LIQTHERM Lite
(LPIPE)

Liquid Pipeline Isothermal Hydraulics

User Manual

SYSTEK

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1. Introduction

LIQTHERM-Lite™ (previously known as **LPIPE**) simulates the steady state hydraulics of an isothermal liquid pipeline with several pump stations. Various liquid products may be injected or stripped at locations along the pipeline. The resultant blended liquid properties (specific gravity and viscosity) are calculated for each pipe segment at the constant flowing liquid temperature. Pressure drop for each pipe segment is calculated using one of the various equations, such as Colebrook-White, Miller, MIT, Moody or Hazen-Williams.

Multiple pump stations along the pipeline may be modeled, considering pump performance curve data. Pump curve data (flow rate, head and efficiency) may be specified for each pump station along with the pump configuration (series or parallel). Calculations may be performed such that maximum allowable operating pressure (MAOP) of each pipe segment is not exceeded. Optionally, the MAOP check may be turned off to determine the maximum pumping capability for a given pipeline and pump station configuration.

The input data consists of pipeline profile (distance, elevation, pipe diameter and wall thickness, pipe roughness), liquid flow rates, specific gravity and viscosity of each liquid, liquid inlet temperature and delivery pressure.

All the above properties may be considered variable along the length of the pipeline. For example, the internal pipe roughness may be varied at specific points along the pipeline to simulate different internal conditions of pipe such as internally coated pipe versus un-coated pipe. The locations of pumps stations are input along with the minimum suction pressure at each pump station. Instead of a pump station at the beginning of the pipeline, a storage tank or an inlet pressure may be specified. If pump curves are not available, average pump efficiency for each pump station is input, for calculating the station horsepower. If pump curve data is specified, pump HP will be calculated using pump efficiencies interpolated from the pump curves.

If the input pipeline flow rate is too high for the pumps or requires pipeline pressure exceeding MAOP, the program iteratively calculates the maximum flow possible. This feature can be turned off, if desired, as indicated above. The hydraulic gradient showing the pipeline pressures superimposed on the pipeline elevation profile along the pipeline may also be plotted.

The output from the program consists of the temperature, specific gravity, viscosity, and the pressures along the pipeline, along with the horsepower required. LIQTHERM-Lite can be used for the design of a new pipeline or checking capabilities of existing pipelines.

Most data are entered in Microsoft Excel compatible spreadsheets that results in easy editing and cut and paste operations via the Windows clipboard. For the sample problem, pipeline profile data (distance, elevation, pipe diameter and wall thickness, pipe roughness, MAOP) is saved in a file named `MyPipe001.TOT`. In addition, all other data such as pump data, liquid flow rate data etc. are also saved in the same text file named `MyPipe001.TOT`. Auxiliary data files such as pump curves, liquid data that may be used with other pipelines will be saved separately from the pipeline data. For example in the `MyPipe001.TOT` file there may be references to pump curves such as `PUMP1.PMP`, `PUMP2.PMP` etc. All liquid properties are stored in a common **Liquid Properties Database** files. Help is available on each data entry screen and on the status bar at the bottom of each data entry screen. Answers to specific queries such as *How to create a pipe data file or pump curve file* can be found under the icon **How Do I?**

Calculations may be performed in English or SI-Metric units.

The results of the hydraulic simulation are displayed on the screen in a scrollable window, as well as saved in a disk file for later viewing or printing. A printed hard copy of the calculated results can be generated after reviewing the screen output.

Last minute changes to the program are documented in a file named README.TXT, if present on the program disk.

This software can be run on Intel and AMD based computers and compatibles with a minimum of 256 MB RAM running Microsoft Windows NT/2000/XP or Windows Vista. A minimum hard disk space of 20 MB is required for installing the program.

2. Getting Started

The software is supplied on a CD-ROM that needs to be installed onto your computer's hard disk as described below. The software is licensed to the user either via the internet registration process or using the hardware key (dongle).

This single user license entitles you to use the software only on one computer at a time. If you purchased a multi-user or network license, you are entitled to use the software on more than one computer as described in other documentation that accompanied the software.

IF YOU PURCHASED A NETWORK VERSION OF THIS SOFTWARE, FIRST REVIEW THE SEPARATE DOCUMENTATION ON LAN/WAN INSTALLATION SUPPLIED WITH THE SOFTWARE.

