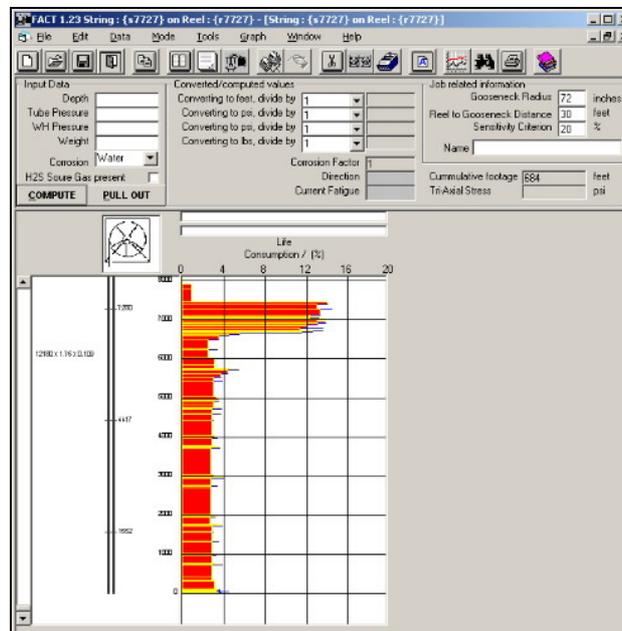




## Fatigue Analysis for Coiled Tubing

***FACT***  
Version 1.xx



## *User Manual*

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## Overview

Fatigue Analysis for Coiled Tubing, FACT version 1.xx, is the latest of the coiled tubing fatigue module produced by MEDCO. This program performs fatigue analysis and tri-axial stress computations of coiled tubing in real time, in post-job mode, and/or using manual data entry.

The fatigue analysis takes into account the geometry of the coiled tubing, material properties, and the equipment used. In addition, corrosion, stress concentrations, and statistical reliability of the empirical data are also considered. FACT keeps track of the coiled tubing fatigue history per job, and gives the user the option of reviewing the fatigue history at any moment of time.

In keeping an accurate account of the fatigue history, this program is a vital tool for managing the coiled tubing strings without the risk of failure.

Coiled tubing goes through several plastic deformation cycles through its usage in and out of wells. The first deformation cycle takes place as the coiled tubing leaves the reel, where the coiled tubing is deformed from being bent to being straight. Next are two cycles of deformation while going through the gooseneck, straight to bent and bent to straight. These cycles are experienced both ways, i.e. when going into the well and when pulling out of the well. Thus the total number of cycles of plastic deformation will be six.

During a coiled tubing job, the coiled tubing is further cycled by the operators, when performing a pull test, for example. But some of these may work part of the coiled tubing over the gooseneck only and other parts that may have left the reel would go back on the reel but do not reach the gooseneck. Thus, to have an accurate record of the cycles, knowledge of the distance between the reel and the gooseneck is required.

The above is only concerned with plastic deformation of the coiled tubing due to axial loading and unloading. The axial forces impose axial stresses that are in excess of the material minimum yield stress. However, our concern is the total stress and not just the axial stress. Thus, internal pressure, corrosion, and stress concentration due to welds and/or presence of H<sub>2</sub>S sour gas all become pertinent. A special technique is utilized to account for each of these effects.

The internal pressure will change the hoop and radial stresses and these can be simply calculated and thus the total stress computed accordingly.

Corrosion and stress concentrations are more difficult to account for. Corrosion will normally reduce the wall thickness of the coiled tubing, however, we do not have an exact measure of how much wall thickness is lost and until such measures become known, we have to make some assumptions to account for the loss of wall thickness. Clearly, the wall loss will reduce the coiled tubing cross-sectional area thus increasing the stresses due to the same load being applied. A number of corrosion factors have been suggested and are basically representative of reduction of wall thickness, i.e. are always less than 100% (in FACT less than 1). Similarly, stress concentration factors are assumed for welds and H<sub>2</sub>S gas and these basically mean that the stresses are increased because even before loading locally concentrated stresses exist. Again, stress concentration factors are less than 100% (in FACT less than 1).

Finally, when a corrosive fluid is pumped through the coiled tubing, the wall loss will take place through the entire length and not just the parts that moved out of the reel. However, FACT will only subject the coiled tubing to stresses if it has moved during the job. Thus to account for the wall loss due to internal corrosion, the whole length of the coiled tubing is cycled once in and out of the well towards the end of the job. (When the **PULL OUT** button in FACT is clicked).

## Theoretical Background

The stress-strain relationship given by Hooke's law, dictates that the coiled tubing must not exceed the minimum yield stress,  $\sigma_y$ , to remain within the elastic range of the curve. Since the slope of the curve is given by the Young modulus,  $E$ , the following condition for the strain,  $\epsilon$ , must be satisfied to remain within the elastic range;

$$\epsilon \leq \frac{\sigma_y}{E}$$

... 1

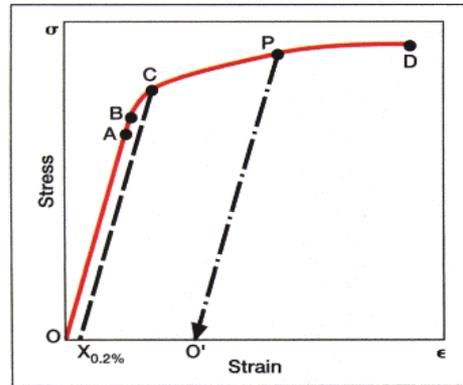


Figure 1: Hooke's law for the stress-strain relationship

If we were to substitute the values of the minimum yield stress and the Young modulus of elasticity for coiled tubing QT-700, say, then we obtain a maximum strain of  $7/3 \times 10^{-3}$  ( $E = 30 \times 10^6$  psi,  $\sigma_y = 70,000$  psi).

