

**Coiled-Tubing Fatigue Model  
(CTLIFE2)**

**Theory and User's Manual**

**DEA-67, Phase II**

**Project to Develop and Evaluate Coiled-Tubing  
and Slim-Hole Technology**

**By**

**MAURER ENGINEERING INC.  
2916 West T.C. Jester Boulevard  
Houston, Texas 77018-7098**

**Telephone: (713) 683-8227 Facsimile: (713) 683-6418**

**Internet: <http://www.maureng.com>**

**E-Mail: [mei@maureng.com](mailto:mei@maureng.com)**

**October 1996**

**TR96-37**

**This copyrighted 1996 confidential report and computer program are for the sole use of Participants on the Drilling Engineering Association DEA-67 project to *DEVELOP AND EVALUATE COILED-TUBING AND SLIM-HOLE TECHNOLOGY* and their affiliates, and are not to be disclosed to other parties. Data output from the program can be disclosed to third parties. Participants and their affiliates are free to make copies of this report for their own use.**



# Table of Contents

	Page
<b>1. INTRODUCTION</b> .....	1-1
1.1 FEATURES OF CTLIFE2 .....	1-1
1.2 REQUIRED INPUT DATA .....	1-2
1.3 DISCLAIMER .....	1-2
1.4 COPYRIGHT .....	1-2
<b>2. THEORY</b> .....	2-1
2.1 APPROACH .....	2-1
2.2 COILED-TUBING FATIGUE LIFE MODEL .....	2-2
2.3 OTHER FACTORS AFFECTING COILED-TUBING LIFE .....	2-5
2.3.1 Job-Related Corrosion Factor .....	2-5
2.3.2 Stress Concentration Factor .....	2-5
2.3.3 Ultimate Strength Compensation Factor .....	2-6
2.3.4 Modification for Diameter/Thickness .....	2-7
<b>3. PROGRAM INSTALLATION</b> .....	3-1
3.1 BEFORE INSTALLING .....	3-1
3.1.1 Hardware and System Requirements .....	3-1
3.1.2 Program Disk .....	3-2
3.1.3 Backup Disk .....	3-2
3.2 INSTALLING CTLIFE2 .....	3-3
3.3 ALTERNATIVE SETUP .....	3-4
<b>4. EXAMPLE RUN OF CTLIFE2</b> .....	4-1
4.1 INTRODUCTION .....	4-1
4.2 STARTING CTLIFE2 .....	4-1
4.2.1 Start CTLIFE2 from Group Window .....	4-1
4.2.2 Start CTLIFE2 from Command-Line Option from Program Manager .....	4-2
4.3 EXAMPLE RUN OF CTLIFE2 .....	4-2
4.3.1 Example Run of "Whole CT String" Analysis .....	4-5
4.3.2 Example Run of "CT Section" Analysis .....	4-24
<b>5. REFERENCES</b> .....	5-1
<b>6. BUG REPORT OR ENHANCEMENT SUGGESTION FORM</b> .....	61
<b>APPENDIX A – INTERNATIONAL KEYBOARD</b>	



# 1. Introduction

*Users not wishing to read the User's Manual can go directly to Section 3.2 — INSTALLING CTLIFE2 (Page 3-3) to install and then go to Chapter 4 to calculate the example in that chapter.*

The use of coiled tubing (CT) in the oil industry is increasing rapidly for drilling, completion, and production applications. Advantages of coiled tubing include reduced costs, time savings, and increased safety. Fatigue failure of coiled tubing is a serious concern because of plastic deformation caused by repeated bending on the reel and gooseneck. Internal pressure in coiled tubing under operating conditions accelerates fatigue failure by causing an increase in the coiled-tubing diameter and a ballooning effect.

To help predict coiled-tubing failure, Maurer Engineering Inc. developed a coiled-tubing life Windows program, CTLIFE2, as part of the DEA-67 project to "Develop and Evaluate Coiled-Tubing and Slim-Hole Technology." This program is written in Visual Basic 3.0 for use with IBM compatible computers. The CTLIFE2 program runs in Windows 3.0 or later versions.

This model is based on experimental and theoretical work conducted by Dr. V.A. Avakov of Halliburton. We want to thank Dr. Avakov and Halliburton for their assistance in developing this model.

The program describes the complex coiled-tubing fatigue failure due to plastic deformation and repeated bending on the reel and gooseneck. The mathematical model is developed by utilizing low-cycle fatigue mechanics and coiled-tubing fatigue statistical data. The model is suitable for any coiled-tubing operation for both inland and offshore applications.

The program predicts the consumed coiled-tubing life along the coiled-tubing string after various operations (e.g., logging and workover). Coiled-tubing fatigue failure is considered to occur when 100% of the life of the coiled tubing is consumed.

## 1.1 FEATURES OF CTLIFE2

The key features of CTLIFE2 are its ability to:

1. Model repeated bending of coiled tubing on the reel and gooseneck and the effect of coiled-tubing internal pressure on coiled-tubing life.
2. Handle coiled-tubing strings with up to 15 different ID sections.
3. Allow different internal coiled-tubing pressures for trips in and out for different well section depths.
4. Graphically animate the coiled-tubing operation and the cumulative consumed life of the string.
5. Simulate real-time operation with common "weight-checking" pick-up routine.

6. Model coiled-tubing life reduction due to acid corrosion and stress concentration in butt-welded sections.
7. Predict the total number of strokes to failure.
8. Perform sensitivity analyses on coiled-tubing OD, grade, wall thickness, weld types, and fluid corrosion.
9. Update the current coiled-tubing life data for the next run.
10. Allow use of English and Metric units in the calculations.

The output window shows a graph of the percent of coiled-tubing life consumed in all previous operations, and the additional amount that will be consumed in the present operation. These data are also presented in a table.

## **1.2 REQUIRED INPUT DATA**

There are four data files associated with CTLIFE2:

1. Well information file (.WDI) – well name, well location, operating company, date, etc.
2. Coiled-tubing/operation data file (.CF2):
  - a) Coiled-tubing OD, wall thickness, section length, strength properties
  - b) Reel core diameter, gooseneck radius, reel core width
  - c) Coiled-tubing internal pressure, working depth (up to 200 points)
3. Coiled-tubing fatigue life history file (.CLH) — previously consumed life on every 50-ft interval on the coiled-tubing string.
4. Project file (.PCT) — containing the above three file path names to load the data files and data automatically.

All input data saved on the disk or in memory are in the English system of units.

## **1.3 DISCLAIMER**

No warranty or representation is expressed or implied with respect to these programs or documentation, including their quality, performance, merchantability, or fitness for a particular purpose.

## **1.4 COPYRIGHT**

Participants in DEA-67 can provide data output from this copyrighted program to third parties and can duplicate the program and manual for their in-house use, but cannot give copies of the program or manual to third parties.

## 2. Theory

### 2.1 APPROACH

Figure 2-1 illustrates the conceptual approach used to model the areas of interest. Coiled tubing is spooled onto reels with a reel core (drum) diameter of about 4–8 ft. Coiled tubing is plastically deformed on the reel since the bending radii is smaller than the minimum bending radii to maintain elastic bending conditions. Table 2-1 lists the minimum bending radii for elastic bending of steel coiled tubing. For typical operations of coiled tubing, there is one bending-straightening cycle on the reel and two bending-straightening cycles on the gooseneck for one stroke or one round-trip in and out of the well.

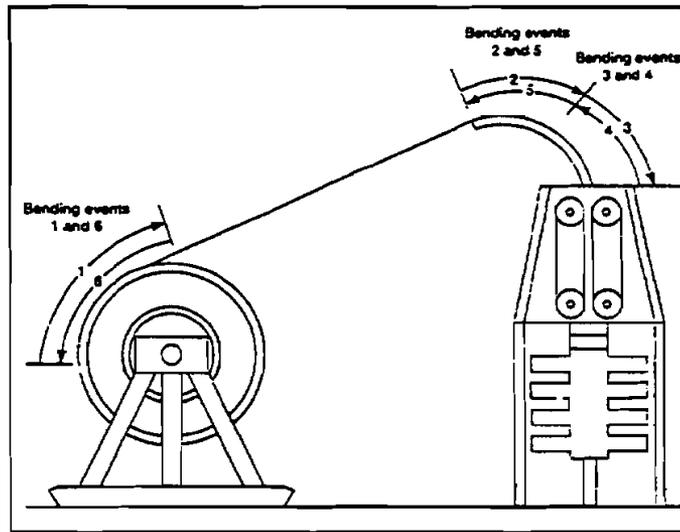


Figure 2-1. Coiled-Tubing Bending on Reel and Gooseneck (Sas-Jaworsky II, 1993)

TABLE 2-1. Minimum Elastic Bending Radii  
(Sas-Jaworksy II, 1993)

Coiled-Tubing OD (in.)	Minimum Elastic Bending Radii (ft)
0.750	13
1.000	18
1.250	22
1.500	27
1.750	31
2.000	36
2.375	42

\* For 70,000 psi, yield strength CT with  $E = 30 \times 10^6$  psi.

Due to repeated plastic deformation of coiled tubing on the reel and gooseneck, the coiled tubing will eventually fail by fatigue failure. This program was developed to calculate the cumulative fatigue damage and predict when fatigue failure occurs.

## 2.2 COILED-TUBING FATIGUE LIFE MODEL

The model used in this program was developed by Dr. V.A. Avakov et al. (1993) with Halliburton. Full-scale tubing fatigue tests were conducted to obtain the constants of the low-cycle S-N (strain versus life) fatigue line (Coffin-Manson equation, Figure 2-2).

$$S = GN^b + FEN^c \quad (2-1)$$

where the first term on the right side of the equation represents the elastic portion of the total strain, and the second term represents the plastic portion of the total strain.

Since coiled tubing is repeatedly bent in a plastic strain range, the second term of Eq. 2-1 is dominant and the S-N fatigue line is simplified and defined as:

$$S = FEN^c \quad (2-2)$$

At  $C = -1/2$  and assuming that life has Logweibull distribution for reliability assessment, we have (Avakov et al., 1994):

$$\frac{N}{N_m} \left( \frac{S}{S_m} \right)^2 = K_Q \quad (2-3)$$

where  $K_Q$  is the reliability factor, and  $N_m$  and  $S_m$  are empirical tubing median life in cycles and tubing median fatigue strength found by test data. The medium fatigue line becomes ( $K_Q = 1$ ):

$$NS^2 = N_m S_m^2 = 1 \quad (2-4)$$

In general,  $K_Q$  is:

$$K_Q = 11.47 \frac{\ln Q}{\ln 0.5}^{\frac{1}{13}} - 1 \quad (2-5)$$

where  $Q$  is the reliability level, and

$K_Q = 1.00$	at	$Q = 0.50$
$= 0.8373$		$= 0.80$
$= 0.7498$		$= 0.90$
$= 0.6779$		$= 0.95$
$= 0.5991$		$= 0.98$
$= 0.5488$		$= 0.99$
$= 0.4222$		$= 0.999$

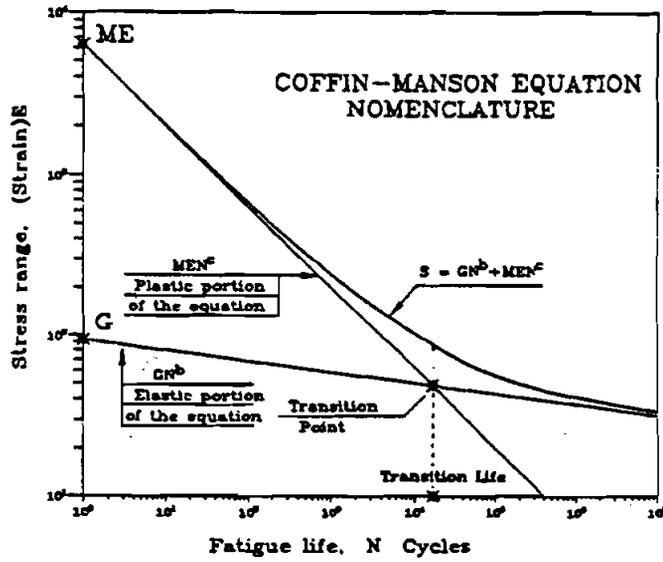


Figure 2-2. Low-Cycle S-N Line (Avakov et al., 1993)

The test data from full-scale fatigue tests indicate that the median fatigue line ( $Q = 0.5$ ) is given by:

$$\begin{cases} N_m = 130 \\ S_m = 1000 \end{cases} \quad (2-6)$$

which is shown in Figure 2-3.

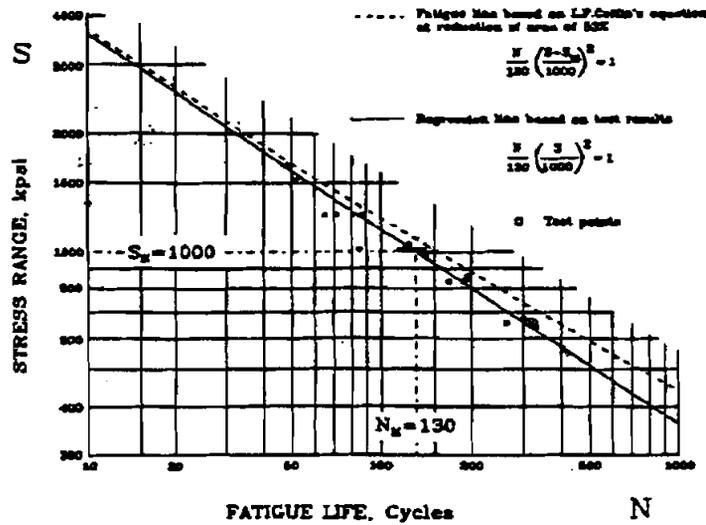


Figure 2-3. Median Fatigue Line (Avakov et al., 1993)

For a higher reliability level ( $Q > 0.5$ ), tubing life is reduced from  $N_m$  to  $N_R$  by the factor of  $K_Q$ :

$$N_R = K_Q \left( \frac{S_m}{S_R} \right)^2 N_m = K_Q N_m \quad (2-7)$$

In order to model the fatigue damage, the coiled tubing full equivalent uniaxial alternating stress is then defined.

$$\begin{cases} S = S_a + S_t^{1.895} & \text{if } S_a > S_y \\ S = 0 & \text{if } S_a \leq S_y \end{cases} \quad (2-8)$$

For bending on the reel, Eq. 2-8 becomes

$$S_r = S_{ar} + S_t^{1.895} \quad (2-9)$$

For bending on the gooseneck, Eq. 2-8 becomes

$$S_g = S_{ag} + S_t^{1.895} \quad (2-10)$$

where

$$S_{ar} = \frac{D_o E}{2R_r} \quad (2-11)$$

$$S_{ag} = \frac{D_o E}{2R_g} \quad (2-12)$$

$$S_t = \frac{2D_i^2 P_i}{D_o^2 - D_i^2} \quad (2-13)$$

$S_a$  - Cycle axial stress imposed on outer fibers bent over the reel or the gooseneck

$S_t$  - Loop stress on outer surface induced by internal pressure

$D_o$  - Coiled-tubing OD

$E$  - Modulus of elasticity

$R_r$  - Current reel radius with spooled coiled tubing

$R_g$  - Gooseneck radius

$D_i$  - Coiled-tubing ID

$P_i$  - Coiled-tubing internal pressure

For one stroke of coiled-tubing operation, there is one bending-straightening cycle on the reel and two bending-straightening cycles on the gooseneck. The total number of cycles during one tubing stroke, as converted to the empirical tubing median fatigue strength  $S_m$ , will be:

$$N_1 = 1 \left( \frac{S_r}{S_m} \right)^2 + 2 \left( \frac{S_g}{S_m} \right)^2 \quad (2-14)$$

The fatigue damage or consumed life in percent from one tubing stroke at a given reliability level is then:

$$FD_1 = \frac{N_1}{K_Q N_m} * 100\% \quad (2-15)$$

Cumulative fatigue damage or consumed life is the sum from each tubing stroke. When the cumulative fatigue damage or consumed life reaches 100%, fatigue failure will occur.

$$TFD = \Sigma FD_1 \quad (2-16)$$

## 2.3 OTHER FACTORS AFFECTING COILED-TUBING LIFE

### 2.3.1 Job-Related Corrosion Factor

Corrosive environments in coiled-tubing operations, such as acid or  $H_2S$ , will result in damage to the coiled tubing. The following corrosion factors are used to account for this damage and modify the coiled-tubing fatigue life (Avakov, 1992; Comgan et al., 1991; Scott, 1994):

$$K_c = \begin{cases} 1.0 & \text{for water and nitrogen} \\ 0.66 & \text{for cement and acid} \\ 0.50 & \text{for } H_2S \end{cases}$$

The fatigue damage from one tubing stroke then becomes:

$$FD_1 = \frac{1}{K_c} * \frac{N_1}{K_Q N_m} * 100\% \quad (2-17)$$

### 2.3.2 Stress Concentration Factor

Stress concentration due to butt welds will reduce coiled-tubing life at the butt weld. The following stress concentration factors are used to account for this life reduction (Quality Tubing, Inc., 1995):

$$K_s = \begin{cases} 1.0 & \text{for non-welded tubing section} \\ 0.9 & \text{for bias-welded tubing section} \\ 0.6 & \text{for tapered bias-welded tubing section} \\ 0.45 & \text{for orbital (automatic) butt-welded tubing section} \\ 0.35 & \text{for manual butt-welded tubing section} \\ 0.2 & \text{for orbital (automatic) tapered butt-welded section} \\ 0.15 & \text{for manual tapered butt-welded section} \end{cases}$$

Figure 2-4 shows the welded section and the heat affected zone (HAZ). If the weld is not dressed, the stress concentration factor may be even lower.

