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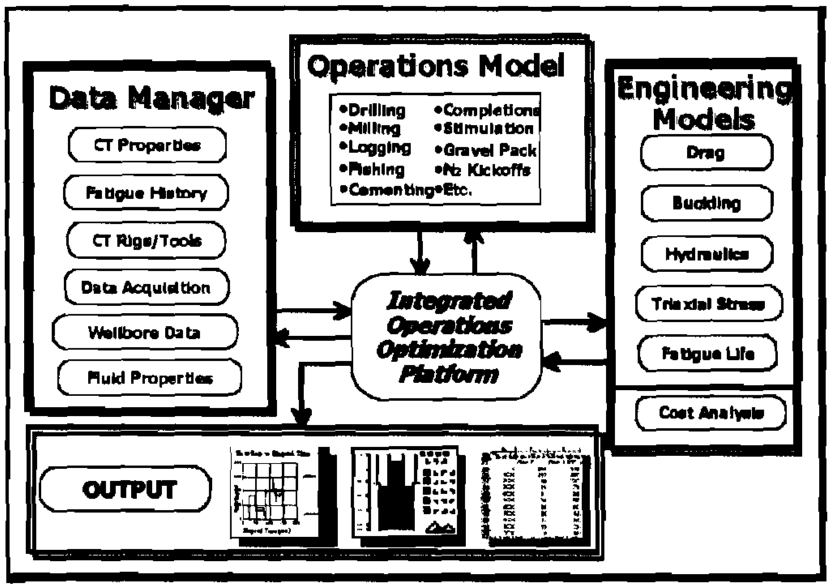
CTPRO

COILED-TUBING PROFESSIONAL PACKAGE

Version 1

USER'S MANUAL



DEA 67
PHASE II

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CTPRO

COILED-TUBING PROFESSIONAL PACKAGE

Version 1

User's Manual

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June 1998
TR98-14

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1. Introduction

> **Note:** Go to Section 2.5 for a **Quick Tour** of the major features and functions of CTPRO.

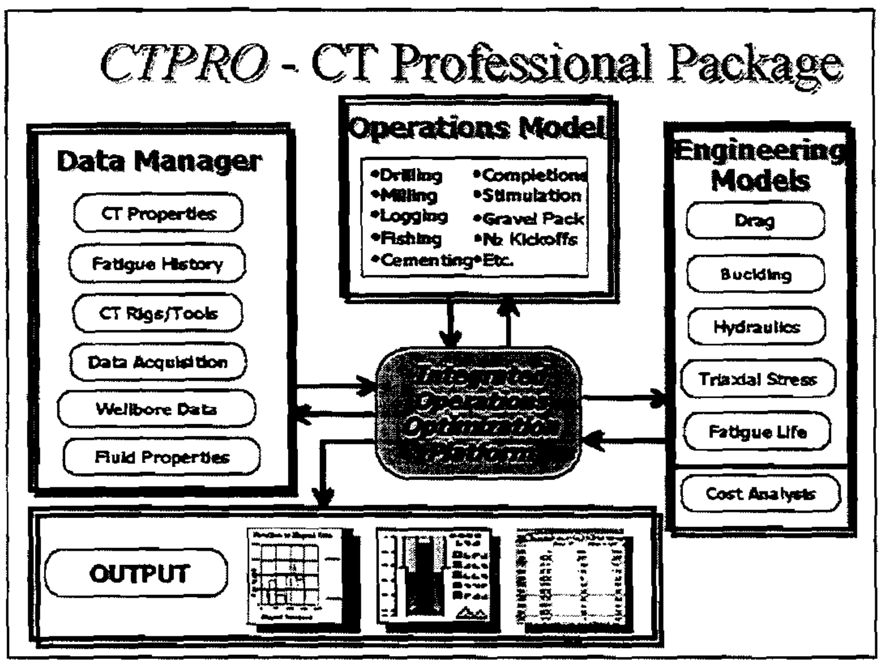
1.1 BACKGROUND

CTPRO was developed by Maurer Engineering Inc. under sponsorship of the joint-industry project DEA-67 *To Develop and Evaluate Coiled-Tubing and Slim-Hole Technology*. CTPRO is written in Visual Basic 5 for use with IBM-compatible computers. It runs in Microsoft Windows 95 or later versions.

A great variety of job-planning and field problems for CT applications and slim-hole operations can be solved by implementing the user-friendly programs developed under the DEA-67 project. Initially, programs were originally conceived and developed as "stand-alone" programs that require separate user input into each application. Each program is itself a powerful engineering tool. However, a job design developed with one program may not be optimum when another aspect of engineering design is considered.

If an engineer planning a field operation with CT changes a design parameter in one area to overcome a specific problem (for example, increasing CT wall thickness to increase penetration limit), other programs must be run and rerun to ensure that new problems are not created (for example, exceeding pressure limits at the surface). Inputting data and modifications to the planned operation into each separate program can be time consuming, and may in some cases limit an engineer's ability to optimize the operation.

CTPRO Concept



The **CTPRO Coiled-Tubing Professional Package** is designed to combine all CT software applications into an integrated software platform. This package streamlines CT job design and will allow real-time intervention in the field. User-friendliness for engineers and field personnel is increased through input screens designed for specific field operations. Critical parameters are calculated and compared simultaneously to provide rapid analysis of the complete job design.

Design of the CTPRO package is centered around five basic components/modules (see graphic on previous page):

1. The **Data Manager** is used to store, access, and modify CT operations reference data which will then be available for use in job planning. These database groups include CT mechanical properties, available equipment (rigs, CT strings, spools, BHAs, downhole tools, etc.), wellbore surveys, casing programs, and other engineering references such as properties of workover fluids. Real-time data are also accessed and stored through data acquisition interfaces, as appropriate.
2. The **Operations Model** is the standard job-planning tool in the CTPRO package. This analysis module is used for a complete multiparameter analysis for which the engineer or operator specifies the job to be performed, the equipment to be used, the wellbore environment, and the mechanical/hydraulic/economic limits to be applied. Output from the analysis includes comparative plots of all critical parameters including drag loads, buckling limits, triaxial stresses, pressures along the circulation path, surface loads, and other parameters.
3. The **Engineering Models** can be accessed for detailed engineering studies of mechanical/hydraulic behavior and sensitivity analyses of critical parameters. More detailed results are provided within each Engineering Model than are given for the standard Operations Model output. These modules are based on individual MEI CT programs.
4. The **Output Interface** is accessed after the calculations are performed. The output may be viewed in a variety of formats (graphs, tables, schedules), printed, saved, or exported.
5. The **Operations Optimization Platform** interfaces the other elements of CTPRO. In later versions of the program, this platform will also include logic for an expert system that will automatically cycle through the CT software modules ensuring that all preset parametric limits are satisfied. CTPRO can then be utilized to quickly optimize planning of CT jobs.

A similar design concept for data sharing between different engineering programs has already been successfully applied to many MEI programs in the Horizontal Well Technology project software suite. The GALAXY database allows these programs to share input data with one another and with third-party databases (Landmark's DIMS and others). CTPRO will take an important step beyond GALAXY by using a single central platform for input and output (making data sharing automatic) and converting the previously separate programs into modules (i.e., subroutines) of the central platform.

1.2 FEATURES OF CTPRO

CTPRO 1 is a major new release in the leading-edge suite of coiled-tubing (CT) design software developed by MEI. The "look and feel" of the program is user-friendly and intuitive. CTPRO runs in the Windows 95 environment, and tabs and icons are used to quickly navigate through the program. Database management is simple, logically designed, and convenient.

Another significant feature is a **complete Help system**. Descriptions and instructions are provided for every input and output screen by clicking or [F1]. The Help system is also context sensitive to allow intuitive navigation by pointing and clicking the mouse on the area of the screen where the user's question originates.

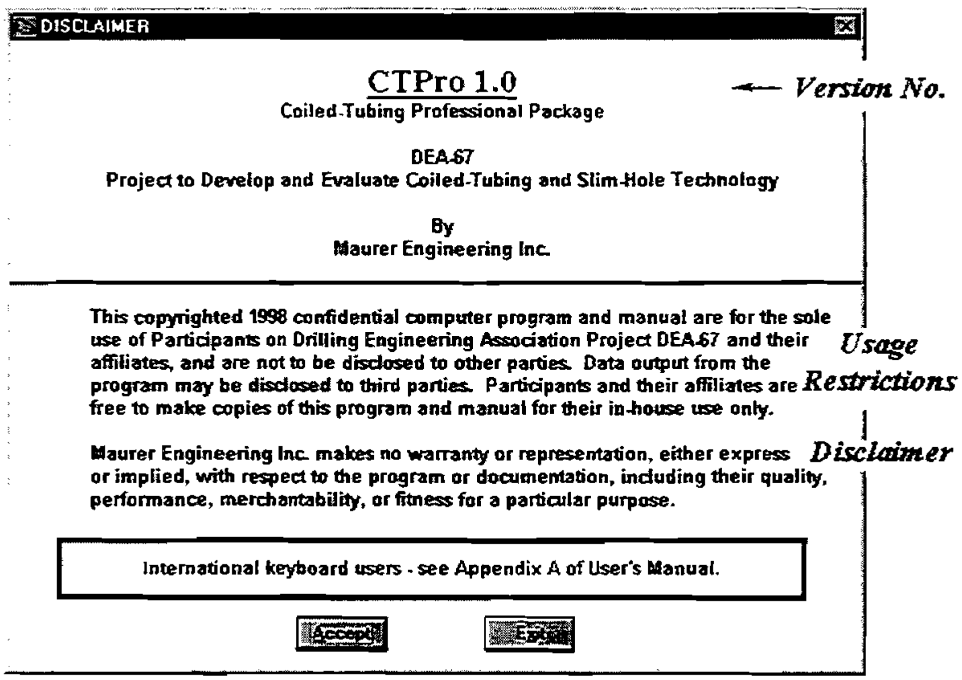
CTPRO runs in the Microsoft Windows 95 and Windows NT environments. ***As a true 32-bit application, the program is not compatible with Windows 3.x.*** It is assumed that the user is familiar with basic operation in the Windows 95 environment. For information about Windows 95, the reader is directed to other texts.

Important benefits and features of the **CTPRO Coiled-Tubing Professional Package** include:

- Increases the speed, accuracy, and user-friendliness of the CT programs
- Reduces CT failures by accurately calculating CT axial loads, normal loads, equivalent stresses, circulating pressures along the flow path, bottom-hole pressures while tripping, wellbore inclination and dogleg, and hook loads at the injector
- Facilitates CT pipe management through comprehensive databases that give immediate access to all required CT, equipment, well and fluids data
- Provides job-specific input/output interfaces that are easily understood by engineers and field personnel
- Provides a choice of systems of units, including English, metric or any custom combination
- Output graphs and tables may be printed, copied to the Clipboard for export into other Windows applications, or stored to disk

1.3 COPYRIGHT AND DISCLAIMER

This software and manual are copyrighted (©1998) by Maurer Engineering Incorporated. The copyright agreement and usage restrictions are described under the Licensing window which is accessed under **Help** → "About..." → "Licensing..." (see below). **By selecting [Accept] at the bottom of this screen, the user signifies that he agrees to abide by the restrictions as presented.** No warranty or representation, either express or implied, is given with respect to the program and documentation, including their quality, performance, merchantability, or fitness for a particular purpose.



2. Getting Started

2.1 HARDWARE AND SYSTEM REQUIREMENTS

CTPRO is written in Microsoft Visual Basic® version 5. It runs in Microsoft Windows 95 or Windows NT (or later versions). As a 32-bit application, CTPRO is **not** compatible with Windows 3. The minimum hardware requirements are:

- IBM-compatible machine with 80486 processor
- Hard disk (about 10 megabytes of storage space required)
- Mouse
- VGA or compatible display

2.2 INSTALLING CTPRO

Program Disks

CTPRO is shipped on one CD or multiple 3½-inch disks. The CTPRO executable files (**CTProDM1.EXE** and **CTProOM1.exe**) should be placed in a special folder (default "C:\MEI\CTPRO\", or as specified by the user) along with the example data files. All of these procedures will be accomplished during the set-up procedure described below.

Backup Disks

If CTPRO was received on floppy disks, it is recommended that the original disks be kept as a backup set and stored in a safe location, and that work disks be made from them. In Windows 95, run Windows Explorer, double-click "My Computer", single-click the icon for your floppy drive, and select "Copy Disk" from the **File** menu.

Installation

The following procedure will install CTPRO from the CD or floppy drive onto the working directory of the hard disk (e.g., copy from A: floppy drive onto hard drive directory C:\MEI\CTPRO\).

1. Choose **Run...** from the **Start** menu. Then type "D:SETUP" (or "A:SETUP" for floppy disks)
2. Follow the on-screen instructions.

After set up, a new folder ("MEI Applications") may be created (depending on your choice during installation) with the shortcut to CTPRO and other MEI programs.

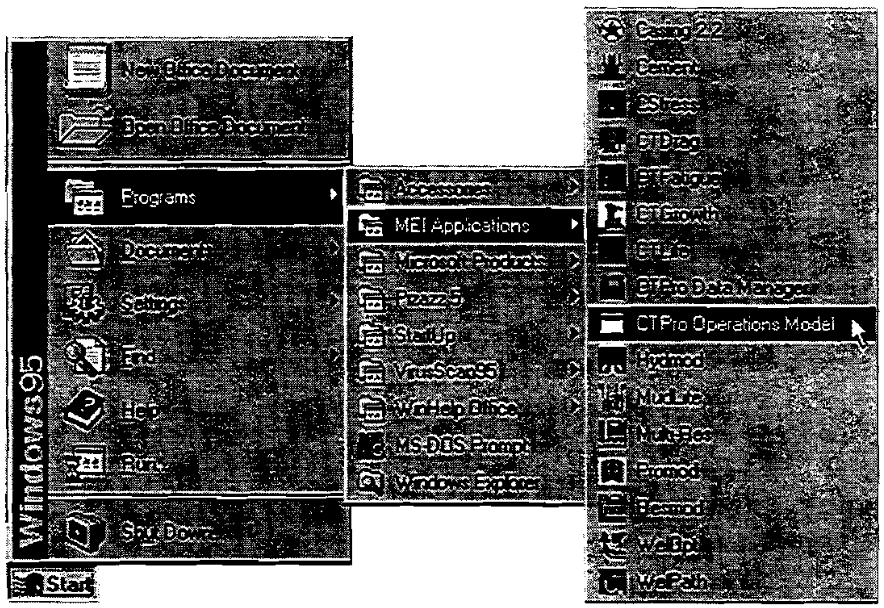
Note: To move other previously installed MEI applications into this folder, select **Start** → **Settings** → **Taskbar...** → **Start Menu** → **Programs** → **Advanced**. Then double-click "Programs" to display the folders in your **Programs** menu. Drag and drop shortcuts to other MEI programs into the **MEI Applications** folder.

2.3 UNINSTALLING CTPRO

Should it ever be necessary to remove CTPRO from your computer, access the **Add/Remove Programs** feature (don't just delete the CTPRO folder). This feature is activated by running **Start → Settings → Control Panel → Add/Remove Programs** and selecting CTPRO from the list of programs currently installed on your computer.

Using this procedure clears the library registry in the Windows system folder and erases the corresponding required library files that are not stored in the CTPRO directory.

2.4 RUNNING CTPRO



To launch CTPRO, select it from the **MEI Applications** program group under the Program Menu (or other program group you assigned during set-up). The design and operation of the **CTPRO Data Manager** are described in Chapter 3. Input to the **Operations Model** is described in Chapter 4; output windows and features are discussed in Chapter 5. For assistance with the program, contact MEI using information presented in Chapter 6. Common problems and solutions are described in Appendix A.

2.5 QUICK TOUR OF CTPRO

The following quick tour will give the new user a rapid overview of the basic structure, features and functions of CTPRO version 1.

Install:

1. Start Windows 95
2. Insert CTPRO CD into drive D: (or floppy disk 1 into drive A:)
3. Choose **Run...** from the Start Menu.
4. Type **D:\SETUP** and press Enter. Follow the on-screen instructions.

CTPRO Data Manager (see Chapter 3)

Run:

5. Launch the **CTPRO Data Manager** by selecting it from the **MEI Applications** folder under **Start Menu → Programs**.

Input:

6. The Project Editor Window is automatically opened. Select a project from the available options by clicking to the right of the project box. Data records in each data category are automatically selected and their names displayed in each box.

Edit Database:

7. Open each of the data editors to review and modify the data records from each of the six data types. Select each editor from the **Edit** menu (string, reel, well, wellsite, fluid, and tool) or by clicking the corresponding icon.

8. Click the tabs to review each page of data within each editor. Edit data entries as desired and save any changes to the data by clicking the Save button on the first page of the editor.

Output:

9. Print the data record. For example, open the Reel Editor and click the print button on the "Select Reel" page. (To select a different printer, change your computer's default printer under **Start → Settings → Printers**.)

10. To close CTPRO Data Manager, click "Exit" from the **File** menu or "Exit to Operations Model" to automatically load the Operations Model.

CTPRO Operations Model (see Chapters 4 and 5)

Run:

11. Launch the **CTPRO Operations Model** by selecting it from the **MEI Applications** folder under **Start Menu → Programs**.

Input:

12. In the Input Window, choose "Open Project..." from the **File** menu or click .

13. From the File Open dialog box, select the example project file "**OMTest1.OM1**", and click OK. ***(Please note that parametric values in the example project file are for illustration only and should not be considered as preferred values.)***

14. Click each of the input window tabs (**Project, Survey, CT, Borehole, Formation, Fluid, BHA,** and **General**) to review each page of input data.

15. Select "Start" from the **Run** menu or click to launch the calculation sequence.

Output:

16. After the Output Window is loaded, select graph windows of interest to enlarge for viewing in more detail. Double-click on the graph area to maximize that graph to full screen. Double-click again to restore the tiled display.

17. Print a graph of interest by selecting "Print" → "Output Graph (Active)" from the **File** menu.

18. Maximize the summary table by double clicking on it. Select different data presentations by clicking radio buttons in the parameter options at the top of the table.

19. Print your selected version of the output table by selecting "Print" → "Output Table (Active)" from the **File** menu. (To select a different printer, change your computer's default printer under **Start** → **Settings** → **Printers**.)

20. To close CTPRO Operations Model, click "Exit" from the **File** menu or in the upper right corner of the main window.

3. Data Manager

3.1 INTRODUCTION

The CTPRO Data Manager allows the engineer and field personnel to select, specify, review and modify all equipment to be used on any CT operation. Database groups include: 1) the CT string, 2) the CT reel, 3) the well, 4) the wellsite (rig and other equipment), 5) the fluids used for the operation, and 6) the BHA tools. Within the Data Manager Main Window, the engineer can browse the file structure on his computer (or network) and select specific files for viewing, editing, and finally for use in the current job design.

Management of complex data for CT operations both in the field and in the office is greatly simplified with the user-friendly CTPRO Data Manager module. Input data are organized by specific type, or records from each database type are grouped together and stored as a project. These projects can then be directly accessed within the companion Operations Model (see Chapter 4). CTPRO Data Manager data types are listed below.

Project:

1. Project documentation (company/client, well location, job description, etc.) (optional)

String:

2. CT string geometry, material properties, location of welds, derated sections
3. Fatigue life history
4. Wireline geometry (size and weight)
5. CT cost

Reel:

6. Reel dimensions
7. CT dimensions for calculating reel capacity

Well:

8. Well description
9. Directional survey (for example, measured depth versus inclination and azimuth)
10. Formation pore and fracture pressures
11. Well geometry (IDs and friction factors)

Wellsite:

12. Wellsite layout of CT equipment (distance from reel to gooseneck, gooseneck length and radius, and distance from injector to zero well depth)

Fluids:

13. Fluid descriptions, rheology model, and mud weight

Tools:

14. Tool dimensions
15. Nozzle sizes and/or total flow area

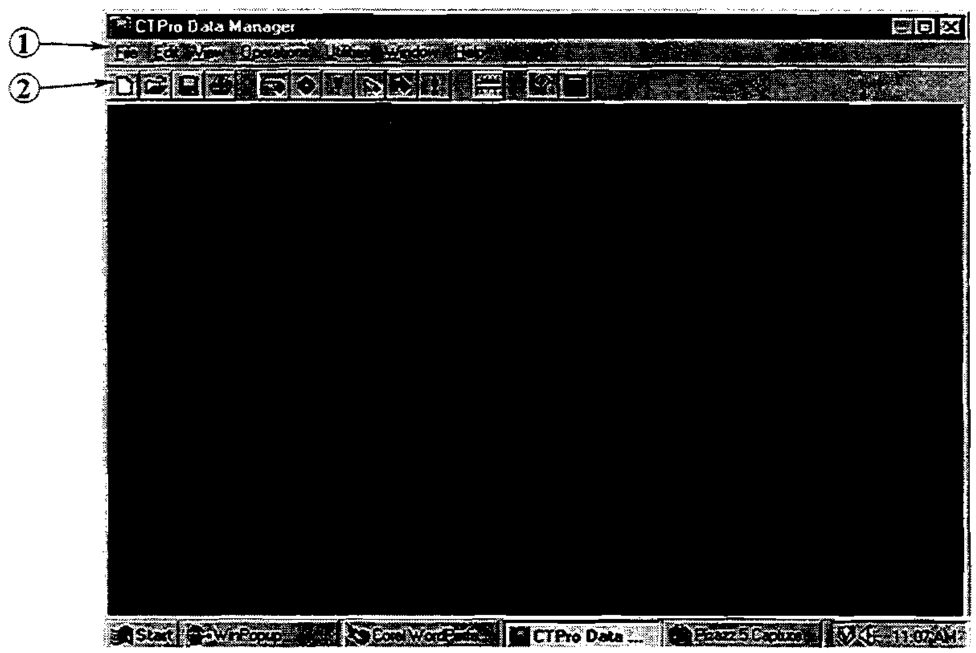
Data can be entered and displayed in English or metric units, or a custom combination of English and/or metric units defined by the user.

3.2 DATA MANAGER MAIN WINDOW

The Main Window in the Data Manager is the central platform for viewing and editing the CT databases. The **most common operation** from this window is to open an existing project for editing. Select "Open Project" from under the **File** menu or click the icon. Then select a project from those listed.

Other basic options from within the Main Window include:

- **Creating or opening existing database *records*** for any of the six data groups (under the **Edit** menu or the editor icons)
- **Viewing CT *specifications*** (under the **View** menu)
- **Transferring to the CTPRO Operations Model** (see Chapter 4) for performing CT engineering analyses of project data created, edited and saved (under the **File** menu)



① ***Menu Bar.*** Functions of the pull-down menus in the Main Window are similar to that in other Windows applications. A description of all functions and features is presented later in this chapter in Section 3.13.

② ***Tool Bar.*** Tool-bar icons can be used to quickly access commonly used functions. The icons are shortcuts for menu options. The functions of the icons are:

New Project. Clears all input data.

Open Project. Activates the Open Project window.

Save. Saves all input data to current project name. If the project is new, the *Save As...* window is activated automatically.

Print. Immediately activates a printout of the current window.

String. Opens the String Editor (see Section 3.4) for creating, reviewing, and editing CT string data records.

Reel. Opens the Reel Editor (see Section 3.5) for creating, reviewing, and editing CT reel data records.

Well. Opens the Well Editor (see Section 3.6) for creating, reviewing, and editing well data records.

Wellsite. Opens the Wellsite Editor (see Section 3.7) for creating, reviewing, and editing wellsite equipment data records.

Fluid. Opens the Fluid Editor (see Section 3.8) for creating, reviewing, and editing fluid data records.

Tool. Opens the Tool Editor (see Section 3.9) for creating, reviewing, and editing BHA tool data records.

Units. Opens the Units Selection window (see Section 3.11). The user can select English, SI, or any custom combination of units.

Help. Opens the Help system for CTPRO directly to help on the current page. Another option is to select "Help Topics..." from the **Help** menu for accessing the table of contents for the Help system.

