computations will assume a range of eccentricity values ranging from 0 to a distance equivalent to the radius of the coiled tubing.
The other two formulae The **Parabolic** and the **Gordon-Rankine**. The Parabolic formula will almost give a result equivalent to a perfectly concentric case while the Gordon-Rankine will give a result almost equivalent to worst case eccentricity.
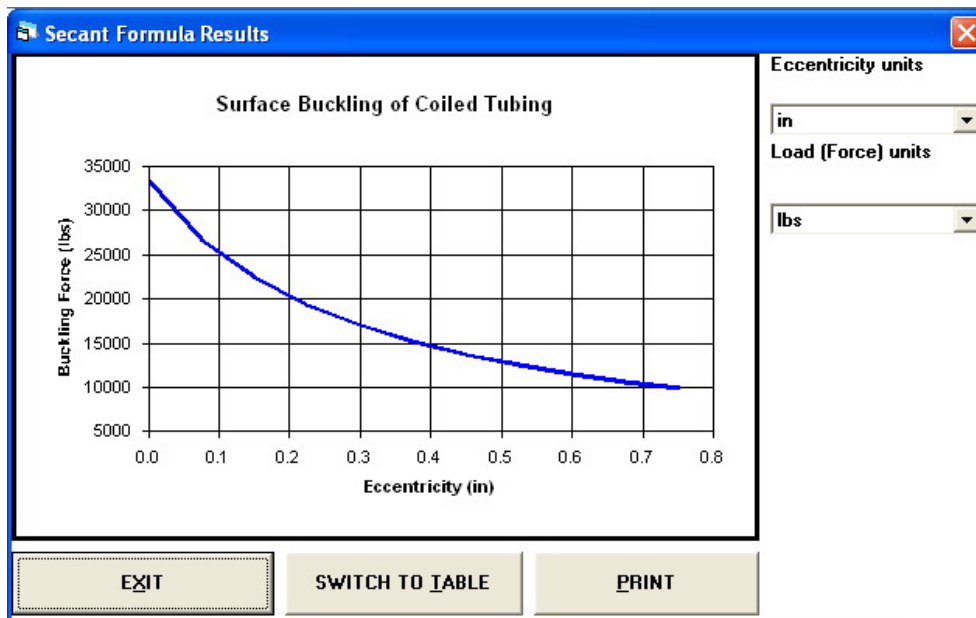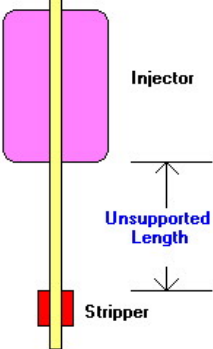
Design Coiled Tubing String

Use this option to design a coiled string. The design is based on a coiled tubing in a dry vertical well. Note that in designing a tapered string the first element that goes in the well must be entered first. The input data required consists of:

Outer Diameter The coiled tubing outer diameter.
Wall Thickness The coiled tubing wall thickness.
The design criterion can be any one of the following:
% of minimum yield This represents designing a string with a safety margin. The safety margin will be 100% less the figure entered here.
length of element The length of the element.
available overpull
% of Minimum Yield

Once the above data has been entered, use the **compute and add** button to perform the computations for this element.

Computed Parameters
Inner Diameter The coiled tubing element inner diameter.
% of minimum yield.
Length of the element.
Overpull available
Weight of Element The weight of the coiled tubing element including the cable if installed.
Inner Volume The inner volume of the element accounting for the cable if installed.
Outer Displacement Volume The outer displacement of the coiled tubing element.
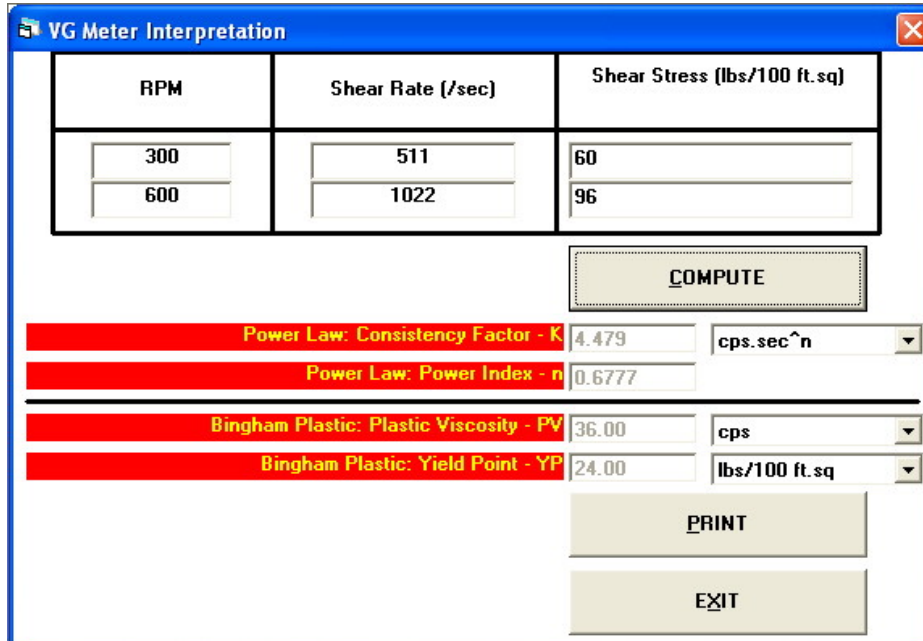
Fluid Pressure Drop