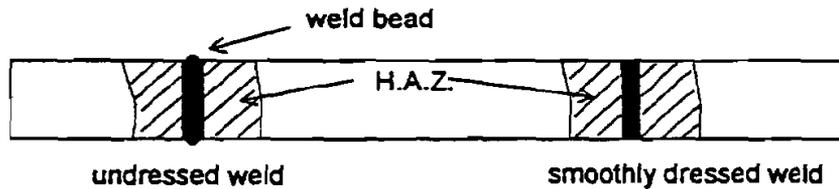


Figure 2-4. Butt-Welded Tubing; Dressed and Undressed

The fatigue damage from one tubing stroke then becomes:

$$FD_1 = \frac{1}{K_c \cdot K_s} * \frac{N_1}{K_Q N_m} * 100\% \quad (2-18)$$

### 2.3.3 Ultimate Strength Compensation Factor

The higher the coiled tubing yield/ultimate strength, the less fatigue damage will result from each stroke of coiled-tubing operation. An ultimate strength compensation factor (Avakov et al., 1994) is used to convert the fatigue lines for various materials based on the test data:

$$K_{us} = \left( \frac{\ln(1 - RA)}{\ln(0.47)} \right)^2 \quad (2-19)$$

where RA is the reduction of area, in the form of a fraction:

$$\begin{cases} \text{RA} = 0.53 \text{ for QT-700 CT and equivalent} \\ \text{RA} = 0.57 \text{ for QT-800 CT and equivalent} \\ \text{RA} = 0.60 \text{ for QT-1000 CT and equivalent} \end{cases} \quad (2-20)$$

the fatigue damage from one tubing stroke then becomes:

$$\text{FD}_1 = \frac{1}{K_c \cdot K_s \cdot K_{us}} * \frac{N_1}{K_Q N_m} * 100\% \quad (2-21)$$

#### 2.3.4 Modification for Diameter/Thickness

$$N_m = 130 * \left( \frac{0.32}{A_t} \right)^{1/2}$$

where

$A_t$  - coiled tubing wall (metallic) area, in.<sup>2</sup>



## 3. Program Installation

### 3.1 BEFORE INSTALLING

#### 3.1.1 Hardware and System Requirements

CTLIFE2 is written in Visual Basic®. It runs in either standard or enhanced mode of Microsoft Windows 3.0 or higher. The basic requirements are:

- Any IBM-compatible machine built on the 80286 processor or higher (with math coprocessor)
- 2 megabytes of RAM; 4 megabytes is recommended
- Hard disk
- Mouse
- CGA, EGA, VGA, 8514, Hercules, or compatible display (EGA or higher resolution is recommended)
- MS-DOS version 3.1 or higher
- Windows version 3.0 or higher in standard or enhanced mode

These are the **minimum** system requirements. We strongly suggest the program be installed on and operated from the hard drive.

The amount of calculation time depends to a great extent on the speed of the machine and the number of calculation intervals used. Usually, calculation time is less than 30 seconds on an 80386 processor.

For assistance with the installation or use of CTLIFE2, contact:

Jiang Wu or Russell Hall  
Maurer Engineering Inc.  
2916 West T.C. Jester Boulevard  
Houston, Texas 77018-7098 U.S.A.  
Telephone: (713) 683-8227 Fax: (713) 683-6418  
Internet: <http://www.maureng.com>  
E-Mail: [mei@maureng.com](mailto:mei@maureng.com)

### 3.1.2 Program Disk

The program disks you received are two 3½-in., 1.44 MB disk containing 21 files. These 21 files are as follows:

```
SETUPKIT.DLL
VBRUN300.DLL
VER.DL_
COMMDLG.DL_
GSWDLL16.DL_
GSW16.EX_
GSWAG16.DL_
SETUP.EXE
SETUP1.EXE
CTLIFE2.EXE
SETUP.LST
CTTEST.PCT
CTTEST.CF2
CTTEST.CLH
CTTEST.WDI
CMDIALOG.VB_
GRAPHX.VB_
GRID.VB_
THREED.VB_
CTDB.DB
MDICHILD.VB_
```

We recommend that all files for running CTLIFE2 be installed in the CTLIFE2 executable (CTLIFE2.EXE) FILE DIRECTORY (default "C:/CTLIFE2"). This can be done by a simple setup command described in Section 3.2. This will avoid possible inconsistency in Visual Basic file versions. Otherwise, the user may copy the .VBX and .DLL files to their MicroSoft WINDOWS/SYSTEM subdirectory in order to save hard disk space.

It is recommended that the original diskette be kept as a backup, and working diskettes be made from it.

### 3.1.3 Backup Disk

It is advisable to make several backup copies of the program disk and place each in a different storage location. This will minimize the probability of all disks developing operational problems at the same time.

The user can use the COPY or DISKCOPY command in DOS, or the COPY DISK on the disk menu in the File Manager in Windows.

### 3.2 INSTALLING CTLIFE2

The following procedure will install CTLIFE2 from the floppy drive onto working subdirectory of the hard disk (i.e., copy from A: or B: drive onto C: drive subdirectory CTLIFE2).

1. Start Windows by typing "WIN" <ENTER> at the DOS prompt.
2. Insert the program disk in drive A:\ or B:\.
3. In the File Manager of Windows, choose **Run** from the **File** menu. Type **A:\setup** or **B:\setup** and press Enter.
4. Follow the on-screen instructions.

This is all that is required to set up CTLIFE2. After set-up, there will be an icon for CTLIFE2 in the DEA Application Group as shown in Figure 3-1. Double clicking the icon will start CTLIFE2.

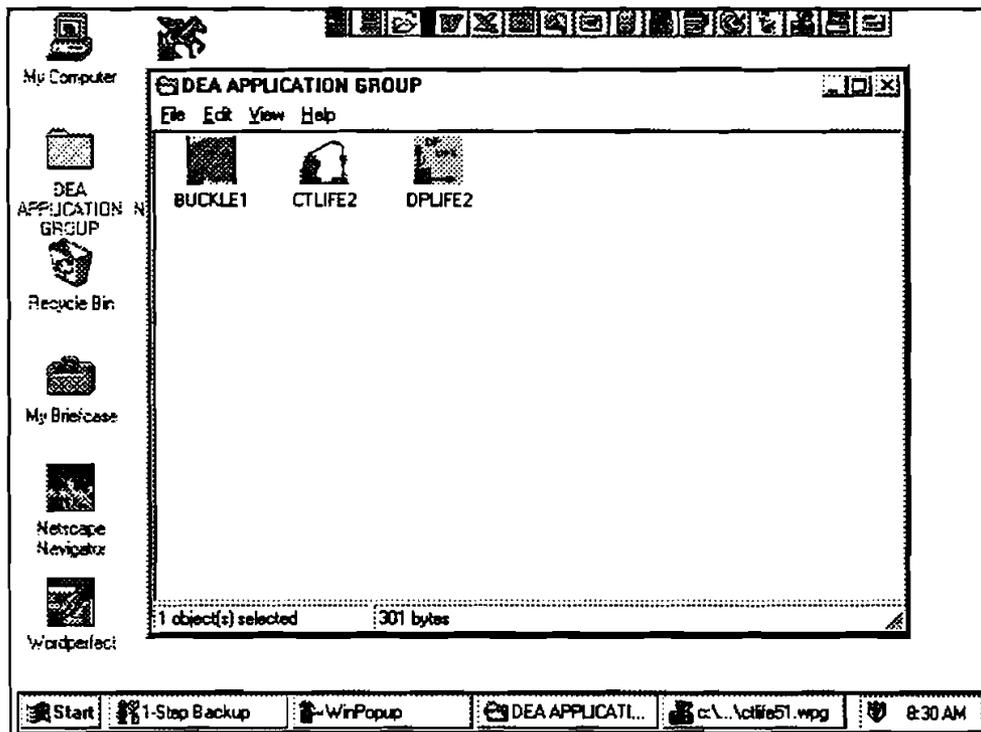


Figure 3-1. DEA Application Group Window Created by Setup

### 3.3 ALTERNATIVE SETUP

Should the SETUP procedure described above fail, follow these steps to install the program:

1. Create a subdirectory on drive C: C:\CTLIFE2.
2. Insert source disk in drive B: (or A: may be substituted for B: in this procedure).
3. Type: C:\CTLIFE2 <ENTER>.

4. At prompt C:\CTLIFE2, type:

```
Copy B:\CTLIFE2.EXE <ENTER>
Copy B:\CTTEST.* <ENTER>.
Copy B:\CTDB.DB <ENTER>.
Copy B:\VER.DL_ VER.DLL <ENTER>.
Copy B:\*.DL_ <ENTER>
Copy B:\VBRUN300.DLL <ENTER>
Copy B:\*.VB_ <ENTER>.
```

Since GSW16.EX\_ is a compressed file, the user needs to expand it by using the program Expand.EXE in the DOS subdirectory. Type: C:\DOS\EXPAND GSW16.EX\_ GSW16.EXE.

Similarly, execute file expansion for the other compressed files:

```
Type: C:\DOS\EXPAND COMMDLG.DL_ COMMDLG.DLL,
Type: C:\DOS\EXPAND GRAPHX.VB_ GRAPHX.VBX
Type: C:\DOS\EXPAND GSWDLL16.DL_ GSWDLL16.DLL.
Type: C:\DOS\EXPAND CMDIALOG.VB_ CMDIALOG.VBX
Type: C:\DOS\EXPAND GRID.VB_ GRID.VBX
Type: C:\DOS\EXPAND THREED.VB_ THREED.VBX
Type: C:\DOS\EXPAND MDICHILD.VB_ MDICHILD.VBX
Type: C:\DOS\EXPAND GSWAG16.DL_ GSWAG16.DLL
```

5. Type: CD.. <ENTER>, then key in "WIN" <ENTER> to start Windows 3.0 or later version.
6. Click menu "File" under "PROGRAM MANAGER," select item "New...," click on "PROGRAM GROUP" option, then [OK] button.
7. Key in "DEA APPLICATION GROUP" after label "Description:," then click on [OK] button. A group window with the caption of "DEA APPLICATION GROUP" will appear.
8. Click on menu "File" again, Select "NEW...," click on "PROGRAM ITEM" option, then [OK] button.
9. Key in "CTLIFE2" after label "Description," key in "C:\CTLIFE2\CTLIFE2.EXE" after label "COMMAND LINE," then click on [OK] button. The CTLIFE2 icon appears.
10. Double click the icon to start the program.

## 4. Example Run of CTLIFE2

### 4.1 INTRODUCTION

CTLIFE2 runs in a Windows environment. It is assumed that the user is familiar with Windows, and that his or her computer is equipped with Windows 3.0 or later.

For information about Windows in a concise and convenient form, *10 Minute Guide to Microsoft Windows 3* by Katherine Murray and Doug Sabotin, published by Sams, is recommended.

These quick start, step-by-step example runs of the program take the user rapidly through the program. To save time and space, data will be input from prefabricated files, TEST.SDI, TEST.CT1, and TEST.CLH, which are included on the program disk and which were stored in directory C:\CTLIFE2 during the set-up process in Section 3.

### 4.2 STARTING CTLIFE2

#### 4.2.1 Starting CTLIFE2 from Group Window

To run CTLIFE2 from Group Window, the user simply double-clicks the "CTLIFE2" icon, or when the icon is focused, press <ENTER> (Figure 4-1).

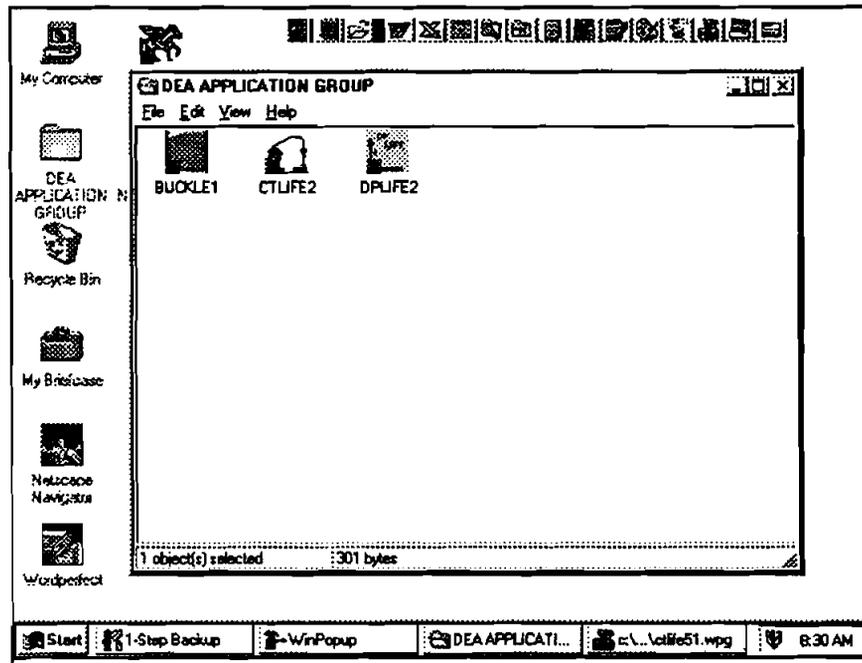


Figure 4-1. DEA APPLICATIONS GROUP Window

#### 4.2.2 Starting CTLIFE2 from Command-Line Option from Program Manager

In *Program Manager*, choose **Run** from the **"File"** menu. Type  
C:\CTLIFE2\CTLIFE2.EXE <ENTER>.