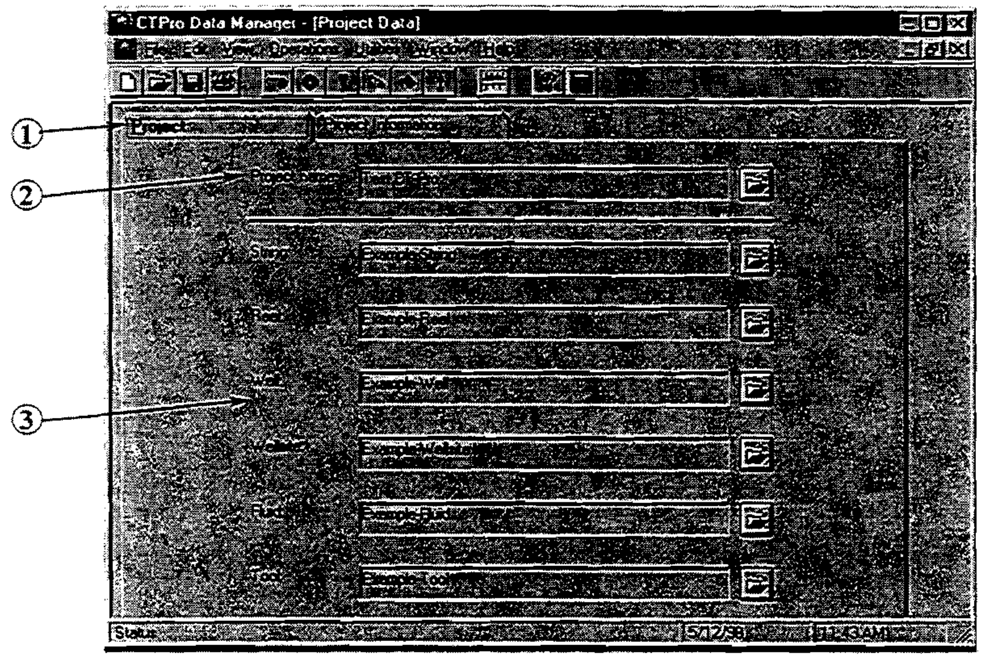
Calculator. Activates the Windows utility calculator.

3.3 PROJECT DATA WINDOW

Projects are a convenient way of storing and modifying a complete set of data records that will be used for a specific field operation (or sequence of similar field operations). The Project Data Window includes two pages for organizing project files and data. Each is accessed by clicking on its tab below the icon tool bar. Functions and parameters on each screen are described in the sections below.

3.3.1 Project File Manager Page

A specific record for each of the six data types is selected on the Project File Manager page.



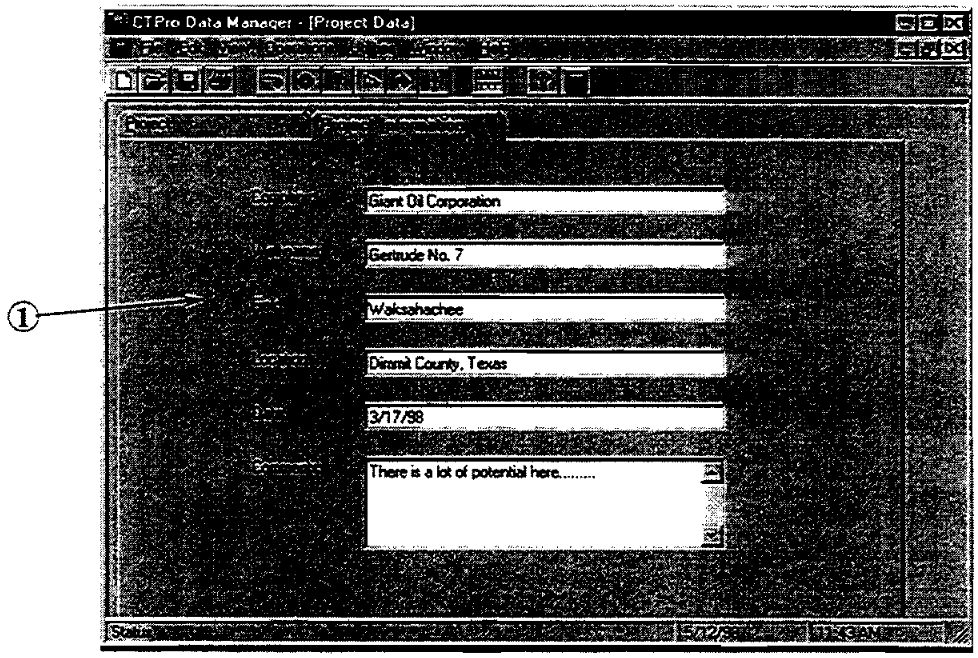
① ***Page Tabs***. Switching between the input pages within a window is simple–just click on the corresponding tab.

② ***Project Name***. The name of the current project is listed here for reference. Use the open icon to the right of the box to view and select from available projects.

③ ***Project Records***. The complete project is specified by selecting six (or fewer) project records–one string, one reel, one well, etc. The currently selected record name is listed in the corresponding box. The open icon to the right of the record name box can be used to quickly open an existing data record for any data type.

3.3.2 Project Information Page

The Project Information page is used for CT project documentation.

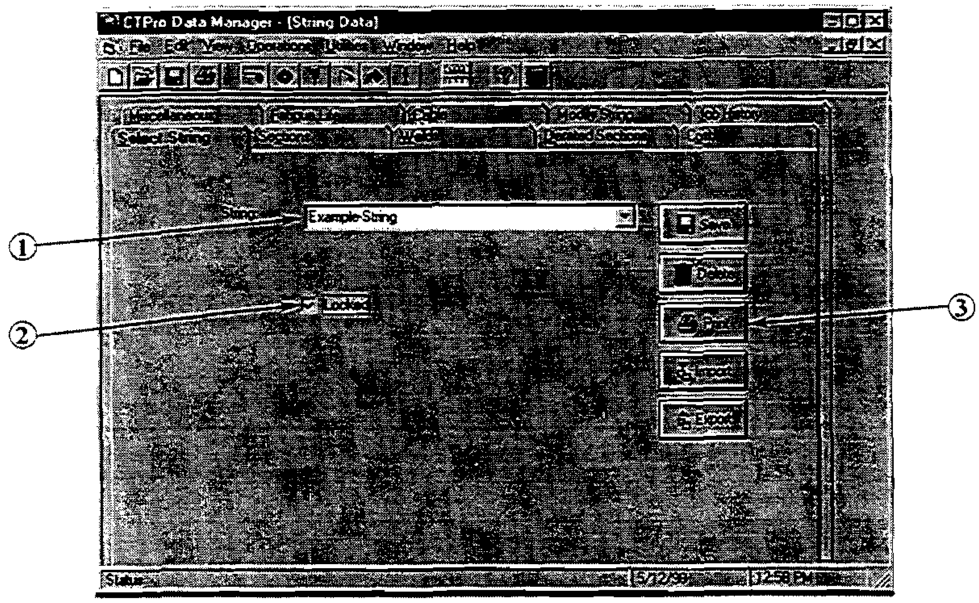


① ***Project Information.*** Project documentation can be entered to identify specific companies, customers, fields, wells, etc. All of these data are optional.

3.4 STRING DATA WINDOW

In the String Data Window, there are ten different pages for organizing CT string data. Each is accessed by clicking on its tab below the icon tool bar. Functions and parameters on each screen are described in this section.

3.4.1 Select String Page



① ***Select String Record.*** Available CT string records are listed in the drop-down list box. Any available string can be selected by clicking its name inside the drop-down list.

② ***Data Lock.*** String data entered on the other nine pages can be locked to prevent accidental changes. Prior to editing any data within the String Editor, the user must uncheck this box.

③ ***Record Edit Buttons.*** Edit buttons are used for managing the current string record.

Save. Saves all string data under the current string name. The string name can be changed by typing a new string name in the list box and clicking this Save button (same as "Save As..." function).

Delete. Deletes the current string record from the database.

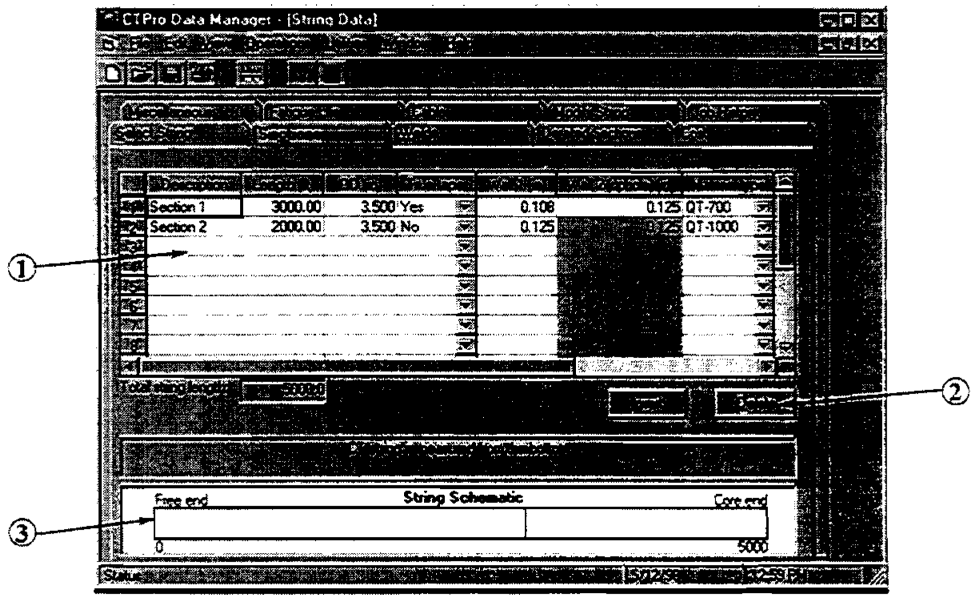
Print. Prints all CT string data under the current string name.

Import. Imports a CT string from an external database specified by the user. A pop-up window is displayed for selecting a database file (***.mdb**).

Export. Exports the current CT string to an external database specified by the user.

3.4.2 String Sections Page

The String Sections page is used to specify the individual tubing sections that comprise the entire CT string.



① *CT Section Data Table.* This table is used to specify the geometry and properties of the CT. The data entered in the **first row is the free end of the spool** (the deepest section in the hole), and other sections are entered proceeding toward the core of the spool. The cumulative length of CT is calculated automatically and displayed below the table.

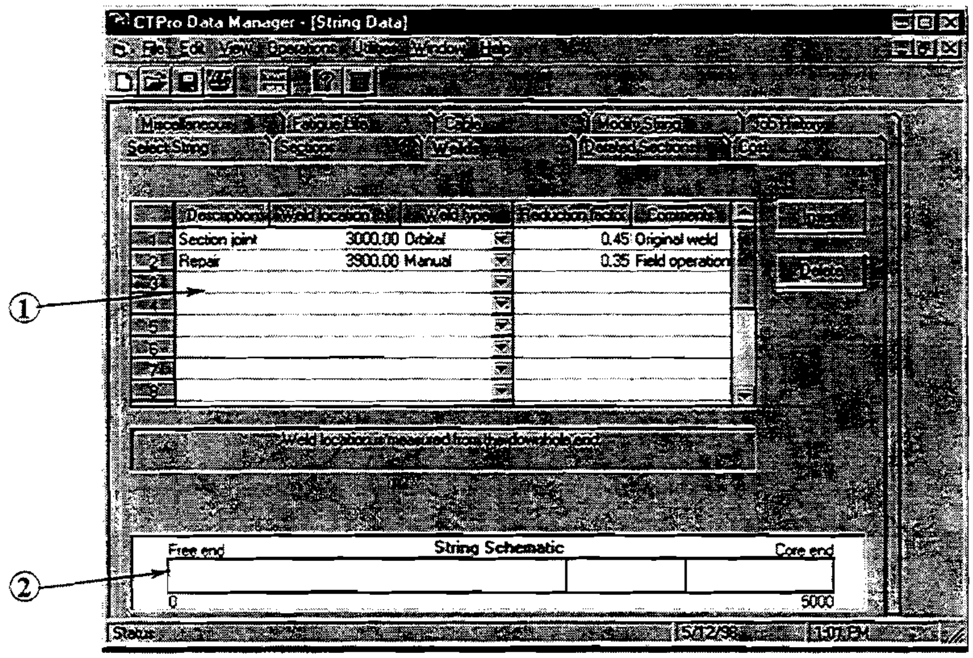
True Taper is an option available from the manufacturer whereby the change in wall thickness along a tapered string is distributed evenly throughout the entire section of CT. When a True-Taper section is used, specify both **Wall 1** (wall thickness at the end closest to the free end of the spool) and **Wall 2** (the end closest to the core of the spool). If the section is not tapered, Wall 2 is filled in automatically.

CT material properties can be selected by clicking the material type drop-down list box, which includes the most commonly used materials. Properties for other special materials can be typed in manually.

② *Table Edit Buttons.* The edit buttons for the data table work on complete rows of data. [Insert] places a new blank row above the cursor position. [Delete] deletes one entire row, whether a single cell or whole row is selected.

③ *CT String Schematic.* The currently input string sections are displayed graphically for the user's reference.

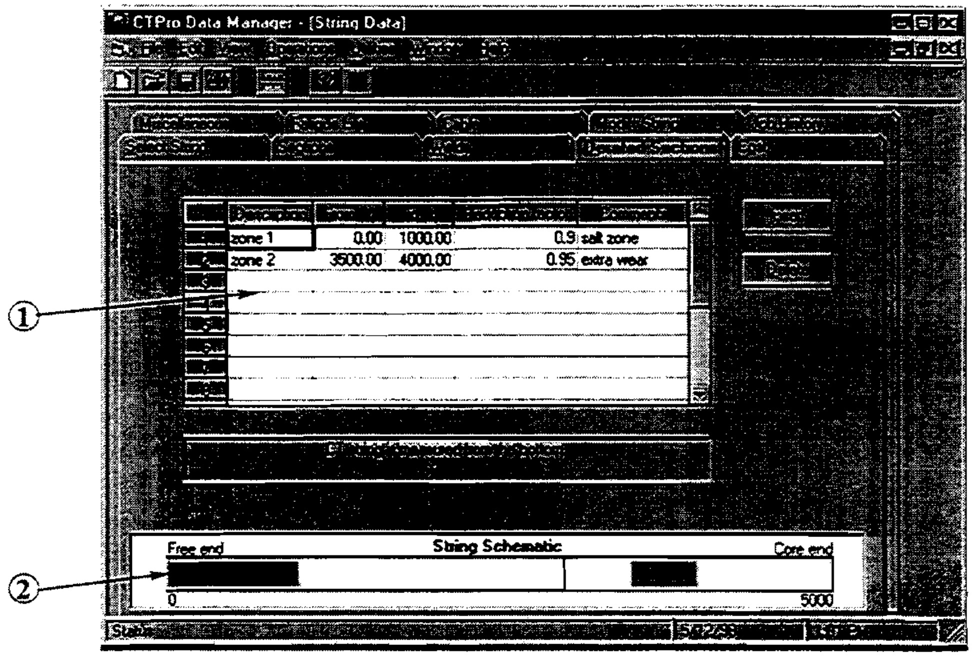
3.4.3 Welds Page



① ***Weld Data Table.*** Weld locations and corresponding reduction factors are entered and edited in this table. The weld type can be selected from the drop-down list box. Three options are available: 1) manual, 2) orbital, and 3) helical/bias. The reduction factor is entered automatically for each weld type selected. The user may change the reduction factor to any other preferred value.

② ***CT String Schematic.*** A simple schematic of the CT string displays the locations of the welds for the user's reference.

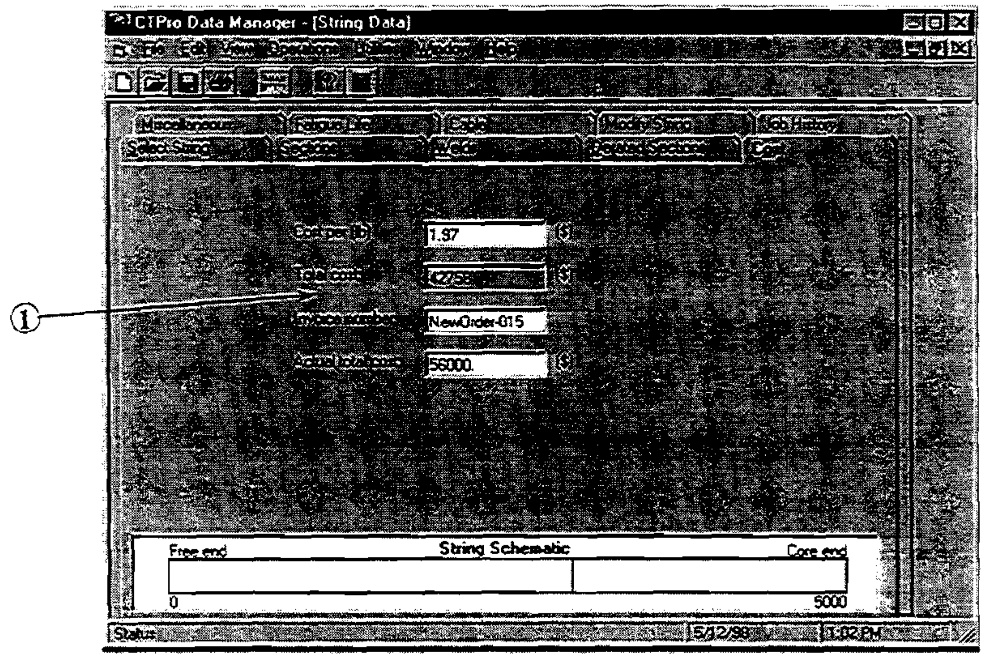
3.4.4 Derated Sections Page



① ***Derated Sections Table.*** Any derated sections (mechanical damage, etc.) of the CT string are specified here along with the corresponding reduction factor. Distances are measured from the free end of the CT.

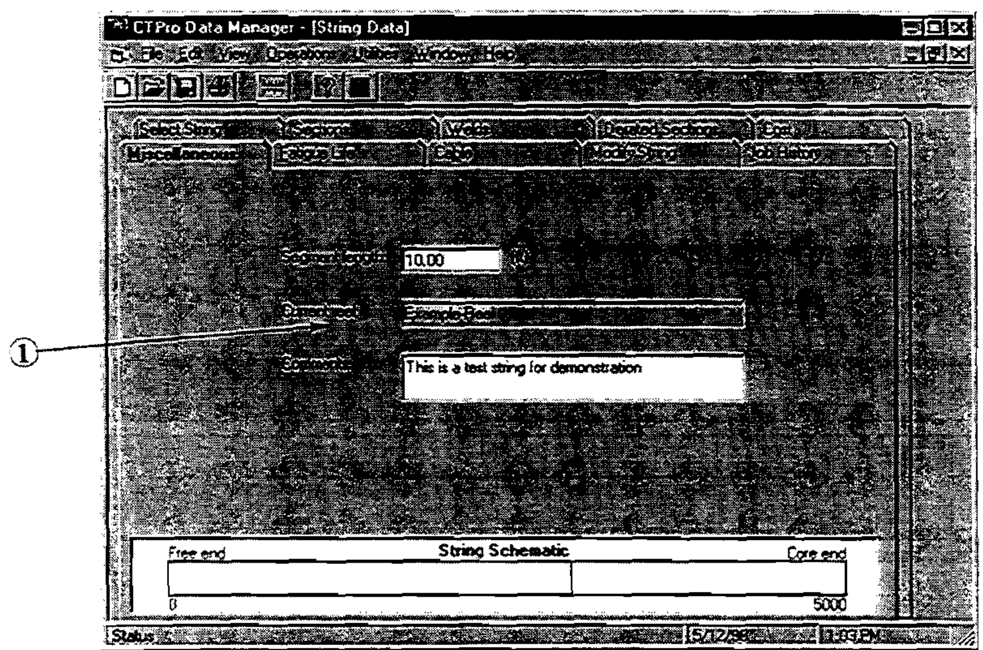
② ***CT String Schematic.*** A simple schematic of the CT string displays the locations of the derated sections for the user's reference.

3.4.5 String Cost Page



① *Cost Data.* Total cost for the string is calculated automatically based on the CT geometry and the unit cost entered by the user. **Invoice Number** and **Actual Cost** may be entered by the user.

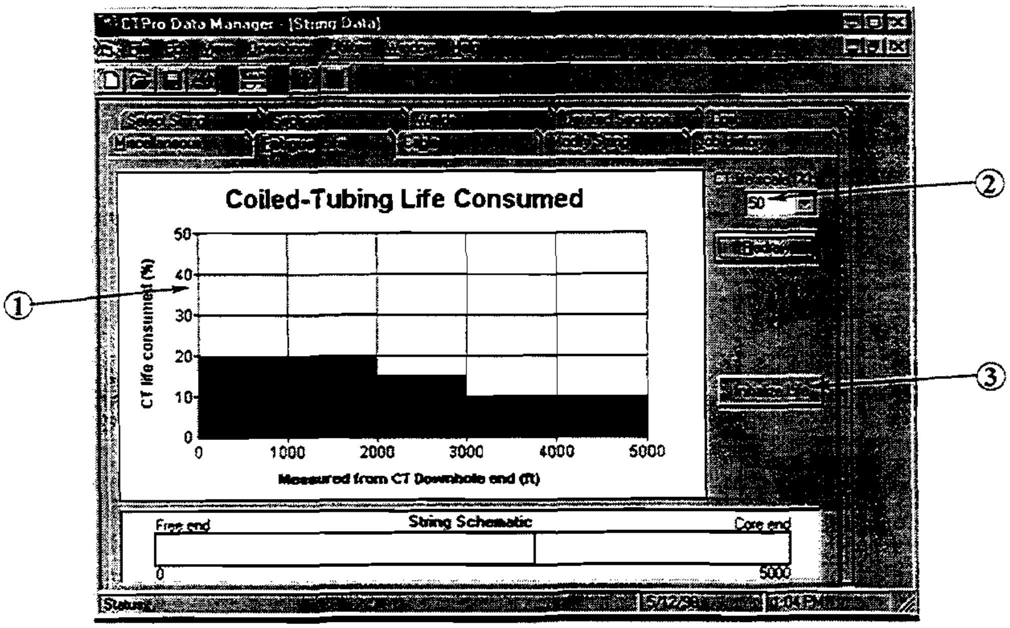
3.4.6 String Miscellaneous Page



① ***Miscellaneous String Data.*** Segment Length is the length increment used for CT fatigue analysis. The default value is 10 ft. The currently selected reel is shown here for reference (and cannot be changed here; go to the Project File Manager page to select another reel). A comments box is provided here for miscellaneous descriptions and comments on the current CT string.

3.4.7 String Fatigue Life Page

The life history of the current string is displayed in the String Life page. Fatigue life of the string can also be initialized here.

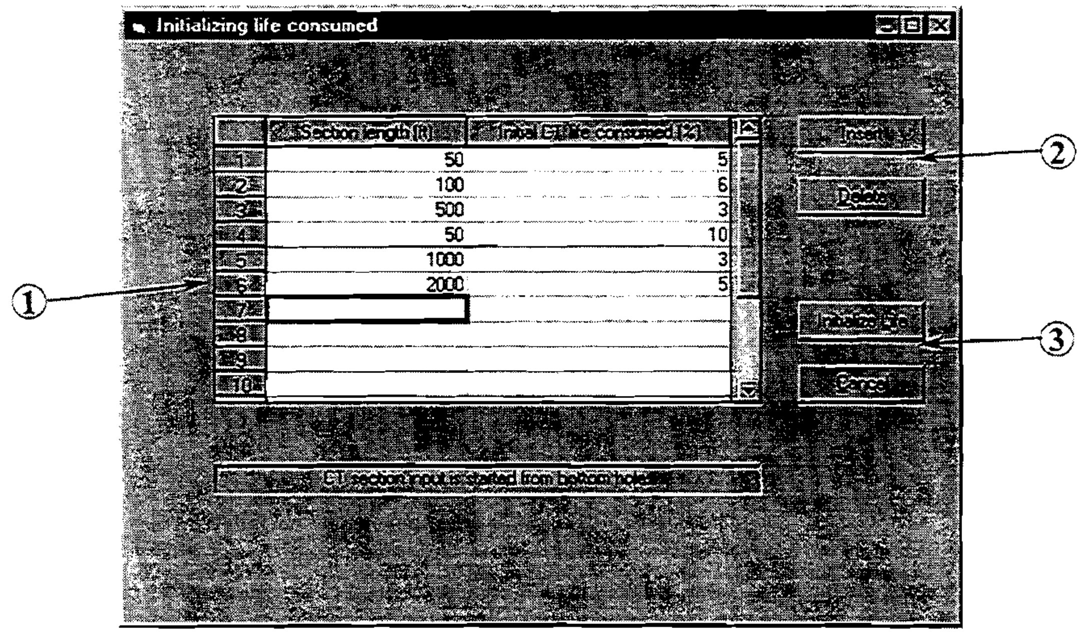


① ***Fatigue Life Graph.*** Consumed fatigue life is displayed from the free end of the string to the core of the spool.