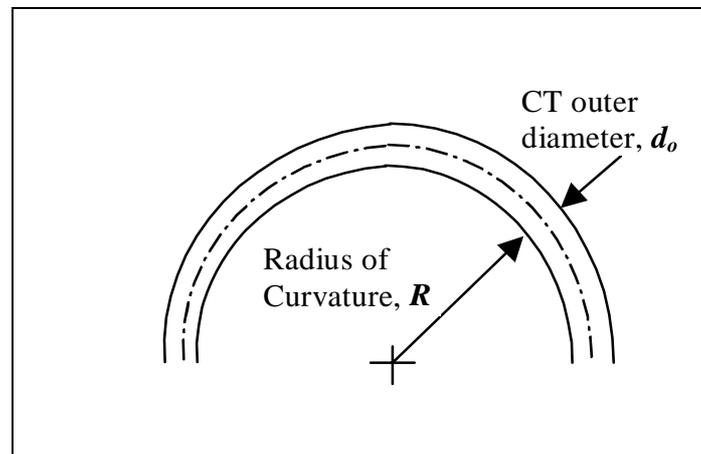


Figure 2: Geometry of coiled tubing when subjected to bending

### Effect of Equipment Size

In figure 2, if we assume the radius of curvature over which the coiled tubing is being bent to be  $R$ , and the coiled tubing outer diameter to be  $d_o$  then the length of the non-deformed coiled tubing is given by;

$$L = 2\pi\left(R + \frac{d_o}{2}\right)$$

... 2

While the length of the outer side of the coiled tubing is given by;

$$L + \Delta L = 2\pi(R + d_o)$$

... 3

Therefore, the strain can be calculated as;

$$\varepsilon = \frac{\Delta L}{L} = \frac{d_o}{2R + d_o}$$

... 4

Or

$$R = \frac{d_o}{2} \left( \frac{1}{\varepsilon} - 1 \right)$$

... 5

Thus, if we were to keep a 2” QT-800 coiled tubing (typical for coiled tubing used in drilling applications) within the elastic range at all times, the radius of curvature must be greater than 31.2 ft. This implies that the gooseneck must have a radius of 32 ft and the reel must have a core diameter of 63 ft. Clearly such dimensions are not acceptable because of the costs involved in building such equipment and the difficulties of transporting them. As a result, the coiled tubing equipment is built with reasonable sizes, which unfortunately dictates that the coiled tubing will suffer plastic deformation.

### Effects of Axial Stress on Fatigue Life

As a result, the coiled tubing is subjected to stresses higher than the minimum yield stress when travelling from the reel to the gooseneck and from the gooseneck into the injector, as shown in figure 3. During this journey, the coiled tubing is subjected to 3 plastic deformation cycles and on the journey out of the well a further 3 plastic deformation cycles are experienced<sup>1</sup>.

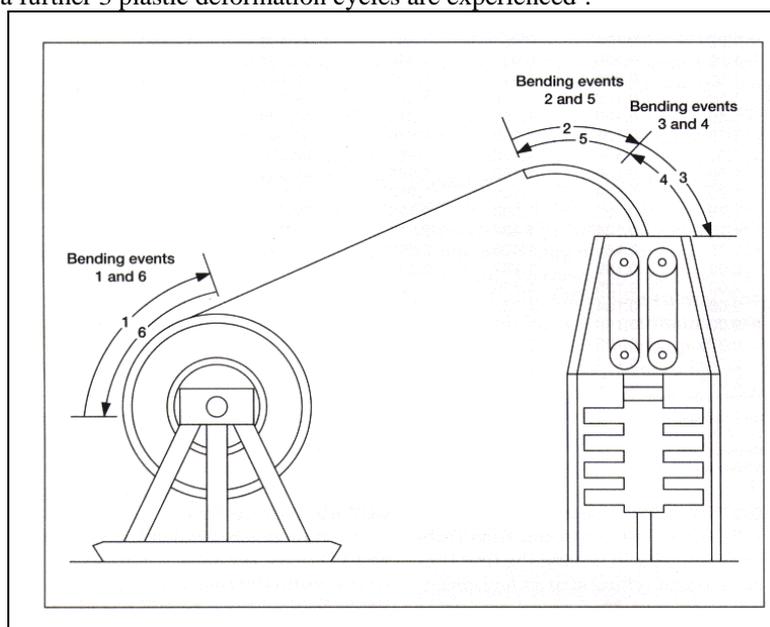


Figure 3: Plastic deformation cycles of coiled tubing during running in and pulling out of a well

Figure 4, shows the effects of stresses on the number of cycles that could be attained before fatigue failure ensues<sup>2</sup>. The figure shows two curves intersecting at the point corresponding to the normalised minimum yield stress (on the Y-axis). To use this figure, the normalised stress should be determined first then go across horizontally until intersecting with the upper of the two curves.

<sup>1</sup> Sas-Jaworsky II, Alexander “Coiled Tubing ... Operations and Services, Part 3 – Tube Technology and Capabilities”, World Oilm Feb. 1992.

<sup>2</sup> Avakov, V.A., Foster, J.C., and Smith, E.J. “Coiled Tubing Life Prediction” OTC 7325, 25<sup>th</sup> Annual OTC, Houston, May 1993.