#### 4.3 EXAMPLE RUN OF CTLIFE2

1. Figure 4-2 is the first window of CTLIFE2.

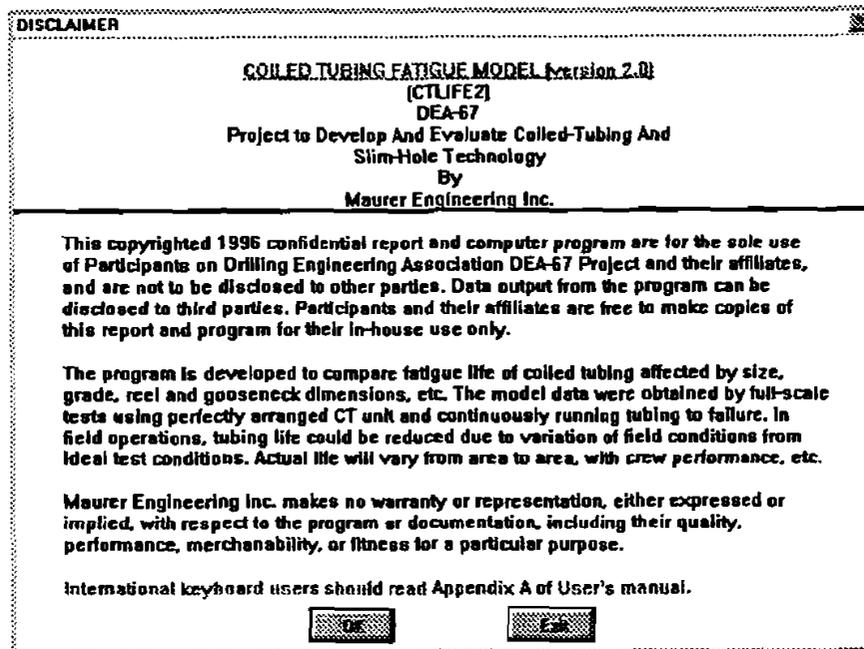


Figure 4-2. Information Window of CTLIFE2

2. Click the [OK] button to open the program Main Window (Figure 4-3) or click [Exit] to terminate the program.
3. There are four features in the Main Window (Figure 4-3):
  - a. Menu Bar and Toolbar: controls the flow of the program
  - b. Analysis Model Option: selects one of the two options
  - c. Filename Box: indicates the data files to use
  - d. Calculate Percentage Indicator: indicates the ongoing status of the calculation

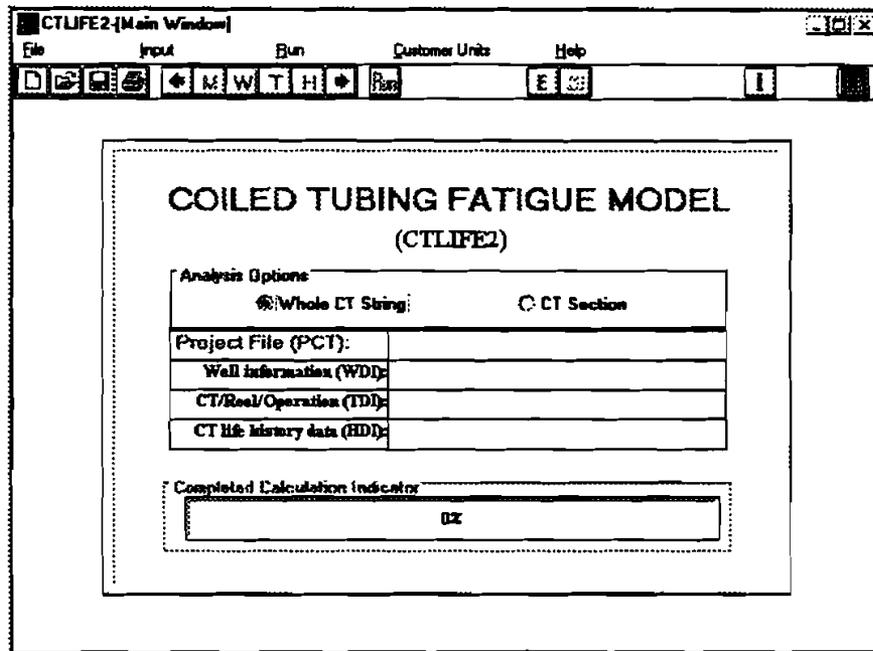


Figure 4-3. CTLIFE2 Program Main Window

4. The five pull-down menus in the menu bar are:
  - a. File
  - b. Input
  - c. Run
  - d. Customer Units
  - e. Help
  
5. The toolbar buttons allow the user to easily and quickly access the same commands in the menu bar:
  - a.  - Same as [New Project] or [New]
  - b.  - Same as [Open Project...] or [Open File...]
  - c.  - Same as [Save Project] or [Save]
  - d.  - Same as [Print Project...] or [Print...]
  - e.  - Go to preceding Window (in the order displayed in the Input Data Window)
  - f.  - Go to Main Window
  - g.  - Go to WDI Window

- h.  - Go to TDI Window
- I.  - Go to HDI Window
- j.  - Go to next Window
- k.  - Same as [Run ]
- l.  - Same as [About...]

6. The two analysis options in the Main Window (Figure 4-3) are:

- 1) Whole CT String, which is the default
- 2) CT Section

The “Whole CT String” option is to calculate the cumulative coiled-tubing life of the whole CT string consumed during field operations, while the “CT Section” is to predict how many strokes will fatigue a coiled-tubing section. To choose an analysis option, click on one of them.

7. To run the “Whole CT String” analysis, two data files have to be input:

- TDI - Coiled-tubing/reel operation data file
- HDI - Coiled-tubing life history data file

Another data file is for documentation purposes:

- WDI - Well information data file (optional)

8. To run the “CT Section” analysis, the user does not need to input a data file first, since it initially takes the default data, or data from the “Whole CT String” analysis, when available.

### 4.3.1 Example Run of "Whole CT String" Analysis

1. When the "Whole CT String" option is chosen, click the "W" button in the toolbar or "WDI" in the pull-down menu under the "Input" menu (Figure 4-4) to open the "WDI" Window (Figure 4-5).

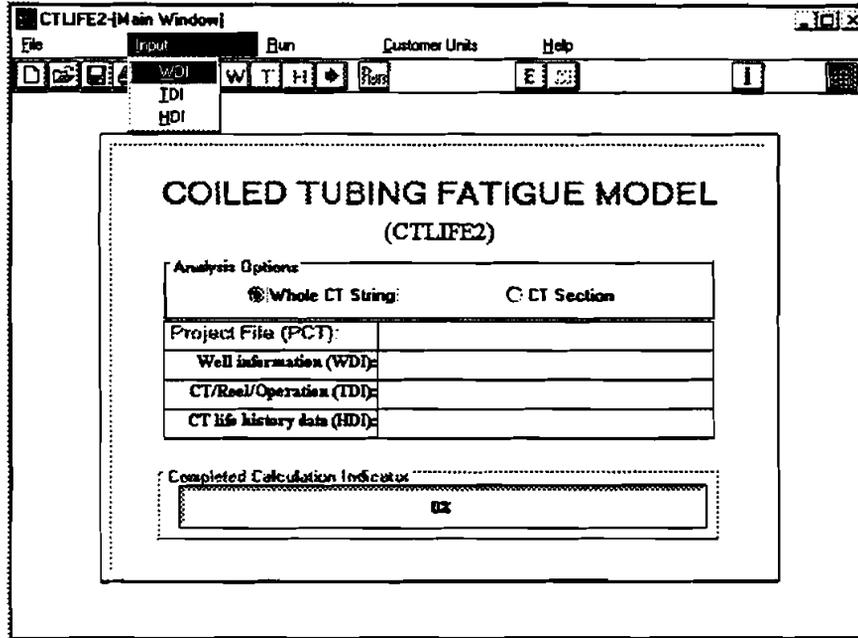


Figure 4-4. CTLIFE2 Program Main Window

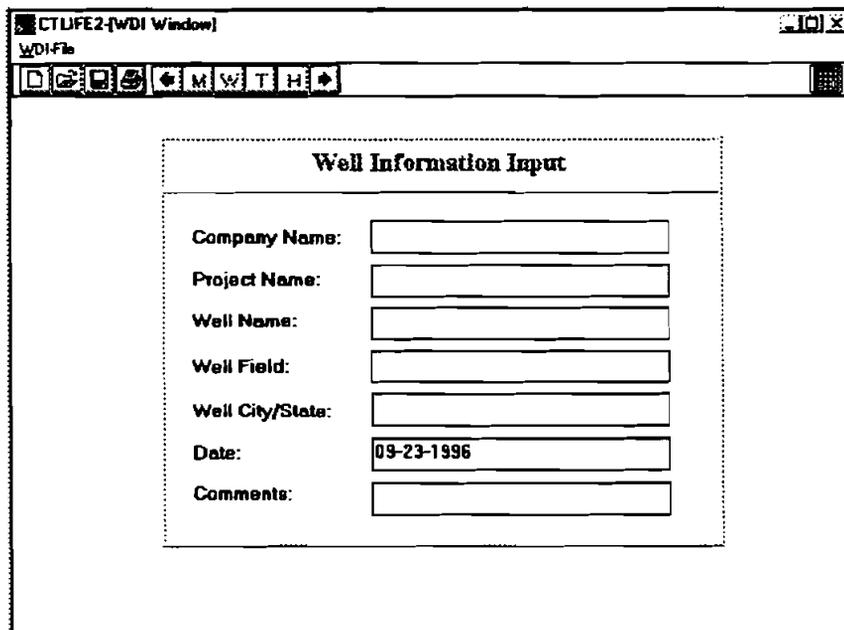


Figure 4-5. Well Information Data Window

- Click the "Open File" button in the toolbar or click "Open ..." under "File" in the menu bar at the top of the Well Information Data Window (Figure 4-5) to open the data stored in the test data file, "cttest.wdi." Select the C:\CTLIFE2 subdirectory and "cttest.wdi" filename and click the [OK] button in the "File open" dialog box (Figure 4-6). The required data are retrieved and entered into the Well Information Window (Figure 4-7). Of course, you can change the data by manually typing in the desired changes.

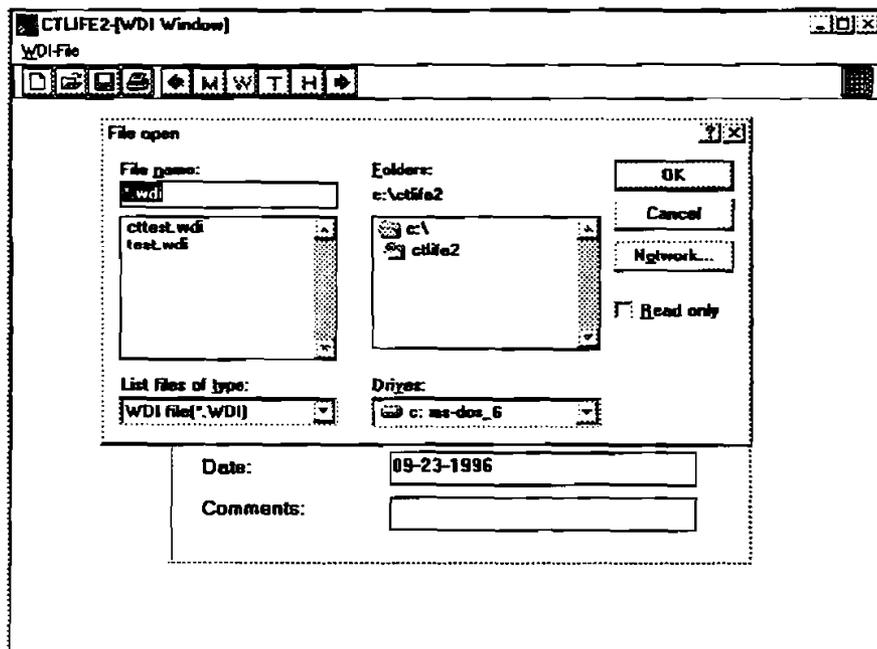


Figure 4-6. File Open Dialog Box

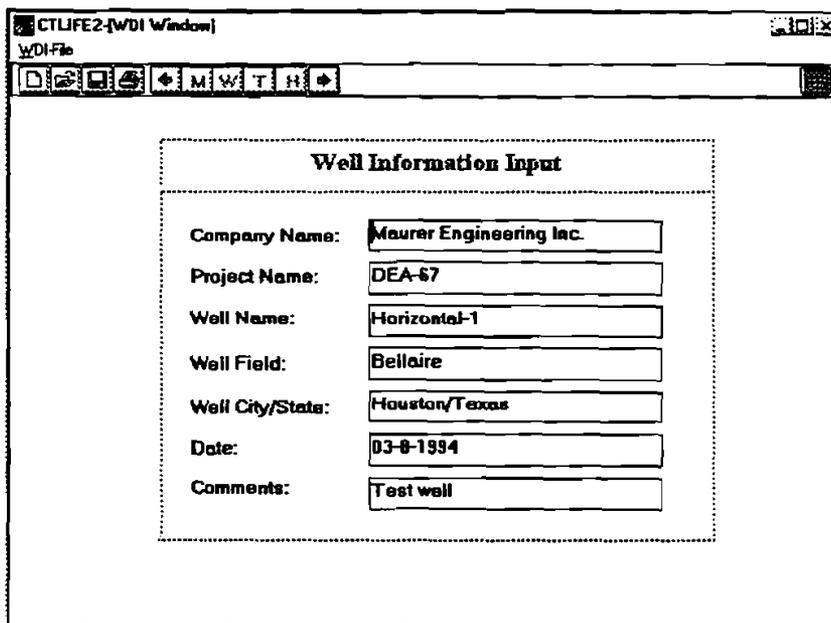


Figure 4-7. Well Information Data Window - Showing Entered Data

- After the well information data has been input, click the "T" button in the toolbar to go to the "TDI" Window (Figure 4-8).

**CTLIFE2 (TDI Window)**  
TDI-File    Input Help

**Coiled Tubing /Reel/Operation Data Input**

Reel/CT Data (CT section from downhole end)

CT Sec.	OD (in.)	Wall (in.)	Length (ft)
1			
2			
3			
4			
5			

Section Edit    Total CT length: 0.0  
 Insert    Delete    CT Data Base    Input Help

Reel identification =  
 Reel drum diameter (in.) =  
 Reel drum width (in.) =  
 Goose-neck radius (in.) =  
 Prediction reliability = 0.95  
 CT Young's modulus (psi) = 3000000  
 CT yield strength (psi) = 70000  
 CT job corrosion factor = 1.0  
 CT Unit Wellbore Geometry  
 CT weld reduction factor = 1.0

Job Operation Data (starting from the surface)

Steps	Description	Depth (ft)	Press. (psi)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Job-step Edit    Est. Pressure  
 Insert    Delete

CT Weld Location (measured from downhole seal)  
 NO WELD

Figure 4-8. Coiled Tubing/Reel Operation Data Window

- To help users understand the terminology used in data input, a "CTLIFE Input Help" Window is provided. Click "Contents" under "Input Help" in the menu bar or the "Input Help" button in the middle of the window to open the "CTLIFE Input Help" Window (Figure 4-9).