② ***Fatigue Graph Scale.*** Select or type in the desired full-scale value for the percent life consumed. Then click [Redraw] to redraw the graph with the new y-axis scaling.

③ ***Initialize Life.*** Click this button to initialize the fatigue life for the current string. (See the section below.)

Initialize Life Window

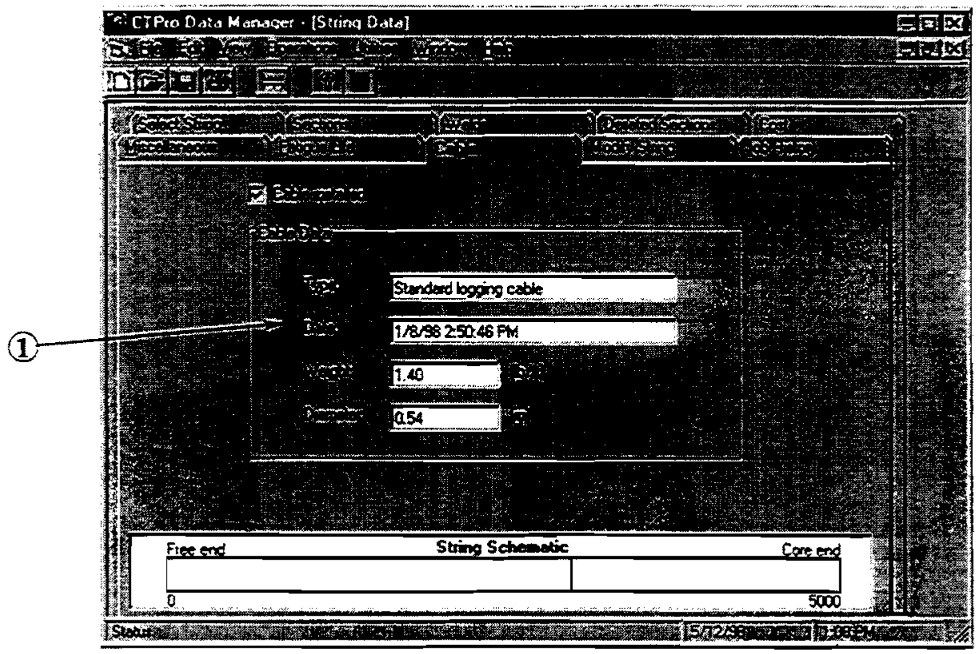


① ***Initial Life Table.*** The initial fatigue life for each section of the string is entered into the table. Enter the data starting at the free end of the spool and proceeding toward the core of the spool.

② ***Table Edit Buttons.*** The edit buttons for the data table work on complete rows of data. [Insert] places a new blank row above the cursor position. [Delete] deletes one entire row, whether a single cell or whole row is selected.

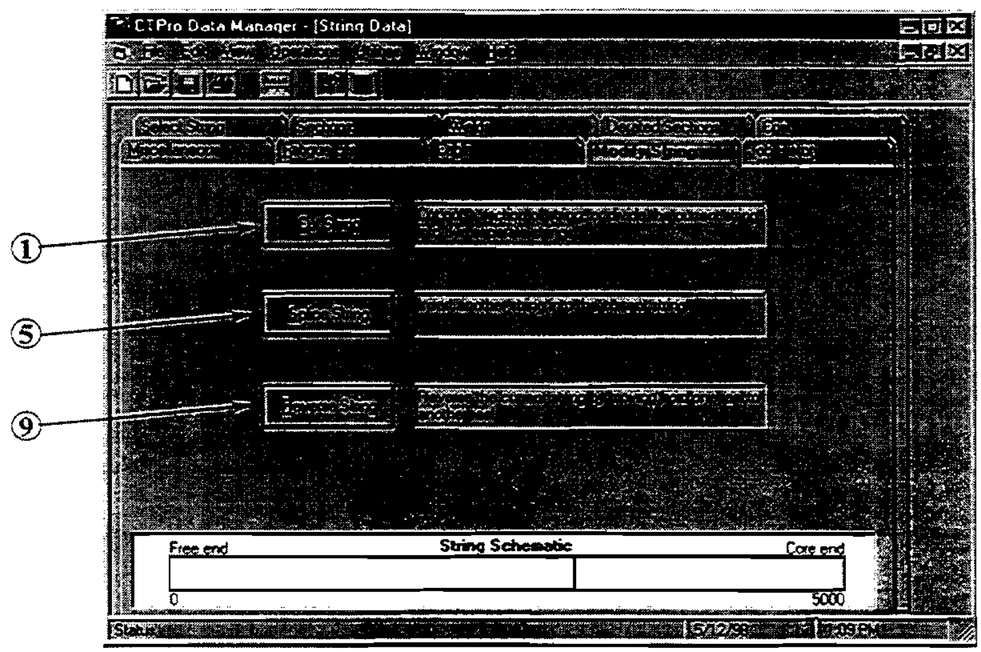
③ ***Initialize Life Control Buttons.*** Click [Initialize Life] after all fatigue data are entered in the table. The database will be updated with the new fatigue life data. Click [Cancel] to discard the data in the table and close this window.

3.4.8 Cable Page



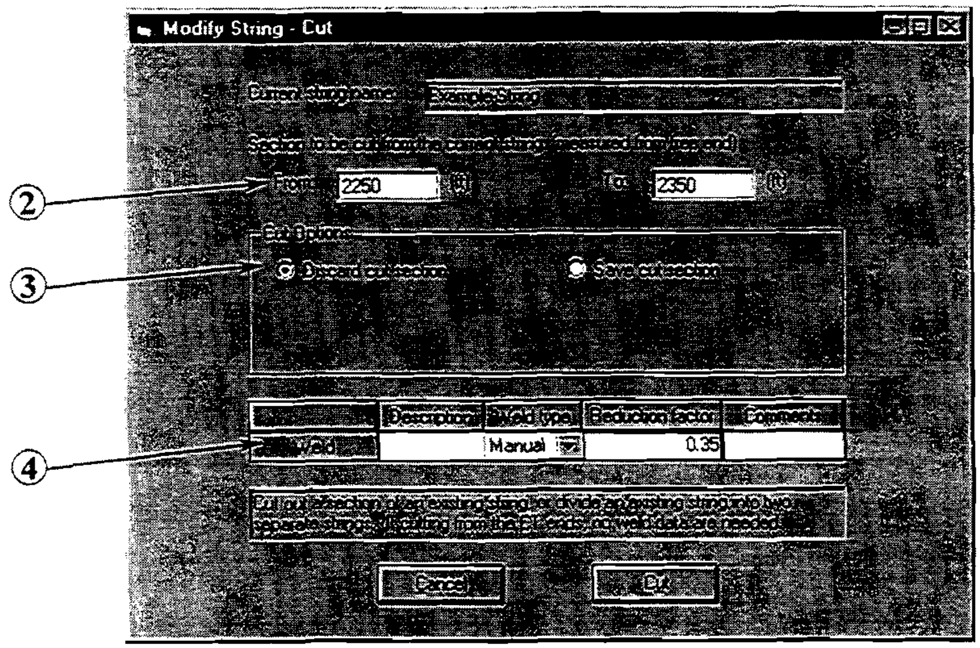
① ***Cable Data.*** Check the Cable Installed box ☑ if wireline is installed in the CT string. Enter data describing the cable in the boxes. Cable diameter and weight affect hydraulics and drag calculations.

3.4.9 Modify String Page



① ***Cut String.*** This function is used to remove a section of CT from the current string, or to divide the existing string into two separate strings. Clicking [Cut String] opens the Cut String Window (see below).

Cut String Window



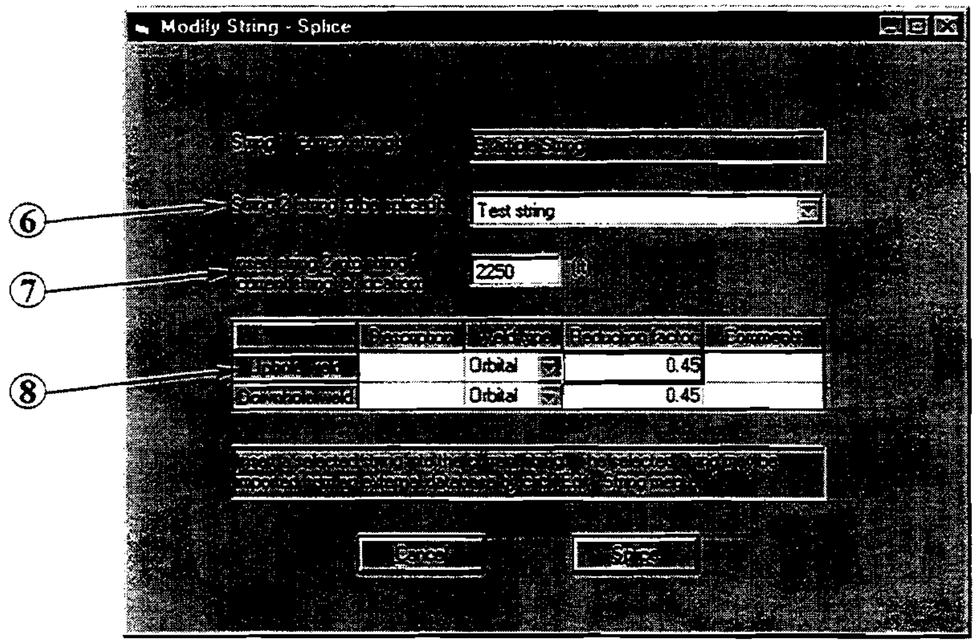
② ***Cut Location.*** Specify the section of CT to be removed, either from one of the ends or from the middle of the string.

③ ***Cut Options.*** Select whether the cut section of CT is to be discarded or saved for future use. If the cut piece is to be saved, provide a name and reel for the new string.

④ ***Weld at Cut.*** If the cut is performed in the middle of the current string, a weld is required to rejoin the string. Select parameters describing the weld.

⑤ ***Splice String.*** This feature on the Modify String page is used to insert a new section of CT into the current string, either on one end or in the middle. Clicking [Splice String] opens the Splice String Window (see below).

Splice String Window



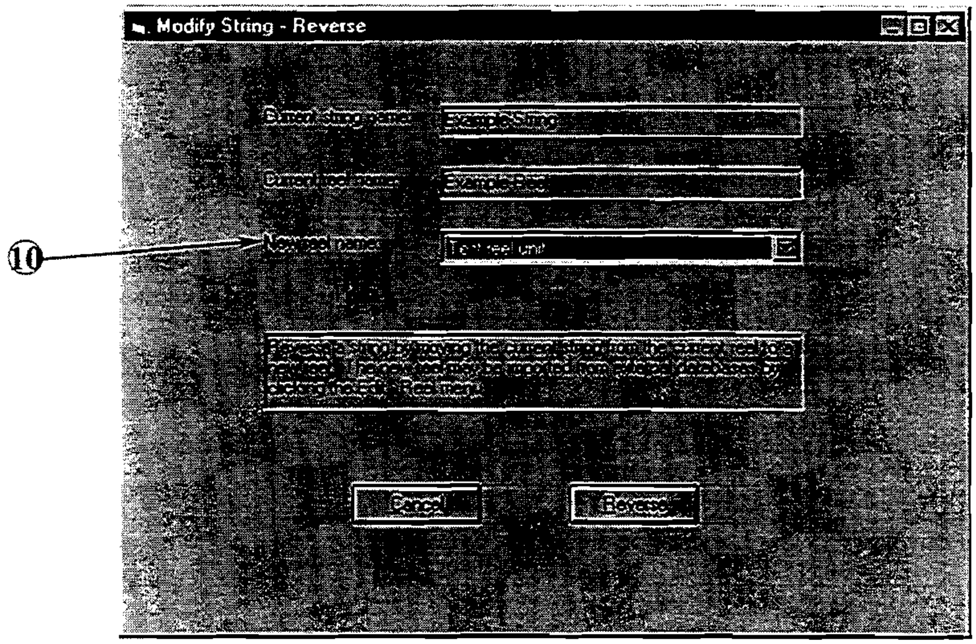
⑥ ***New String***. Select a new CT string from the database that is to be inserted into the current string.

⑦ ***Splice Location***. Specify the location on the current string where the new string will be inserted. Enter "0" if the new string is to added at the free end of the current string.

⑧ ***Weld at Cut***. If a splice is performed in the current string, one or two welds are required to rejoin the string. Select parameters describing the weld(s).

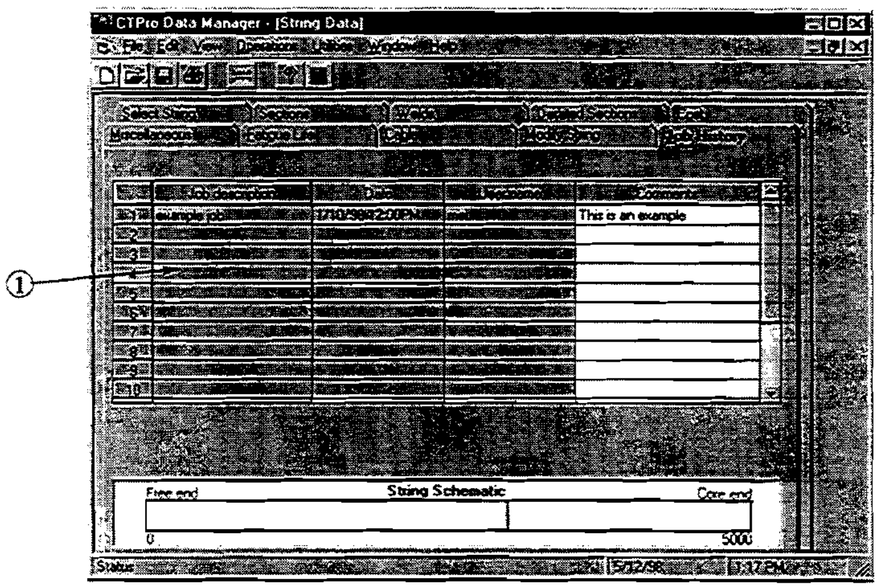
⑨ ***Reverse String***. This feature on the Modify String page is used when the free end and core end of the string are switched by spooling onto another reel. Clicking [Reverse String] opens the Reverse String Window (see below).

Reverse String Window



⑩ *New Reel Name.* Select a new reel from the drop-down list box onto which the string will be spooled. If the second reel is not on the list, a new reel may be entered directly or imported from another database in the Reel Data Window (Section 3.5). Click [Reverse] to complete the string reversal onto the new reel.

3.4.10 Job History Page



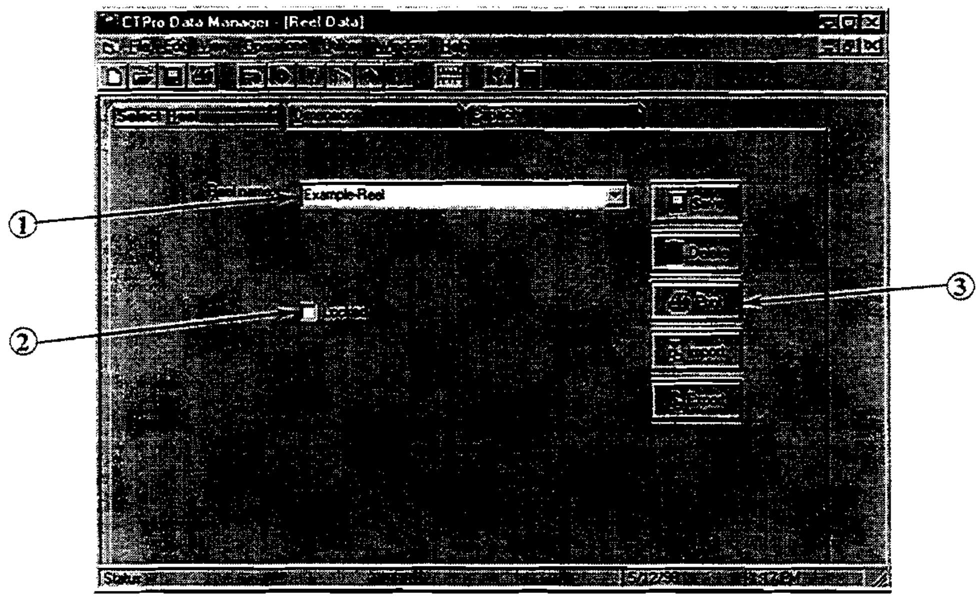
The previous operations performed with the current CT string are summarized for reference on the Job History page.

① ***Job History Table.*** Operational data related to the field history of the current string are entered and edited from the table.

3.5 REEL DATA WINDOW

In the Reel Data Window, there are three different pages for organizing CT reel data. Each is accessed by clicking on its tab below the icon tool bar. Functions and parameters on each screen are described in this section.

3.5.1 Select Reel Page



① ***Select Reel Record.*** Available CT reel records are listed in the drop-down list box. Any reel can be selected by clicking its name from the list.

② ***Data Lock.*** Reel data entered on the Reel Dimensions page can be locked to prevent accidental changes. Prior to editing any data, the user must uncheck this box.

③ ***Record Edit Buttons.*** Edit buttons are used for managing the individual reel data record.

Save. Saves all current reel data under the current reel name. The name can be changed by typing a new reel name in the list box and clicking this button (same as "Save As..." function).

Delete. Deletes the current reel record from the database.

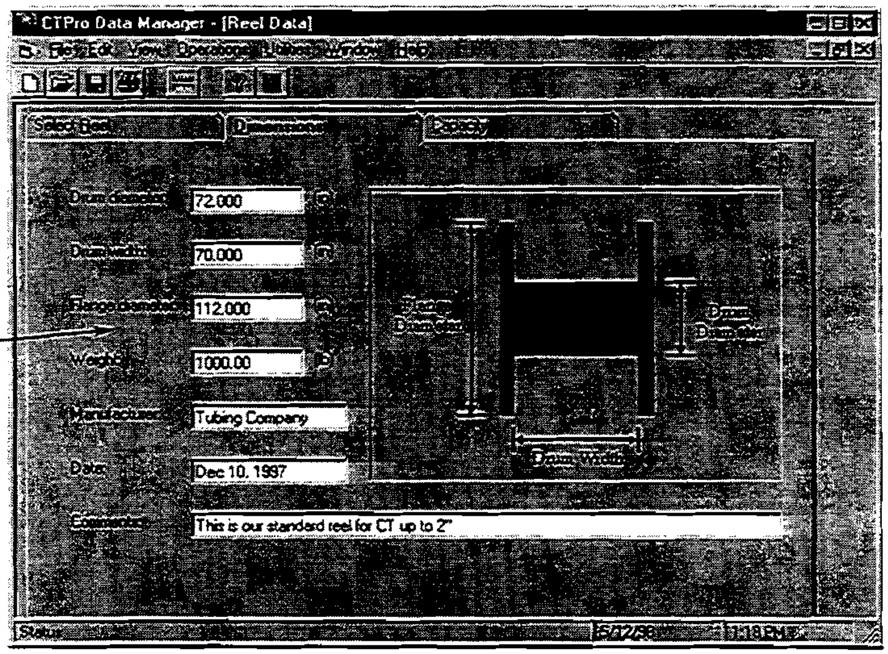
Print. Prints all CT reel data under the current reel name.

Import. Imports a CT reel from an external database specified by the user. A pop-up window is displayed for selecting a database file (***.mdb**).

Export. Exports the current CT reel to an external database specified by the user.

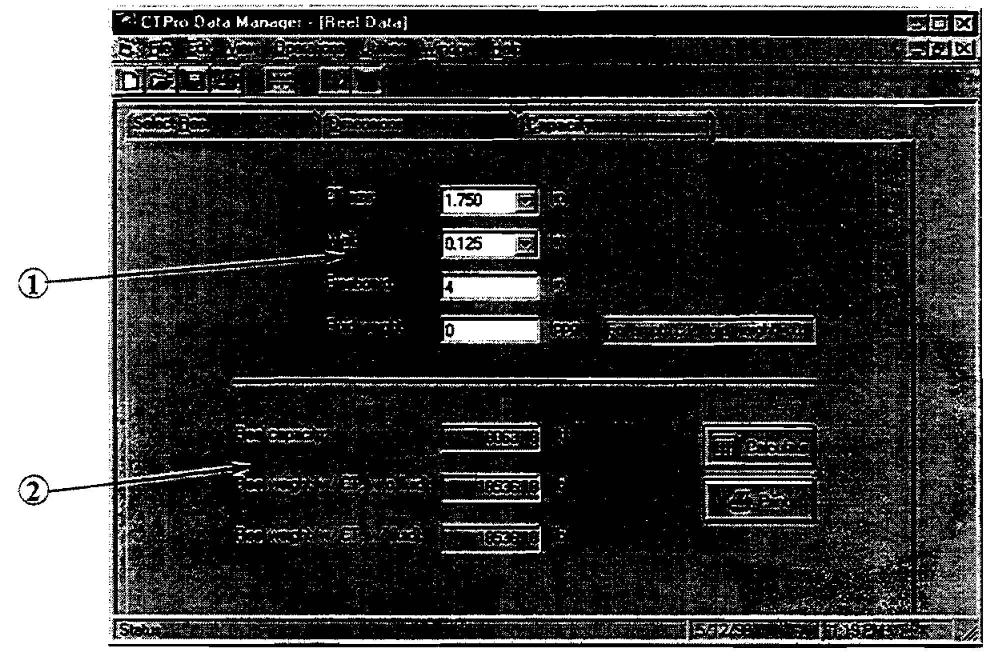
3.5.2 Reel Dimensions Page

①



① ***Reel Dimensions.*** Enter the reel dimensions and weight. Definitions of required dimensions are shown in the reel schematic on the right side of the window. Reel capacity is calculated on the Reel Capacity page (next section).

3.5.3 Reel Capacity Page



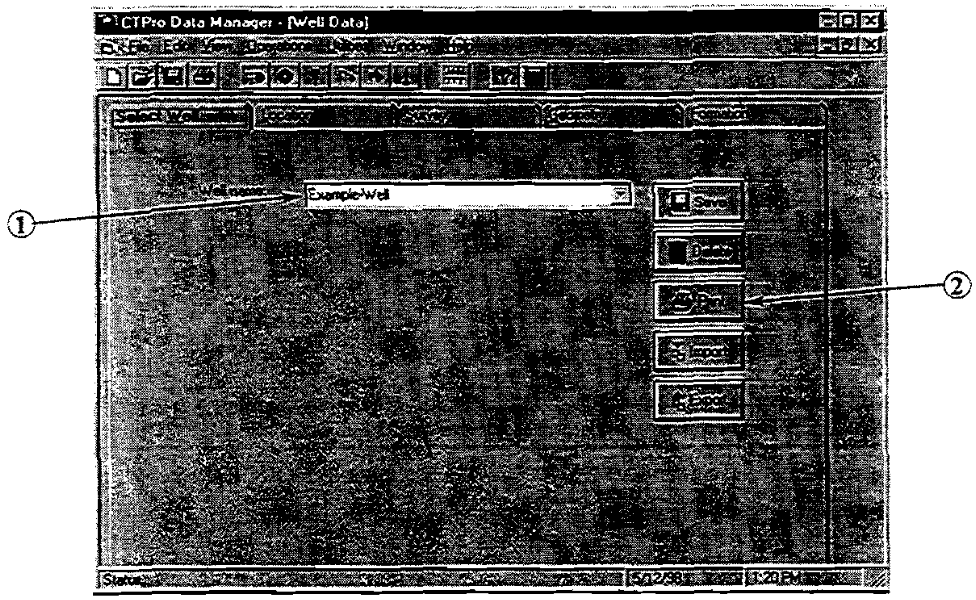
① *CT Capacity*. Select the CT dimensions for calculating reel capacity. The **freeboard** dimension is the radial height left empty above the outer layer of CT and the reel flange. Freeboard provides room for imperfect layers of CT after it is spooled off and respooled in the field.

② *Reel Capacity Calculation*. The calculated reel capacity, and the weight with and without fluid are displayed. Click [Calculate] after the data are entered in the upper half of the page to update the calculation results. [Print] prints the reel capacity results.

3.6 WELL DATA WINDOW

In the Well Data Window, there are five different pages for organizing data describing the well. Each is accessed by clicking on its tab below the icon tool bar. Functions and parameters on each screen are described in this section.