This computation can be used to compute the fluid pressure drop, friction pressure only, in either **pipe** or **annular** flow domains. The fluids can be either **Newtonian**, **Power-Law**, or **Bingham-Plastic**. The parameters required are the **flow rate**, **fluid density**, **rheological properties** of the fluid, flow domain **dimensions**, and the **absolute roughness**.

Fluid Rheology

Use this option to compute the rheological parameters of fluids. The setup is for a standard **Fann Rheometer.**

Note that you can still use this for measuring the viscosity of **Newtonian** fluids. If you use a Power-law model to describe a Newtonian fluid then the **power index (n)** will be unity and the **consistency factor (K)** will represent the fluid **viscosity** in centipoise, while if you use a Bingham-plastic model then the **Yield Point,YP,** will be zero and the **Plastic Viscosity, PV,** will represent the fluid viscosity.

VG Meter Interpretation

RPM	Shear Rate (/sec)	Shear Stress (lbs/100 ft.sq)
300	511	60
600	1022	96

COMPUTE

Power Law: Consistency Factor - K	4.479	cps.sec^n
Power Law: Power Index - n	0.6777	
Bingham Plastic: Plastic Viscosity - PV	36.00	cps
Bingham Plastic: Yield Point - YP	24.00	lbs/100 ft.sq

PRINT

EXIT

Gas Computations

Any one of three types of computations can be carried out here:

Displacement Volume
Computes the quantity of gas required to fill the casing or tube.

Hydrostatic Column
Computes the hydrostatic pressure difference between two true vertical depths.

Volume Factor
Computes the compressibility factor, z-factor, of the gas selected. Also computes the amount of standard cubic units of measurement per unit of space.

According to the type of computation selected some parameters will not be required and will automatically dissappear. The parameters required are;

Gas Type/Specific Gravity The gas can be either Nitrogen or Natural Gas. Natural Gas is further specified by the its specific gravity.

Tubing Inner Diameter The inside diameter of the tube to be filled with the gas. Only required for displacement volume.

Measured Depth The depth difference between the two depth points. Although the terminology uses the words **surface** and **bottom hole**, the computations will be valid between any two points not necessarily at surface or bottom hole.

True Vertical Depth The true vertical depth difference between the two points. The same logic as in **Measured Depth** above applies.

Surface Temperature The surface temperature or the temperature at the upper most point.

Bottom Hole Temperature The bottom hole temperature or the temperature at the lower most point.

Average Temperature The average temperature of the gas. Applies only to computation type **Volume**.

Average Pressure The average pressure of the gas. Applies only to computation type **Volume.**

Pressure Known At Does not apply to computation type **Volume**. Only one pressure is required by the user and the computations will compute the pressure at the other end.

The Results
Depending on the computation type, the results will include;

> **Z-Factor** The compressibility factor of the gas at the prevailing conditions. Applies only to computation type **Volume**.
> **SCF per Barrel of Space OR SCM per m³ of Space** Applies only to computation type **Volume**.
> *Other End* **Pressure** The *other end* will change according to the **Known Pressure At** selection.
> **Total Hole Volume** The actual hole volume between the two points of interest.
> **Total Displacement Volume** The actual quantity of Nitrogen or Natural Gas required to fill the hole between the two points of interest.

Inflow Interpretation

This option is provided to enable the user interprete the **inflow performance** data in terms of a **productivity index** or **Fetkovitch** parameters. The desired option should be selected, i.e. Productivity Index or Fetkovitch Equation, together with the option for the main production, i.e. oil or gas, then the required data should be supplied. After clicking the **Calculate** button, the required parameters will be computed.