**CTLIFE2 (INPUT HELP Window)**

**CTLIFE Input Variables Glossary**

Reel/CT S  
 1  
 2  
 3  
 4  
 5  
 Sect  
 Ins  
 Re  
 Go  
 CT Y  
 C

CT weld reduction factor  
 CT job corrosion factor  
 CT pressure  
 Prediction reliability  
 Reel drum diameter  
 Reel drum width  
 Strokes

OK

CT job corrosion factor = 1.0  
 CT Unit Wellbore Geometry  
 CT weld reduction factor = 1.0

NO WELD

Figure 4-9. CTLIFE Help Input Window

5. Move the mouse to point to any of the variable names and click; the definition of that variable will be shown as in Figure 4-10. Click "Back" button and then the "OK" button to go back to the "TDI" Window.

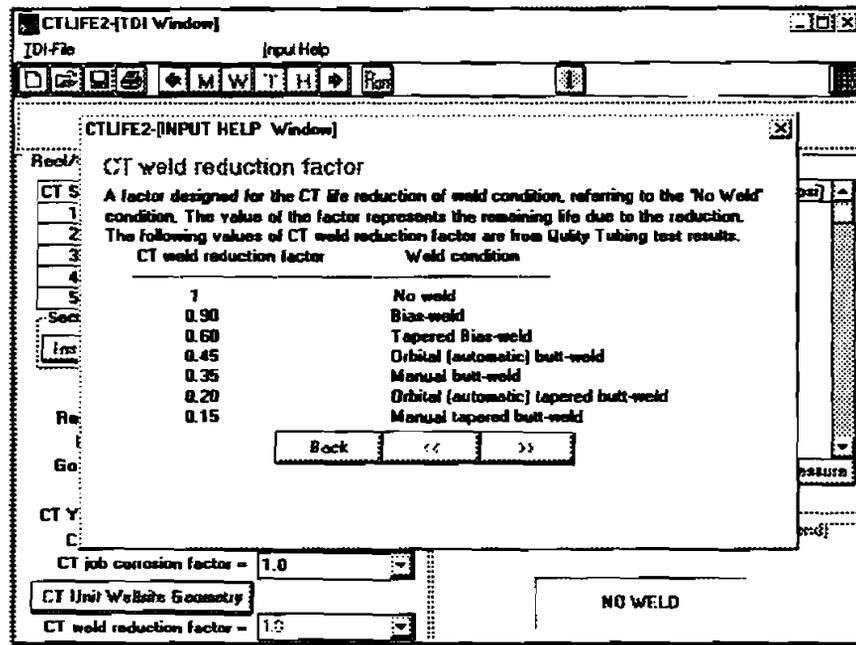


Figure 4-10. Input Variables Definitions

6. Click the "Open" file button in the toolbar or the "Open ..." under : "File" in the menu bar to open the "File Open Dialog Box" to retrieve data stored in the data file (Figure 4-11).

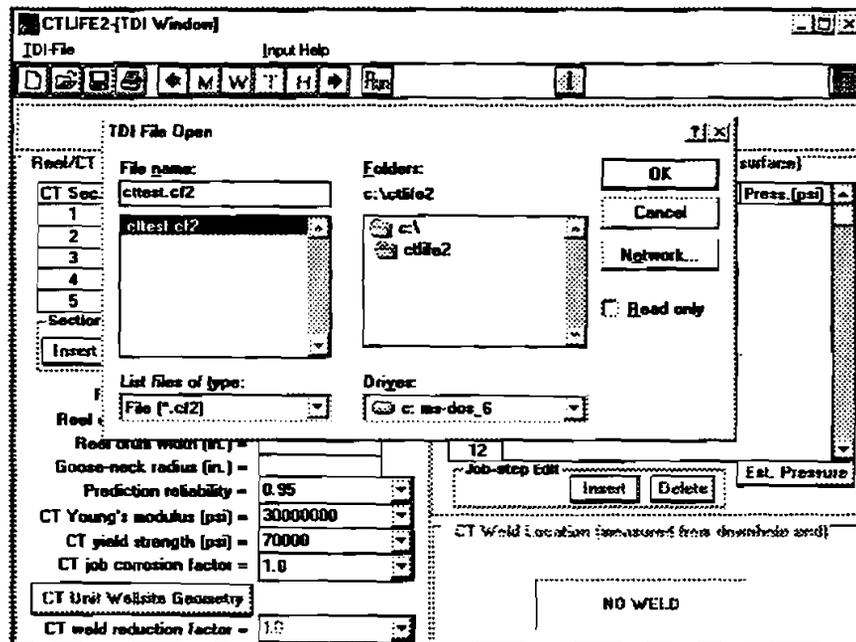


Figure 4-11. File Open Dialog Box

7. Select C:\CTLIFE2 subdirectory and "cttest.cf2" filename. Click the [OK] button in the CTI File Open dialog box (Figure 4-11) to retrieve the stored data and enter them into the Coiled Tubing/Reel/Operation Data Window (Figure 4-12).

**Coiled Tubing/Reel/Operation Data Input**

Reel/CT Data (CT section from downhole end)

CT Sec.	DD (in.)	Wall (in.)	Length (ft)
1	2.000	0.188	10000
2			
3			
4			
5			

Total CT length: 10000.0

Reel identification = test1  
 Reel drum diameter (in.) = 72.0  
 Reel drum width (in.) = 44  
 Goose-neck radius (in.) = 72  
 Prediction reliability = 0.95  
 CT Young's modulus (psi) = 30000000  
 CT yield strength (psi) = 70000  
 CT job corrosion factor = 1.00

CT Unit Wellbore Geometry  
 CT weld reduction factor = 0.60

Job Operation Data (starting from the surface)

Steps	Description	Depth (ft)	Press. (psi)
1	Start Job	0.0	1000
2	Run into hole	3000.0	1000
3	Check weight	2900.0	1000
4	Run into hole	4800.0	1000
5	Check weight	3900.0	1000
6	Run into hole	5000.0	1000
7	Check weight	4500.0	1000
8	Run into hole	6000.0	1000
9	Check weight	5500.0	1000
10	Run into hole	7000.0	1000
11	Check weight	6500.0	1000
12	RIH, TD	8000.0	1000

CT Weld Location (measured from downhole end)

No.	Weld location (ft)	Reduction factor
1	3000	0.60
2	6000	0.60
3	9000	0.60

Figure 4-12. Coiled Tubing/Reel/Operation Data Window with Example Data

8. Again, any data can be manually changed by typing a new number or selecting new conditions. Additionally, there is a "Coiled Tubing Data Base" associated with the window. By clicking [CT DataBase] button, a file open dialog box will be displayed (Figure 4-13).

**CT Database Open**

File name: ctdb.cf2  
 Folder: c:\ctlife2

List files of type: CT DB-File (CTDB.DB)  
 Drive: c: ms-dos\_5

Reel/CT Data (CT section from downhole end)

CT Sec.	DD (in.)	Wall (in.)	Length (ft)
1			
2			
3			
4			
5			

Reel drum diameter (in.) = 72  
 Goose-neck radius (in.) = 72  
 Prediction reliability = 0.95  
 CT Young's modulus (psi) = 30000000  
 CT yield strength (psi) = 70000  
 CT job corrosion factor = 1.00

CT Unit Wellbore Geometry  
 CT weld reduction factor = 0.60

Job Operation Data (starting from the surface)

Steps	Description	Depth (ft)	Press. (psi)
12	RIH, TD	8000.0	1000

CT Weld Location (measured from downhole end)

No.	Weld location (ft)	Reduction factor
1	3000	0.60
2	6000	0.60
3	9000	0.60

Figure 4-13. File Open Dialog Box to Open Data Base

- Select C:\CTLIFE2 subdirectory and "CTdb.db" filename. Click [OK] on the File open dialog box to open the coiled-tubing database (Figure 4-14).

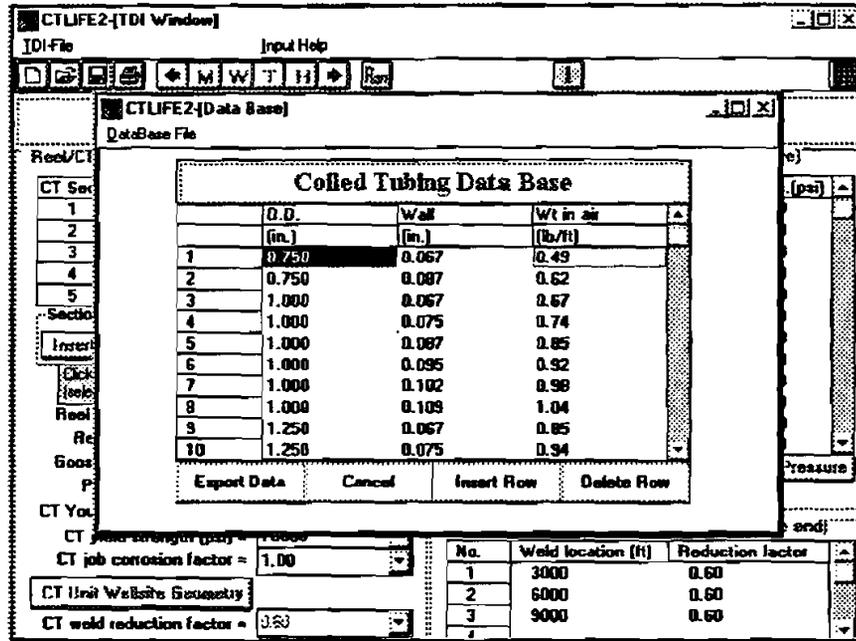


Figure 4-14. Coiled Tubing Data Base Window

10. By selecting the coiled-tubing type needed and clicking the [Export Data] button, the coiled-tubing data will be sent to the Coiled Tubing/Reel Operation Window (Figure 4-12). There is also a simple estimation of coiled-tubing internal pressure at the gooseneck from pump pressure. By clicking the [Est. pressure] button, a small window will be shown to input pump pressure and CT inside pressure drop (Figure 4-15). Click [Esti.] button to calculate "CT pressure at gooseneck," and then click [Export] button to send the result back to the "Coiled Tubing/Reel Operation" Window.

**Coiled Tubing / Reel / Operation Data Input**

Reel/CT Data (CT section from downhole end) | Job Operation Data (starting from the surface)

CT Sec.	OD (in)	Depth (ft)	Press. (psi)
1	2.00	0.0	1000
2		3000.0	1000
3		2900.0	1000
4		4000.0	1000
5		3900.0	1000
		5000.0	1000
		4900.0	1000
		6000.0	1000
		5900.0	1000
		7000.0	1000
		6900.0	1000
		8000.0	1000

**Estimate CT Internal Pressure at Gooseneck**

Job start: 10

Pump Pressure (psi):

CT inside pressure drop (psi/ft):

CT Pressure at Gooseneck (psi):

[Esti.] [Export] [Cancel]

Goose-neck radius (in) = 7.2  
 Prediction reliability = 0.95  
 CT Young's modulus (psi) = 30000000  
 CT yield strength (psi) = 70000  
 CT job corrosion factor = 1.00  
 CT Unit Wellbore Geometry  
 CT weld reduction factor = 0.50

**CT Weld Location (measured from downhole end)**

No.	Weld location (ft)	Reduction factor
1	3000	0.50
2	6000	0.50
3	9000	0.50

Figure 4-15. Coiled-Tubing Internal Pressure Estimation



13. Select C:\CTLIFE2 subdirectory and file "ctest.CLH." Click the [OK] button on the HDI File Open Dialog Box to retrieve the data stored and enter into the Coiled Tubing Life History Window (Figure 4-18).

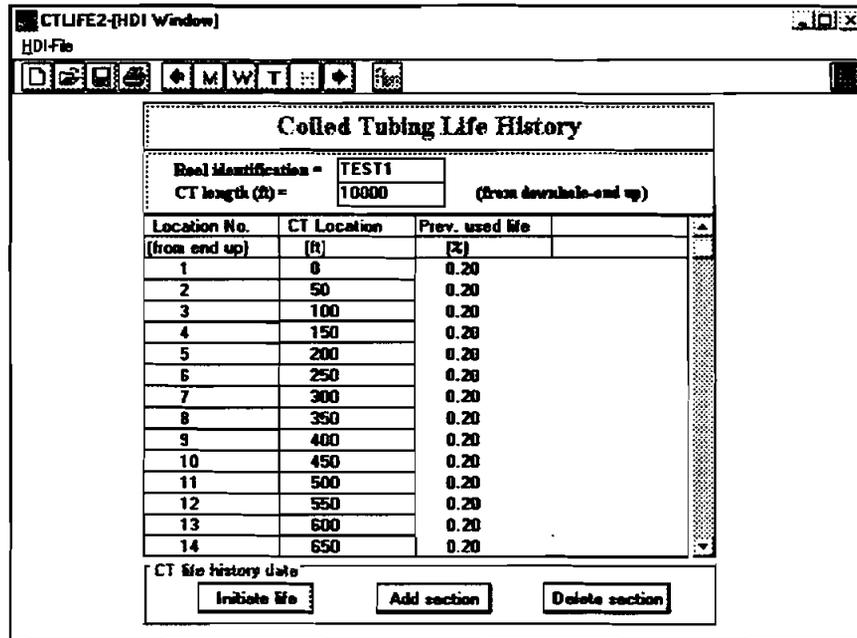


Figure 4-18. Coiled Tubing Life History Data Window with Entered Data

14. The coiled-tubing life history data can be modified by:
  - a) Delete section
  - b) Add section
  - c) Initiate life

By choosing a location on the coiled-tubing string and clicking the [DELETE SECTION] button, a coiled-tubing section (50-ft long) will be deleted at that location.

By choosing a coiled-tubing location and clicking the [ADD SECTION] button, a coiled-tubing section (50-ft long) will be added at that location.

By clicking the [INITIATE LIFE] button, a dialog box will be shown (Figure 4-19). Inputting the coiled-tubing locations of "from" and "to" and the coiled-tubing life initiation value, and clicking the [OK] button, will initiate/reset the coiled-tubing life data for that section of the coiled tubing.

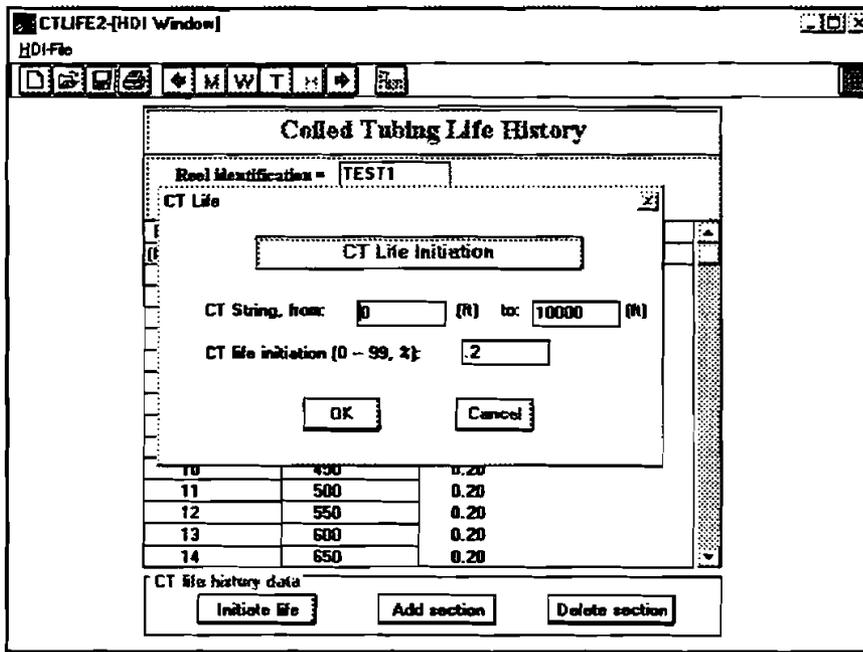


Figure 4-19. Input Box for Coiled-Tubing Life Initiation

- Click the "M" button in the toolbar or the "Return" under "File" in the menu bar to go back to the Main Window. Note that the three data filenames are recorded in the filename boxes in the Main Window. If any data window is manually input without retrieving a data file, and you do not save the data into a data file, "Undefined" will be shown in the corresponding filename box of the Main Window.