3.6.1 Select Well Page



① ***Select Well Record.*** Available well records are listed in the drop-down list box. Any well can be selected by clicking its name inside the list.

② ***Record Edit Buttons.*** Edit buttons are used for managing the well record.

Save. Saves all well data under the current well name. The well name can be changed by typing a new well name in the list box and clicking this Save button (same as "Save As..." function).

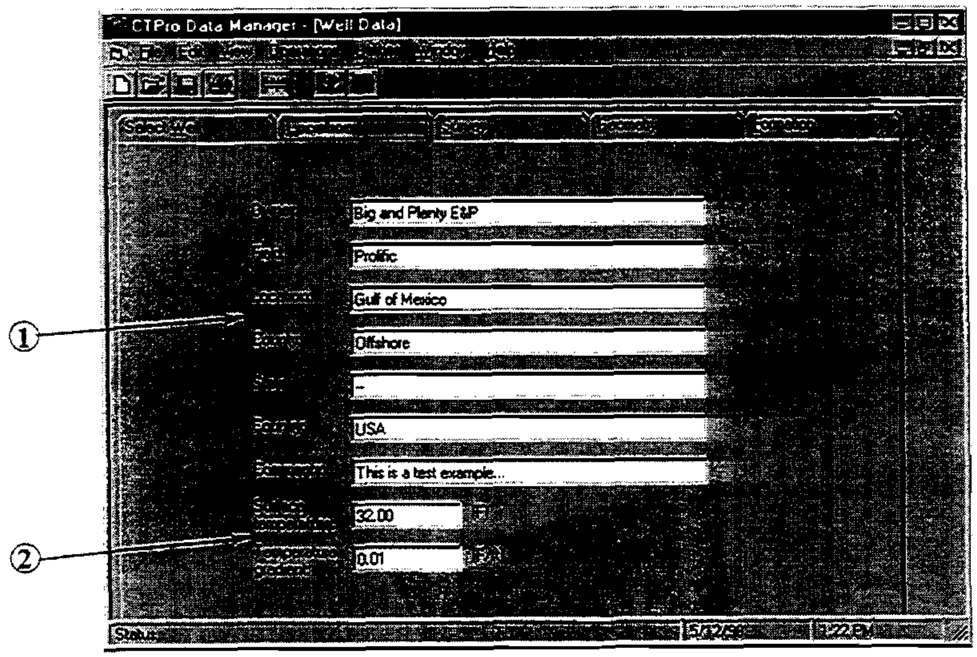
Delete. Deletes the current well record from the database.

Print. Prints all well data under the current well name.

Import. Imports a well from an external database specified by the user. A pop-up window is displayed for selecting a database file (***.mdb**).

Export. Exports the current well to an external database specified by the user.

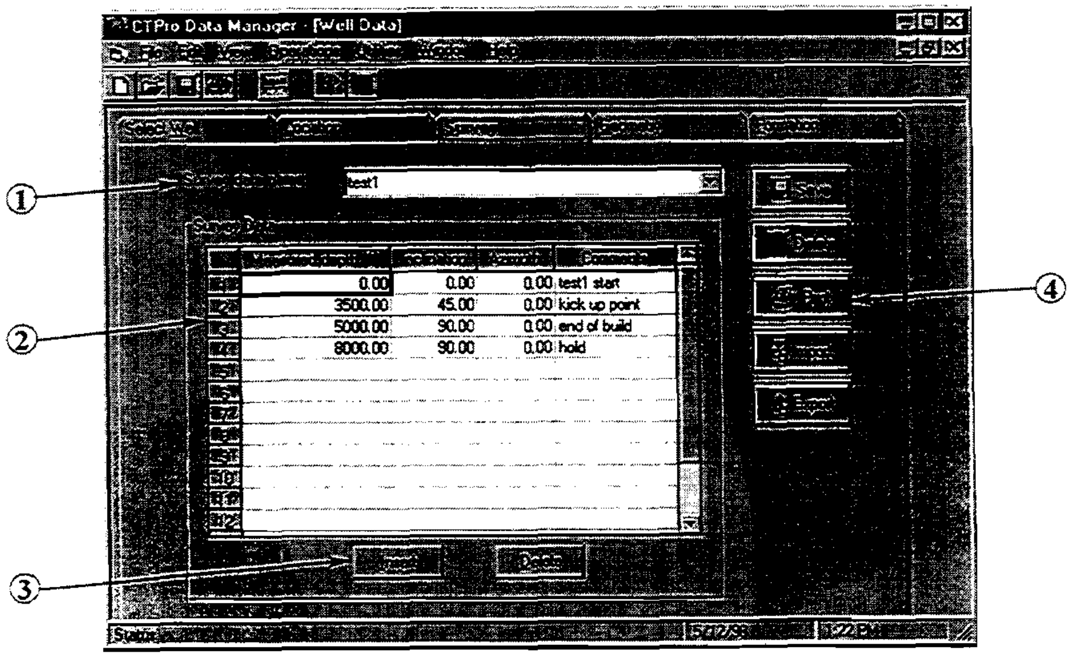
3.6.2 Location Page



① ***Location Data.*** A description of the well location serves to document the operation.

② ***Temperature Data.*** Undisturbed temperature gradients should be entered. Temperature can then be estimated at any depth based on the surface temperature and the temperature gradient.

3.6.3 Survey Page



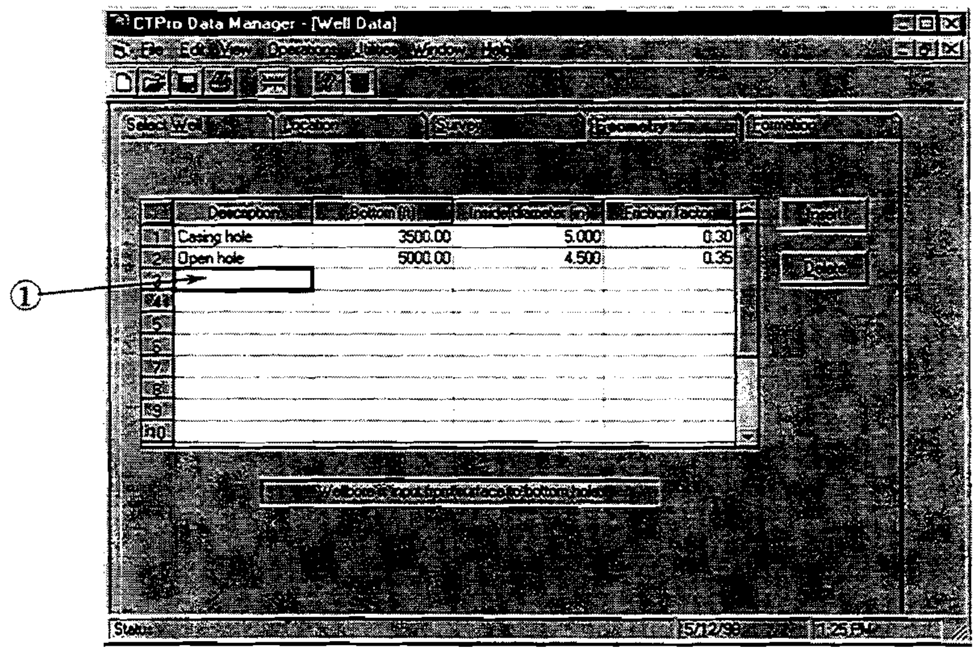
① ***Survey Data File.*** Survey data available within the database are listed in the drop-down box. Click on the survey name to pull the data into the project.

② ***Survey Data Table.*** Survey data describing the well trajectory can be entered into the table manually, by importing from a text file or *.SDI file from another MEI program, or by pasting from the Windows Clipboard. To paste from the Clipboard, arrange the columns in order in Excel, select the data, press control+C to copy, return to CTPRO, place the cursor at the top of the table, and press control+V to paste the data into the table.

③ ***Table Edit Buttons.*** The edit buttons for the data table work on complete rows of data. [Insert] places a new blank row above the cursor position. [Delete] deletes one entire row, whether a single cell or whole row is selected.

④ ***Survey Control Buttons.*** The function of these buttons is similar to those on the Select Well page described above. The principal difference is that **importing and exporting survey data is from or to *.SDI (MEI standard format) or text files, rather than databases (*.mdb).** Well surveys can be imported from any style of text file in which the survey data are arranged in rows. The user can preview the text file and specify which rows contain headings from within a special import window.

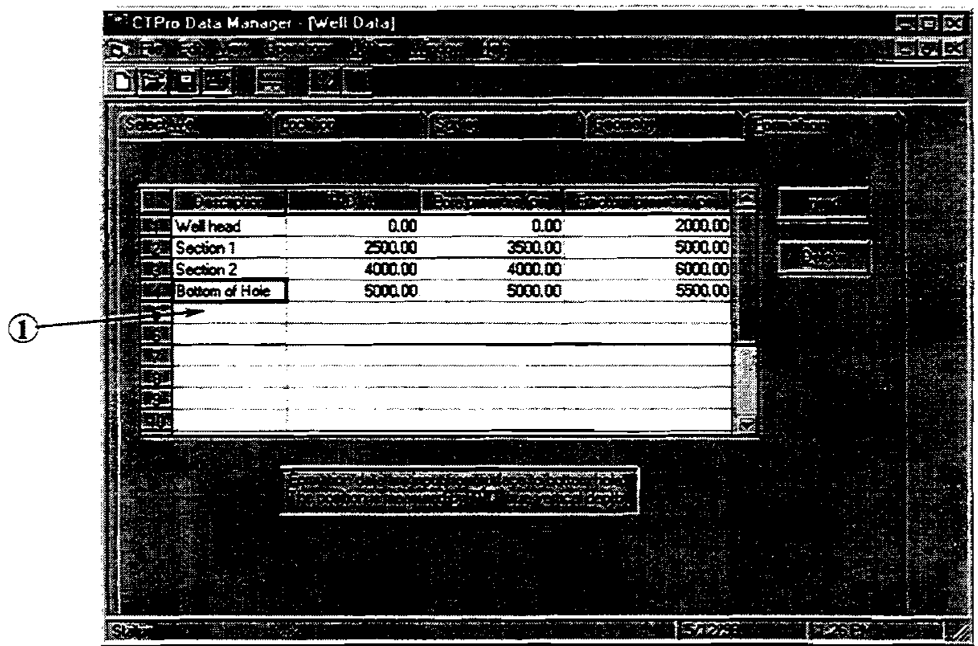
3.6.4 Well Geometry Page



① ***Well Geometry Table.*** Depth, ID and friction factor are entered for each section of the wellbore. Row 1 starts from the surface. The last row is the bottom of the hole at TD.

Typical values for friction factor are 0.30-0.40 with water-base muds and 0.20-0.30 with oil-base muds. The lower end of the range is appropriate in cased holes; higher values are typical for open-hole sections.

3.6.5 Formation Page

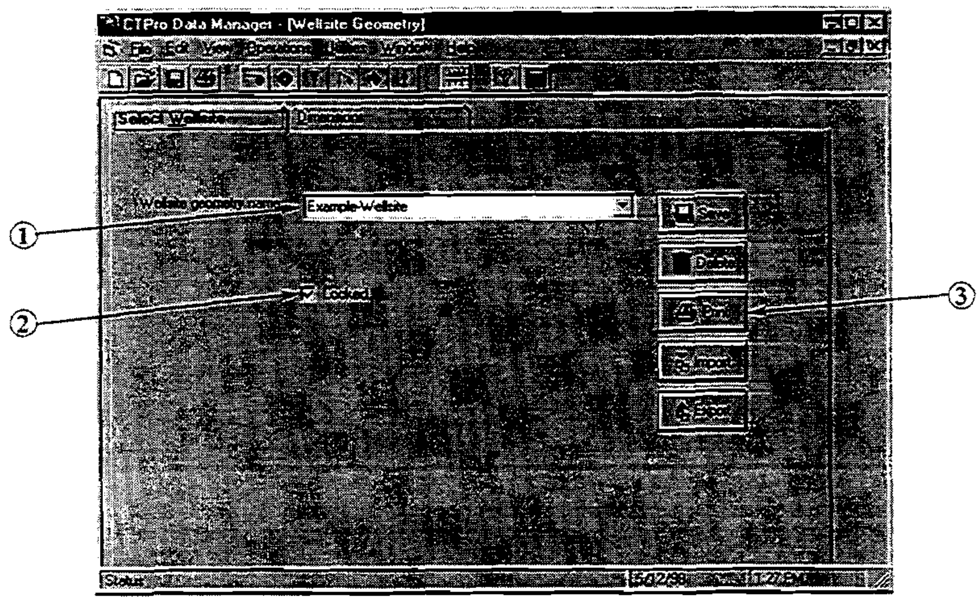


① ***Formation Data Table.*** Pore and fracture pressures are specified at each TVD. The first row is always at the surface; the final row is at the bottom of the well. Note that depth is entered as TVD (true vertical depth).

3.7 WELLSITE DATA WINDOW

In the Wellsite Data Window of CTPRO, there are two pages for organizing input data. Each is accessed by clicking on its tab below the icon tool bar. Functions and parameters on each screen are described below.

3.7.1 Select Wellsite Page



① ***Select Wellsite Record.*** Available CT wellsite records are listed in the drop-down list box. Any wellsite can be selected by clicking its name inside the list.

② ***Data Lock.*** Wellsite data entered on the other page can be locked to prevent accidental changes. Prior to editing any data, the user must uncheck this box.

③ ***Record Edit Buttons.*** Edit buttons are used for managing the wellsite data record.

Save. Saves all wellsite data under the current wellsite name. The wellsite name can be changed by typing a new wellsite name in the list box and clicking this button (same as "Save As..." function).

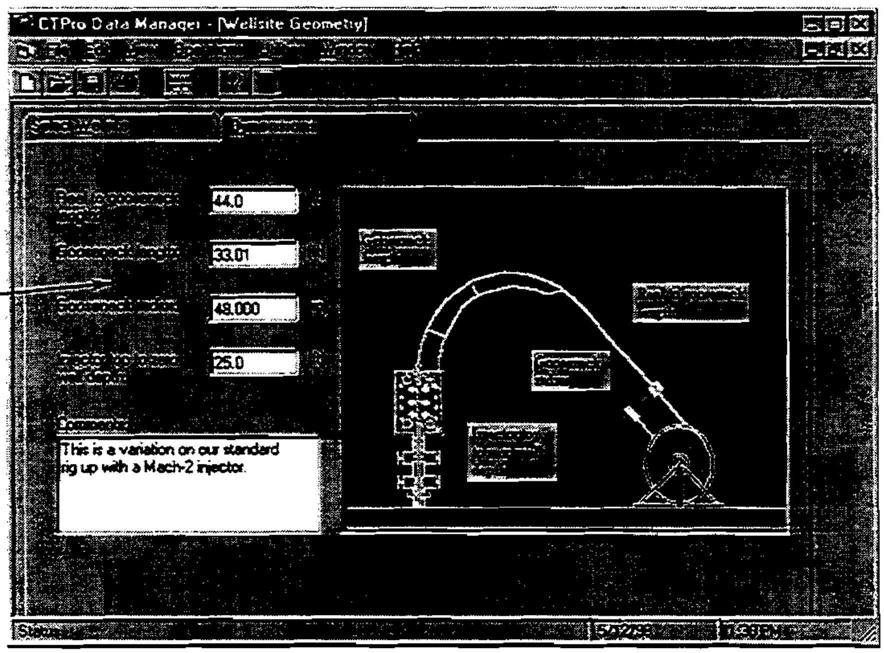
Delete. Deletes the current wellsite record from the database.

Print. Prints all wellsite data under the current wellsite name.

Import. Imports a wellsite from an external database specified by the user. A pop-up window is displayed for selecting a database file (***.mdb**).

Export. Exports the current wellsite to an external database specified by the user.

3.7.2 Wellsite Dimensions Page

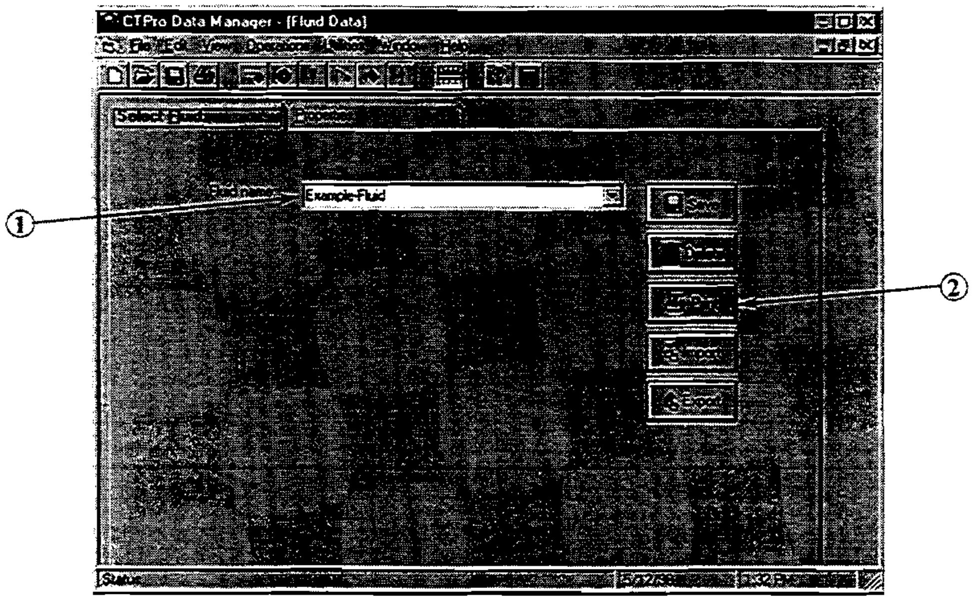


① ***Wellsite Dimensions.*** Rig and equipment dimensions required for CT length and fatigue calculations are specified on this page. Refer to the schematic on the right half of the page for definitions of the parameters.

3.8 FLUID DATA WINDOW

In the Fluid Data Window of CTPRO, there are two pages for organizing input data. Each is accessed by clicking on its tab below the icon tool bar. Functions and parameters on each screen are described in the sections below.

3.8.1 Select Fluid Page



① ***Select Fluid Record.*** Available CT fluid records are listed in the drop-down list box. Any fluid can be selected by clicking its name inside the drop-down list.

② ***Record Edit Buttons.*** Edit buttons are used for managing the current fluid record.

Save. Saves all fluid data under the current fluid name. The fluid name can be changed by typing a new fluid name in the list box and clicking this Save button (same as "Save As..." function).

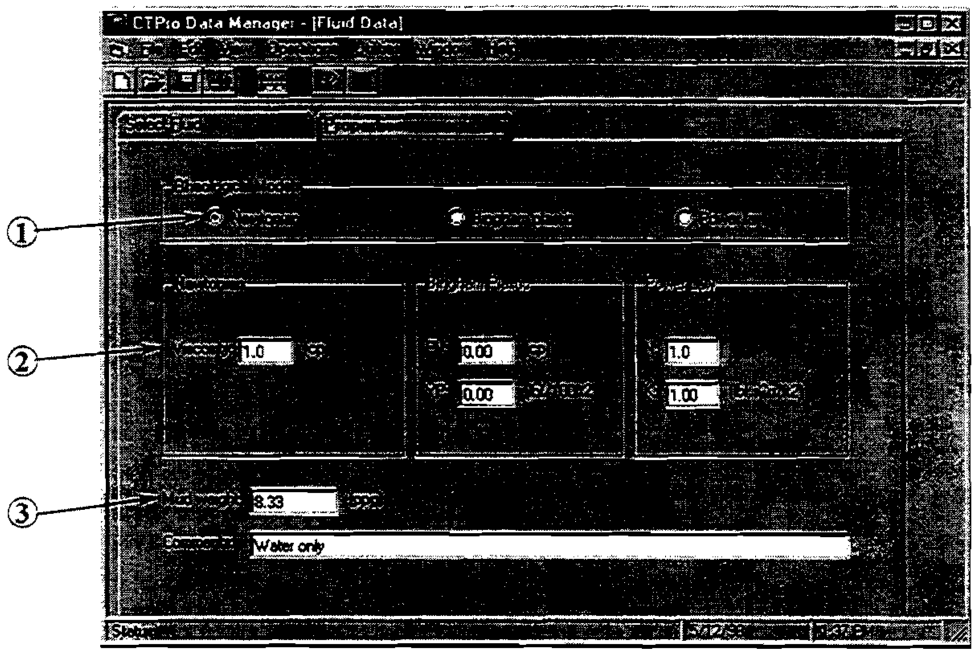
Delete. Deletes the current fluid record from the database.

Print. Prints all fluid data under the current fluid name.

Import. Imports a fluid from an external database specified by the user. A pop-up window is displayed for selecting a database file (***.mdb**).

Export. Exports the current CT fluid to an external database specified by the user.

3.8.2 Fluid Properties Page



① ***Rheology Models.*** Select the rheology model that best describes the fluid for the field operation. Options include Newtonian, Bingham plastic and power-law. After a model is selected, the corresponding parameter boxes on this page become active. More discussion on rheological models is presented in Section 4.3.3.

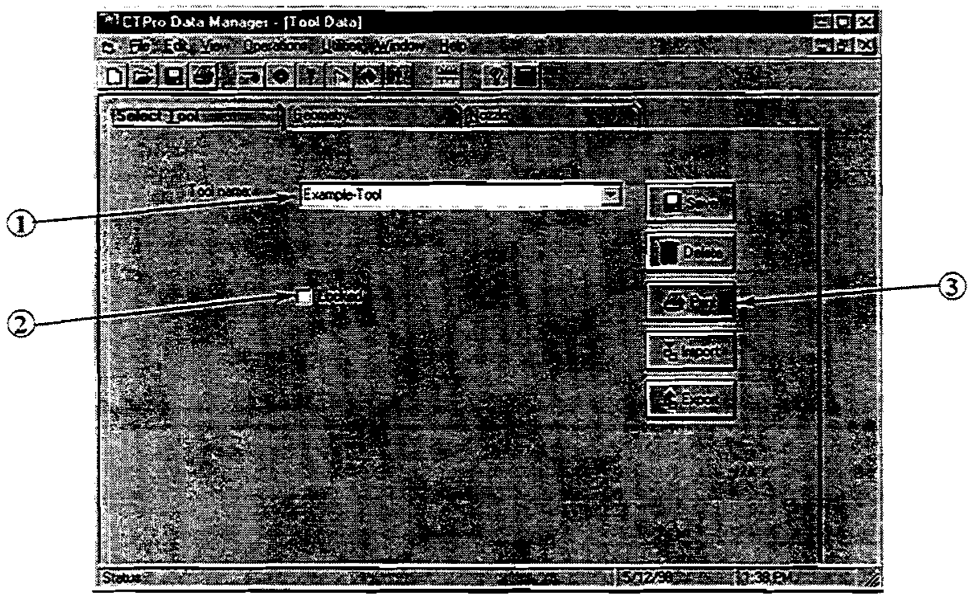
② ***Rheological Constants.*** Enter the viscosity for Newtonian fluids. For Bingham plastic fluids, enter the plastic viscosity (PV) and the yield point (YP). For power-law fluids, enter the flow behavior index (N) and the consistency index (k).

③ ***Mud Weight.*** Enter the fluid density and any comments pertaining to the current fluid.

3.9 TOOL DATA WINDOW

In the Tool Data Window of CTPRO, there are three pages for organizing input data that describes the BHA to be run for the current project. Each page is accessed by clicking on its tab below the icon tool bar. Functions and parameters on each screen are described in the sections which follow.

3.9.1 Select Tool Page



① ***Select Tool Record.*** Available CT tool records are listed in the drop-down list box. Any tool can be selected by clicking its name inside the list.

② ***Data Lock.*** Tool data entered on the other pages can be locked to prevent accidental changes. Prior to editing any data, the user must uncheck this box.

③ ***Record Edit Buttons.*** Edit buttons are used for managing the tool data record.

Save. Saves all tool data under the current tool name. The tool name can be changed by typing a new tool name in the list box and clicking this button (same as "Save As..." function).