Installation

Before starting the installation process, close all currently running programs and turn off any virus checking software, if present on the hard disk. If you want to ensure that the program disk is free of any virus you may run the virus scanning software and check the program CD prior to starting installation.

Insert the software CD into the CD-ROM drive. If *Autostart* is enabled on the CD-ROM drive, setup will start automatically. If not, from the Windows **Start** button choose **Run.**

Type the following in the resulting screen:

`G:\setup` and press Enter

Where G represents the drive letter for your CD-ROM drive.

Follow the subsequent screen instructions to continue with the installation process.

After the setup is completed, the **User Registration screen** will prompt you to enter your name, company name and the program serial number. ***The serial number found on the program CD container must be entered exactly***. Otherwise the installation will be incomplete.

You must be connected to the Internet to register the program and obtain a license. Otherwise you will not be able to run the software after installation.

Once installation is completed, a program icon and program folder will be automatically created. You may launch the program from the Windows **Start** button. You may also create a shortcut to the program on your desktop.

Installation on a Network

If you are licensed to use the program in a network environment, the software may be installed on multiple workstations on your network. The software can then be run from any workstation on the network, subject to the maximum user limit programmed during the installation process and in accordance with your license. **PLEASE REVIEW SEPARATE DOCUMENTATION ON LAN/WAN INSTALLATION SUPPLIED WITH PROGRAM.**

Retaining and Releasing the Program

To launch the program, you will either use the Windows **Start** button or click the program icon from the Program menu. If the program is properly registered and the license obtained, you will be able to start the program.

When you quit the program, you will be prompted to either retain control or release control of the program in the event you want to use the current license on another computer. *This enables you to quit the program on your work computer, release control and restart the program on your home computer or on a laptop while traveling. However each time you quit the program you must release control if you want to run the program on another computer. Also, internet access is required to do this.*

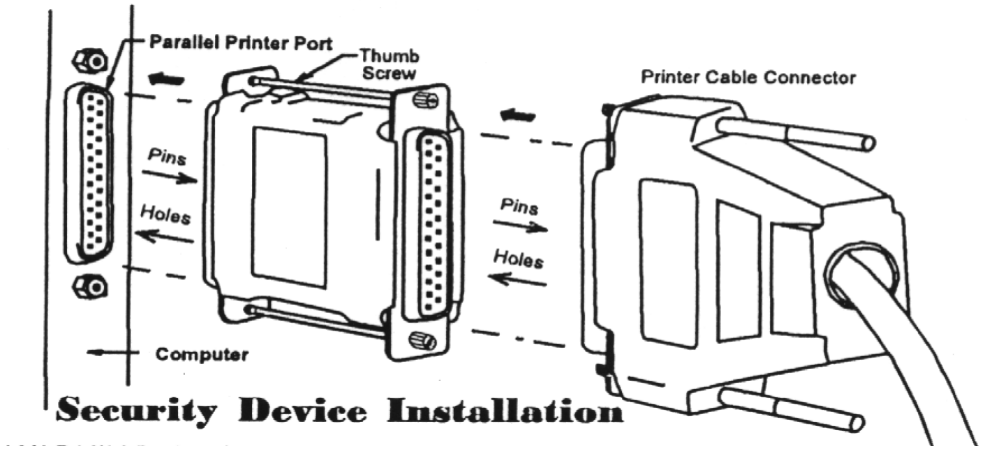
Remember that once a program is registered and control is retained on the computer, the license can only be released from *that* computer. If you have multiple SYSTEK programs installed on your computer, you can use the utility program called **SYSTEK Control Panel** to release or retain control of selected SYSTEK programs. This program **ControlPanel.exe** is located in the **LIQTHERM-Lite** folder.

Installation for Hardware Key Users

The software program is supplied on a CD-ROM that must be installed onto your computer's hard disk as described below for optimum operation. Depending on the type of hardware key you received (parallel port key or a USB port key) follow the instruction for the installation of that particular type of hardware key (dongle or KEYLOK) as described below.

Parallel port hardware key installation

This software is protected by a hardware key security device (dongle) that plugs into your computer's parallel printer port. This dongle *must* be in place for the software to operate properly. *With the computer turned off, plug the dongle into the parallel port of your computer between the computer and the printer cable as shown in the diagram below.*



All printer commands are passed through unaffected, transparent to the *dongle.* Since the *dongle* is critical to the operation of the software, it must be stored safely when not in use. It is recommended that Laptop computer users remove the *dongle* from the printer port before packing the laptop in its carrying case.