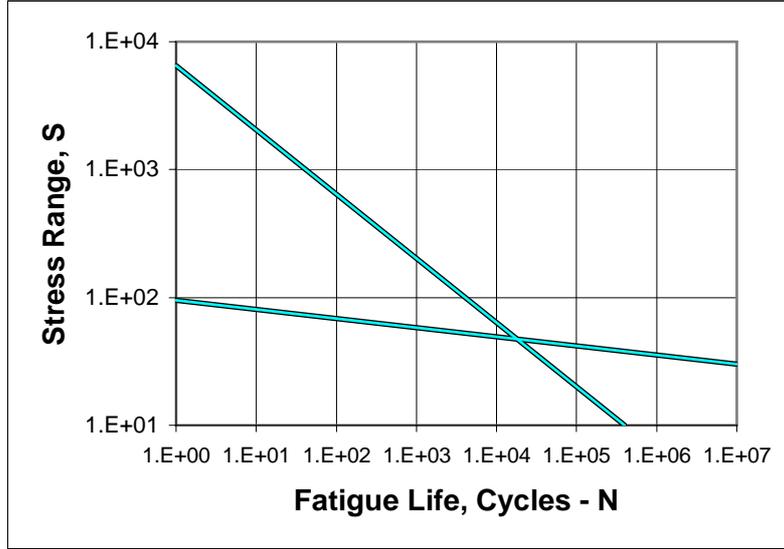


Figure 4: Low-cycle S-N Line (Avakov et al, 1993)

As can be seen, within the elastic range the number of cycles would be in the order of  $10^4$  and more while in the plastic range the number of cycles is reduced significantly.

An equation of the form  $S = aN^\alpha + bN^\beta$  will sufficiently describe the upper bound curve of figure 4. The term  $aN^\alpha$  represents the elastic range while the term  $bN^\beta$  represents the plastic range. Since the coiled tubing is being used in the plastic range, the first term of the equation can be neglected. Hence, we can rewrite the equation as;

$$S = bN^\beta$$

... 6

The power index  $\beta$  has a value of  $-1/2$ . Using empirical median life in cycles,  $N_m$ , and median fatigue strength,  $S_m$ , found by tests, we can write an expression for the fatigue damage,  $\lambda$ , caused by a stress cycle as;

$$\lambda = \frac{(S / S_m)^2}{N_m} \times 100\%$$

... 7

The value given in the literature for  $S_m$  is 1000 and for  $N_m$  is 130. As we have seen before, the coiled tubing goes through 2 cycles of plastic deformation on the reel and further 4 on the gooseneck. Each of these cycles induces axial stress, which can be calculated as follows;

- Over the gooseneck the axial stress,  $S_{ag}$ , is;

$$S_{ag} = \frac{d_o E}{2R_g}$$

... 8

Where  $R_g$  is the gooseneck radius.

- Over the reel the axial stress,  $S_{ar}$ , is;

$$S_{ar} = \frac{d_o E}{D_R}$$

... 9

Where  $D_R$  is the reel diameter.

## Effects of Pressure

Internal coiled tubing pressure induces further hoop (circumferential) and radial stresses. The additional stresses due to the internal pressure will adversely affect the coiled tubing life because they will increase the overall stress, i.e. moving upwards on the Y-axis of figure 4. Note, however, if no axial stress were present (no movement of coiled tubing taking place simultaneously), then the stresses due to the internal pressure will only be within the elastic range thus having an insignificant effect on the coiled tubing life.

The additional stress component due to the internal pressure can be computed as;

$$S_t = \frac{2d_i^2 P_i}{d_o^2 - d_i^2} \quad \dots 10$$

The total stress is computed using an empirical formula and is given as;

$$S = S_a + S_t^m \quad \dots 11$$

Where  $m$  is a constant determined empirically. Equation (11) is applicable to both cases of the stress over the gooseneck and the reel, where  $S_a$  is the axial stress.

## Effects of Weight

The coiled tubing parts being held by the chain blocks support the weight of the coiled tubing in the well. This part of the coiled tubing is not being subjected to any bending, thus the stresses are only due to the weight of the coiled tubing and any additional stresses due to pressure. However, since in practice these stresses are always kept below the minimum yield stress, the cycling in this section will not affect the coiled tubing life significantly.

## Other Effects

### Material Strength

Higher strength coiled tubing will be able to sustain more fatigue cycles. This effect is included in a strength factor,  $F_m$ , which is a function of the reduction in area,  $RA$ , in fractions

$$F_m = \left\{ \frac{\ln(1 - RA)}{\ln(0.47)} \right\}^2 \quad \dots 12$$

The factor  $RA$  has a value of 0.53 for QT-700 and 0.57 for QT-800 or equivalent.

### Welds

The effect of welds is to induce stress concentration locally. Depending on the type of weld used, a weld factor,  $F_w$ , will reflect the effect. Typical values for weld factor are 0.7 for smoothly dressed butt-welded section, 0.5 for poorly dressed butt-welded section, and 0.31 for undressed butt-welded section.

### Corrosion

Two types of corrosion may be encountered in coiled tubing applications, acid corrosion and corrosion due to sour gases. The two corrosion effects are different in nature. The acid will corrode the material of the coiled tubing and reduce the wall thickness while the sour gas molecules will embed themselves in between the material molecules thus inducing stress concentration.

A corrosion factor,  $F_c$ , is normally used to account for either effect. Typical values for the corrosion factor are 0.66 for 15% HCl acid and 0.5 for H<sub>2</sub>S gas.

### Reliability of Empirical Data

A reliability factor,  $F_R$ , is also introduced to reflect the confidence in the test data. The reliability factor is a function of the reliability level,  $Q$ , and is given as;

$$F_R = 11.47 \left( \frac{\ln Q^{\frac{1}{15}}}{\ln 0.5} - 1 \right)$$

... 13

Note that using 50% reliability will appear to be the best fit of the sample data as it does represent the *average* number of cycles that can be sustained before a failure occurs. In reality, though, this will mean that 50% of the coiled tubing will survive the predicted number of cycles while the other 50% are likely to fail before reaching the predicted number of cycles. To increase the reliability of the predictions, we need to consider a much higher reliability factor, probably in the order of 95%.