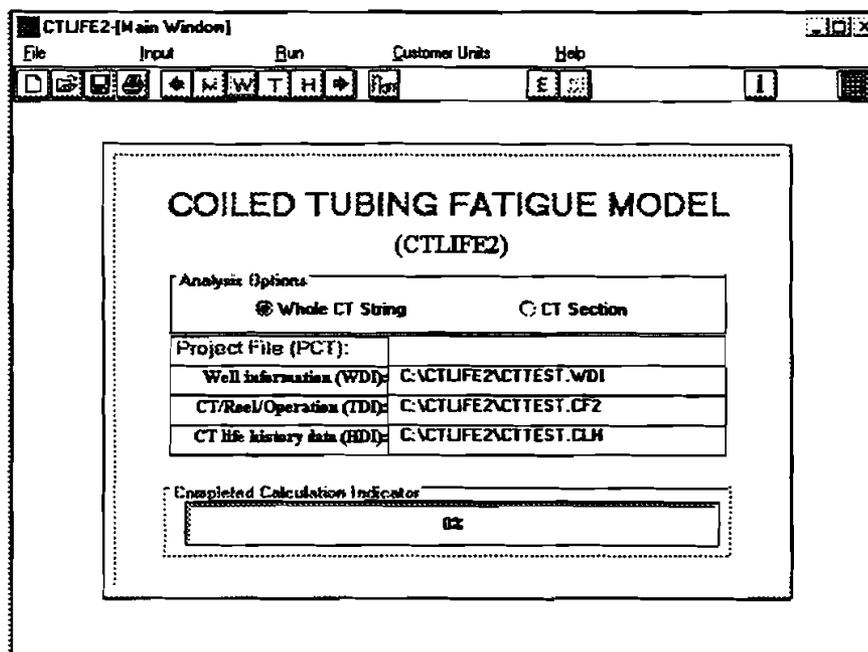


Figure 4-20. Main Window - Displaying with Data Files' Names

16. A project file is designed to store the three data filenames and paths. Clicking the "Save File" button in the toolbar or the "Save Project As ..." under "File" on the menu bar in the Main Window (Figure 4-21) allows you to open the "Project File Save" Dialog Box (Figure 4-22). If you type in "cttest.pct" as the project filename, and then click the [OK] button, the project file named "cttest.pct" is established. It can be used for opening the project and retrieving all of the data from the three data files automatically next session. The Main Window now displays the project filename (Figure 4-23).

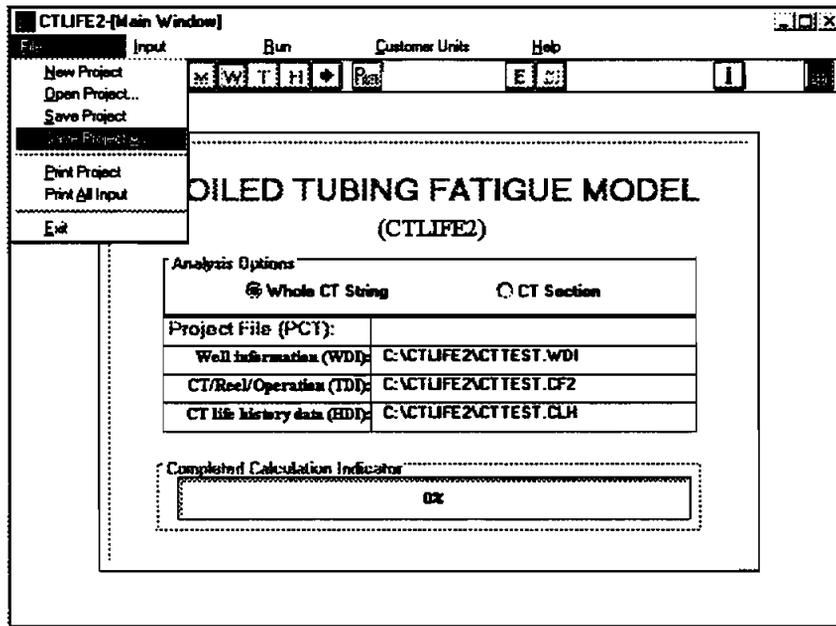


Figure 4-21. Saving Project

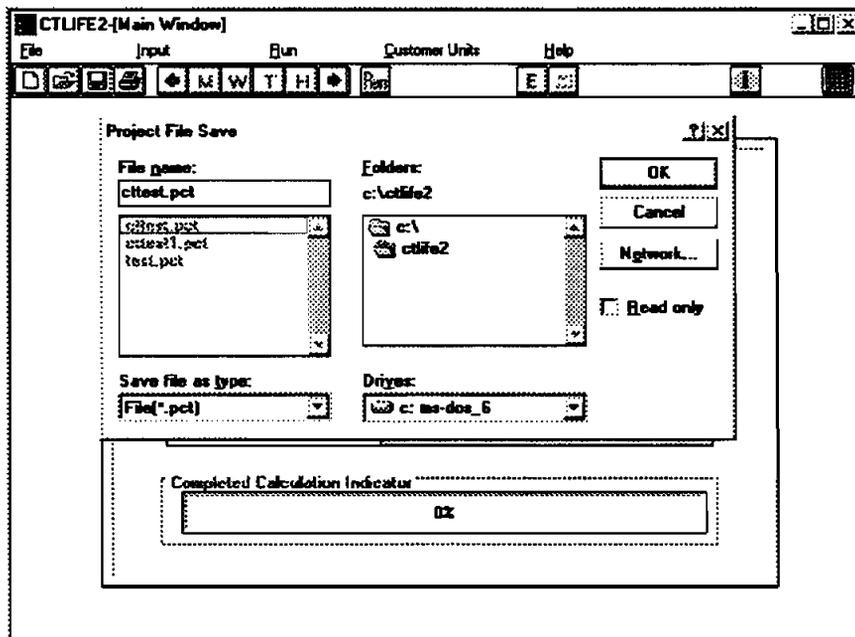


Figure 4-22. Project File Save Dialog Box

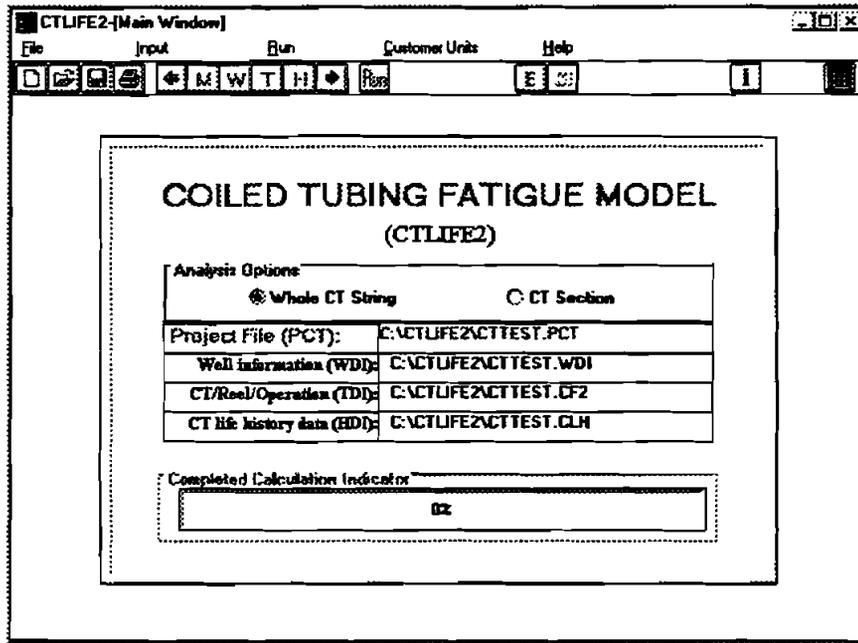


Figure 4-23. Main Window - Displaying Project Filename

- Click the "Run" button in the toolbar or "Start" under "Run" on the menu bar in the Main Window to start computing. The "Calculation Percentage" indicator will display the percent of the computation finished. When the indicator reaches 100%, the "Output" Window will be displayed (Figure 4-24).

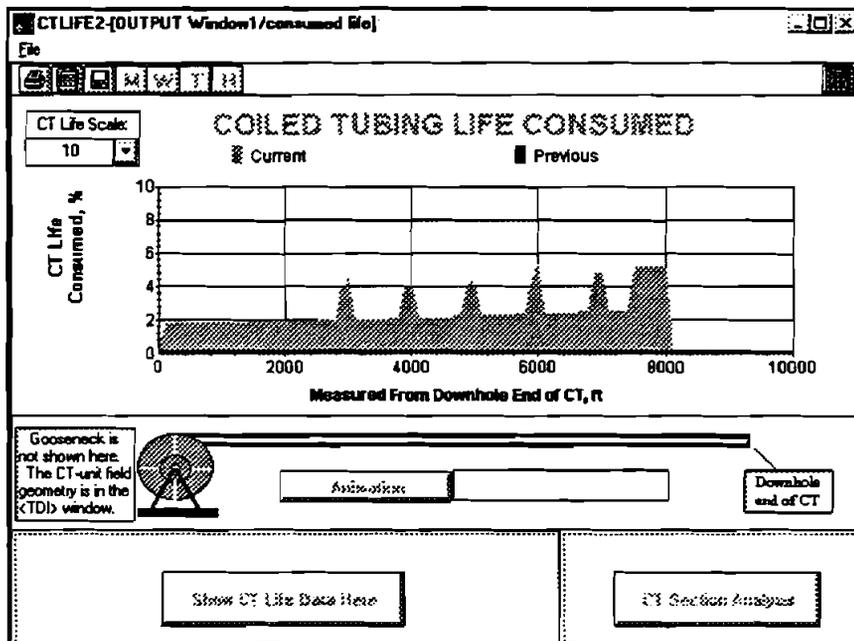


Figure 4-24. Result Output Window

18. An animation feature is built into the program. Click the "Animation" button in the middle of the "Output" Window to view the cumulation of coiled-tubing consumed life as the operation is being performed.
19. Click the "Print" button in the toolbar or "Print Report" under "File" in the menu bar of the "Output" Window to print a report for the results including all of the input, output data and the predicted coiled-tubing life plot, as shown below.

### COILED TUBING FATIGUE MODEL

Maurer Engineering Inc.

#### Project File Data

File Name: C:\CTLIFE2\CTTEST.PCT

09-26-1996

Well Information (WDI):	C:\CTLIFE2\CTTEST.WDI
CT/Reel Operation Data (TDI):	C:\CTLIFE2\CTTEST.CF2
CT Life History Data (HDI):	C:\CTLIFE2\CTTEST.CLH

#### 1. Well Information

File Name: C:\CTLIFE2\CTTEST.WDI

09-26-1996

Company Name	Maurer Engineering Inc.
Project Name	DEA-67
Well Name	Horizontal-1
Well Field	Bellaire
Well City/State	Houston/Texas
Date	09-26-1996
Comments	Test well

#### 2. CT/Reel/Operation Data

File Name: C:\CTLIFE2\CTTEST.CF2

09-26-1996

(1) CT / Reel Data ( CT sections start from bottom of CT):

CT section	OD (in.)	Wall (in.)	Length (ft)
1	2.000	0.188	<u>10000</u>
			Total: 10000

(2) CT Weld Location (measured from downhole end):

No.	Weld location (ft)	Weld Reduction Factor
1	3000.0	0.6
2	6000.0	0.6
3	9000.0	0.6

CT Young's modulus (psi)	=	30000000
CT yield strength (psi)	=	70000
CT job corrosion factor	=	1
CT weld reduction factor	=	.6
Reel identification	=	test1
Reel drum diameter (in.)	=	72.0
Reel drum width (in.)	=	44.0
Goose-neck radius (in.)	=	72.0
Design reliability	=	.95

(3) Job Operation Data (starting from the surface):

Job step	Description	Depth(ft)	Pressure(psi)
1	Start Job	0.0	1000.0
2	Run into hole	3000.0	1000.0
3	Check weight	2900.0	1000.0
4	Run into hole	4000.0	1000.0
5	Check weight	3900.0	1000.0
6	Run into hole	5000.0	1000.0
7	Check weight	4900.0	1000.0
8	Run into hole	6000.0	1000.0
9	Check weight	5900.0	1000.0
10	Run into hole	7000.0	1000.0
11	Check weight	6900.0	1000.0
12	RIH, TD	8000.0	1000.0
13	POOH, wash	7500.0	1000.0
14	RIH, TD	8000.0	1000.0
15	POOH	6500.0	1000.0
16	End job	0.0 0.0	

**3. Coiled Tubing Life History Data**

File Name: C:\CTLIFE2\CTTEST.CLH

09-26-1996

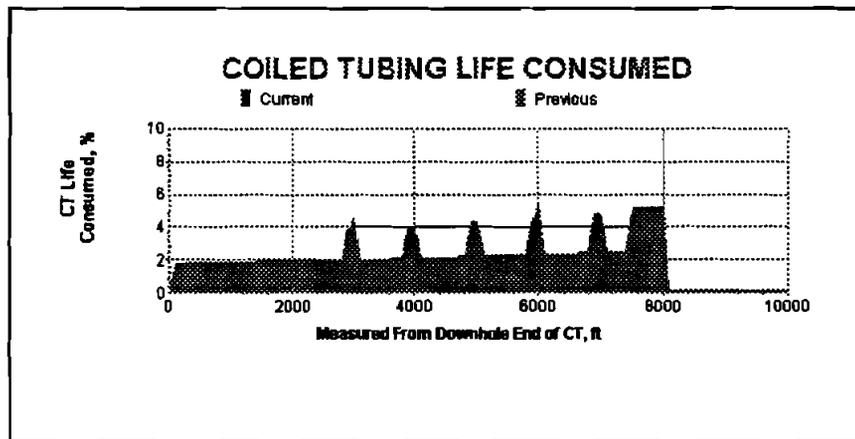
No.	CT Location (ft)	Previous Life (%)	Current Life (%)
1	0.00	0.20	0.81
2	50.0	0.20	0.81
3	100.0	0.20	1.80
4	150.0	0.20	1.80
5	200.0	0.20	1.80
6	250.0	0.20	1.80
7	300.0	0.20	1.87
8	350.0	0.20	1.87
9	400.0	0.20	1.87
10	450.0	0.20	1.87
11	500.0	0.20	1.87
12	550.0	0.20	1.87
13	600.0	0.20	1.87