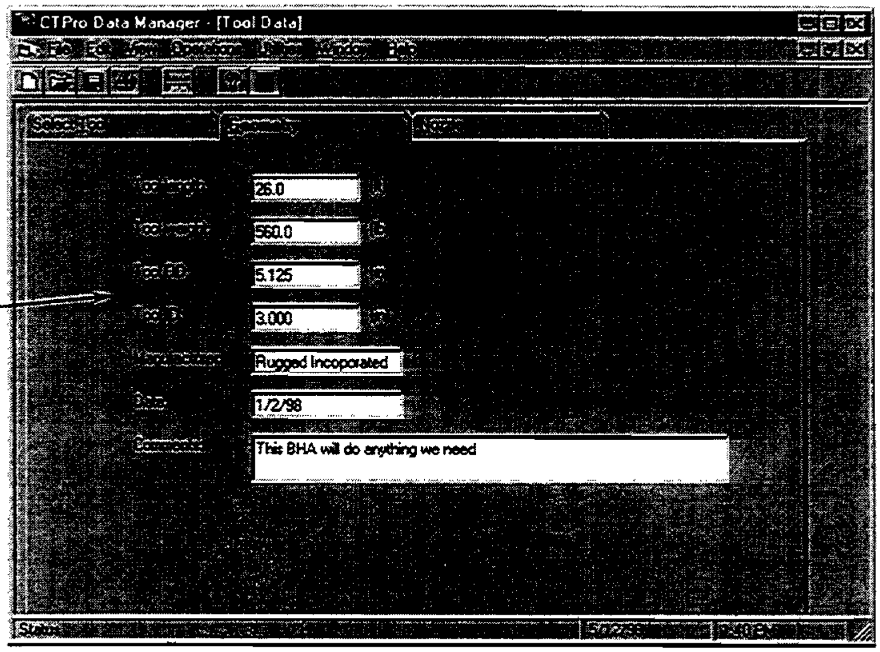
Delete. Deletes the current tool record from the database.

Print. Prints all CT tool data under the current tool name.

Import. Imports a CT tool from an external database specified by the user. A pop-up window is displayed for selecting a database file (***.mdb**).

Export. Exports the current CT tool to an external database specified by the user.

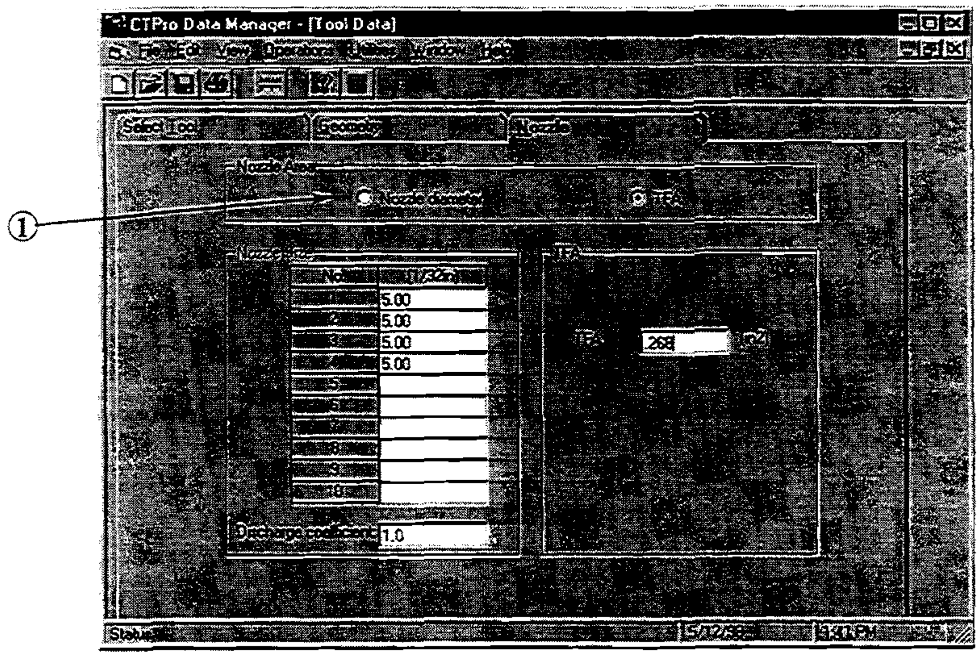
3.9.2 Tool Geometry Page



①

① ***Tool Geometry.*** Tool dimensions and weight are used for engineering calculations (drag, buckling, hydraulics, etc.). Manufacturer, Date and Comments are optional entries.

3.9.3 Nozzle Page

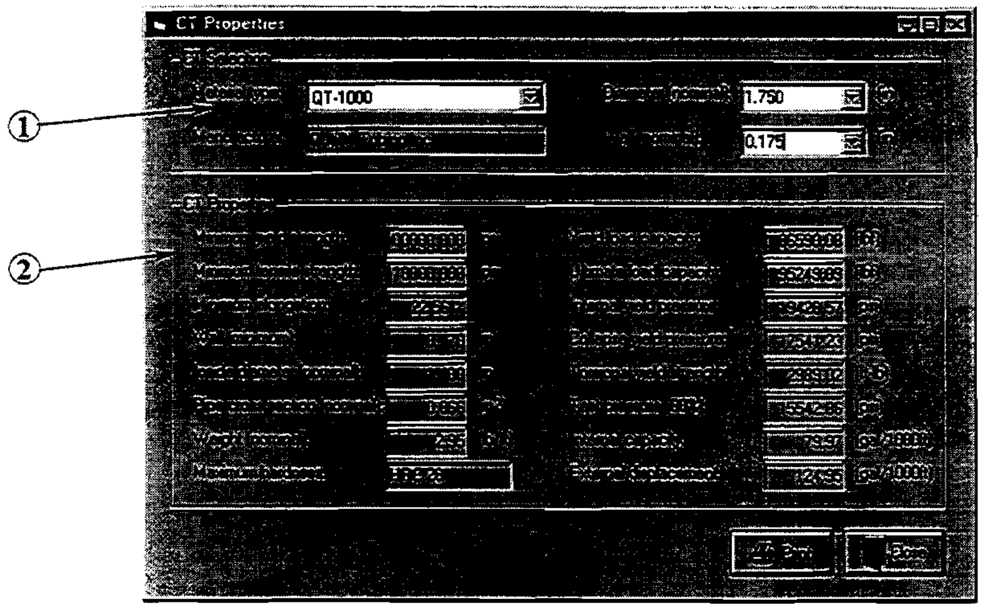


① *Nozzle Area.* Effective nozzle area and its impact on hydraulics can be modeled based on either individual nozzle sizes or total flow area (TFA). If **Nozzle Diameter** is selected, fill in the nozzle diameters in the table below. If **TFA** is chosen, the TFA box below becomes active.

Discharge Coefficient is a correction factor for the exit velocity through the nozzle. According to Bourgoyne et al. in *Applied Drilling Engineering*, 0.95 is a practical limit for this factor.

3.10 CT PROPERTIES WINDOW

The CT Properties Window provides a convenient and useful reference for viewing properties of particular grades and sizes of CT. This window is accessed by selecting "CT Properties" from the View menu.

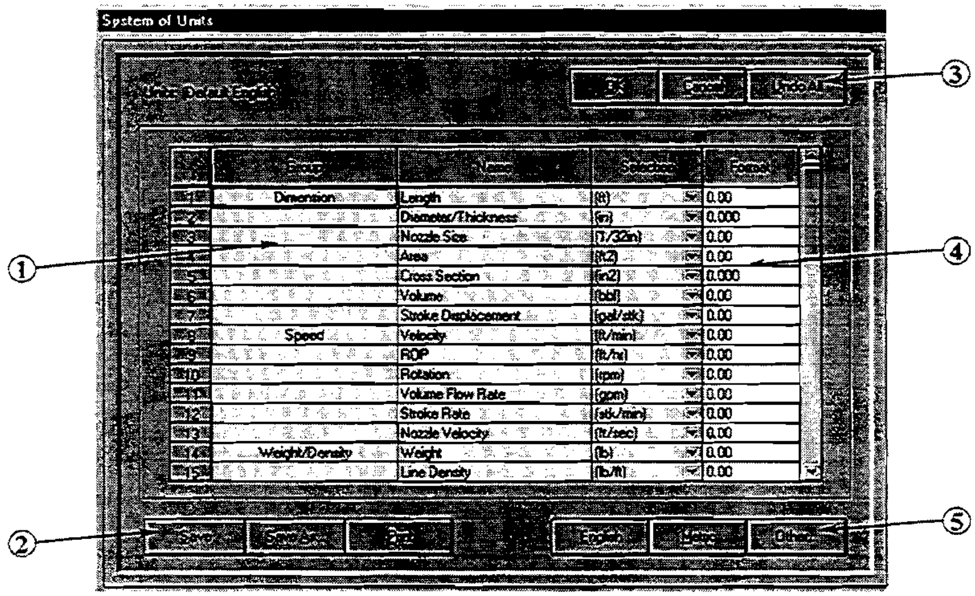


① *CT Selection*. Click on the drop-down boxes to specify CT material, diameter, and wall thickness. Common sizes and grades are readily available.

② *CT Properties*. CT Properties supplied by the manufacturers are listed for the selected CT grade and size. These properties are not editable within this window.

3.11 UNITS WINDOW

The Units window is used to select and edit the system of units for screen displays and printouts. This window is accessed by selecting "Units..." from the Utilities menu or by clicking .



① ***Units Table.*** Physical parameters and currently assigned units for each quantity are displayed in the Units table. The cells with a yellow background cannot be edited directly. Allowable options for each quantity are accessed by pulling down the drop-down box attached to each quantity.

② ***Custom Units Control Buttons.*** If any changes are made to the default English or SI systems of units by selecting another option from one or more of the pull-down boxes, the new custom system will need to be saved for future use. Use the [Save] button for new custom systems or updates to previously created systems. The [Save As...] button is used when a new combination of units is designed, and the user wishes to save it separately, rather than overwriting the previous custom system. Both save buttons will cause a save dialog box to pop up. Custom systems of units are stored as *.UNT files.

The [Print] button will print the Units table for documentation or reference. (This functions only after a save.)

③ ***System of Units Selection Buttons.*** These buttons select entire systems of units, which then appear in the table, and in all CTPRO windows. The [Other] button will display the file names of the custom systems previously created and stored.

The name of the currently selected system of units is displayed in the upper left corner of the Units window ("Default English" in the figure above).

④ ***Numeric Display Format Table.*** The number of decimal digits displayed for each parameter can be set by the user. The number of zeroes after the decimal point for each quantity will be used as standard for the input windows and printouts.

Within the decimal section of the number (which defines how many decimals are displayed), a zero denotes a "hard" digit (always displayed) and a "#" denotes a "soft" digit (displayed if required).

⑤ ***Units Control Buttons.*** These buttons control operations for the entire Units window. [OK] accepts the current settings after any changes are made and then returns to the previous screen. [Cancel] ignores any changes made since this units screen was activated and returns to the previous screen. [Undo All] deletes all changes made since this units screen was activated, but stays in the Units window for further editing.

3.12 DATABASE TOOLS WINDOW

The Database Tools Window provides three useful functions for managing the CTPRO databases.

Compress Database. This function makes a copy of the CTPRO database, rearranges how the file is stored on disk (that is, compressing it while removing superfluous data), and saves the database under the original name. *Users are encouraged to launch this function on a periodic basis to make the most efficient use of disk resources.*

Backup Database. Makes a copy of the database under a different name. Users are encouraged to back up the CTPRO database regularly.

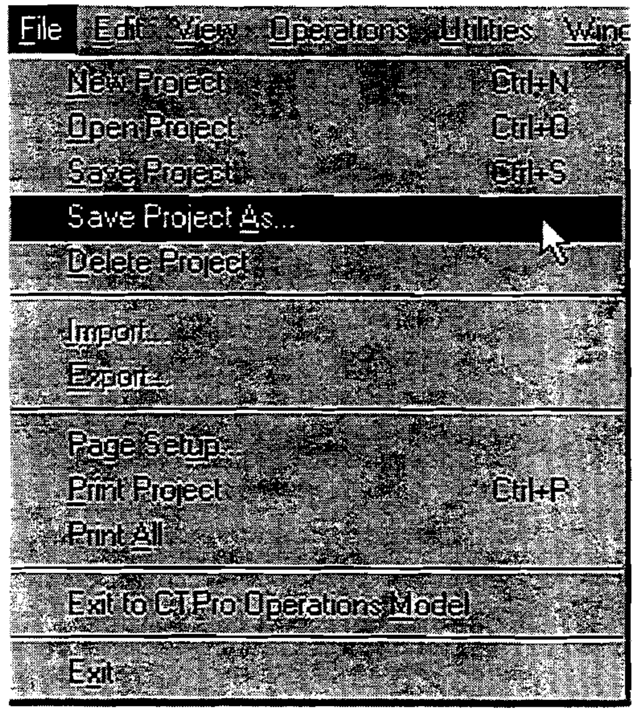
Repair Database. This function may repair the database if the program quits unexpectedly, for example, if power is lost or a hardware problem develops.

Return. This closes the Database Tools Window and transfers back to the previous main or edit window.

3.13 MENUS IN DATA MANAGER

The menu system used in CTPRO is similar to other Windows applications. Many functions are self-explanatory. There are seven menus in Data Manager: **File**, **Edit**, **View**, **Operations**, **Utilities**, **Window** and **Help**.

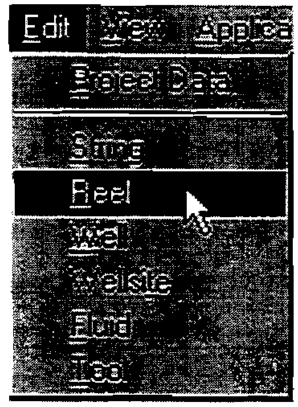
File Menu



The File menu contains commands for creating, retrieving, and saving CTPRO projects; importing/exporting data from external databases; printing project data; and exiting the program. The functions of the individual menu options are:

1. "New Project" first prompts the user for a name for the new project. Select Edit Project to select existing database records for the new project. Same as .
2. "Open Project" opens a dialog box for exploring the list of available projects in the CTPRO database. Same as
3. "Save Project" replaces the previous version of the project with the current modifications. No additional prompt is given before overwriting the previous version. Same as .
4. "Save Project As..." saves the current version of the project under a different name. A dialog box is opened to let the user specify the drive, directory, and name of the project file.
5. "Delete Project" deletes the current project from the CTPRO project list.
6. "Import..." opens a dialog box for specifying a database from which to import a data record. This feature is available only while editing one of the six data records within a project (string, reel, well, etc.).
7. "Export..." opens a dialog box for specifying a database to which to export the current data record. This feature is available only while editing one of the six data records within a project.
8. "Page Setup..." provides options for selecting and controlling the printer.
9. "Print Project" prints the record names and project documentation data in a summary table. Same as
10. "Print All" prints all data saved under the current project.
11. "Exit to CTPRO Operations Model" transfers out of the **Data Manager** to the **Operations Model** for performing engineering analyses of any CT project.
12. "Exit" concludes the current session in the Data Manager. CTPRO will prompt for saving the project file if data have been changed and not yet saved.

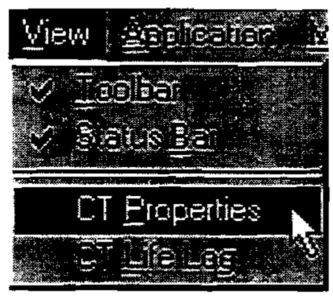
Edit Menu



The **Edit** menu is used to access the project and data record windows for viewing and modifying the CTPRO database.

1. "Project Data" opens the Project Data window (see Section 3.3) for selecting the six equipment records within the current project.
2. "String" opens the String Data window (see Section 3.4) for selecting, viewing and editing the current CT string data record.
3. "Reel" opens the Reel Data window (see Section 3.5) for selecting, viewing and editing the current CT reel data record.
4. "Well" opens the Well Data window (see Section 3.6) for selecting, viewing and editing the current well data record.
5. "Wellsite" opens the Wellsite Data window (see Section 3.7) for selecting, viewing and editing the current wellsite data record.
6. "Fluid" opens the Fluid Data window (see Section 3.8) for selecting, viewing and editing the current fluid data record.
7. "Tool" opens the Tool Data window (see Section 3.9) for selecting, viewing and editing the current tool data record.

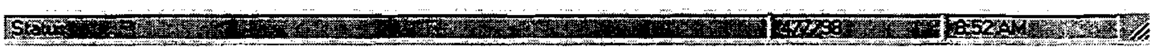
View Menu



The **View** menu can be used to 1) switch on/off the toolbar and status bar within the Data Manager windows and 2) access the CT Properties window and the CT Life Log.

1. "Toolbar" toggles on/off the icon toolbar in the Data Manager. The icons (see Section 3.2) are available for quickly accessing some of the most common menu functions.

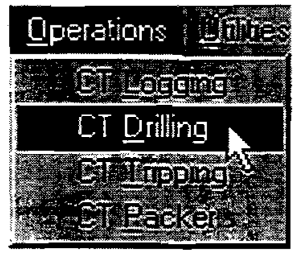
2. "Status Bar" toggles on/off the status bar (bottom of the Data Manager window). Turning off the Status Bar will provide more room if the complete Data Manager window can't be viewed simultaneously on your computer screen.



3. "CT Properties" opens the CT Properties window (see Section 3.10) for selecting and viewing detailed performance parameters for a variety of CT grades and sizes.

4. "CT Life Log" opens the Fatigue Life page in the String Data window (see Section 3.4.7) for rapid review of the fatigue life of the current string.

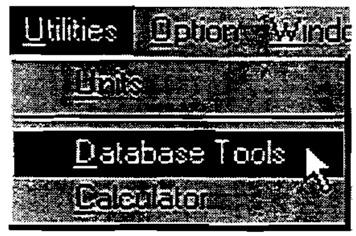
Operations Menu



The **Operations** menu is used to transfer the user out of the Data Manager directly to the CTPRO Operations Model (see Chapter 4). The CT operation selected from the list of options is sent automatically along with the current database project data. More operations will be added to this list in later versions of CTPRO. The options in this version include:

1. "CT Logging" for operations without weight on bit; and with additional drag at the BHA
2. "CT Drilling" for operations with WOB
3. "CT Tripping" for operations without WOB or additional drag at the BHA
4. "CT Packer" for operations applying weight downhole only at a specific depth

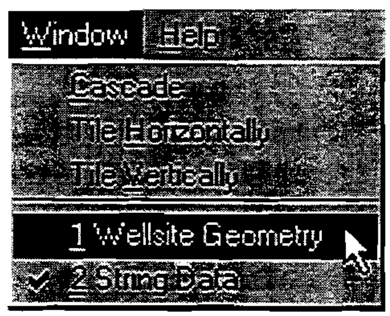
Utilities Menu



The **Utilities** menu contains three useful features for use in the Data Manager. These include:

1. "Units..." opens the Units Selection Window (see Section 3.11). Same as .
2. "Database Tools..." contains three useful functions for compressing, backing up, and repairing the current CTPRO database (see Section 3.12).
3. "Calculator" pops up the Windows calculator for quick calculations. Same as .

Window Menu



The **Window** menu is used to select the current (active) window among any that are open. Note that each secondary window such as **Edit Project Data, Edit String Data, View CT Properties**, and others open a new subwindow inside the main Data Manager window. After being opened, each of these secondary windows may be listed under the **Window** menu and can be immediately reaccessed by selecting it from the list.

The normal view mode is for the current open window of interest to be maximized to full screen. Alternatively, the standard Windows 95 options are available.

1. "Cascade" arranges the graphs and tables in a front to back display with the title block of each graph window remaining visible. The program adjusts the size of each open window to occupy the same amount of display space. The windows are then stacked starting from the upper left corner of the Output Window. Individual plots can be pulled to the top of the stack for viewing by clicking on their title blocks or by selecting them from the list in the **Window** menu.
2. "Tile Horizontally" displays all open windows simultaneously with a horizontal division between each.
3. "Tile Vertically" displays all open windows simultaneously with a vertical bar separating each.

4. Operations Model Input

4.1 REQUIRED INPUT DATA

Engineering analysis of a wide variety of CT operations both in the field and in the office is greatly simplified with the user-friendly CTPRO Operations Model. Input data are organized by specific type, or records from each database type are grouped together and stored as a project. Data files can be created and saved directly within the Operations Model. As another convenient administrative alternative, project files created in the Data Manager (see Chapter 3) can be opened directly inside the Operations Model for analysis. CTPRO Operations Model data requirements are summarized below.

Project Documentation:

1. Well/project description (company name, project name, well location, etc.) (optional)

Survey Data:

2. Directional survey data for the well, including survey station depths, inclinations and azimuths

CT Data:

3. Description of CT string, including OD, wall thickness, weight per unit length, whether the wall thickness is tapered, length, yield strength and Young's modulus. If the string consists of multiple sections, these data are required for each section.

Well Data:

4. ID and friction factor for each section of the wellbore
5. Pore and fracture pressures (or gradients) for each section of the wellbore
6. Wellhead pressure

Fluid Data:

7. Fluid flow rate and density
8. Rheology model and required parameters (viscosity, yield point, etc.)

BHA/Tool Data:

9. Bit nozzle sizes or TFA (total flow area)
10. BHA length, weight, OD, and ID
11. Drag due to BHA, and set-down weight (WOB)

Operations Data:

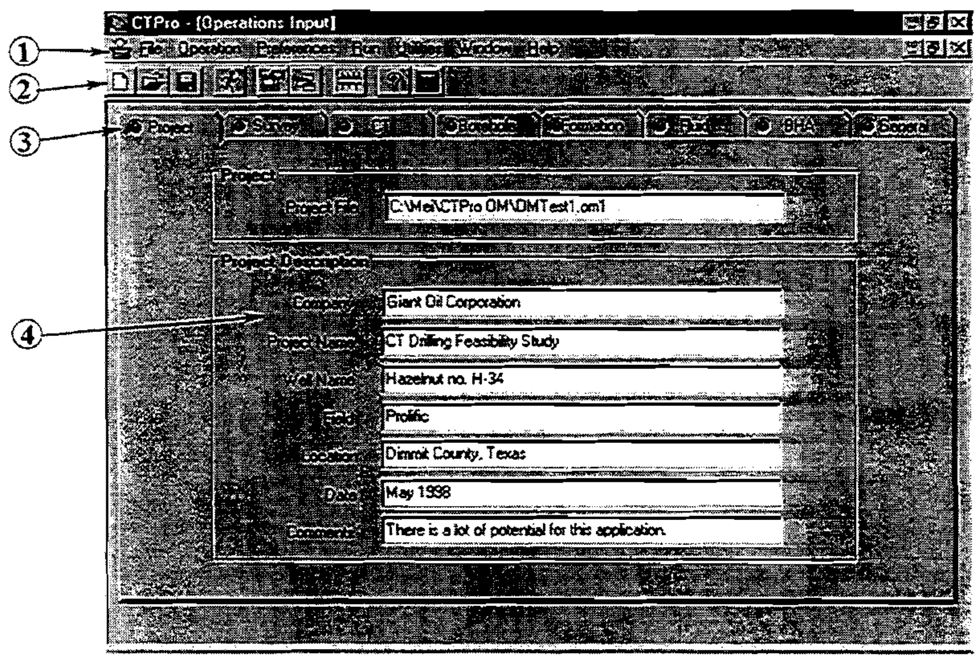
12. CT running speed
13. Safety factor to apply to CT yield load
14. Pulling capacity of CT injector
15. Stuffing box drag
16. Reel back-tension
17. OD and weight for wireline inside CT string

Data may be entered and displayed in English or metric units, or a custom combination of units defined by the user.

4.2 INPUT WINDOW

The Input window in the Operations Model is used to enter and edit data describing the CT operation. After the operation is selected, all required data describing the operation are entered on the eight pages. The calculations are launched by clicking [icon], after which the output graphs will be loaded automatically.

4.2.1 Project Page



① *Menu Bar.* Functions of the pull-down menus in the Main Window are similar to that in other Windows applications. A description of all functions and features is presented later in this chapter in Section 4.4.

② ***Tool Bar.*** Tool-bar icons can be used to quickly access commonly used functions. The icons are shortcuts for menu options. The functions of the icons are:

New Project. Clears all input data.

Open Project. Activates the open project file window.

Save. Saves all input data to current file name. If the project is new, the *Save As...* window is activated automatically.

Run. Launches the calculations of the predicted CT operations performance.

Go to Input. Used to return to the Input window for reviewing and modifying input data after the calculations are performed.

Go to Output. Used to transfer directly back to the Output window graphs and tables without recalculating. Only valid after first calculating and then returning to the Input window.

Units. Opens the Units Selection window (see Section 3.11). The user can select English, SI, or any custom combination of units.