USB port hardware key installation

The software will work **only** with the specific USB hardware key (dongle) included with the program CD. The USB dongles cannot be interchanged. Each dongle is specific to the software.

With one licensed copy, the program may be concurrently installed on more than one computer. However, the software will only run on the computer that has the USB dongle attached.

USB dongle installation

The software is protected by a USB dongle that plugs into your computer's USB port. This dongle is plugged into the USB port *after* the installation of the software. ***Do not attach the dongle until after the dongle installation step is completed.***

Since the dongle is critical to the operation of the software, it must be stored safely when not in use. It is recommended that Laptop computer users remove the dongle from the USB port before packing the laptop in its carrying case.

A lost or damaged dongle is equivalent to losing the software. A replacement dongle can only be obtained at the full retail price of the software. In other words, the dongle costs as much as the software itself.

Installation

Before starting the installation process, close all running applications and turn off any virus checking software, if currently present on the hard disk. If you want to ensure that the program disk is free of any virus you may run the virus scanning software and check the program CD prior to starting installation.

Step-1:

Insert the software CD into the CD-ROM drive. If *Autostart* is enabled on the CD-ROM drive, setup will start automatically. If not, from the **Start** button choose **Run.**

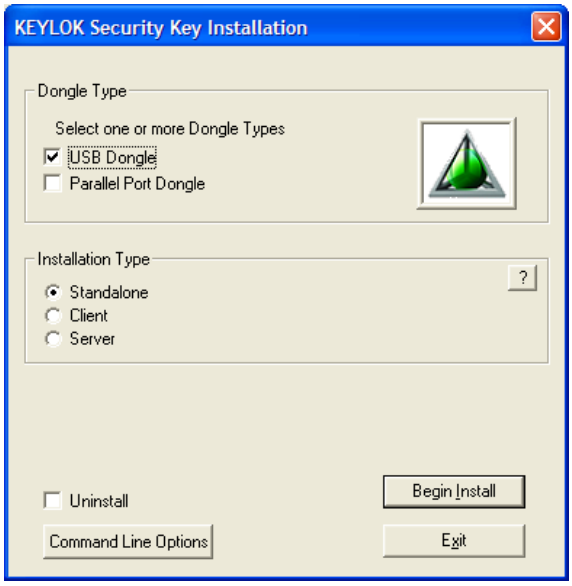
Type the following in the resulting screen: `G:\setup` and press Enter

Where G represents the drive letter for your CD-ROM drive.

Follow the subsequent screen instructions to continue with the installation process.

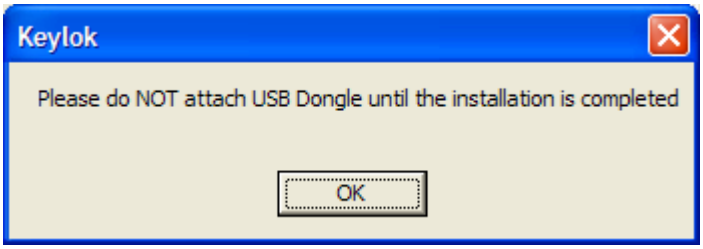
Step-2:
After the software is installed, the Dongle Installation will automatically start.
Do not attach the dongle until after the dongle installation step is completed.

Initially, the screen below is displayed:

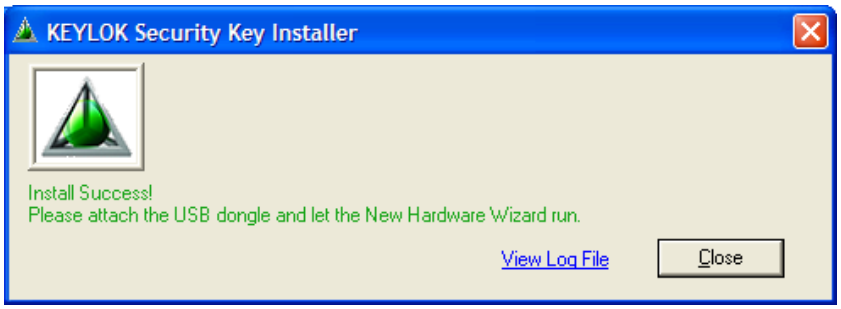


Choose the **USB Dongle** type and **Standalone** installation type as shown and click **Begin Install**.