No.	CT Location (ft)	Previous Life (%)	Current Life (%)
14	650.0	0.20	1.87
15	700.0	0.20	1.87
16	750.0	0.20	1.87
17	800.0	0.20	1.87
18	850.0	0.20	1.87
19	900.0	0.20	1.87
20	950.0	0.20	1.87
21	1000.0	0.20	1.87
22	1050.0	0.20	1.87
23	1100.0	0.20	1.87
24	1150.0	0.20	1.87
25	1200.0	0.20	1.87
26	1250.0	0.20	1.87
27	1300.0	0.20	1.87
28	1350.0	0.20	1.87
29	1400.0	0.20	1.87
30	1450.0	0.20	1.95
31	1500.0	0.20	1.95
32	1550.0	0.20	1.95
33	1600.0	0.20	1.95
34	1650.0	0.20	1.95
35	1700.0	0.20	1.95
36	1750.0	0.20	1.95
37	1800.0	0.20	1.95
38	1850.0	0.20	1.95
39	1900.0	0.20	1.95
40	1950.0	0.20	1.95
41	2000.0	0.20	1.95
42	2050.0	0.20	1.95
43	2100.0	0.20	1.95
44	2150.0	0.20	1.95
45	2200.0	0.20	1.95
46	2250.0	0.20	1.95
47	2300.0	0.20	1.95
48	2350.0	0.20	1.95
49	2400.0	0.20	1.95
50	2450.0	0.20	1.95
51	2500.0	0.20	1.95
52	2550.0	0.20	2.04
53	2600.0	0.20	2.04
54	2650.0	0.20	2.04
55	2700.0	0.20	2.04
56	2750.0	0.20	2.04
57	2800.0	0.20	2.04
58	2850.0	0.20	2.96
59	2900.0	0.20	3.87
60	2950.0	0.20	3.87

No.	CT Location (ft)	Previous Life (%)	Current Life (%)
61	3000.0	0.20	4.49
62	3050.0	0.20	2.96
63	3100.0	0.20	2.04
64	3150.0	0.20	2.04
65	3200.0	0.20	2.04
66	3250.0	0.20	2.04
67	3300.0	0.20	2.04
68	3350.0	0.20	2.04
69	3400.0	0.20	2.04
70	3450.0	0.20	2.04
71	3500.0	0.20	2.04
72	3550.0	0.20	2.04
73	3600.0	0.20	2.04
74	3650.0	0.20	2.14
75	3700.0	0.20	2.14
76	3750.0	0.20	2.14
77	3800.0	0.20	2.14
78	3850.0	0.20	3.11
79	3900.0	0.20	4.07
80	3950.0	0.20	4.07
81	4000.0	0.20	4.07
82	4050.0	0.20	3.11
83	4100.0	0.20	2.14
84	4150.0	0.20	2.14
85	4200.0	0.20	2.14
86	4250.0	0.20	2.14
87	4300.0	0.20	2.14
88	4350.0	0.20	2.14
89	4400.0	0.20	2.14
90	4450.0	0.20	2.14
91	4500.0	0.20	2.14
92	4550.0	0.20	2.14
93	4600.0	0.20	2.14
94	4650.0	0.20	2.14
95	4700.0	0.20	2.25
96	4750.0	0.20	2.25
97	4800.0	0.20	2.25
98	4850.0	0.20	3.27
99	4900.0	0.20	4.30
100	4950.0	0.20	4.30
101	5000.0	0.20	4.30
102	5050.0	0.20	3.27
103	5100.0	0.20	2.25
104	5150.0	0.20	2.25
105	5200.0	0.20	2.25
106	5250.0	0.20	2.25
107	5300.0	0.20	2.25

No.	CT Location (ft)	Previous Life (%)	Current Life (%)
108	5350.0	0.20	2.25
109	5400.0	0.20	2.25
110	5450.0	0.20	2.25
111	5500.0	0.20	2.25
112	5550.0	0.20	2.25
113	5600.0	0.20	2.25
114	5650.0	0.20	2.25
115	5700.0	0.20	2.38
116	5750.0	0.20	2.38
117	5800.0	0.20	2.38
118	5850.0	0.20	3.47
119	5900.0	0.20	4.56
120	5950.0	0.20	4.56
121	6000.0	0.20	5.28
122	6050.0	0.20	3.47
123	6100.0	0.20	2.38
124	6150.0	0.20	2.38
125	6200.0	0.20	2.38
126	6250.0	0.20	2.38
127	6300.0	0.20	2.38
128	6350.0	0.20	2.38
129	6400.0	0.20	2.38
130	6450.0	0.20	2.38
131	6500.0	0.20	2.38
132	6550.0	0.20	2.38
133	6600.0	0.20	2.38
134	6650.0	0.20	2.52
135	6700.0	0.20	2.52
136	6750.0	0.20	2.52
137	6800.0	0.20	2.52
138	6850.0	0.20	3.69
139	6900.0	0.20	4.85
140	6950.0	0.20	4.85
141	7000.0	0.20	4.85
142	7050.0	0.20	3.69
143	7100.0	0.20	2.52
144	7150.0	0.20	2.52
145	7200.0	0.20	2.52
146	7250.0	0.20	2.52
147	7300.0	0.20	2.52
148	7350.0	0.20	2.52
149	7400.0	0.20	2.52
150	7450.0	0.20	3.69
151	7500.0	0.20	4.85
152	7550.0	0.20	5.18
153	7600.0	0.20	5.18
154	7650.0	0.20	5.18

No.	CT Location (ft)	Previous Life (%)	Current Life (%)
155	7700.0	0.20	5.18
156	7750.0	0.20	5.18
157	7800.0	0.20	5.18
158	7850.0	0.20	5.18
159	7900.0	0.20	5.18
160	7950.0	0.20	5.18
161	8000.0	0.20	5.18
162	8050.0	0.20	2.69



\*\*\* End of Report \*\*\*

20. Click the "H" button in the toolbar of the "Output Window" to go to the Coiled Tubing Life History Data Window to update the coiled-tubing life history data, or click the "M" button in the toolbar or "Return" under "File" in the menu bar to return to the Main Window.
21. To update the coiled-tubing life history data, click "update" under "File" in the menu bar of the Coiled Tubing Life History Data Window (Figure 4-16). A File save dialog box will be shown to allow you to assign a filename to the updated life history file (Figure 4-25). After selecting the updated filename, click [OK] button to execute the update. The third column data (prev. used life) in the Coiled Tubing Life History Data Window is also replaced by the fourth column data (cur. used life) as shown in Figure 4-26.

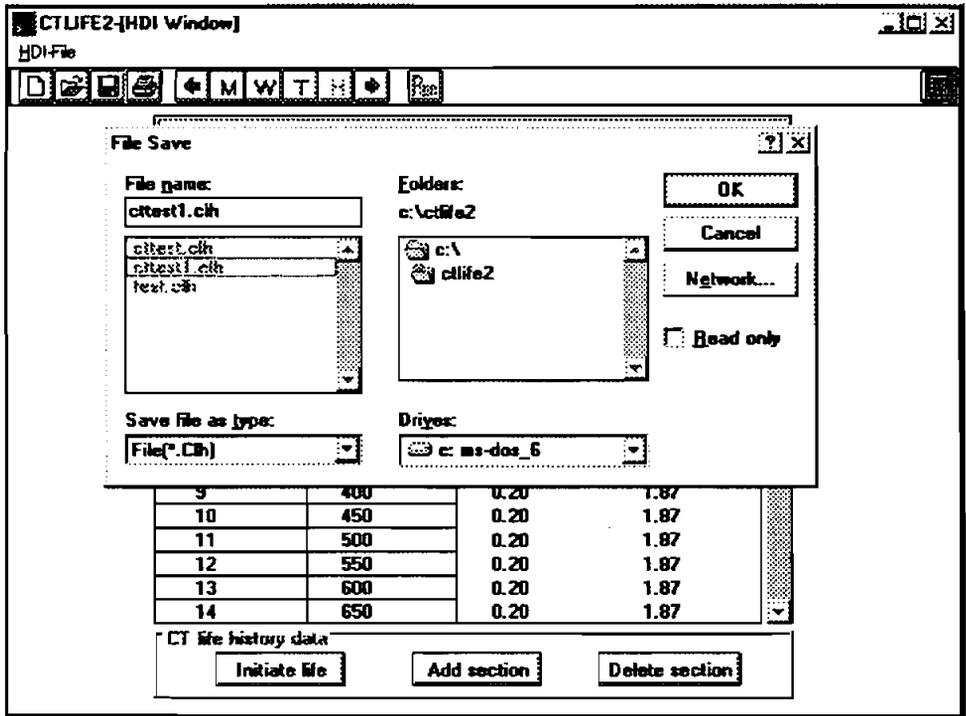


Figure 4-25. File Save Dialog Box for Coiled-Tubing Life History Update

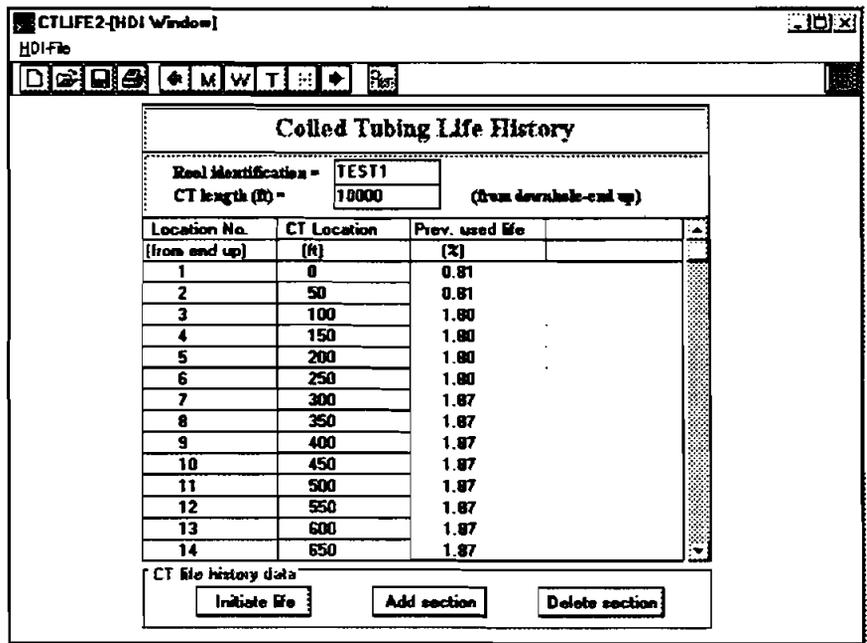


Figure 4-26. Coiled Tubing Life History Data Window - Updated

### 4.3.2 Example Run of a "CT Section" Analysis

1. When the "CT Section" option is chosen, no data files are needed. Just click the "Run" button in the toolbar or "Start" under "Run" in the menu bar of the Main Window (Figure 4-4). The following "Total Strokes" Window will be displayed with the defaults "CT/Reel Data" and calculated total strokes curve as a function of the coiled-tubing internal pressure (Figure 4-27). This "Total Strokes" Window can also be accessed from the "Output" Window for the "Whole CT String" (Figure 4-24) by clicking the "Strokes to Fail" button.

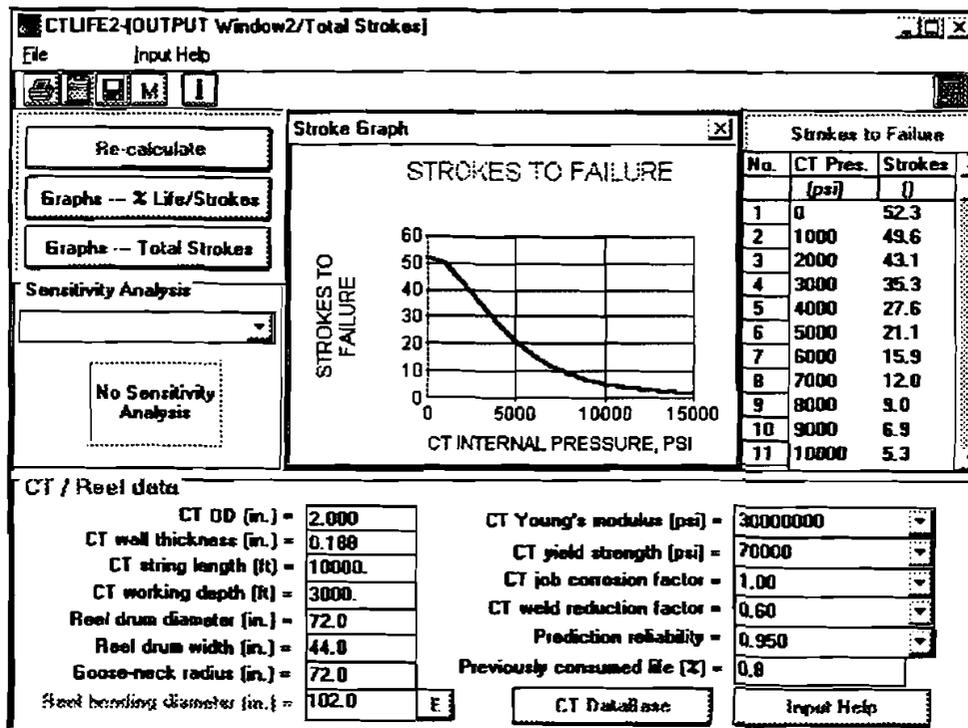


Figure 4-27. Total Strokes Window

2. By manually changing any of the "CT/Reel" data, and then clicking the "Recalculate" button, the total strokes curve will be updated. The table beside the graph shows the stroke values for the curve.
3. Click "Print" under "File" in the menu bar of the "Total Strokes" Window and the following report will be printed.
4. More than one curve can be shown and compared in the graph by activating the "Sensitivity Analysis" list box. To do this, select one item from the list box, such as "CT OD," (Figure 4-28) and click the "Recalculate" button (Figure 4-29).

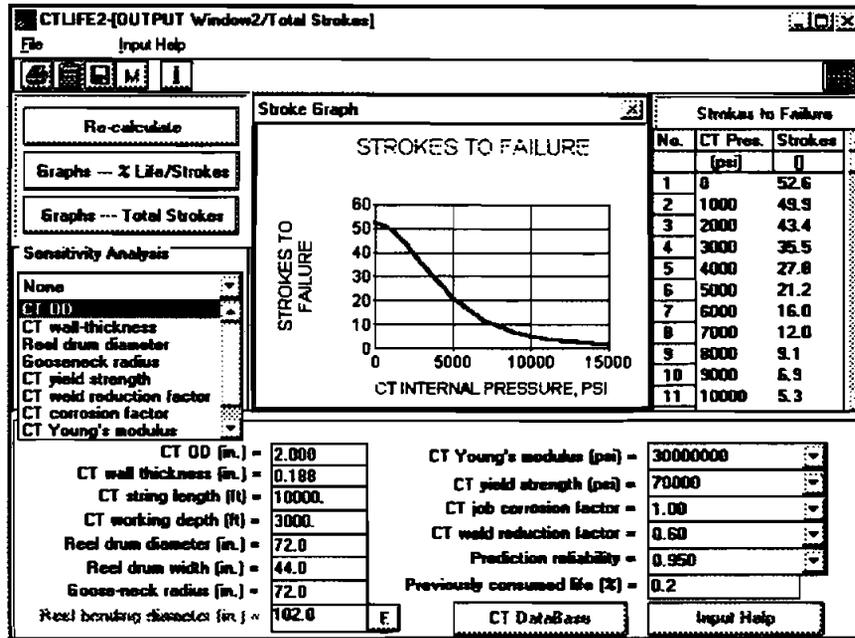


Figure 4-28. Total Strokes Window — Sensitivity Analysis Selection

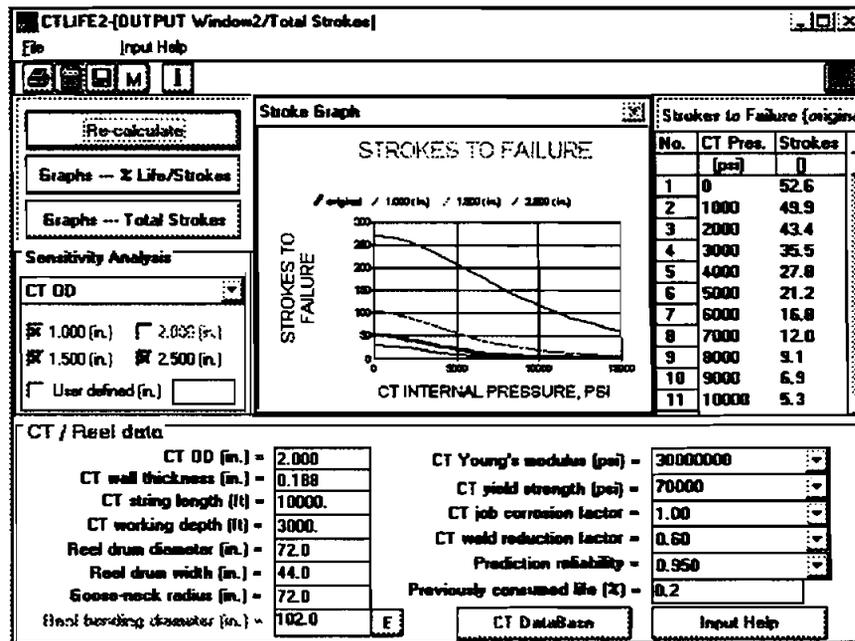


Figure 4-29. Total Strokes Window — Sensitivity Analysis Graph

## COILED TUBING FATIGUE MODEL

Maurer Engineering Inc.