Equation (7) can now be modified to include all the above factors;

$$\lambda = \frac{1}{F_m F_w F_c F_R} \times \frac{(S / S_m)^2}{N_m} \times 100\%$$

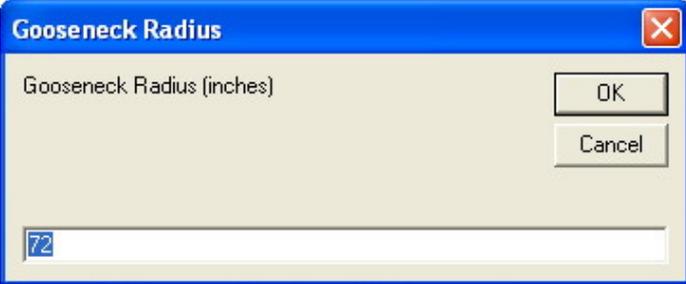
... 14

## Using FACT

Upon starting FACT the user is prompted to enter some job related parameters. The job parameters required are the gooseneck radius, the distance between the reel and the gooseneck, the distance between the gooseneck to the stripper, the bottom hole assembly length, the coiled tubing string, and the reel geometry data.

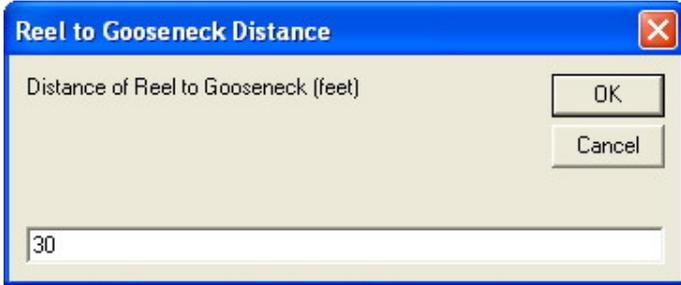
### Job Related Data

#### Gooseneck Radius



A dialog box titled "Gooseneck Radius" with a blue header and a red close button. The main area is light gray and contains the text "Gooseneck Radius (inches)" on the left. On the right, there are two buttons: "OK" and "Cancel". At the bottom, there is a text input field containing the number "72".

#### Distance between Reel to Gooseneck



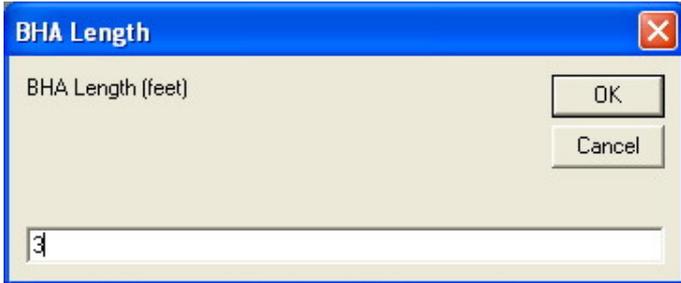
A dialog box titled "Reel to Gooseneck Distance" with a blue header and a red close button. The main area is light gray and contains the text "Distance of Reel to Gooseneck (feet)" on the left. On the right, there are two buttons: "OK" and "Cancel". At the bottom, there is a text input field containing the number "30".

#### Distance of Gooseneck to Stripper



A dialog box titled "Distance of Gooseneck to Stripper" with a blue header and a red close button. The main area is light gray and contains the text "Gooseneck to Stripper (feet)" on the left. On the right, there are two buttons: "OK" and "Cancel". At the bottom, there is a text input field containing the number "12".

#### Bottom-hole Assembly Length



A dialog box titled "BHA Length" with a blue header and a red close button. The main area is light gray and contains the text "BHA Length (feet)" on the left. On the right, there are two buttons: "OK" and "Cancel". At the bottom, there is a text input field containing the number "3".

## Coiled Tubing String/Reel



The default values will be the same as last used and the default units are those selected in TOOLS > OPTIONS.

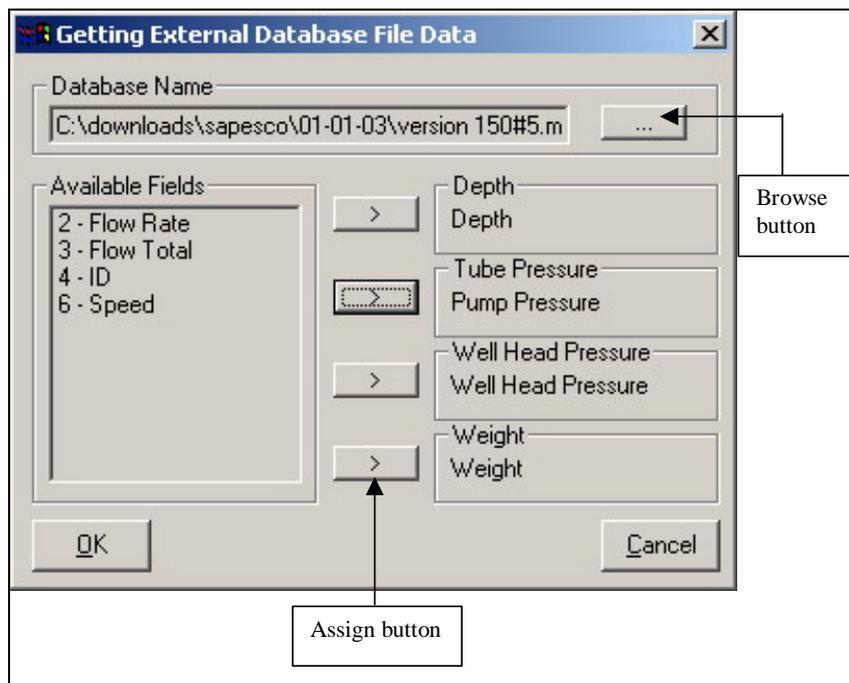
If you have been using previous versions of the FATIGUE module, such as TAS – FATIGUE ANALYSIS, or CTFATIGUE, then use the IMPORT OLD FORMAT function to import the strings/reels.