Next, the following screen is displayed. Click OK to confirm.



When the dongle installation is completed (may take a few minutes), and a message is displayed to this effect, you should attach the dongle to one of the USB ports as directed in screen below.



The computer will recognize the dongle and the software driver will be installed automatically.

After the setup is completed and you start LIQTHERM-Lite software from the Windows Start button, the User Registration screen will prompt you to enter your name, company and the software serial number.

The serial number found on the* software *CD container must be entered exactly. Otherwise the installation will be incomplete.

The Licensed User is eligible to receive **free** technical support for 60 days from the date of purchase. After this 60-day period, the User may sign up for an annual Software Maintenance Program. After this 60-day period, the User may sign up for an annual Software Maintenance Program.

Put your original software CD-ROM away safely.

Manual Installation of dongle files

If for some reason the dongle installation does not start automatically then you must manually start the dongle program (Keylok.exe) from the Start/Run button as follows:

Keylok /B *and press enter*

The above must be executed from the SYSTEK folder containing the Keylok.exe program. After this go back to Step 2 above to continue installation.

Un-installation

Prior to uninstalling **LIQTHERM-Lite,** save all data files and results of calculations that you may need for later use. To **uninstall** the software from the hard disk, go to the **Start button** and choose **Settings**. Next select the **Control Panel** and click on **Add/Remove** Programs. Follow subsequent instruction to uninstall **LIQTHERM-Lite**

*You can no longer run the program, until you **re-install** it again as described in the Installation section.*

Put your original program disk away safely.

3. Features

LIQTHERM-Lite (LPIPE) for windows is a steady state, isothermal hydraulic simulation software. It will make all your pipeline isothermal hydraulic simulation easy. Use it to calculate the pipeline hydraulics, pressure profile, pump station HP required, and pump performance. Despite the complexity of the program, it is very user friendly. Online HELP is available for all data entry screens and the program has extensive error checking features. In addition, answers to specific queries such as "How to create a pipe data file or pump curve file" can be found under the icon **How Do I?**

Here are the salient features:

- Pipe diameter, wall thickness, roughness and MAOP can all be varied along the pipeline. An Excel compatible spreadsheet for data entry makes it easy to create and save pipe data files.

- All input data are combined into one compact XML style data file for each pipeline.

- Simulate isothermal flow of water, light crude and refined petroleum products.

- Liquid may be injected or delivered at various points along the pipeline.

- Pressure drop calculations may be based on Colebrook-White, Hazen- Williams, MIT, Moody or Miller equations.

- The pipeline may have several pump stations (maximum 5 for LIQTHERM-Lite version) with pumps in series or parallel at each pump station. Calculations may be performed *with* or *without* considering pump curve data. There may be a maximum of 5 pumps at each station. Pumps may be in series or parallel configuration.

- Turn pump stations ON/OFF to simulate station shut-down conditions.

- Turn individual pumps ON/OFF at each pump station.

- Mix variable speed (VSD/VFD) pumps with constant speed, electric motor driven pumps.

- Individual pump curve data can be viewed, edited and plotted on the screen or the printer.

- Viscosity corrected pump performance curve can be generated.

- The maximum pipeline throughput for a given MAOP can be calculated for a specified pump station configuration.

- Plot hydraulic pressure gradient with MAOP plot.