Help. Opens the Help system for CTPRO. Same as [F1]

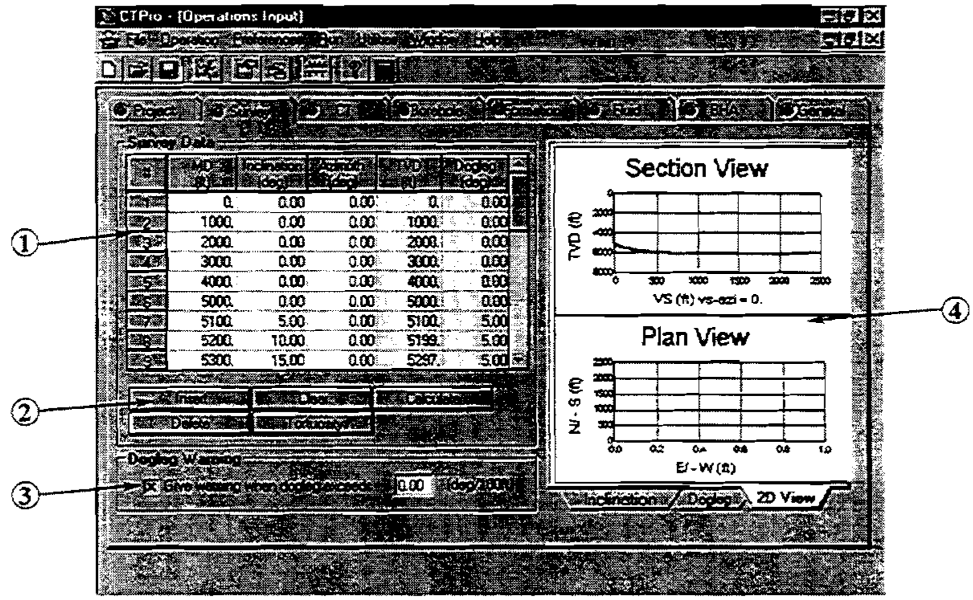
Calculator. Activates the Windows utility calculator.

③ ***Page Tabs.*** Switching between the five input pages for entering or checking data is simple—just click on the corresponding tab. The small circle on the left side of each tab is like a traffic signal. A red light indicates that data entry is not complete on that page. A green light on all tabs means that all required data have been entered and that the calculation sequence may be launched.

Note that the tab may not change color until the page is redrawn (by selecting a different tab).

④ ***Project Documentation.*** These data provide specific information about the project to identify the company, project name, well location, date, and miscellaneous comments. Any or all of these items may be left blank if desired. The function of the program will not be affected. The maximum string length for each entry is 60 characters.

4.2.2 Survey Page



① ***Survey Data Table.*** Wellbore survey data are entered into the first three columns of the table. Column 1 is *Measured Depth* of the survey point. Column 2 is *Inclination Angle* at that depth. Column 3 is *Azimuth Angle* at that depth. Column 4, TVD (true vertical depth), and column 5, DL (dogleg angle) are calculated quantities. The yellow background on these columns denotes they cannot be entered or edited by the user.

The user may input up to 600 survey positions in the table. The survey depth in row 1 should be 0 feet (or 0 meters). Survey depths must be in increasing order (i.e., descending down the hole). The measured depth, inclination angle and azimuth angle each have two unit options, independent of the general system of units selected for the overall application.

Entering/Editing Survey Data

To enter survey data, click on the appropriate box in the spreadsheet table. The most straightforward technique for data entry is to type the number and then press <Enter>. This will automatically shift the cursor position for the next entry. The order of entry when the <Enter> key is used is:

[ROW 1] MD, Inclination, Azimuth; *[ROW 2]* MD, Inclination, Azimuth; *[ROW 3]*......

Moving Around

When editing data within the survey table, the arrow keys are the easiest way to navigate. The up/down arrow keys are used to move up or down within a single column. The right/left arrow keys are normally used when editing individual cell values. *To move from column to column, use* ***control+right/left arrow.*** **Do not use the Tab Key**; this will move the cursor out of the table to the next button.

② *Table Control Buttons*. The table control keys can be used for editing the survey table data. [Insert] will place a new blank row above the cursor position. [Delete] will clear the current row. A confirmation pop-up box appears before any data are deleted.

When data entry is complete, the [Calculate] button must be pressed for calculating Columns 4 and 5 in the data table. These data will also be used to generate or refresh the survey graph on the right half of the screen.

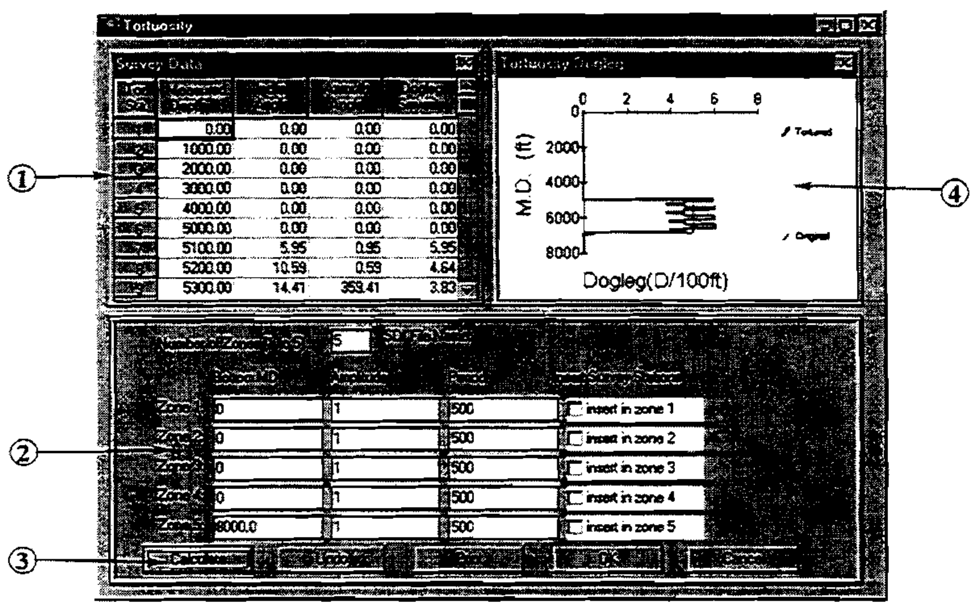
[Tortuosity] activates the **Tortuosity Window** (next section)

③ *Dogleg Error Warning*. The dogleg warning feature is provided in MEI software based on requests from our clients. If this feature is activated, the computer will beep when the dogleg severity exceeds the limit entered by the user in the box. This alarm can be used for indicating significant errors in inclination or azimuth data. Large errors (which produce large doglegs) will be quickly found and corrected.

④ *Survey Graphs*. The survey data are plotted graphically in one of three formats chosen by the user. Options, which include inclination angle with depth, dogleg severity with depth, and a 2D wellbore profile, are selected by clicking the radio buttons at the bottom of the graph area. These plots can be very helpful for spotting errors in the survey data. The selected graph can be sent to the printer by selecting "Print" from the **File** menu.

4.2.3 Tortuosity Window

The Tortuosity window is accessed from the Survey page of the Input window.



When planning a well, surveys generated from geometric considerations (kick-off point, build rate, well-path shape, etc.) are usually smooth curves. Actual wells contain doglegs and other irregularities that increase drag. When ideal (smooth) curves are input into a drag model, the model predicts drag values that are *lower* than those in actual wells containing doglegs and other irregularities.

Exxon developed a simple and elegant way to modify the survey data so that conditions are more representative of real wells. Tortuosity is added to the wellpath; that is, a small-scale sinusoidal variation with a given period (or cycle length) is added to both inclination and azimuth angles.

The amplitude of the tortuosity (maximum value in degrees of the sine-wave variation) is chosen according to hole conditions. *Exxon found that a tortuosity of T = 1 ° represents typical field conditions.* The original survey data are then modified ("tortured") by adding the corresponding dogleg to each survey point. These data are exported to the Survey Page and used to predict drag and buckling in a real wellbore.

① ***Survey Data Table.*** The values initially appearing in this table are copied from the Survey Data Table. After tortuosity is added to inclination and azimuth, the adjusted values will appear in this table for review. Data cannot be edited within this table. Return to the Survey page (click [OK] or [Cancel]) to make changes to any survey data. The table can be enlarged by using the Windows control buttons and .

② ***Tortuosity Zone Parameters.*** The survey can be divided into as many as five zones (for example: surface to KOP, first build section, first tangent section, second build section, second tangent section...). Each survey zone may then be given a different amplitude and/or period for its distributed tortuosity. The bottom measured depth should always be equal to the maximum survey depth.

Amplitude is the maximum dogleg added to the data. Exxon found that a tortuosity of T = 1 ° represents typical field conditions.

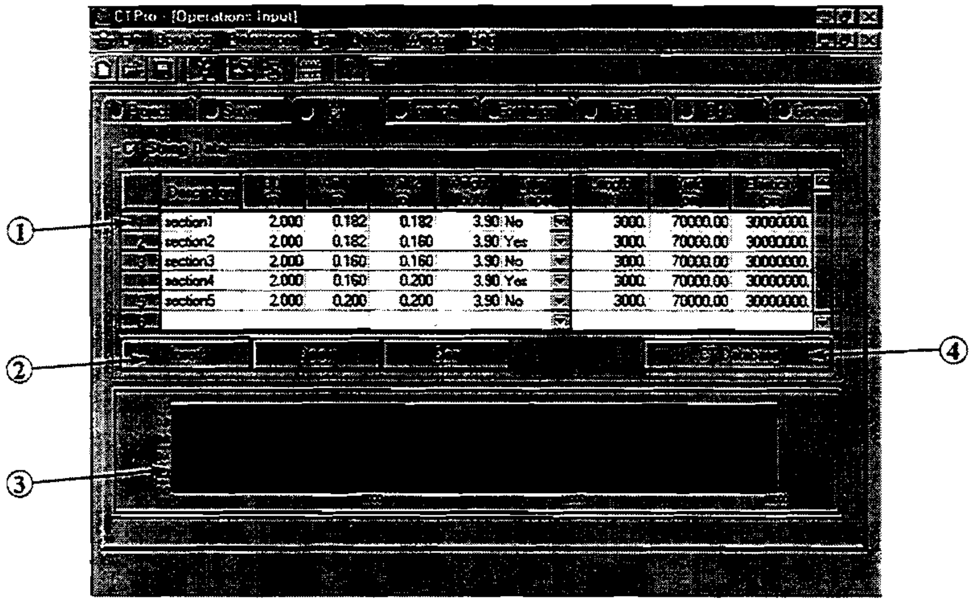
The **Period** is the length of one sine-wave cycle. This value is generally greater than the distance between survey data points. Note that, *in selecting the tortuosity period, one potential problem needs to be avoided.* If the untortured survey data are equally spaced and the tortuosity period Δ is assigned a value such that the measured depth of each survey station is $n \cdot \Delta/2$ (where n is any integer), then after calculation the survey data will remain untortured (the value of the tortuosity sine function will be zero exactly at every station). *This means that the tortuosity period should not be assigned a value that is 2/n (2, 1, ⅔, ½, etc.) times the distance between survey stations.* **It is recommended that Δ be at least five times greater than the interval between survey stations.**

Insert Survey Stations is used if the survey depths are too widely spaced for a reasonable tortuosity period. Click "**insert in zone x**" to add stations. The default interval between inserted stations is 100 ft.

③ ***Tortuosity Control Buttons.*** There are five command buttons at the bottom of the Tortuosity Window. [Calculate] tortures the original survey data, and both the survey data table and dogleg severity graph show the tortured survey. [Undo] resets the data to the original survey. [Print] prints the active window. (If the table or graph is maximized on the screen and the print command button is hidden, press [F6] to print.) [OK] copies the tortured survey data to the Survey Page. [Cancel] closes the Tortuosity Window without any changes to the survey data.

④ ***Tortured Dogleg Graph.*** The impact of adding tortuosity to the survey can be visualized by inspecting the dogleg graph. The graph may be enlarged for easier viewing by using the Windows control buttons and .

4.2.4 CT Page



① *CT String Data Table.* This table is used to specify the geometry and properties of the CT string used for this operation. The data entered in the first row is the free end of the spool (the deepest section in the hole), and other sections are entered proceeding toward the core of the spool. The cumulative length of CT is calculated automatically and displayed below the table.

True Taper is an option available from the manufacturer whereby a change in wall thickness along a section of a tapered string is distributed evenly throughout the entire section of CT. When a True-Taper section is used, specify both Wall 1 thickness (at the end of the section closest to the free end of the spool) and Wall 2 thickness (the end of the section closest to the core of the spool).

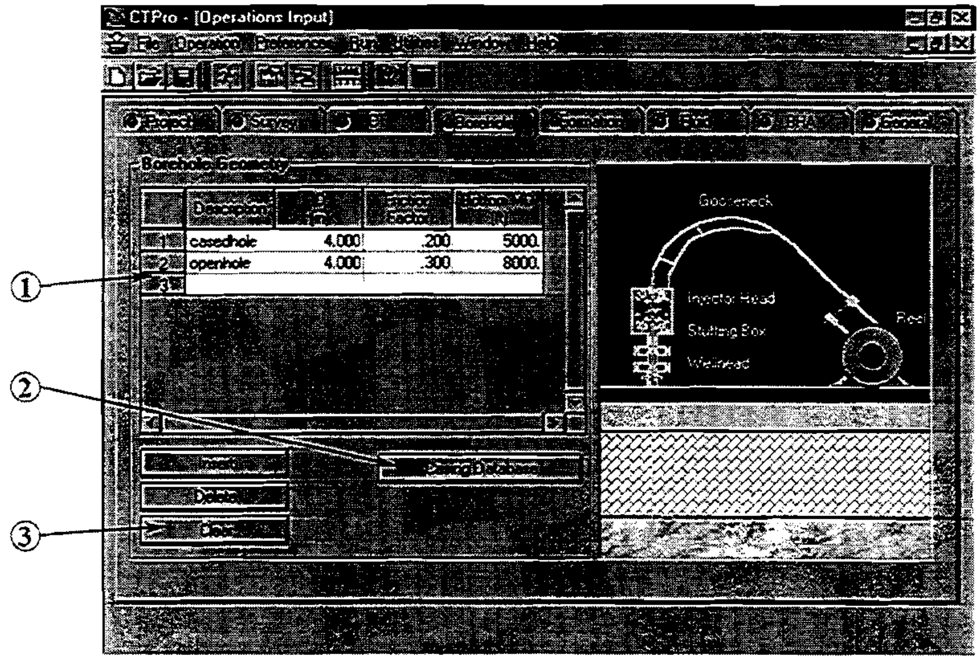
CT material properties can be selected by clicking the material type drop-down list box, which includes the most commonly used materials. Properties for other special materials can be typed in manually.

② *Table Edit Buttons.* The edit buttons for the data table work on complete rows of data. [Insert] places a new blank row above the cursor position. [Delete] deletes one entire row, whether a single cell or whole row is selected. [Clear] removes all entries from the table.

③ *CT String Schematic.* Currently input string sections are displayed graphically for the user's reference.

④ *CT String Properties Database.* Several parameters can be pulled directly into the CT String Data table from an attached database of common CT properties.

4.2.5 Borehole Page

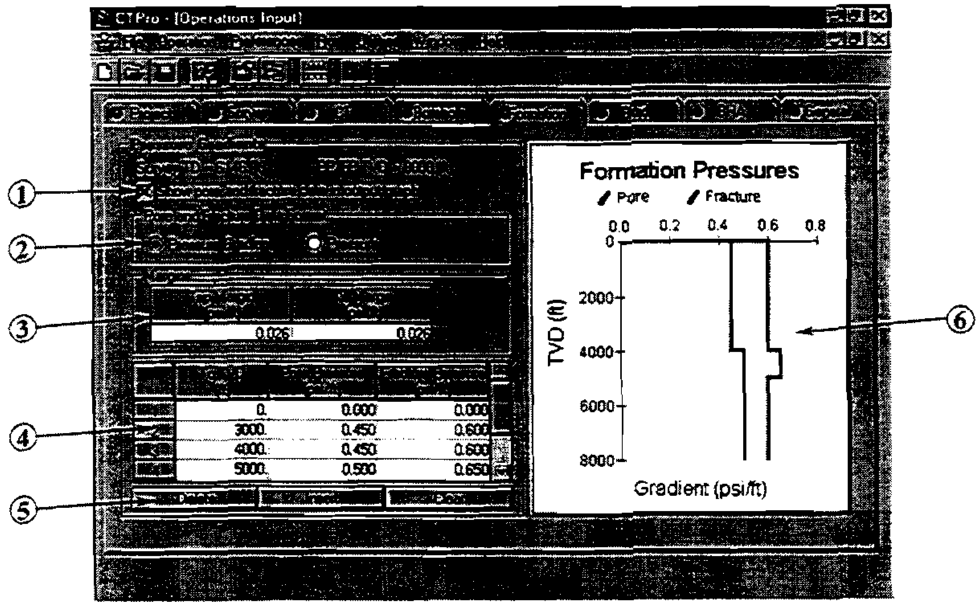


① ***Borehole Geometry Table.*** Borehole size and friction should be specified for the proposed operation. *Enter the shallowest section* (at the surface) *in the first row.* Then proceed deeper in the well to TD.

② ***Casing Properties Database.*** A database of casing geometry can be accessed for determining casing ID, if unknown.

③ ***Table Edit Buttons.*** The edit buttons for the data table work on complete rows of data. [Insert] places a new blank row above the cursor position. [Delete] deletes one entire row, whether a single cell or whole row is selected. [Clear] removes all entries from the table.

4.2.6 Formation Page



① ***Show Pore and Frac Pressure in Graphs.*** When pore and frac pressure limits are of interest, these can be displayed on the output graphs for verifying that hydraulic pressures stay within these limits. If pore and frac pressure limits are not a concern, unselect this option. The output graphs will be less crowded and easier to view.

② ***Pore and Fracture Data Format.*** The user chooses whether the pore and fracture pressures are entered in units of pressure drop per unit length (psi/ft, ppg or kPa/m) or as gauge pressures at each depth. This option can be changed before or after data are entered.

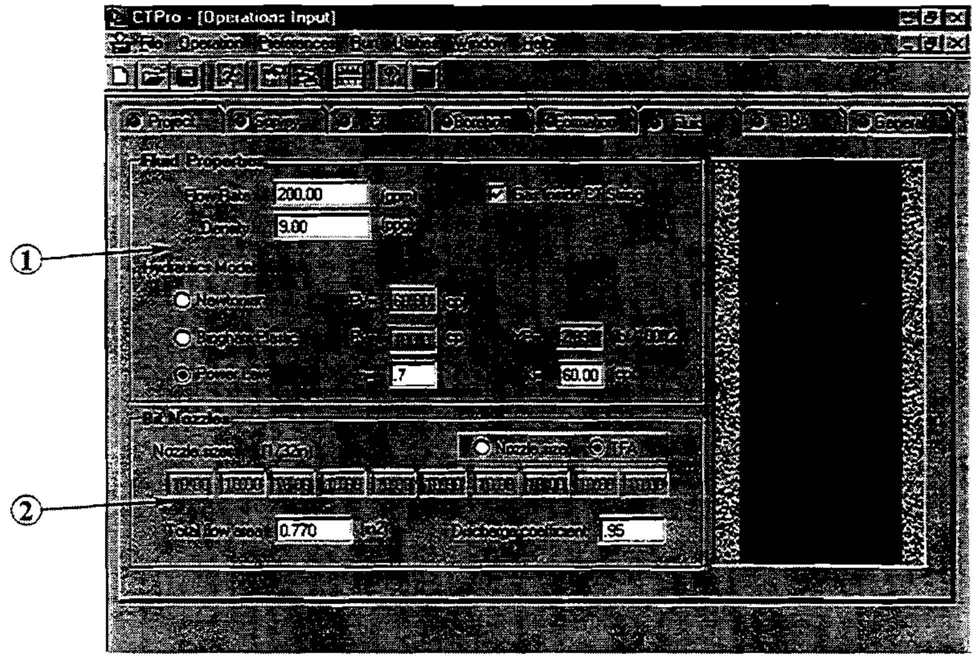
③ ***Trip and Kill Margins.*** Trip and kill margins function as safety factors for avoiding exceeding pore or fracture limits. Typical values range from about 0.5 to 1.0 ppg above pore pressure or below frac pressure (0.026 to 0.052 psi/ft or 0.6 to 1.2 kPa/m). Exact values depend on how accurately formation behavior can be predicted. Safety margins will be plotted in corresponding graphs as more restrictive limits within those defined by pore/frac pressures.

④ ***Pore and Frac Gradient Data Table.*** Up to 100 data points (consisting of TVD, pore pressure and frac pressure) may be entered in the data table. Enter the shallowest hole section in the first row.

⑤ ***Table Edit Buttons.*** The edit buttons for the data table work on complete rows of data. [Insert] places a new blank row above the cursor position. [Delete] deletes one entire row, whether a single cell or whole row is selected. [Clear] removes all entries from the table.

⑥ ***Pore and Frac Gradient Graph.*** Depth and gradient data in the Formation Data table are plotted for inspection. To print the graph, select "Print Input Data" from the File menu.

4.2.7 Fluid Page



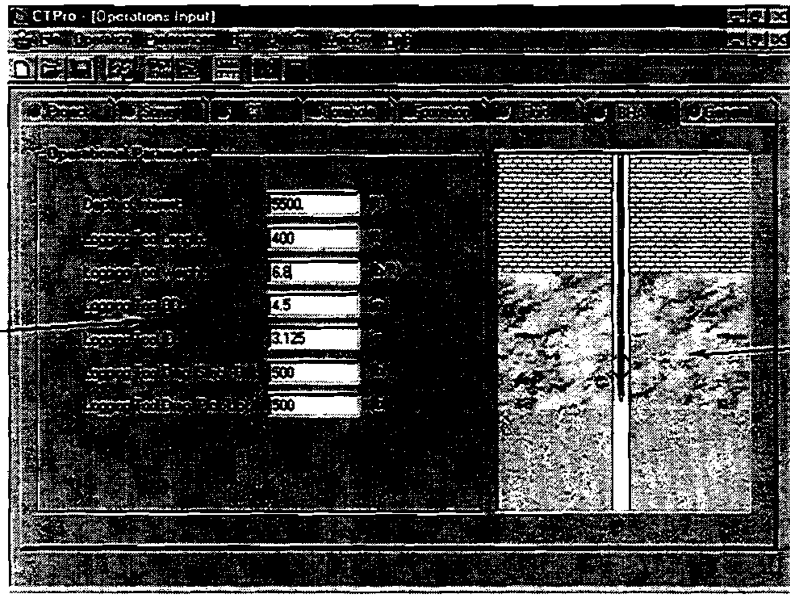
① ***Fluid Properties.*** Enter the pump rate and fluid density for the operation. Check "Gas Inside CT String" for operations (such as logging) when the string is buoyed to decrease effective weight.

Select the rheology model that best describes the fluid for the field operation. Options include Newtonian, Bingham plastic and power-law. After a model is selected, the corresponding parameter boxes on this page become active. More discussion on rheological models is presented in Section 4.3.3. Enter the viscosity for Newtonian fluids. For Bingham plastic fluids, enter the plastic viscosity (PV) and the yield point (YP). For power-law fluids, enter the flow behavior index (N) and the consistency index (k).

② ***Bit Nozzles.*** Effective nozzle area and its impact on hydraulics can be modeled based on either individual nozzle sizes or total flow area (TFA). If **Nozzle Diameter** is selected, fill in the nozzle diameters in the table below. If TFA is chosen, the TFA box below becomes active. Note that the TFA is calculated and displayed as nozzles are input.

Discharge Coefficient is a correction factor for the exit velocity through the nozzle. According to Bourgoyne et al. in *Applied Drilling Engineering*, 0.95 is a practical limit for this factor.