The OPEN EXPORTED function is described in more detail in the SYSTEM MAINTENANCE section.

### FACT Modes of Operation – Automatic and Manual

There are two modes of operation for FACT, **automatic** and **manual**. The automatic mode gets the data from a database file being created by a data acquisition system/software in real time, such as DART. In this mode any changes that take place will activate the calculations of the coiled tubing fatigue. All changes will be considered as actual depth changes or job events.

The DART program announces to WINDOWS the database file being used. When FACT starts it searches for the current, or last, database file created by DART (this information is available to all WINDOWS applications through the system registry). FACT will then prompt the user to use the data in the most recent database file created by DART (if applicable, i.e. if DART does not exist then this procedure will be ignored). Alternatively, if the user wishes to use another database file, then the browse button can be used to locate the file.



If the parameters required in FACT have exactly the same names as those in the database file, then FACT will automatically assign them to the appropriate fields, else the user should do this manually by clicking on the field name in AVAILABLE FIELDS and clicking on the appropriate assign button to match it to the required parameter in FACT.

When using FACT in real time, the program will read data from the specified database file being produced in real time by some data acquisition system/program such as DART. If FACT is started after the creation of the real time database file, then FACT will read 100 records at a time, or to the end of file, approximately every 5 seconds.

If the user does not wish to have real time or post job automatic data entry, then the CANCEL button will remove this window and the program will entered in manual mode. While in manual mode, the user can still switch to automatic mode by selecting the menu option MODE > AUTOMATIC.

#### *Manual Mode*

In manual mode the user simply enters the job events and click the COMPUTE button or press the ENTER key on the keyboard and the computations are performed. The events should be entered as they occur on the job.

FACT requires information regarding depth and tube pressure as well as information regarding corrosion, gooseneck radius, distance between reel and gooseneck, coiled tubing geometry, welds, and reel geometry to compute fatigue. In addition, wellhead pressure and string weight are needed to compute tri-axial stresses. The gooseneck radius, the distance between the reel to gooseneck, distance of gooseneck to stripper, and BHA length are information required only once for any one job. Similarly, the coiled tubing string geometry and history, the welds, and the reel geometry are only required once.

#### **Converting to API English units**

FACT does all the computations using API English units. These are *feet* for depth and *psi* for pressure. Thus, if non-API English units are being used (in both operation modes) the appropriate conversion factors should be selected or entered. FACT by default assumes a conversion factor of 1 or whatever the user previously used. Conversion factors for *meters* to *feet*, *kPa* to *psi*, and *MPa* to *psi* are included in the lists.

When finishing a job, the user should select the PULL OUT button to finish then SAVE to save the history of the string.

## Creating New String

To create a new string, select FILE > NEW, a blank data form will appear. There are three options' frames and five data frames within the form. Initially, however, you will only see four data frames, as the last one is dependent on the Cable/Capillaries option.

The **option frames** are as follows:

- **Units** – Selects the units system to be used for entering the data. The units system will apply to the whole form. During the entry of the data the user may change to the other units system by clicking on the *Convert Units To* and select one of the available options. This will convert all data entered thus far to the newly selected units system.
- **Convert Units To** - Use this to convert the entered data from one units system to another. You may use this as many times as you wish but bear in mind that some round off errors may occur.
- **String with Cable/Capillaries** - By default this option is set to NO. If however, the string does have a cable or capillaries then you may use this option and select the YES option. By selecting the YES option the fifth data frame will appear. Note that the cable/capillaries existence will not affect the fatigue analysis but have been included here to allow for compatibility with TAS data files. Thus, when using the same string in TAS for fluid or force analysis computations the string will have the appropriate data relating to the cable/capillaries.

The **Data Frames** are as follows:

- **Coiled Tubing String Data** - You may select coiled tubing from the database, create a true tapered section, or enter data directly into the grid. The length of each coiled tubing segment must be entered manually. To add more rows in the grid, point the mouse to the grid and right-click then select INSERT ROW. Ideally, you should insert sufficient rows in the grid before starting to enter data (applicable to tapered strings). Ideally, the user should enter the string data as supplied by the manufacturer, i.e. enter the strip number in the component name column and name the string by its number. The minimum yield stress of each element of the coiled tubing string must be selected from the list available in the MIN YIELD column. Note that when creating a tapered string, care must be taken to ensure that the data is entered in the correct order. The correct order is to start the top row in the grid with the free end of the coiled tubing string.
- **Welds Data** - This data is optional. If the coiled tubing string has no welds then simply ignore this frame. If, however, there are welds then they should be entered here even if they were

manufacturer's welds. Most manufacturers of coiled tubing claim that the stress concentration is removed from the welds done at the factory by a process of stress relief (annealing). However, it is recommended that you keep track of these welds by specifying a weld factor of 0.95 or higher, up to a maximum of unity (meaning that 95% of the stress concentration is relieved). If you wish to change the manufacturer's weld factor in the database then see Corrosion and Weld Factors section.