Reservoir Pressure The static reservoir pressure.
At BHFP The bottom hole flowing pressure.
Flow Rate The flow rate of the produced fluids or gases.

Unload Gas Wells

Use this option to compute the minimum required gas velocity to keep the condensate in a gas well unloaded.

Gas Type/Specific Gravity Either Nitrogen or natural gas can be used. The natural gas is identifed by it's specific gravity.
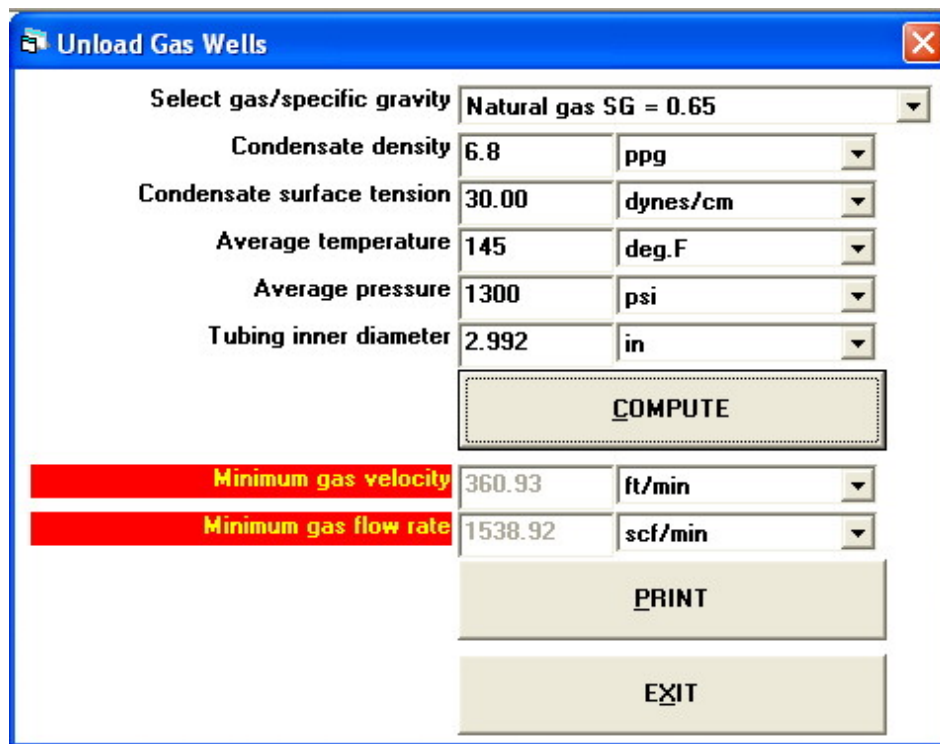**Condensate Density** The density of the condensate to be lifted.
Condensate Surface Tension The surface tension of the condensate to be lifted.
Average Temperature The average temperature of the well.
Average Pressure The average pressure of the well.
Tubing Inner Diameter The production tubing inner diameter. If this is left blank then the computations will only produce the **minimum gas velocity**, or the **condensate fall velocity**.

These computations are based on the fact that there is a maximum condensate droplet size after which the droplet will shatter due to the drag pressure forces on the surface of the droplet exceeding the surface tension forces that hold the droplet together. The shattering takes place at the critical **Webber number**.

List of Computed Parameters

An alphabetically sorted list of the parameters that are computed in TAS is included here for reference. Use this list to select the appropriate parameters required in **Customised graphs and reports**.