4.2.8 BHA Page

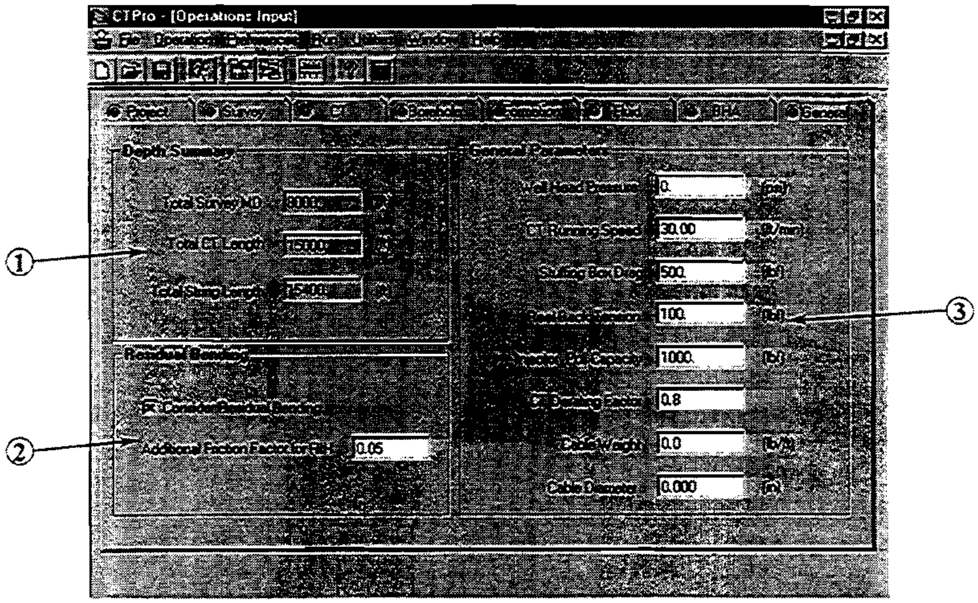


① *BHA Parameters*. Miscellaneous parameters related to the operation and the tool run on the end of the CT are specified here. Text labels on these boxes change to reflect the selected operation.

Depth of Interest defines the current working depth of the BHA. For logging, packer, and other similar operations in existing wells, the CT may not need to penetrate to TD as specified in the wellbore survey. All output graphs will display results from the surface to the Depth of Interest.

② *BHA Schematic*. An animated graphic depicting the BHA in the hole is shown to remind the user of the currently selected operation. Access the Animation window (under the **Preferences** menu) to turn the BHA Animation on or off. Operation type is selected under the **Operation** menu.

4.2.9 General Page



① ***Depth Summary***. Total lengths of the hole, CT, and CT+BHA are shown here for reference. These quantities may not be edited here.

② ***Residual Bending.*** Coiled tubing is not completely straight as it emerges from the injector. Residual bends in the tubing cause buckling to occur at lower axial loads than would be the case for perfectly straight tubing. The impact of residual bending is simulated in CTPRO by increasing the friction factor when running in the hole. Typical values for increases in friction factor due to this effect range from about 0.05-0.10.

Miska et al. (1996) at The University of Tulsa reported laboratory results of buckling tests in SPE 37056. Effective friction factors for new straight CT and residually bent CT varied by about 0.09.

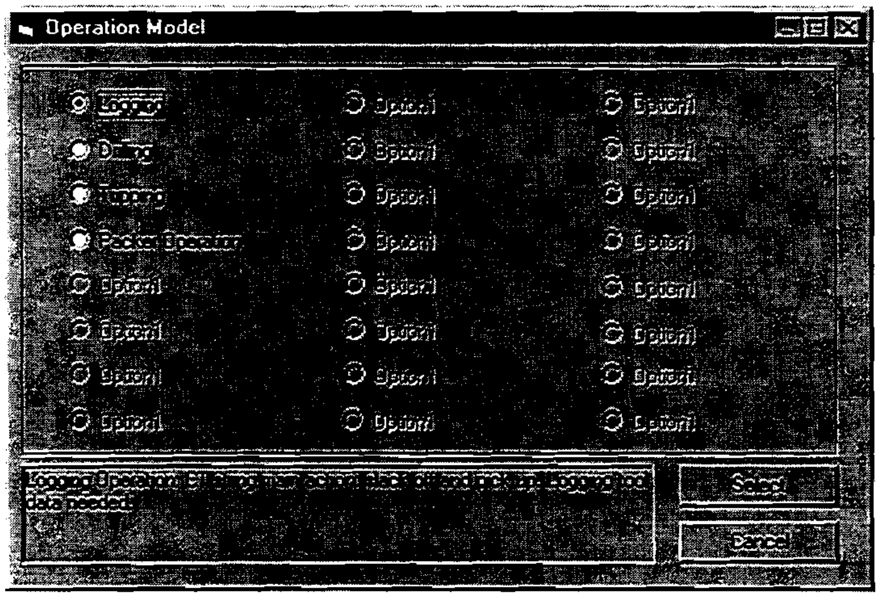
③ ***General Parameters.*** Several general parameters relating to CT field operations are specified here. **Well Head Pressure** impacts pressure drop and hydraulics calculations. **CT Running Speed** also impacts pressure drop. Input the highest running speed anticipated during the operation. **Derating Factor** is the traditional safety factor for exceeding yield stress. A typical value is 0.80 (80%).

4.3 SELECTION WINDOWS

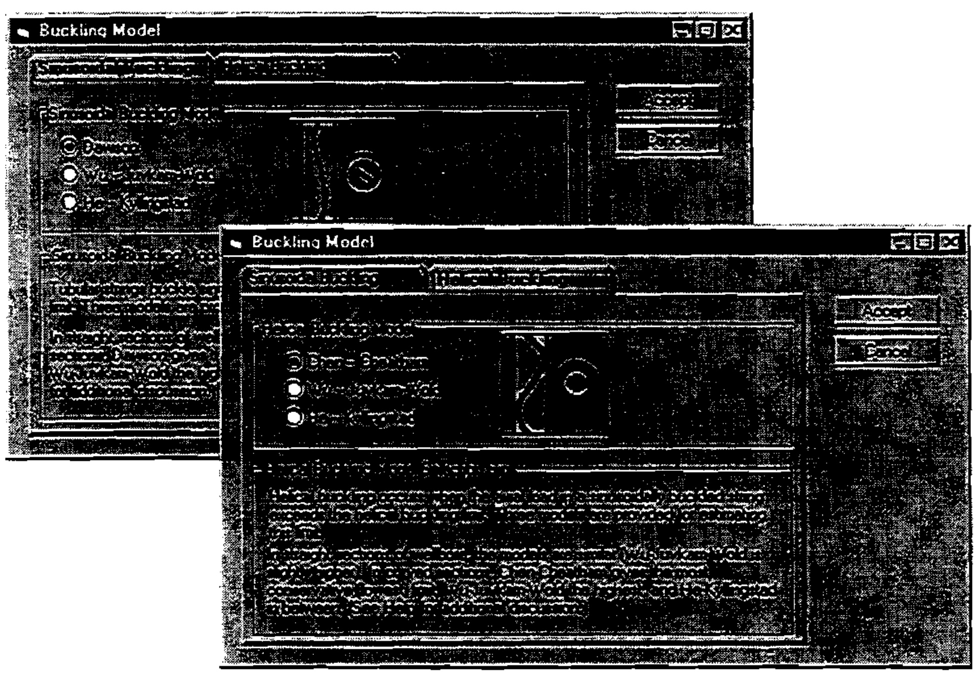
The user can select the specific field operation to be modeled, default buckling models (for sinusoidal and helical buckling modes) and the fluid rheology model. These windows are accessed under the **Operation** and **Preferences** menus.

4.3.1 Operation Model Selection Window

Select a CT operation from the available options. This selection changes text labels on several parameter entries and deactivates parameters not appropriate for the selected operation. Additional operations will be added to this list in later versions of CTPRO.



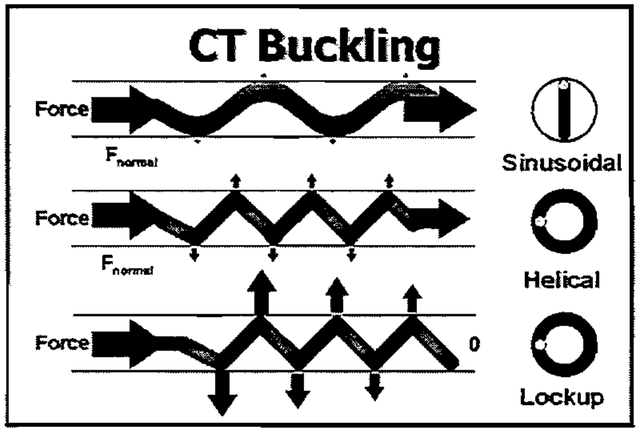
4.3.2 Buckling Model Selection Window



Drag and buckling predictions are very useful for planning CT operations and avoiding problems in the field. The compressive loads required to initiate sinusoidal and helical buckling are indicated on the graphs output of the slack-off plots. The tubing yield limit is also shown. The significance of these stages of buckling is described below.

Sinusoidal Buckling

As compressive force is increased on a length of tubing lying along the bottom of an inclined hole, a point is reached where the tubing will assume a sinusoidal configuration (basically a two-dimensional undulation) side to side across the bottom of the hole. The axial force required to initiate this first mode of buckling is calculated in CTPRO using one of three models selected by the user. Parameters that affect sinusoidal buckling load include:



- cross sectional area of tubing
- Young's modulus of CT
- moment of inertia of tubing cross section
- radial clearance between tubing and borehole
- tubing density
- inclination of hole

Helical Buckling

If the compressive load is increased beyond the point where sinusoidal buckling occurs, helical buckling will eventually be initiated. In this buckling mode, the tubing forms a helix (spiral) along the wall of the hole (a 3-dimensional shape like a stretched spring). The pitch of the helix decreases as the compressive load increases. Helical buckling begins when the axial compressive force is about 1.4 times the value of the sinusoidal critical load (based on the assumption of a straight hole).

Which Buckling Criterion Do I Use?

As indicated above, the smallest critical force is the compressive load that initiates sinusoidal buckling. Next is the critical compressive force that shifts the tubing from sinusoidal to helical buckling. Finally, axial load increases to the point where the tubing begins to yield. *What is the safe upper limit for job planning?*

Field experience has been reported by several authors and participants in MEI DEA projects. Newman et al. ("Safely Exceeding the 'Critical Buckling Load' in Highly Deviated Holes," SPE 19229, 1989) and other authors indicate that CT can safely be pushed into a hole using compressive loads considerably in excess of the sinusoidal buckling limit. In the field cases reported, compressive forces greater than the sinusoidal limit have been used to push CT into inclined holes. Because of well geometry, they were not able to test compressive forces greater than the helical buckling limit. Many field operations conducted since then have verified that compressive forces larger than the helical buckling limit can safely be used to push CT into deviated holes.

The CT yield criterion is normally significantly higher than the helical buckling limit. This condition is closely associated with lock up. After the CT just begins to yield, significant additional force may be placed on the string before it fails completely, but little additional penetration will be achieved. The yield limit with an appropriate safety factor is a practical upper bound for tubing forces. The safety factor applied to the yield limit (Derating Factor on the **General** page) is applied to the output graphs and should be based on practical experience.

Buckling criteria should be used carefully and as guides rather than as absolute indicators. Judgment based on experience, though sometimes expensive to acquire, is of great value when dealing with concepts like buckling and all its implications. Buckling itself does not imply failure, but it indicates the onset of a condition which may precipitate failure.

Which Buckling Model Do I Use?

Three different models for calculating sinusoidal and helical buckling loads are provided in CTPRO. These include:

Sinusoidal Buckling	Helical Buckling
1. Dawson/Paslay (Exxon)	1. Chen/Cheatham (Rice University)
2. Wu/Juvkam-Wold (Texas A&M)	2. Wu/Juvkam-Wold
3. He/Killingstad (Rogaland Research)	3. He/Killingstad

A single model that has been accepted by several authors is used to calculate the load above the helical limit that begins to yield the CT.

From a historical perspective, the Dawson/Paslay model was developed first and published in 1984. It quickly became widely applied. Chen/Cheatham published their model for helical buckling in 1990. The other models were developed later (Wu/Juvkam-Wold and He/Killingstad were both published in 1993) and sought to examine and improve the assumptions and boundary conditions of the earlier models.

There are two primary areas where these buckling models differ.

Straight Wellbores

For straight wellbores (for example, horizontal sections), the primary difference between the models is the nature of the changing axial load in the interval between sinusoidal and helical buckling. The assumption made by Chen/Cheatham is that the axial load between the development of sinusoidal buckling and the onset of helical buckling is constant. Since the load does actually increase between these two buckling modes, Chen/Cheatham used a constant value that is the average axial load during the helical buckling process.

Wu/Juvkam-Wold proposed that, rather than the average load, a linearly increasing load should be assumed for the helical buckling process. The result of this difference in assumptions is that Wu/Juvkam-Wold predicts a helical buckling load that is about 30% higher than Chen/Cheatham. Again, note that this applies for straight sections.

The sinusoidal buckling load in a straight hole section is the same for all three models in CTPRO.

Curved Wellbores

Buckling criteria in curved wellbore sections can be significantly different depending on the model selected. Tubing that is constrained in a curved wellbore is already bowed and will be supported against the bottom side of the curve. Much greater axial loads are required in this case to force the tubing to lift off the bottom of the hole and buckle. Dawson/Paslay and Chen/Cheatham *do not consider* the impact of curvature on the development of buckling.

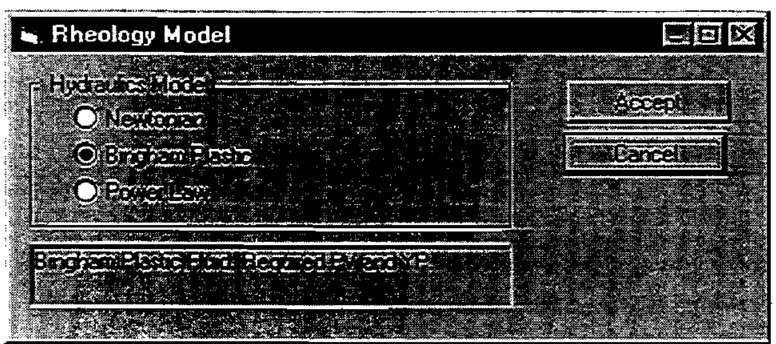
Wu/Juvkam-Wold and He/Killingstad both consider the impact of wellbore curvature. Their analysis and experiments showed that, the larger the build rate, the larger the load to initiate buckling in curved wellbores with increasing inclination. Wu/Juvkam-Wold also model the increasing axial load between sinusoidal and helical buckling in curved wellbores, and consider the difference in length of the inner and outer curve of the casing. He/Killingstad assume a constant load (as did Chen/Cheatham) and ignore the length difference.

Comparison of Models

Due to the differences in these assumptions of axial loads and buckling in curved wellbores, the buckling models in CTPRO can produce different results. This is especially true for helical buckling in curved sections with increasing inclination (going to horizontal, etc.). Generally, *Chen/Cheatham will produce the lowest (most conservative) helical buckling load criterion, He/Killingstad a higher load, and Wu/Juvkam-Wold the highest.* In engineering analyses of this type, the engineer often tends to choose the most conservative model. However, since the constraining effect of a curved wellbore can be very significant, it is most probable that Chen/Cheatham is **too conservative** in these instances; that is, the string can be subjected to much higher loads without buckling helically.

4.3.3 Fluid Rheology Window

The Fluid Rheology window is used to set the default fluid rheology displayed on the Fluids page (see Section 4.2.7). Note that the fluid model can also be changed from the default setting while on the Fluids page.



Three basic fluid models are provided in CTPRO. These include:

1. **Newtonian.** These are fluids in which shear stress is directly proportional to shear rate. Examples of Newtonian fluids are water, air, nitrogen, glycerin, and light oil. A single parameter, viscosity, characterizes these fluids.

Most drilling fluids are non-Newtonian, with shear stress not directly proportional to shear rate. Fluids are shear thinning when they have less viscosity at higher shear rates than at lower shear rates.

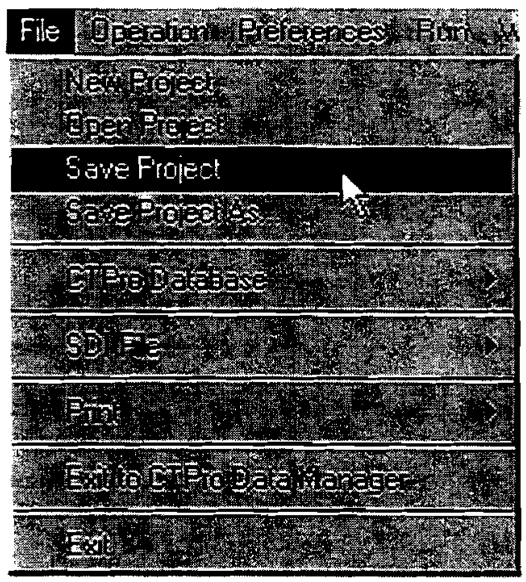
2. **Bingham Plastic.** This is the most common rheological model for drilling fluids. These fluids have a linear shear-stress/shear-rate ratio once a threshold shear stress is exceeded. Two parameters, plastic viscosity and yield point, are used to characterize these fluids. Because these constants are determined between the specified shear rates of 500 to 1000 sec^{-1}, this model characterizes fluids in the higher shear-rate range.

3. **Power Law.** This model applies to shear-thinning or pseudoplastic drilling fluids. Shear stress versus shear rate is a straight line when plotted on a log/log scale. Two constants, n and K, are determined from data at any two speeds.

4.4 MENUS IN OPERATIONS MODEL

The menu system used in CTPRO is similar to other Windows applications. Many functions are self-explanatory. There are six menus in the Operations Model: **File, Operation, Preferences, Run, Utilities, Window** and **Help**.

File Menu



The **File** menu contains commands for creating, retrieving, and saving CTPRO projects; importing/exporting data from databases created within the Data Manager (see Chapter 3); and exiting the program. The functions of the individual menu options are:

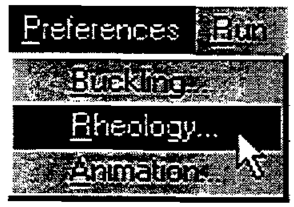
1. "New Project" first prompts the user for a name for the new project. Select Edit Project to select existing database records for the new project. Same as .
2. "Open Project" opens a dialog box for exploring the list of available projects in the CTPRO database. Same as
3. "Save Project" replaces the previous version of the project with the current modifications. No additional prompt is given before overwriting the previous version. Same as
4. "Save Project As..." saves the current version of the project under a different name. A dialog box is opened to let the user specify the drive, directory, and name of the project file.
5. "CTPRO Database" is used to access and save projects from the CTPRO database. These projects can be created and edited from within the Data Manager (see Chapter 3).
6. "Survey File (SDI)" is used to open survey data files created by other MEI software in the standard *.SDI format. In addition, survey data entered into CTPRO can be saved in *.SDI format for use in other MEI programs.

7. "Print" prints the record names and project documentation data in a summary table. Same as .
8. "Exit to CTPRO Data Manager" closes the Operations Model and immediately loads the Data Manager (see Chapter 3) for editing the CTPRO databases.
9. "Exit" concludes the current session in the Operations Model. CTPRO will prompt for saving the project file if data have been changed and not yet saved.

Operation Menu

"Selection..." opens the Operation Model Selection window (see Section 4.3.1) for selecting the CT field operation to be modeled.

Preferences Menu



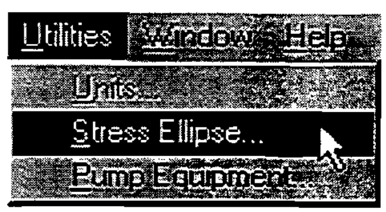
The **Preferences** menu is used to set several default values for buckling models, rheology models, and program operation.

1. "Buckling Model..." opens the Buckling Model Selection window (see Section 4.3.2) for selecting the default models for CT buckling and lock-up criteria.
2. "Rheology Model..." opens the Fluid Rheology window (see Section 4.3.3) for selecting the default fluid rheology model.
3. "Animation..." opens the Animation options window for activating or deactivating the animated graphics in the Input window (on the Borehole and Operation pages). When the animation is active, computer response will be slowed on some machines. Turn this feature off if computer response is impacted.

Run Menu

The **Run** menu is used to launch the calculations. Click "Start" to calculate CT operations model results and load the main Output window with graphs and tables. Same as .

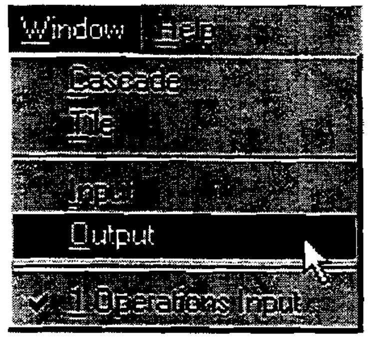
Utilities Menu



The **Utilities** menu contains three useful features for use in the Data Manager. These include:

1. "Units..." opens the Units Selection window (see Section 3.11).
2. "Stress Ellipse..." displays a stress ellipse summarizing the triaxial and biaxial stress conditions for each section of the CT string. See Section 5.3.1.
3. "Pump Equipment..." opens a window for calculating pump power requirements taking CT string geometry into account. See Section 5.3.2.

Window Menu

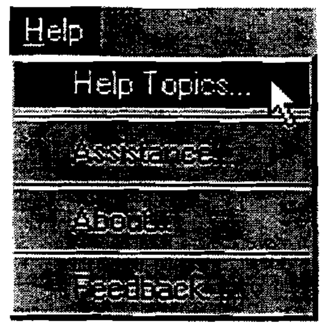


The **Window** menu is used to select the current (active) window among those open. After being opened, each of the secondary windows will be listed under the **Window** menu and can be immediately reaccessed by selecting it from the list.

The normal view mode is for the current open window of interest to be maximized to full screen. Alternatively, the standard Windows 95 options are available.

1. "Cascade" arranges the graphs and tables in a front to back display with the title block of each graph window remaining visible. The program adjusts the size of each open window to occupy the same amount of display space. The windows are then stacked starting from the upper left corner of the Output Window. Individual plots can be pulled to the top of the stack for viewing by clicking on their title blocks or by selecting them from the list in the **Window** menu.
2. "Tile" displays all open output graphs and tables simultaneously in a tiled format.
3. "All Graphs" displays all open windows simultaneously with a vertical bar separating each.
4. "Input" displays the main Input window. See Section 4.2.
5. "Output" displays the main Output window. See Section 5.2.

Help Menu

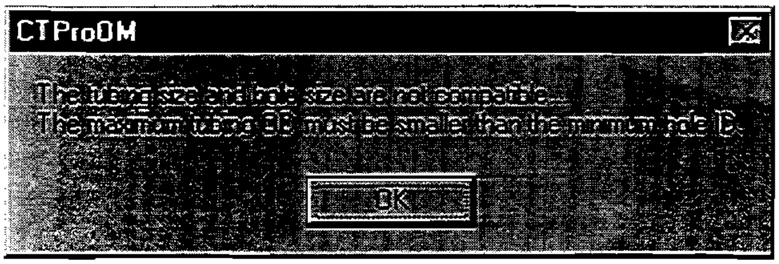


The **Help** menu provides assistance for running CTPRO and presents various parameters describing the user's computer.

1. "Help Topics..." launches the CTPRO Help system from the Table of Contents. Alternatively, clicking [F.] or opens the Help system directly on a description of the current screen.
2. "Assistance..." opens a pop-up box which displays MEI's address, phone number, e-mail address and other information. Use these contacts to obtain additional help with CTPRO.
3. "About..." opens the About pop-up box, which displays the version number of CTPRO along with hardware in the user's computer. **Click "Licensing..." to view a summary of the restrictions for copying the program and manual, and the program disclaimer.**
4. "Feedback..." opens a special screen form for documenting specific bugs, problems, etc. and communicating with MEI. The form can be printed for faxing or saved to disk and attached to an e-mail routed to *MEI@maureng.com*.

4.5 ERROR DETECTION FOR INPUT DATA

CTPRO includes basic routines for detecting missing data and obvious errors in the input data. These routines are run as soon as the Run command is activated (under the **Run** menu or icon). When input data are outside the boundaries and/or appropriate range of values, the error-checking routines will detect the error. The program will halt calculation, display an error message describing the problem, and allow the user to go back and correct the data.



Obviously, CTPRO is not capable of detecting small errors in the input data (i.e., when the incorrect parameters represent solutions that are physically reasonable), but the error checks will help prevent simple typing mistakes from having an enormous impact on the results.