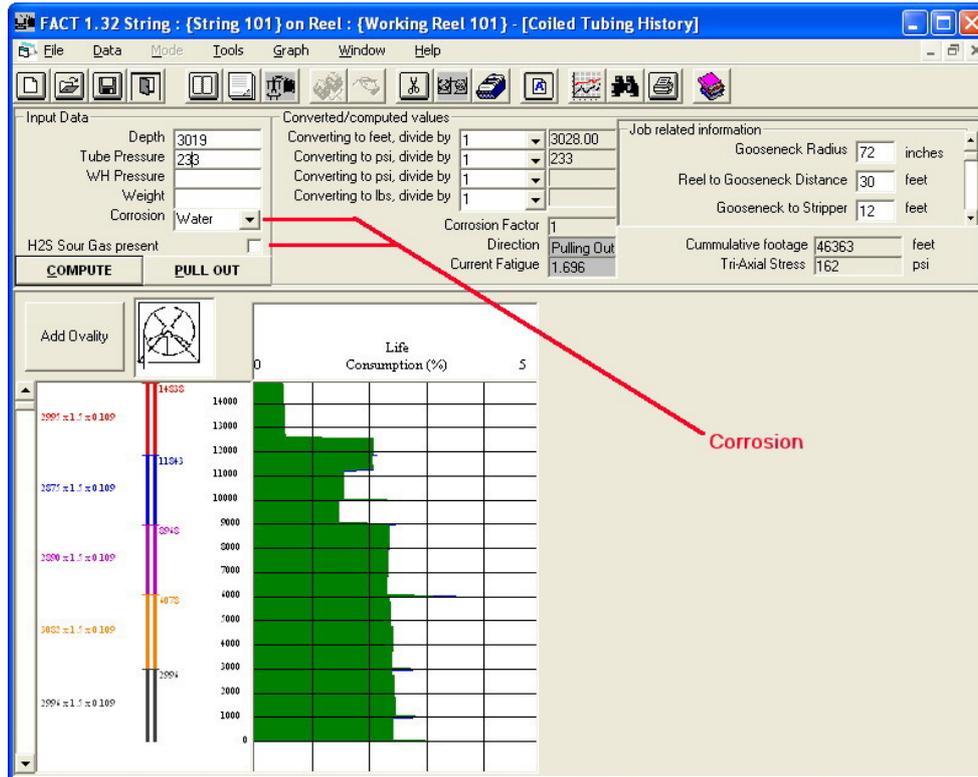
- **Reel Geometry Data** - You must enter the dimensions of the reel. Otherwise, the program will report many errors during the fatigue computations. You may wish to specify a name of the reel different to that of the string.
- **Material Properties** – With the exception of the minimum yield stress, the remaining material properties are set to default values 30,000 *Kpsi* Young Modulus and 0.2833 *lbs/in<sup>3</sup>* material density. You may change any of these by typing the appropriate value.
- **Cable/Capillaries Data** - As mentioned above, this group of data is not used in the fatigue analysis. However, the same files created using this program are compatible with the Tubing Analysis System (TAS). Thus, when using fluid circulation or force and stress analysis in TAS this data will be pertinent. They are, therefore, included here for completeness.

## Entering Job Events Data

When using FACT in AUTOMATIC MODE, there will be no need for the user to enter data into the program. The user simply has to ensure that the appropriate fields are assigned (see FACT Modes of Operation – Automatic and Manual).

On the other hand, if the user wishes to use the program in post-job analysis, then the data can be entered either manually from a tally book record or directly from database files produced by the data acquisition system or software.

To enter the data manually, there are again two options. The first option would be to enter the data in the DEPTH and TUBE PRESSURE fields in the program's main form then pressing the ENTER key on the keyboard or using the COMPUTE button. If corrosion effects are to be included, then select the corrosive material from the list.



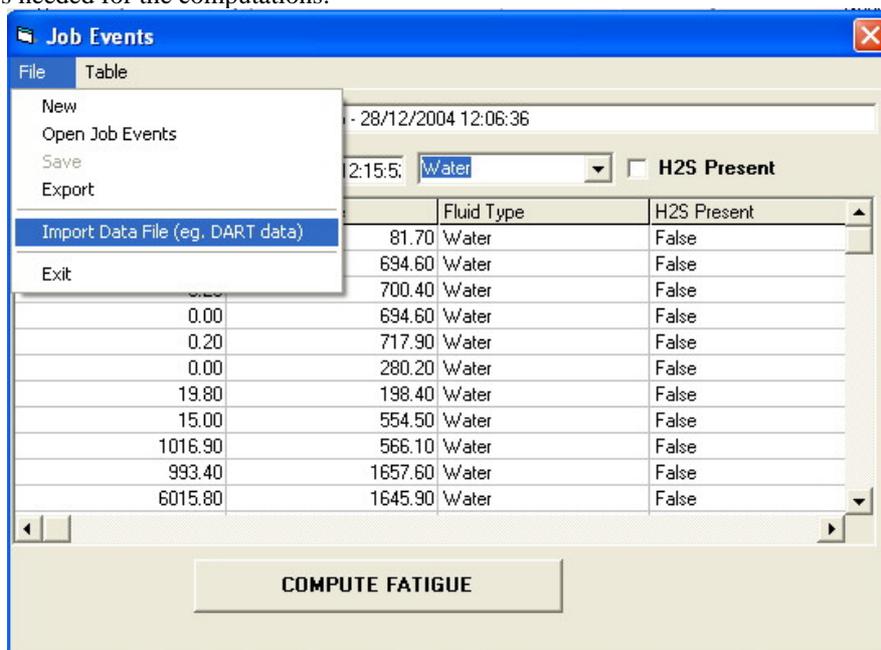
The second alternative for entering data manually is to select DATA > EVENTS DATA and enter the job events in the table, again selecting the appropriate corrosion factor where applicable.

The screenshot shows the "Job Events" dialog box. It includes a "Job Name" field (Job - 28/12/2004 12:06:36), a "Date" field (28/12/2004 12:15:5), a "Fluid Type" dropdown (Water), and an "H2S Present" checkbox. Below these fields is a table with the following data:

Depth	Tube Pressure	Fluid Type	H2S Present
0.00	81.70	Water	False
0.00	694.60	Water	False
0.20	700.40	Water	False
0.00	694.60	Water	False
0.20	717.90	Water	False
0.00	280.20	Water	False
19.80	198.40	Water	False
15.00	554.50	Water	False
1016.90	566.10	Water	False
993.40	1657.60	Water	False
6015.80	1645.90	Water	False

At the bottom of the dialog box is a "COMPUTE FATIGUE" button.