CT Section Analysis Data

09-26-1996

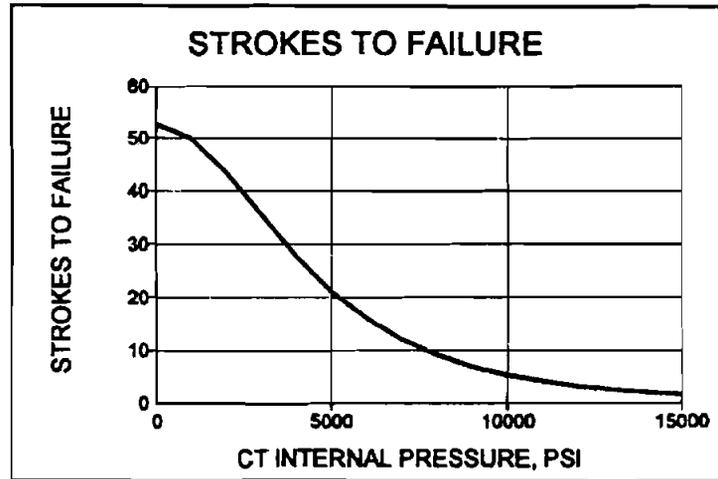
---

CT OD(in.)	=	2.000
CT wall thickness (in.)	=	0.188
CT string length(ft)	=	10000.0
CT working depth (ft)	=	3000.0
Reel drum diameter (in.)	=	72.0
Reel drum width (in.)	=	44.0
Goose-neck radius (in.)	=	72.0
Reel bending diameter (in.)	=	102.0
CT Young's modulus (psi)	=	30000000
CT yield strength (psi)	=	70000
CT job corrosion factor	=	1.00
CT weld reduction factor	=	0.60
Prediction reliability	=	0.950
Previously consumed life (%)	=	0.20

---

No.	CT Pressure (psi)	Strokes to Failure
1	0	52.6
2	1000	49.9
3	2000	43.4
4	3000	35.5
5	4000	27.8
6	5000	21.2
7	6000	16.0
8	7000	12.0
9	8000	9.1
10	9000	6.9
11	10000	5.3
12	11000	4.1
13	12000	3.2
14	13000	2.6
15	14000	2.0
16	15000	1.7

---



\*\*\*End of Report\*\*\*

- Click the "Graphs — % Life/Strokes" button to show the consumed coiled-tubing life per stroke for varied CT OD, wall thickness, GT Grade, weld condition, and corrosion condition (Figure 4-30).

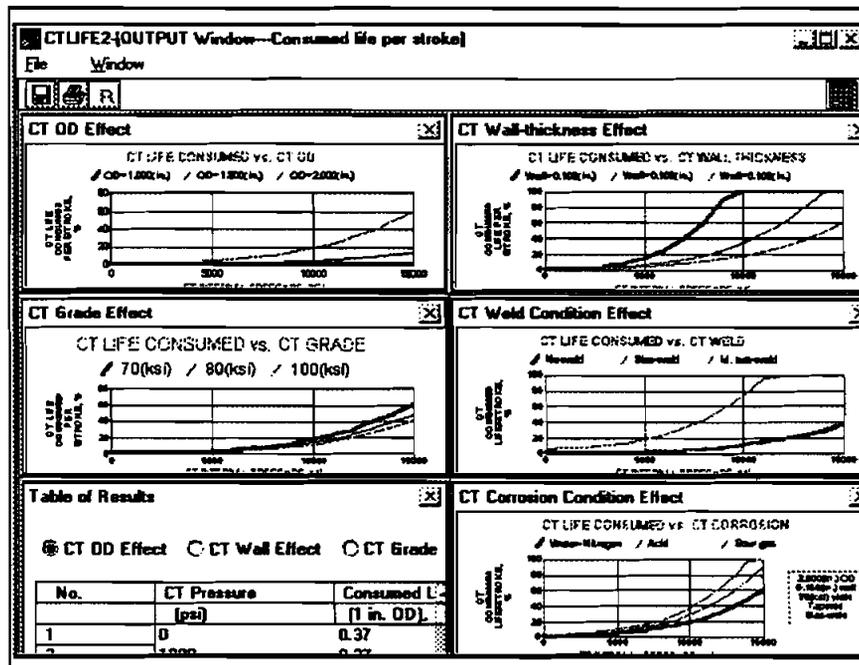


Figure 4-30. Consumed Life Per Stroke Graphs

- Click "R" button on the tool bar of Figure 4-30 to go back to the "Total Strokes" Window (Figure 4-29). Then Click the "Graphs --- Total Strokes" button to show the strokes to cause the CT failure for varied CT OD, Wall thickness, CT Grade, Weld Condition, and Corrosion Condition (Figure 4-31).

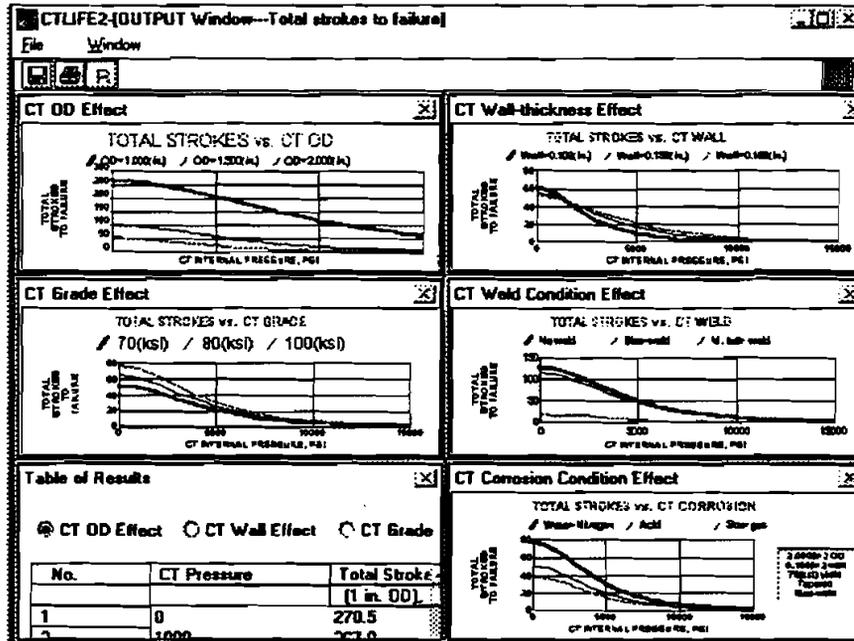


Figure 4-31. Strokes to Failure Graphs

- In the Main Window, there are five items under "Help" on the menu bar: "About," "Assistance," "Theoretical Model," "Field Example," and "User Feedback." Clicking on "About ..." opens a Program Information Window listing the equipment used to run the program (Figure 4-32). Clicking on "Assistance ..." opens an Assistance Information Window with the name, telephone, fax and telex numbers to contact regarding program support (Figure 4-33). Clicking on "Theoretical Basis ..." opens an Information Window showing the source of the theoretical background (Figure 4-34). Clicking on "Field Example" opens a field example graph showing the importance of predicting CT Life (Figure 4-35). Clicking on "User Feedback" opens a form to let user make any comments and send to Maurer Engineering (Figure 4-36).

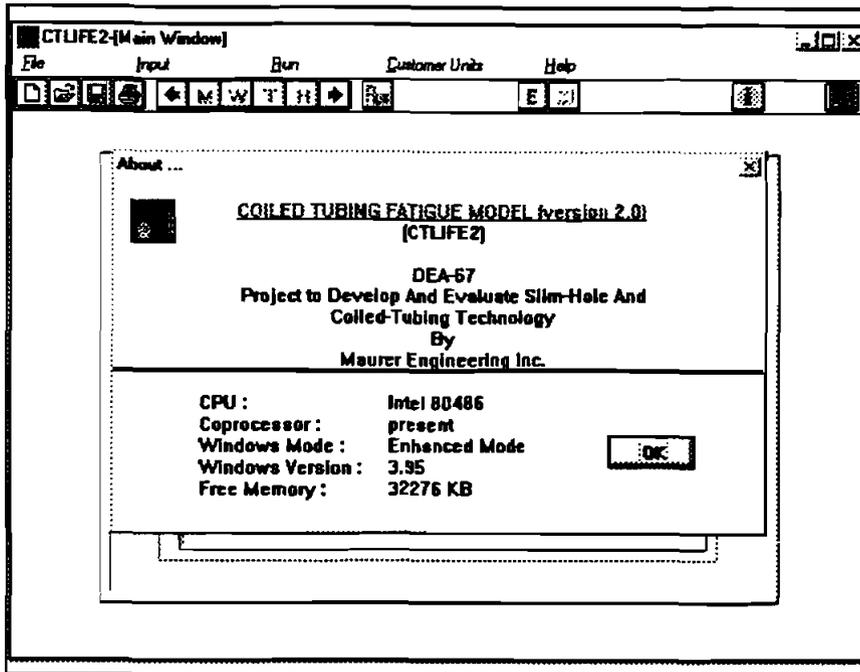


Figure 4-32. "About" Window

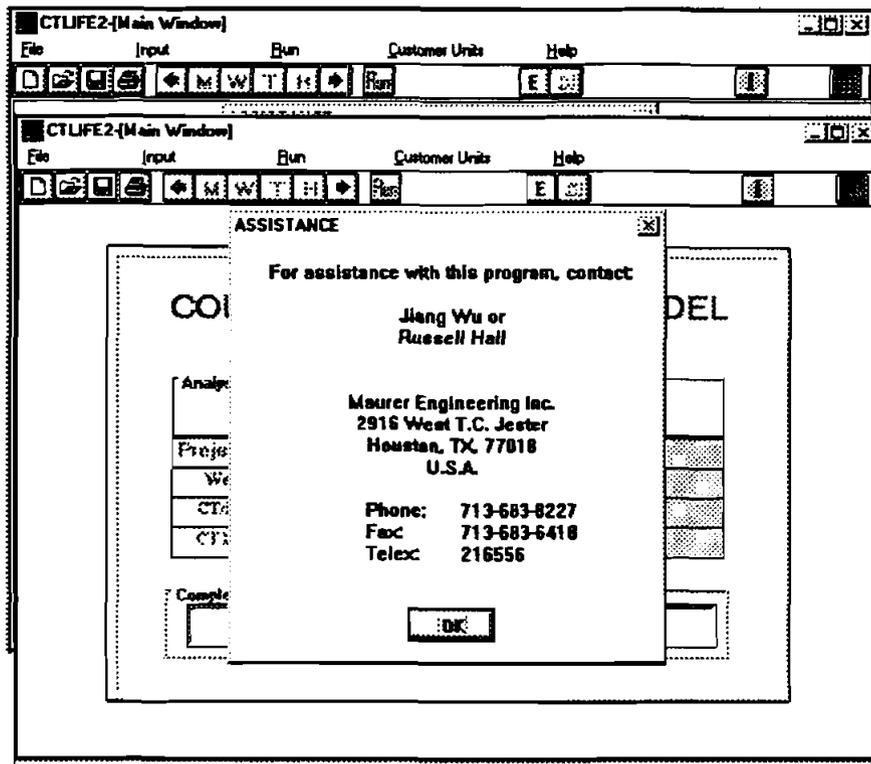


Figure 4-33. "Assistance" Window

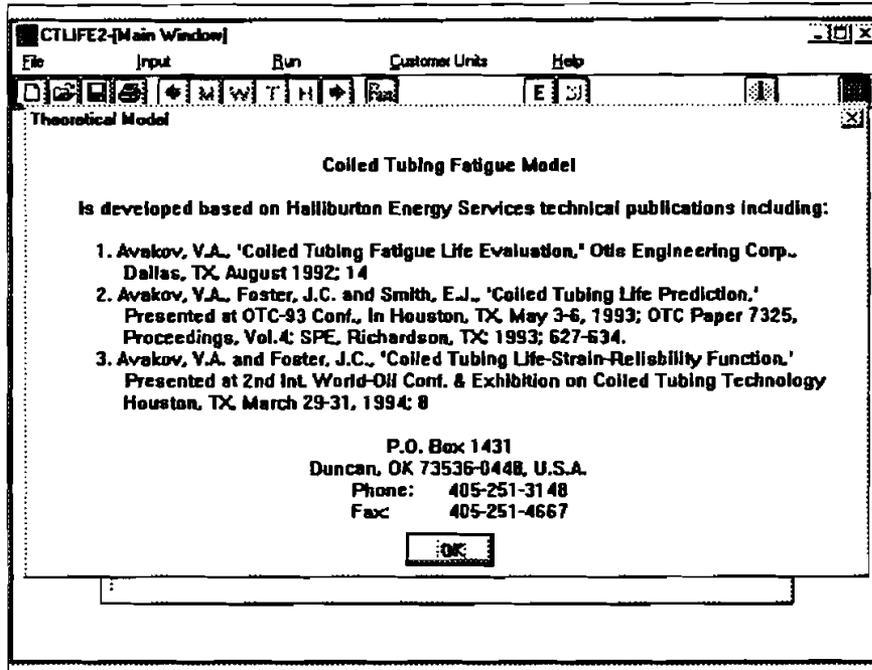


Figure 4-34. "Theoretical Model" Window

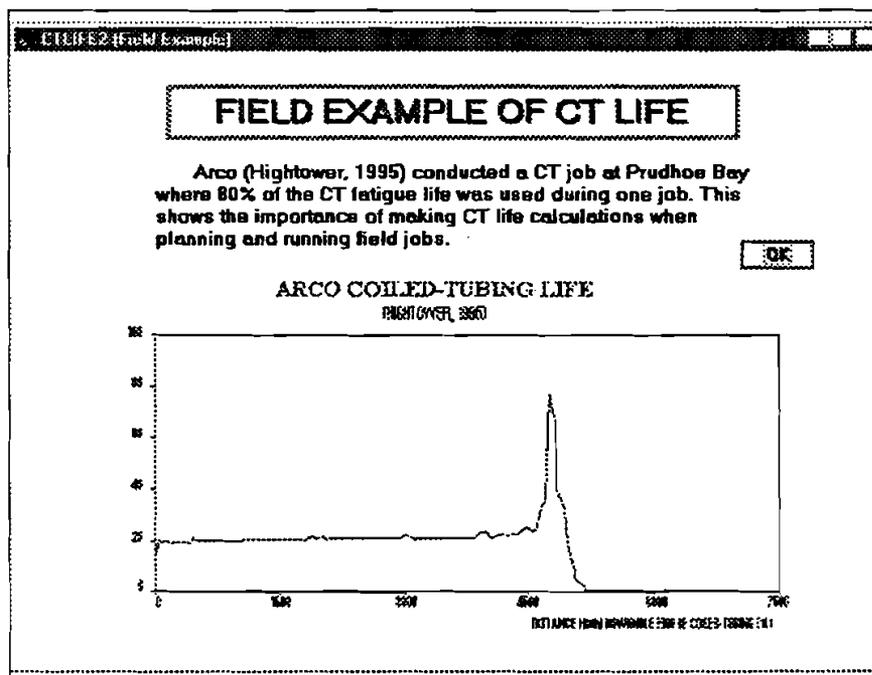


Figure 4-35. Field Example of CT Life

**User Feedback**

Model: RWEAR ver 1.0 Time 3/24/96 1:24:48 PM

---

**User Information:**

Company:  Department:

Address:

User Name:

Telephone:  Fax Number:

e-mail:

**Comments/Problem:**

**Options:**

Print for Fax to (713) 683 - 6418     Save File for e-mail to [msi@maurong.com](mailto:msi@maurong.com)

Figure 4-36. User Feedback Form



## 5. References

1. Avakov, V.A., and Foster, J.C., 1994: "Coiled Tubing Life-Strain-Reliability Function," 2nd International World Oil Conference and Exhibition on Coiled Tubing Technology, Houston, Texas, March.
2. Avakov, V.A., Foster, J.C., and Smith, E.J., 1993: "Coiled Tubing Life Prediction," OTC 7325, 25th Annual OTC in Houston, Texas, May.
3. Avakov, V.A., 1992: "Coiled Tubing Fatigue Life Evaluation," Technical Report, Otis Engineering Corporation, Dallas, Texas, August.
4. Comgan, M. and Gray, B., 1993: "Determining the Working Life of a Coiled Tubing String," Technical Report, *Petromin*, March.
5. Newman, K.R., and Newburn, D.A., 1991: "Coiled-Tubing - Life Modeling," SPE 22820, 66th Annual Technical Conference and Exhibition of SPE, Dallas, Texas, October.
6. Sas-Jaworsky II, A., 1992: "Coiled Tubing ... Operations and Services, Part 3 - Tube Technology and Capabilities," *World Oil*, February.
7. Scott, W.S., 1994: "Coiled-Tubing Fatigue Testing," TD94-22, Maurer Engineering.
8. Wu, J., 1995: "Coiled Tubing Working Life Prediction," SPE 29461, Production Operations Symposium, Oklahoma City, Oklahoma, April.
9. Quality Tubing, Inc., 1995: "Application Challenges Promote New Product Developments," Paper at the 3rd Annual Conference on Emerging Technology - CT-Horizontal, Aberdeen, Scotland, May 31 - June 2.



## 6. Bug Report or Enhancement Suggestion Form

Name: \_\_\_\_\_ Company: \_\_\_\_\_  
Address: \_\_\_\_\_ City: \_\_\_\_\_ State: \_\_\_\_\_  
Phone No.: \_\_\_\_\_ Fax No.: \_\_\_\_\_  
E-Mail: \_\_\_\_\_ Date: \_\_\_\_\_

Bug/Problem Report

Enhancement Suggestion

Program Name and Version Number: \_\_\_\_\_

Bug/Problem Description or Enhancement Suggestion: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Other Comments: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

### Data/Parameters Causing Bug

Will be mailed on diskette

Will be faxed

Attached

None

### Operating System

MS-DOS Version No.: \_\_\_\_\_

MS-Windows Version No.: \_\_\_\_\_ (Win 3.1/Win 95)

OS2 \_\_\_\_\_

MS-Windows NT Version No.: \_\_\_\_\_

Other \_\_\_\_\_

Please mail, fax, or e-mail to:

**Lee Chu**  
**MAURER ENGINEERING INC.**  
2916 West T.C. Jester  
Houston, TX 77018-7098  
Ph: 713/683-8227 • Fax: 713/683-6418  
E-Mail: mei@maureng.com



**Appendix A**



## Appendix A International Keyboard

All DEA computer programs developed at Maurer Engineering Inc. are written using the "U.S." Keyboard. Under this keyboard, the "1000 separator" is a comma, and the "decimal separator" is a period. Thus, the number **one thousand, two hundred and thirty-four and twenty-two/100** is written

1,234.22

Numbers input into the programs are filed in this format.

Problems have occurred for some of our Participants who use the "International Keyboard," as is common in Europe and South America. Here, the same number would be written

1.234,22

Here, the "1000 separator" is a period, and the decimal separator is a comma.

European and South American users find that their computers garble input data being loaded into our DEA programs.

This problem can be readily solved by changing the Windows "numbers format" from the International to the U.S. format. This is accomplished as follows:

1. From the DOS prompt, type

WIN <ENTER>

to open WINDOWS.

2. From the Menu bar, choose "Window" either by clicking on "Window" or keying in

<ALT> W

This brings down the "Select Window" menu screen, as shown in Figure A-1.

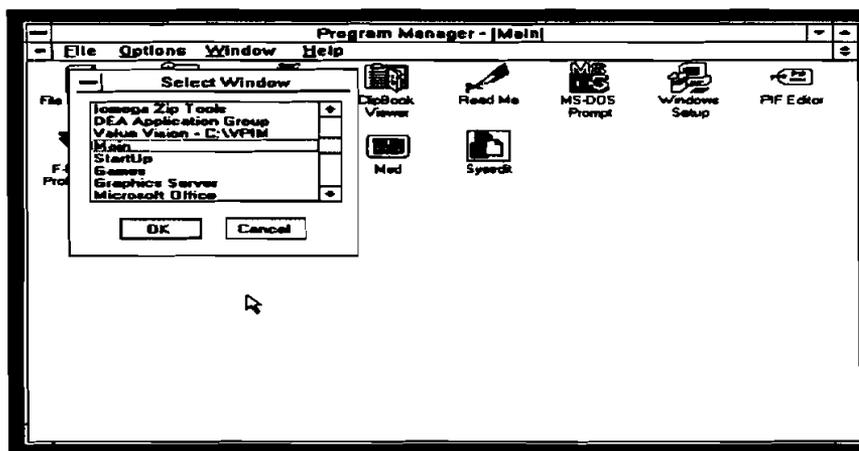


Figure A-1. Windows Menu Bar

3. Select "Main" by clicking on "Main" and then clicking on the "OK" button. This brings down the "Main" menu screen, as shown in Figure A-2.

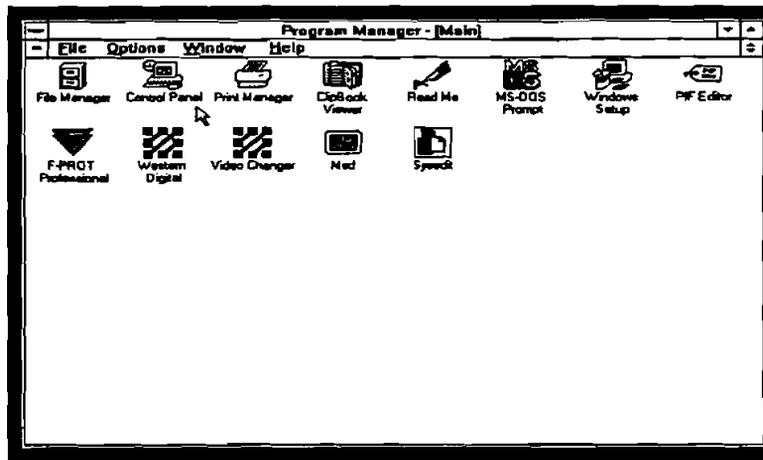


Figure A-2. Main Menu Screen

4. Select the "Control Panel" icon from the "Main" menu screen. This is done by pointing the mouse to this icon and double clicking. This brings up the "Control Panel" menu screen, as shown in Figure A-3.

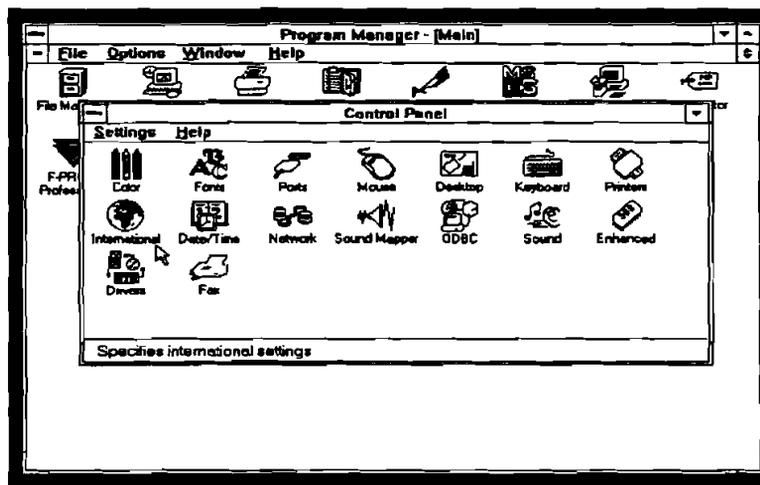


Figure A-3. Control Panel Menu Screen

5. Select the "International" icon from this menu screen by pointing to it with the mouse and double clicking. This brings up the "International" Menu screen, as shown in Figure A-4.

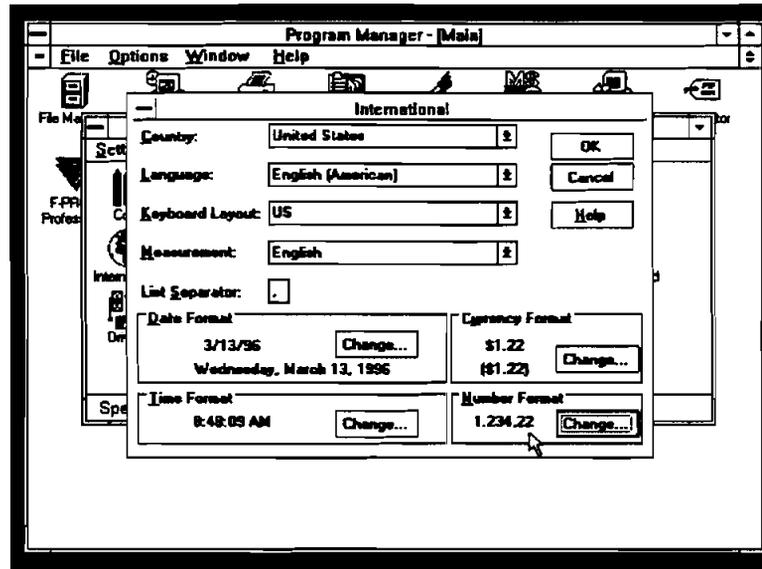


Figure A-4. International Menu Screen

6. In the lower right hand corner of the "International" menu screen is the "Number Format." If the number under the words "Number Format" is

1,234.22

The DEA programs will run. Click on the "Cancel" button in the upper right of this screen and back out to the "Windows" menu screen to run your program.

If the number under the words "Number Format" is

1.234,22

it must be changed before a DEA program will run successfully.

7. To change "Number Format," click on the "Change" button in the "Number Format" box on the screen. This will bring up the "International - Number Format" screen. The "1000 Separator" box will be highlighted, as shown in Figure A-5. Key in

<DEL> ,

This will erase the period from the "1000 separator" box and replace it with a comma.

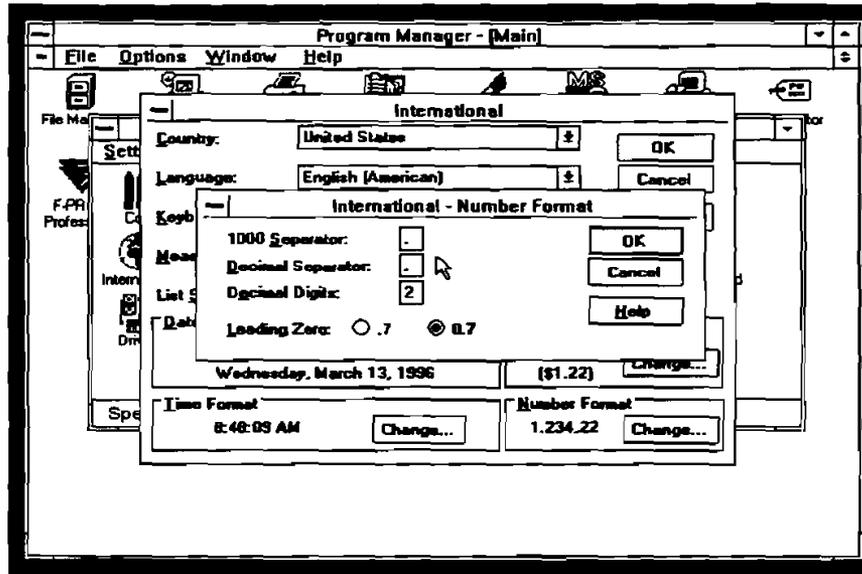


Figure A-5. International — Number Format Screen

8. Either point the mouse to the box labeled "Decimal Separator" and click, or key in

<TAB>

This will highlight the "Decimal Separator" box.

9. Key in

<DEL> .

This will erase the comma from the box and replace it with a period.

10. Either key in

<ENTER>

or point the mouse to the "OK" button in the "International - Number Format" box and click. This will return you to the "International" menu screen, as shown in Figure A-6.

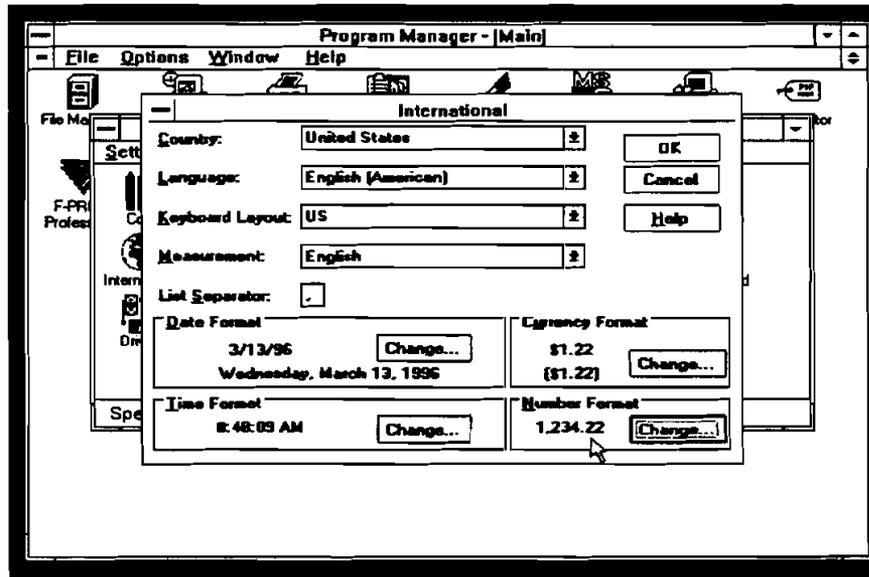


Figure A-6. International Menu Screen, with Correct Number Format

11. Click on the "OK" button to return to the "Main" menu screen.