5. Operations Model Output

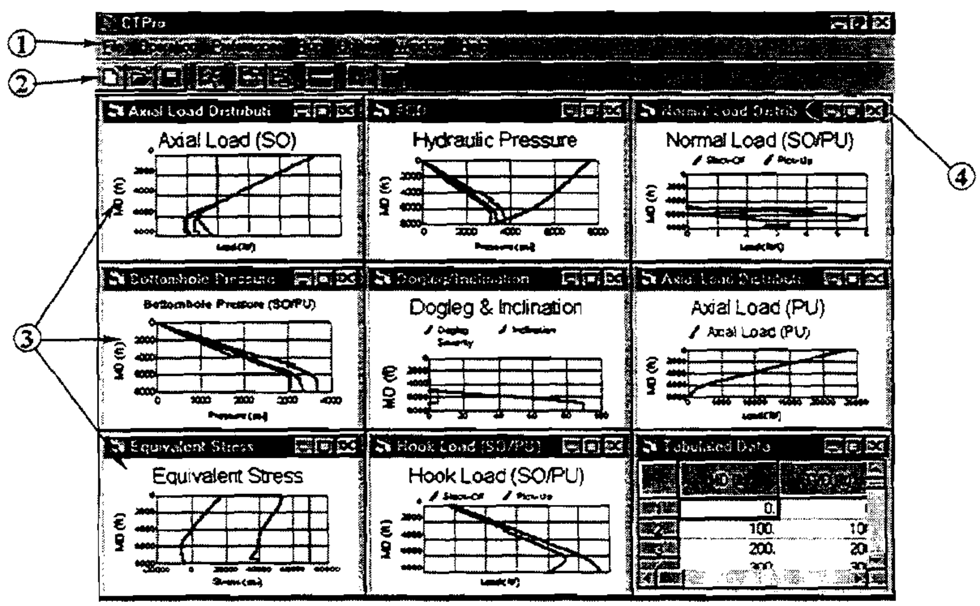
5.1 INTRODUCTION

A comprehensive array of output data is generated by CTPRO for evaluating CT field operations. Output presentations include eight x-y graphs and a table whose column layout is selectable by the user. The format of the printouts is very concise and informative. After being customized by the addition of your company's logo, the printouts are ready for inserting into proposals, reports, etc.

5.2 MAIN OUTPUT WINDOW

The Main Output window of CTPRO is loaded automatically after the calculation sequence is completed within the Input window (by clicking). Results of CT load, buckling and hydraulics analyses are presented in a variety of useful graphs, as well as in a table that can be tailored by the user. Options are provided to view the graphs individually or in groups, to easily customize the output for specific applications, to document the results in professional-style printouts, to copy data to the Clipboard for importing into Word, WordPerfect, Excel, PowerPoint, etc., as well as several other convenient features. Screens accessible within the Output window of CTPRO and all corresponding functions are described in the following sections.

5.2.1 Output Graphs and Tables



① ***Menu Bar.*** The pull-down menus in CTPRO are used to arrange output presentation, export data, and for several other useful functions. A description of functions and features of the output menus is presented in Section 4.4.

② ***Tool Bar***. Tool-bar icons can be used to quickly access commonly used functions from the menus. The functions of CTPRO icons are:

New Project. Clears all input data.

Open Project. Activates the open project file window.

Save. Saves all input data to current file name. If the project is new, the *Save As...* window is activated automatically.

Run. Launches the calculations of CT operations performance.

Go to Input. Used to return to the Input window for reviewing and modifying input data after the calculations are performed. (See Chapter 4.)

Go to Output. Used to transfer directly back to the Output window graphs and tables without recalculating. Only valid after first calculating and then returning to the Input window.

Units. Opens the Units Selection window (see Section 3.11). The user can select English, SI, or any custom combination of units. (The Units window is not accessible from within the Output window; return to the Input window first, since a change in units requires a new calculation.)

Help. Opens the Help system for CTPRO keyed to the current window. Same as [F1].

Calculator. Activates the Windows utility calculator.

③ ***Graph and Table Windows***. The output from CTPRO is presented for evaluation in nine tiled windows. These include:

1. ***Axial Load Distribution (Slack Off)***. This is a snapshot of loads across the string when the BHA is at the depth of interest and slack-off (compression) loads are being applied. The maximum depth (the depth of interest) is set by the user on the **BHA** page in the Input window. Buckling conditions are easily visualized by noting sections of the string where the axial load crosses over (to the left of) the buckling limit curves.

2. ***Axial Load Distribution (Pick Up)***. This is a snapshot of loads across the string when the BHA is at the depth of interest and pick-up (tension) loads are being applied. The exact condition shown is when the WOB just falls to zero. (Note that buckling cannot occur when the string is in tension.)

3. ***Normal Force Distribution***. Normal forces (the components of compression, tension and/or gravity forces that push the string against the side of the wellbore) are plotted as a snapshot when the BHA is at the depth of interest. Traces for both slack off (the BHA has just arrived at the target depth with the required WOB) and pick up (at the point when the WOB just falls to zero) are plotted together.

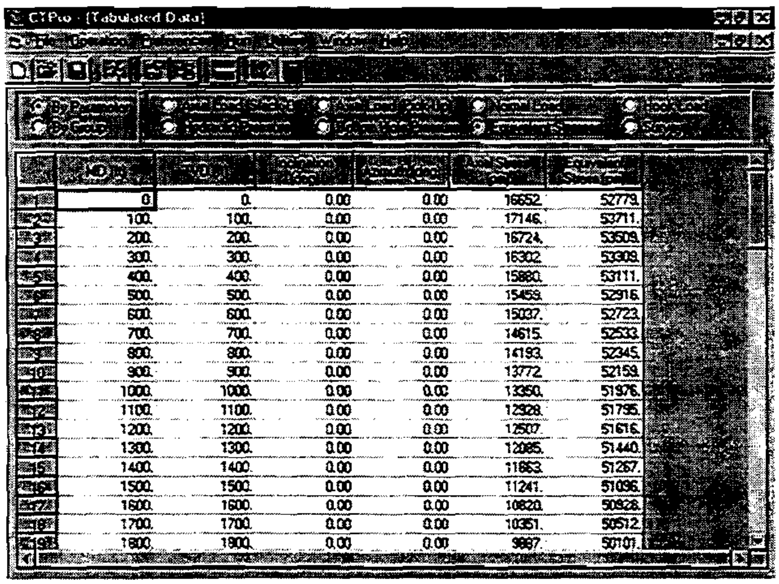
4. ***Hook Load at Injector***. This graph shows predicted push/pull loads at the bottom of the injector (above the stuffing box) throughout the planned operation. Results can be quickly evaluated to determine whether loads during the planned operation are near limits of the equipment. Unlike the snapshot views in Graphs 1, 2, and 3, Graph 4 is a dynamic view of the variation in load at a single position (below the injector) as the CT is run in and out of the hole.

5. ***Dogleg and Inclination Angle.*** The wellbore survey is summarized with plots of both inclination angle (degrees from vertical orientation) and dogleg angle (local rate of change of inclination).

6. ***Circulating Pressure Distribution.*** This is a snapshot of hydraulic pressures inside and outside the CT string when the BHA is at the depth of interest.

7. ***Equivalent Stress Distribution.*** This is a snapshot of axial and equivalent stress along the CT string when the BHA is at the depth of interest. Equivalent stress is impacted by axial load, bending load, and hydraulic pressure.

8. ***Bottom-Hole Pressure for Slack Off/Pick Up.*** This is a dynamic view of pressure immediately below the BHA as the CT string is run in and pulled out of the well. For some cases, the pressure for running in and pulling out is almost the same; consequently, the blue curve for pick up may not be visible.



1	0	0.	0.00	0.00	16652.	52779.
2	100.	100.	0.00	0.00	17146.	53711.
3	200.	200.	0.00	0.00	16724.	53509.
4	300.	300.	0.00	0.00	16302.	53309.
5	400.	400.	0.00	0.00	15880.	53111.
6	500.	500.	0.00	0.00	15459.	52916.
7	600.	600.	0.00	0.00	15037.	52723.
8	700.	700.	0.00	0.00	14615.	52533.
9	800.	800.	0.00	0.00	14193.	52345.
10	900.	900.	0.00	0.00	13772.	52159.
11	1000.	1000.	0.00	0.00	13350.	51976.
12	1100.	1100.	0.00	0.00	12928.	51795.
13	1200.	1200.	0.00	0.00	12507.	51616.
14	1300.	1300.	0.00	0.00	12085.	51440.
15	1400.	1400.	0.00	0.00	11663.	51267.
16	1500.	1500.	0.00	0.00	11241.	51096.
17	1600.	1600.	0.00	0.00	10820.	50928.
18	1700.	1700.	0.00	0.00	10351.	50512.
19	1800.	1800.	0.00	0.00	9887.	50101.

9. ***Tabulated Results.*** All axial load, buckling, normal force, and hydraulic results are summarized in the table. Column options include 1) measured depth, 2) vertical depth, 3) inclination, 4) azimuth, 5) dogleg angle, 6) axial load (pick up), 7) axial load (slack off), 8) normal load (pick up), 9) normal load (slack off), 10) hook load (pick up), 11) hook load (slack off), 12) sinusoidal buckling limit, 13) helical buckling limit, 14) hydraulic pressure (inside CT), 15) hydraulic pressure (outside CT), 16) bottom-hole pressure (pick up), 17) bottom-hole pressure (slack off), 18) axial stress, and 19) equivalent stress.

   The user selects which columns are displayed in the table according to a specific parameter (click "By Parameter") or by a related groups of parameters (click "By Group").

④ ***Window Control Buttons.*** The standard Windows 95 control buttons are useful for maximizing and minimizing individual graphs for rapid review and evaluation of results. The button will enlarge a tiled graph or table to occupy the full screen. The button will minimize a graph or plot (i.e., convert it to an icon at the bottom of the screen). To reactivate a minimized plot, press to replace the graph into the tiled screen or to zoom the graph to full screen. The button will temporarily turn off a graph; however, a closed graph is turned off only for the current run and will be redrawn the next time a calculation is completed.

Note: Another convenient feature was added for rapidly reviewing the graphs. When in the tiled display format, **double-click anywhere on a graph to maximize it**. Review the plot, and double-click again to restore the tiled display.

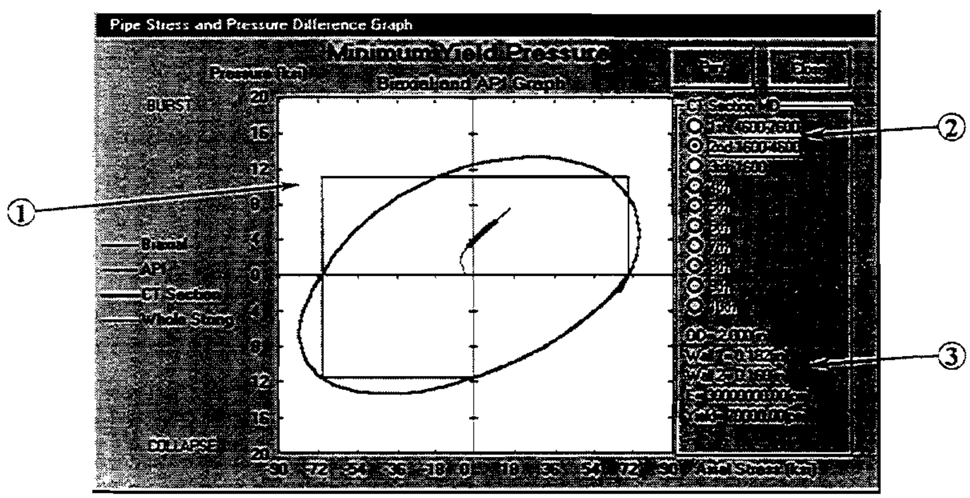
5.2.2 Output Window Menus

The menu system used in CTPRO is similar to other Windows applications. Many functions are self-explanatory. There are seven menus in the Operations Model: **File**, **Operation**, **Preferences**, **Run**, **Utilities**, **Window** and **Help**. See Section 4.4 for a complete description of the menu structure and functions.

5.3 SECONDARY OUTPUT WINDOWS

5.3.1 CT Stress Analysis Window

The CT Stress Analysis window is used to evaluate biaxial and API stress for each section of the CT string. This window is accessed by selecting "Stress Ellipse..." from the **Utilities** menu. This feature is available only after a calculation has been completed.



① *CT Stress Graph*. Biaxial and API stress limits are shown for the currently selected section of CT. These limits reflect the operational safety factor specified by the user (CT Derating Factor on the **General** page). The upper right quadrant of the graph corresponds to a combination tension/burst-pressure environment, the lower right quadrant to a tension/collapse-pressure environment, the lower left quadrant to a compression/collapse-pressure environment, and the upper left quadrant to a compression/burst-pressure environment. The stress for each section of the string (shown as the blue line near the center of the plot) should remain inside the boundaries defined by the stress-limit curve.

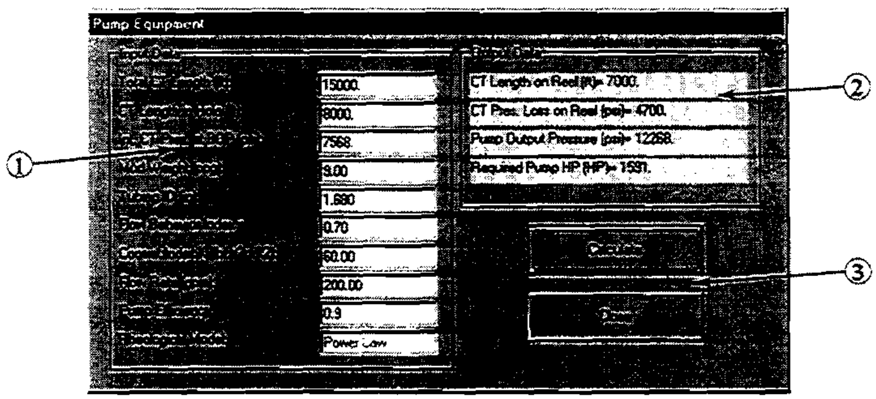
The upper half of the plot is based on zero external pressure and the lower half on zero internal pressure. The pressure difference based on the hydraulics calculations in the output graphs is used for these results.

② ***String Section Selection.*** Select the specific section of the CT string plotted on the graph. These sections correspond to those entered on the CT String Data table on the **CT** page in the Input window.

③ ***CT Parameters.*** These CT dimensions and material properties are presented for reference for the currently selected CT section and may not be edited within this window. Changes are made on the **CT** page in the Input window.

5.3.2 Pump Equipment Window

The pump equipment window is used to calculate pressure loss in the CT on the reel and estimate output pressure and hydraulic horsepower requirements for the fluid pump. This window is accessed by selecting "Pump Equipment" from the **Utilities** menu. This feature is available only after a calculation sequence has been completed.



① ***Pump Equipment Input Data.*** Type in the required parameters describing the flow system. The fluid model cannot be changed here. Model selection is performed on the Fluid page in the Input window. After all parameters are entered, click [Calculate].

② ***Pump Equipment Output Data.*** Pressure loss, pump pressure, and hydraulic horsepower requirements are shown in these boxes after a calculation. (These are not editable.)

③ ***Pump Equipment Control Buttons.*** Click [Calculate] after the input data are entered. [Return] closes this pump window and returns to the Main Output window.

6. Getting Help

6.1 CONTACTING MEI

For additional assistance with installation or operation of CTPRO, contact:

Dr. Xichang Zhang ***(Data Manager)***
or
Lee Chu ***(Operations Model)***
MAURER ENGINEERING INC.
2916 West T.C. Jester Boulevard
Houston, Texas 77018-7098 U.S.A.

Telephone: (713) 683-8227
Fax: (713) 683-6418
E-mail: mei@maureng.com

6.2 REPORTING PROBLEMS

Even though CTPRO has been carefully checked before its release, software bugs are a fact of life. Please report to us any bugs you find and describe the input parameters and conditions selected when the bug occurred.

MEI is also very appreciative of your comments and suggestions for improving CTPRO. Let us know if there are additional features you would like to see added to the program. Though it may not be feasible to incorporate every suggestion into the next version, many important improvements have been made to this and other MEI programs based directly on suggestions from users.

Please use the form on the next page to report bugs in the program, as well as suggestions on improving the function and usefulness of CTPRO.

Bug Report/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 Suggested Enhancement: ______________________

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 — Common Problems and Solutions

Specific problems related to installing and running MEI software are described in this section. These problems have been reported by multiple users and are often related to computer settings and file locations.

A.1 INTERNATIONAL KEYBOARD SETTINGS

"Type Mismatch" Error

All computer software developed at Maurer Engineering Inc. is written using the U.S. Keyboard format. Under this numeric standard, the 1000 separator is a comma, and the decimal separator is a period. Thus, the number **one thousand, two hundred and thirty-four and 22/100** is written as

1,234.22

Numbers input into MEI programs are stored in this format.

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

1.234,22

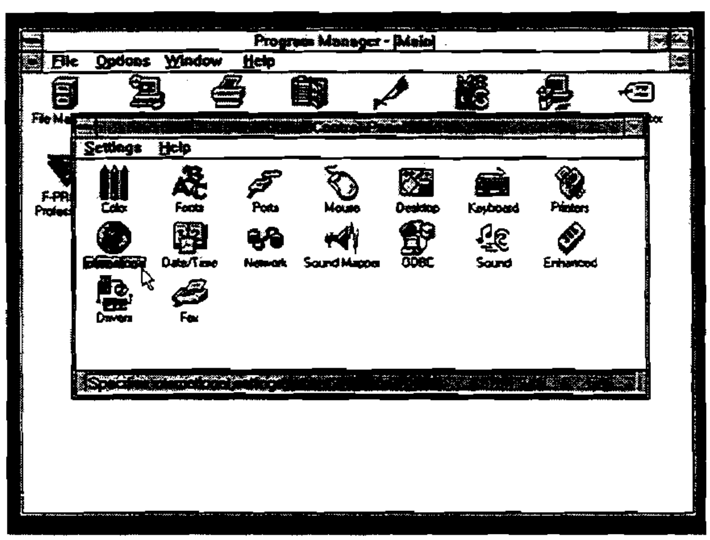
where the 1000 separator is a period, and the decimal separator is a comma.

Users with the International Keyboard format find that their computers garble input data being loaded into MEI programs. Often, a "Type Mismatch" error halts the program.

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

In Windows 3.x

1. 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 below.



2. 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.

3. In the lower right corner of the "International" menu screen is the "Number Format." If the number under the words "Number Format" is **1,234.22,** MEI programs should run successfully. Click <Cancel> to back out of this screen.

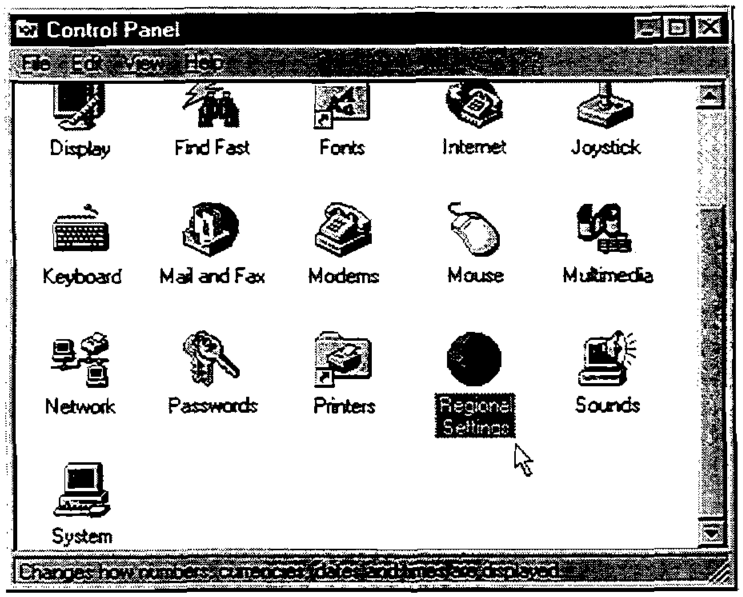
   If the number under the words "Number Format" is **1.234,22**, it must be changed before MEI programs will run successfully.

4. To change the number format, click on the "Change" button in the "Number Format" box on the screen. This will bring up the "International—Number Format" screen. Change the "1000 Separator" from a decimal to a comma. Next, highlight the "Decimal Separator" box and erase the comma from the box and replace it with a period.

5. Click <OK> to exit the "International – Number Format" box. Click <OK> to return to the **Main** menu screen.

In Windows 95

1. Select "Settings"→ "Control Panel" from under the **Start** menu. This brings up the "Control Panel" menu screen, as shown below.



2. Double-click the "Regional Settings" icon.

3. The simplest method to change the number format is to select "English (United States)" from the drop-down list on the "Regional Settings" page. This changes all conventions to U.S. format. To change only the number format, click on the "Number" tab and change the **Decimal symbol** to "." and the **Digit grouping symbol** to ",". You may have to restart your computer for these changes to take effect.

A.2 POTENTIAL LIBRARY FILE PROBLEMS

Most of Maurer Engineering's computer programs are MS Windows-based programs which run under Windows 3.x, Windows 95, and Windows NT operating systems. When our Windows programs are run, several library files are needed (.VBX, .OCX, .DLL, and .EXE) to support the Windows interface functions. These library files might also be used by other Windows programs, which means all types of Windows applications theoretically can share the same library file from a "common library."

The basic concept of a common library is sound. Since one library file may support many programs, storing the library once in an accessible location saves space on the hard drive. However, because of compatibility issues with different versions of the same library files, the wrong library version can cause a program error. Programs developed/compiled with older versions of library files may not run with newer versions or vice versa.

When running a Windows application, Windows searches for required library files in the following sequence:

1. the **\Windows\System** subdirectory
2. the **\Windows** subdirectory
3. the **local** program subdirectory which contains the executable application .EXE file

These rules were established by Microsoft and, unfortunately, may lead to serious problems. Placing the wrong version of the common library into **\Windows\System** subdirectory will cause all programs which use a different version of that library file(s) to malfunction. Maurer Engineering has received many reports of problems with our software after users have installed another company's software. These problems are the result of the third party software installing its own (different) version of the library into the **\Windows\System** subdirectory. This new version then gets priority over the correct version in the local MEI subdirectory.

All MEI Windows programs install the required library into the local program subdirectory to avoid conflict with other programs already installed. Though this method requires slightly more disk space be reserved for libraries, **this is the safest approach.** If this procedure is followed, users should not be apprehensive about installing MEI's programs.

If a user finds that an MEI program will not run or the output graphs will not display, the following procedure should solve any library incompatibility problems.

1. Most of the time, MEI's programs will display an error message to indicate which library files are incompatible. If so, go to Step 4.

2. Look at the specific program's subdirectory to find all the library files needed by the program. Usually, the library file extensions are .VBX, .OCX, .DLL, .EXE.

3. Check the **\Windows\System** and **\Windows** subdirectories to see if there is a different version of the library file (different size or different date) stored there.

4. Move these library files from the **\Windows\System** or **\Windows** subdirectories to a temporary subdirectory (**do not erase these files**) to determine whether library incompatibility is the problem. If these files are used by another (non-MEI) program, copy these files to the other program's subdirectory.

The following library files most frequently cause problems: **GRAPH.VBX, GSWDLL.DLL, GSW.EXE, GSWAG16.DLL, GSW16.EXE, VBDB300.DLL, THREED.VBX,** and **GRID.VBX.**

If the problems persists after these steps are taken, please contact MEI.

A.3 PRINTER SELECTION

MEI programs support a wide range of monochrome and color printers. However, most programs written in Visual Basic 3 (16-bit) do not provide options within the program for selecting individual printers. All print jobs are sent to the current Windows default printer.

Changing Printers

If you wish to switch to a special printer, **assign that printer as the Windows default printer before running the MEI program**. The default printer is selected under the Printers control window. This window is accessed in Windows 95 by selecting **Start** → "Settings" → "Printers". After the Printers window is open, click once on the printer of interest to highlight it. Then, select "Set as Default" from the **File** menu.

Network Printers

Some users have experienced problems when trying to send output from MEI software to network printers. Most difficulties can be addressed by modifying the printer port entry. If a network printer will not print from an MEI program, follow these steps:

1. Select **Start** → "Settings" → "Printers"; then double-click the network printer icon.
2. Select "Properties" from the **Printer** menu. Select the "Details" tab from the Properties window (see figure).
3. Place the cursor on the entry in the text box under **Print to the following port:**. Copy the text string by pressing *control+C*.
4. Click the "Capture Printer Port..." button.
5. Select "LPT2" or "LPT3" under the **Device** pull-down menu.
6. Click the **Path:** text box; then paste the text string into the box by pressing *control+V*. Click <OK> to close the "Capture Printer Port" window.
7. On the "Details" window, pull down the list of options under the **Print to the following port:** box. Select the new entry (that you just created) with "LPT2" or "LPT3" followed by the text string copied and pasted.
8. Select <OK> and close all printer windows.

   This procedure should allow printing to a network printer, provided that printer is also selected as the Windows default printer.