If, on the other hand, the job events data were available from a data acquisition system or software program, then this data can be imported directly into the JOB EVENTS table shown above. To do this, the data must be in a database format and the user can select the FILE > IMPORT DATA FILE. The same field assignments form will appear to ask the user to assign the appropriate fields to the parameters needed for the computations.



Once the data has been successfully imported, the COMPUTE button can then be clicked to compute the fatigue damage.

## Reviewing String History

At any time, the user can review the string history and if necessary revert back to an earlier date. This is true as long as the string has not been deleted from the database.

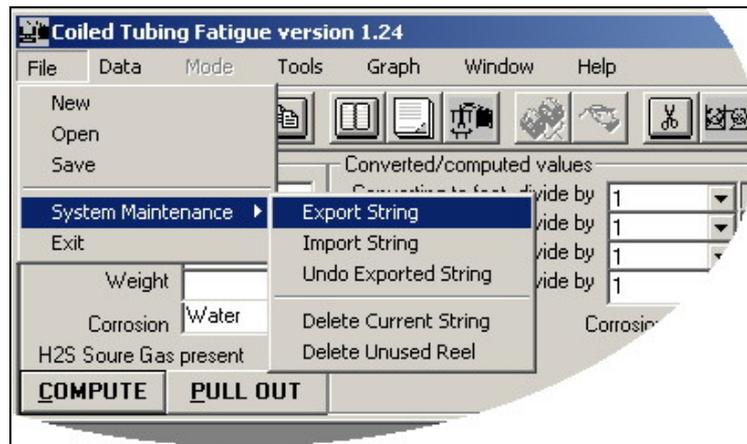
To review the string history, select DATA > LIFE CONSUMPTION DATA and a table of the string history data will appear. The Life Consumption data will be reflective of the current status of the coiled tubing. To revert to an earlier date, simply select the BROWSE button.

Current Date	From feet	To feet	Consumed Life (%)	Browse Factor
28/12/2004 12:07:33	0.0	0.0	0.0	1.696
28/12/2004 12:07:33	0.0	0.0	9.2	2.035
28/12/2004 12:07:33	9.2	9.2	9.2	2.035
28/12/2004 12:07:33	9.2	9.2	9.2	2.219
28/12/2004 12:07:33	9.2	9.1	9.1	2.219
28/12/2004 12:07:33	9.1	9.1	9.1	2.219
28/12/2004 12:07:33	9.1	9.0	9.0	2.219
28/12/2004 12:07:33	9.0	10.0	10.0	2.974
28/12/2004 12:07:33	10.0	24.0	24.0	2.778

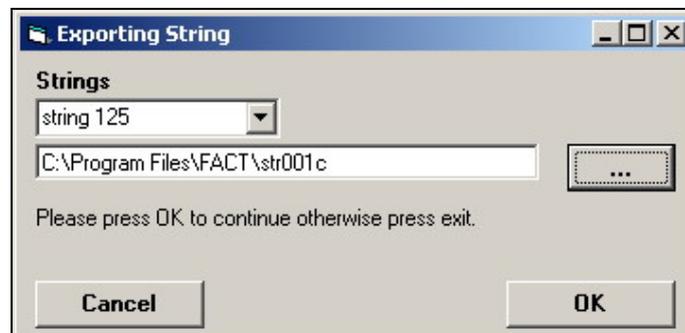
Total Footage = 46363  
Job - 28/12/2004 12:03:40 ; 28225  
Job - 28/12/2004 12:06:36 ; 18137.5999240875

## System Maintenance

To export/import a string/reel data, use the facility in FILE > SYSTEM MAINTENANCE.



This facility is particularly useful when you have several copies of FACT and one of them is being used as an administrator system keeping records of all coiled tubing strings/reels in the company.



When another user, using another copy of FACT, needs to work on a particular coiled tubing string/reel, the string/reel can be exported from the administrator copy onto a separate file, which can be named anything (with or without an extension) then copied across to the user's computer or workspace. The file can then be directly accessed using FILE > OPEN and then selecting OPEN EXPORTED. The string/reel can then be used to update the coiled tubing history, real-time or manual. Finally when finished, the string/reel can be imported back into the administrator's copy.



To revert back to the original string/reel data as it were on the administrator's records, use the UNDO EXPORTED STRING.

If data related to a coiled tubing string is no longer needed then the string can also be cleared to simplify the system maintenance. Load the string then go to FILE > SYSTEM MAINTENANCE > DELETE CURRENT STRING.

Similarly, if a reel is no longer in use, then the data related to the reel can be removed by going to FILE > SYSTEM MAINTENANCE > DELETE UNUSED REEL. Note, though, that this option will only apply to an empty reel. Thus, the string associated with the reel must be removed first.

## Manipulating Coiled Tubing Strings

Several functions exist in FACT enabling the user keep track of various tasks that can be implemented on the coiled tubing string. These can be accessed through the menu option TOOLS > CUT CT.

### Cutting and Dispose CT

FACT allows the cutting and disposal of pieces of the coiled tubing. The cutting is not restricted to the free end of the coiled tubing. However, if a cut is to take place in the middle of the string then the program will automatically prompt the user to add a weld.

**Cutting CT**

**Spooling**

Spool to another reel     Spool off and back on     No spooling

From length  feet

To length  feet

Spool to reel

2nd reel core diameter  inches

2nd reel width  inches

Weld type

**O.K.**    **Cancel**

### Spool and Cut

If, for example, there is a need to remove a damaged portion by spooling the string to some empty reel or wooden spool then spooling back on the original reel, then this can be achieved by selecting the *Spool off and back on* option.