Annular Flow Regime	The flow regime for the fluids in the annulus. When plotted in a graph will be represented as an integer
Annular Fluid Pressure	The fluids pressure in the annulus between the well and the coiled tubing due to fluid circulation
Annular Fluid Velocity	The commingled fluid velocity in the annulus between the well and the coiled tubing
Annular Foam Quality	The foam quality of the fluids in the annulus between the well and the coiled tubing. Foam quality is defined as the ratio of the gas volume to the total volume. Equally applies to multi-phase flow.
Annular Liquid Velocity (Slug Flow)	The liquid phase velocity in multi-phase flows accounting for the slip between the phases.
Annular Relative Roughness	The relative roughness of the completion.
Azimuth	The well azimuth in radians.
BH Pull at a given Hook Load	The bottom hole pull when surface weight is constant at all depths.
Bottoms-Up Time	The time taken for the fluids, after leaving the coiled tubing, to reach the depth
Casing Size	The casing size or the size of the well bore (equals internal diameter of the completion).
Coiled Tubing Inner Diameter	The inner diameter of the coiled tubing. Null if beyond the computation depth. Cable or capillaries not accounted for.
Coiled Tubing Inner Flow Area	The inner coiled tubing cross-sectional area accounting for cable and capillaries if any.
Coiled Tubing Outer Diameter	The outer diameter of the coiled tubing. Null if beyond the computation depth.
Critical Helical Force	The critical compressive force beyond which helical buckling is initiated
Critical Sinusoidal Force	The critical compressive force beyond which sinusoidal buckling is initiated
CT Bottoms-Up Time	The time taken for fluids, from the pump, to reach the depth.
CT Flow Regime	The flow regime for the fluids in the coiled tubing. When plotted in a graph will be represented as an integer
CT Fluid Pressure	The fluids pressure inside the coiled tubing due to fluid circulation
CT Fluid Velocity	The commingled fluid velocity inside the coiled tubing
CT Foam Quality	The foam quality of the fluids in the coiled tubing. Foam quality is defined as the ratio of the gas volume to the total volume. Equally applies to multi-phase flow.
CT Pressure at Surface (Drag Computations)	The pressure inside the coiled tubing over the gooseneck. This parameter is computed hydrostatically and the pressure is then used for computing tri-axial stresses. Normally, this pressure will be a constant unless the CT is pressured prior to running in the well then the pump is shut-off. Should this be the case, then possible leakage of the fluids to the well could occur which will affect this parameter.
Depth	The measured depth
Deviation	The well deviation in radians.

Fluid in CT Density	The fluid density inside the coiled tubing. This may vary if the Circulation Fluid is used in the Mud and Fluid in CT Data.
Friction Factor	The friction factor between two surfaces at the depth.
Hanging Tension/Compression	The state of tension/compression while hanging the coiled tubing and the coiled tubing end is at the depth (specified as the compute to depth in compute drag)
Hanging Weight	The predicted weight when the CT is hanging in the well or stationary
Horizontal Distance-Absolute	The absolute horizontal distance from the well head.
Horizontal Distance-East	The horizontal distance east of the well head. If the well is heading west then this distance will be negative.
Horizontal Distance-North	The horizontal distance north of the well head. If the well is heading south then this distance will be negative.
Maximum Bottom Hole Pull	The maximum pull force available at the bottom end of the coiled tubing when applying maximum pull at surface.
Maximum Pull	The maximum weight to which the coiled tubing could be pulled at the specified safety factor.
Maximum WOB	The maximum weight-on-bit that could be applied at the minimum weight (i.e. at the limit at which lock-up would occur).
Minimum Weight	The minimum weight to which the coiled tubing could be pushed before lockup occurs.
Mud Weight	The density of the annular fluids. This may vary if the Circulation Fluid is used in the Mud and Fluid in CT Data.
Penetration Rates	The recommended penetration rate when performing sand cleanout and/or drilling. This rate corresponds to the rate at which the fill is being removed from the well. The fill is assumed to occupy the full well bore and the liquid phase is carrying the sand or the cuttings at a specified concentration ratio (in sand data).
Pick-Up Tension/Compression	The state of tension/compression during pulling-out when the coiled tubing end is at the depth (specified as the compute to depth in compute drag)
Pick-Up Tri-Axial Stress	The state of tri-axial stress during pulling-out when the coiled tubing end is at the depth (specified as the compute to depth in compute drag)
Pick-Up Weight	The predicted picking-up or pulling-out weight
Pick-up Weight at a given BH Pull	The predicted pick-up weight when applying a bottom hole constant pull force.
Sand Settling Velocity	The settling velocity for particles (defined in the sand data) in a vertical well
Slack-Off Tension/Compression	The state of tension/compression during running-in when the coiled tubing has reached the depth (specified as the compute to depth in compute drag)
Slack-Off Tri-Axial Stress	The state of tri-axial stress during running-in when the coiled tubing has reached the depth (specified as the compute to depth in compute drag)
Slack-Off Weight	The predicted slacking-off or running-in weight
True Vertical Depth	The true vertical depth
Weight at fixed WOB	The predicted slacking-off weight at a fixed weight-on-bit.
WOB at a given Hook	The weight-on-bit computed at a given constant hook load

| Load | (or slacking-off weight). |