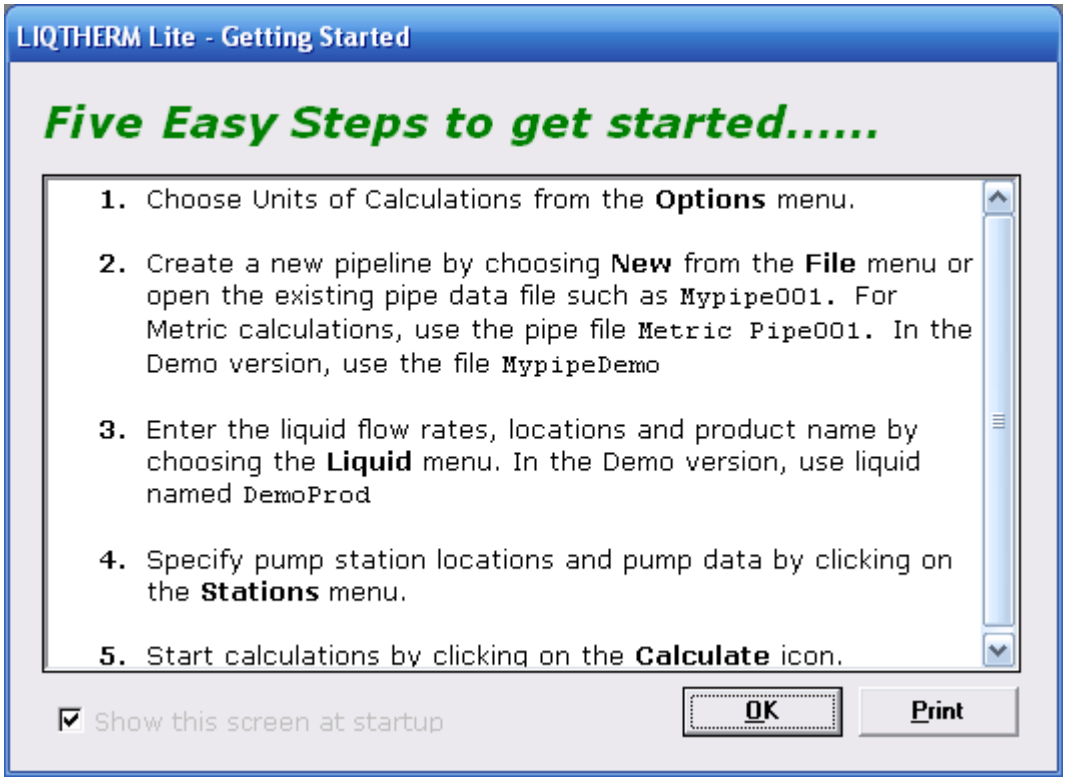
- The Quick Pressure Drop Option calculates the inlet or outlet pressure of a pipe segment, given one of the two pressures and the flow rate for isothermal flow.

Running the Program

To run the program, click on the **LPIPE** or **LIQTHERM-Lite** program icon or click the **Start** button, followed by **RUN** and type the following command **C:\LPIPE\LPIPE.EXE** in the resulting screen. Note that the program names **LPIPE** and **LIQTHERM-Lite** are used interchangeably in the Manual.

The initial program screen will be momentarily displayed as follows:

An introductory screen shown below describes the 5 steps necessary to solve a typical pipeline problem using LIQTHERM-Lite.



By clicking the **How Do I?** icon on the left panel, additional help is available to perform specific tasks such as “Create a pipe data file, Determine pump requirements, etc.

A toolbar consisting of icons for commonly used menu items is available below the menu bar. These menu items or commands can be accessed by clicking on the icons. As the mouse is moved over an icon, a tool tip help appears explaining the function of each icon, as shown below:

The menu bar along the top has several pull down options under each menu item, such as *File, Edit* etc. as explained below:

The pull down menu under **File** has the following:

New - To create a new pipe data file.
Open - To open and edit an existing data file.
Close - To close a data file.
View - To view the results of the last calculation
Import - To open a VTS file and convert to TOT file
Save - To save the current data file onto the disk drive under the current file name.
Save As - To save a data file under a new name.
Print - To print the spreadsheet data file or the last output file.
Send Email - To send email of a spreadsheet data file or an output file to an associate or to SYSTEK for technical support.
Exit - To quit the program

The pull down menu under **Edit** has the following:

Cut - To remove selected (highlighted) data from the spreadsheet to the Windows clipboard.
Copy - To copy selected (highlighted) data from the spreadsheet to the Windows clipboard.
Paste - To paste the data from Windows clipboard to the current cursor location in the spreadsheet.
Insert row - To insert a new row in the spreadsheet
Delete row - To delete a row of data in the spreadsheet.
Format cells - To format the cells in the spreadsheet.

Accelerator keys, such as **Ctrl-X** for ***Cut*** and **Ctrl-I** for ***Insert row*** are available for several menu items.

The pull down menu under **Options** has the following:

Units - This screen is used to choose English or Metric units of calculation. Options are available for different sets of units for pipeline distance, pipeline flow rates, pressures and temperatures. For pump curve data you may choose the units for flow rate and head. *Note that the pipeline flow rate units need not necessarily be the same as the pump curve flow rate units.*

Pump curves - For selecting pump curve data that can be viewed, edited, printed and plotted on the screen or printer.