**Cutting CT**

**Spooling**

Spool to another reel     Spool off and back on     No spooling

From length  feet

To length  feet

Spool to reel

2nd reel core diameter  inches

2nd reel width  inches

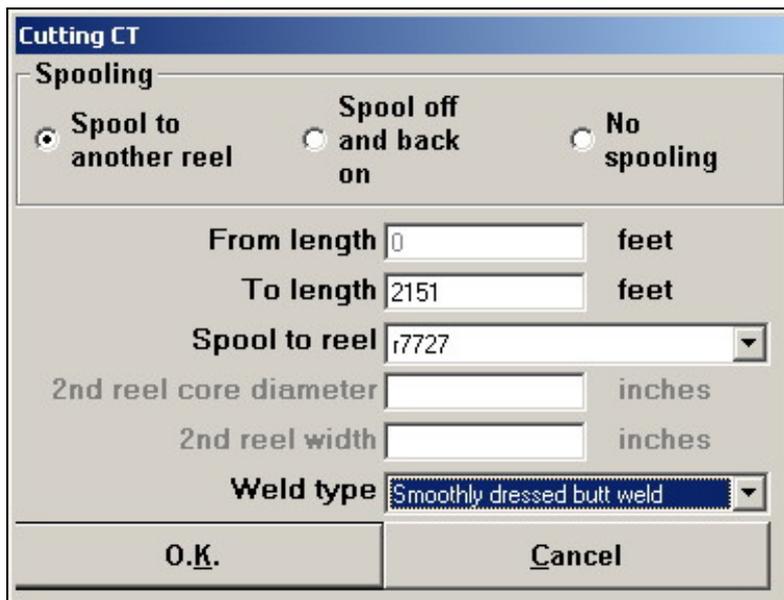
Weld type

**O.K.**    **Cancel**

### Spool to another reel

This option is used for moving a portion or the whole length of a string from one reel to another, with or without an existing string. To use this option, at least one coiled tubing string must be loaded while

the second may just be an empty reel or a reel with an existing string. To load more than one reel, use the menu option TOOLS > SPOOL CT.



The image shows a software dialog box titled "Cutting CT". It contains several input fields and radio buttons. The "Spooling" section has three radio buttons: "Spool to another reel" (selected), "Spool off and back on", and "No spooling". Below this are two text boxes for "From length" (0) and "To length" (2151), both followed by "feet". There is a dropdown menu for "Spool to reel" with the value "i7727". Below that are two text boxes for "2nd reel core diameter" and "2nd reel width", both followed by "inches". At the bottom is a dropdown menu for "Weld type" with the value "Smoothly dressed butt weld". The dialog has "O.K." and "Cancel" buttons at the bottom.

Cutting CT	
<b>Spooling</b>	
<input checked="" type="radio"/> Spool to another reel	<input type="radio"/> Spool off and back on
<input type="radio"/> No spooling	
From length	0 feet
To length	2151 feet
Spool to reel	i7727
2nd reel core diameter	inches
2nd reel width	inches
Weld type	Smoothly dressed butt weld
O.K.	Cancel

## **DataBase**

### **Corrosion and Weld Factors**

The corrosion and weld factors are stored in a database file called "FACT.mdb". This file is compatible with Microsoft Access. It is strongly recommended that any editing of this file be done from within FACT. To edit either of the tables, select TOOLS > DATABASE > CORROSION FACTORS or > WELD FACTORS.

The supplied database includes corrosion and weld factors suggested in the literature and are not in any way considered comprehensive.

### **Coiled Tubing**

This database is provided to aid the user when entering data while creating a new coiled tubing string. The database includes most known coiled tubing sizes. The user may edit this database as required by going to TOOLS > DATABASE > COILED TUBING.

## 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 a complete run in and out of the hole.

This option is used to get some idea of the effects of changing equipment size, material properties, and internal pressure. To access this option select TOOLS > FATIGUE CYCLES.

**Fatigue Cycles to Failure**

**Units**  
 API English    API Metric

**Convert Units To**  
API English

Select coiled tubing: 1.5" x 0.095" CT

Outer Diameter: 1.500 inches

Wall Thickness: 0.095 inches

Reel Diameter: 72.00 inches

Gooseneck Radius: 72.00 inches

Select Minimum Yield: 70000 psi

**Internal Pressure Range**  
From: 0   To: 5000.00 psi

Pressure (psi)	Number of Cycles
0	75.2
500	73.8
1000	70.2
1500	64.9
2000	58.7
2500	52.1
3000	45.5
3500	39.3
4000	33.6
4500	28.6
5000	24.3

**DRAW CHART**   **REPORT**   **EXIT**

## Program Options

Several options may be changed through the menu option **TOOLS > OPTIONS**. These options are mainly to give the program the look and feel that best suits the user. This option is protected by a password "FACT" to prevent un-authorized access.

In addition, there are some constants that are used in the fatigue computations. The constants are used in the equations mentioned in the *Theoretical Background* section of this manual. As these can have a dramatic effect on the calculations, it is strongly recommended that no changes be made to the constants without consulting with MEDCO first. To see the current constants settings, the "Program Options" window must be vertically stretched then click the **SHOW CONSTANTS** button. Again, this is deliberately hidden to prevent un-authorized access.

The equivalent parameters in the equations of the *Theoretical Background* section are as follows:

- $P_i$ : m in equation 11.
- $Q\_Factor$  is the reliability factor.
- $N_m$ : used in equation 7.
- $S_m$ : used in equation 7.
- $S_p$ : used in equation 11.

**Program Options**

Owner Company: Medco

Default Units: API English

Fill Color:  for life sections

Border Color:  for life sections

Language: English

O.K. Cancel

Show Constants

$P_i$ : 1.895

$Q\_Factor$ : 0.95

$N_m$ : 130.0

$S_m$ : 1000000.0

$S_p$ : 1000.0

These constants will affect the model calculations. Do not change without consulting with MEDCO first.