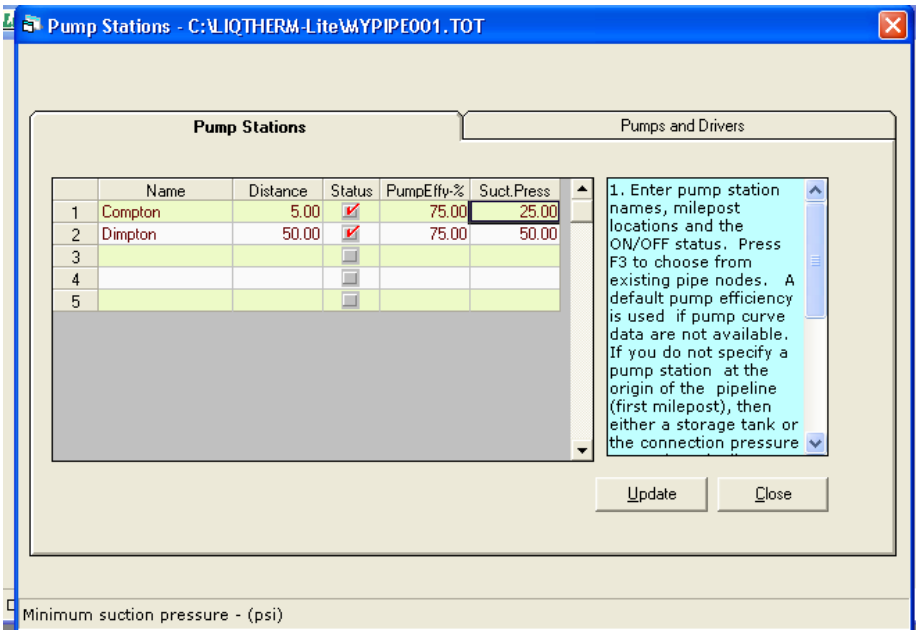
Formula - For selecting the pressure drop formula to be used. Options include Colebrook-White, Miller, Hazen-Williams, Moody friction factor and the MIT equations.

Interpolate - For interpolating pipeline elevations.

The pull down menu under **Stations** is used for specifying pump station data.

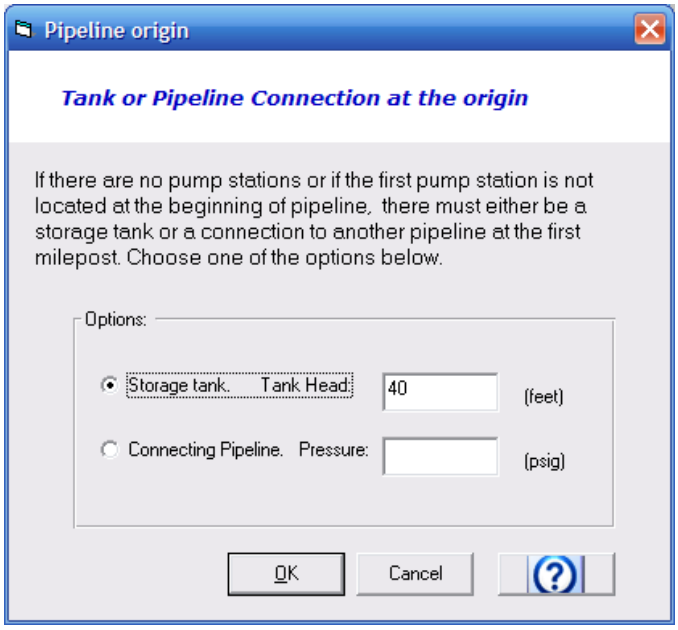
On clicking the **Pump stations** option, a tabbed screen is displayed. The **Pump Stations** tab is used to enter the name of each pump station, its distance from the beginning of the pipeline (mile post), ON/OFF status, pump efficiency and the minimum station suction pressure. The default efficiency value of 75% is used to calculate the pump HP required at each pump station, if pump curve data is not specified. You may change this default efficiency, if desired. Click **Update** button to save all data.
Note: A maximum of 5 pump stations can be specified in the Lite version.

With the cursor in the station name or distance column, press **F3** and a screen showing all the available pipeline nodes are displayed. You may specify pump station location, by choosing the pipe nodes as desired. If a desired pump station location is not present in the list of pipe nodes, close the pipe node screen and enter the desired location in the **Pump Stations** tab below. This additional pipe node will be automatically added to the pipe data file.



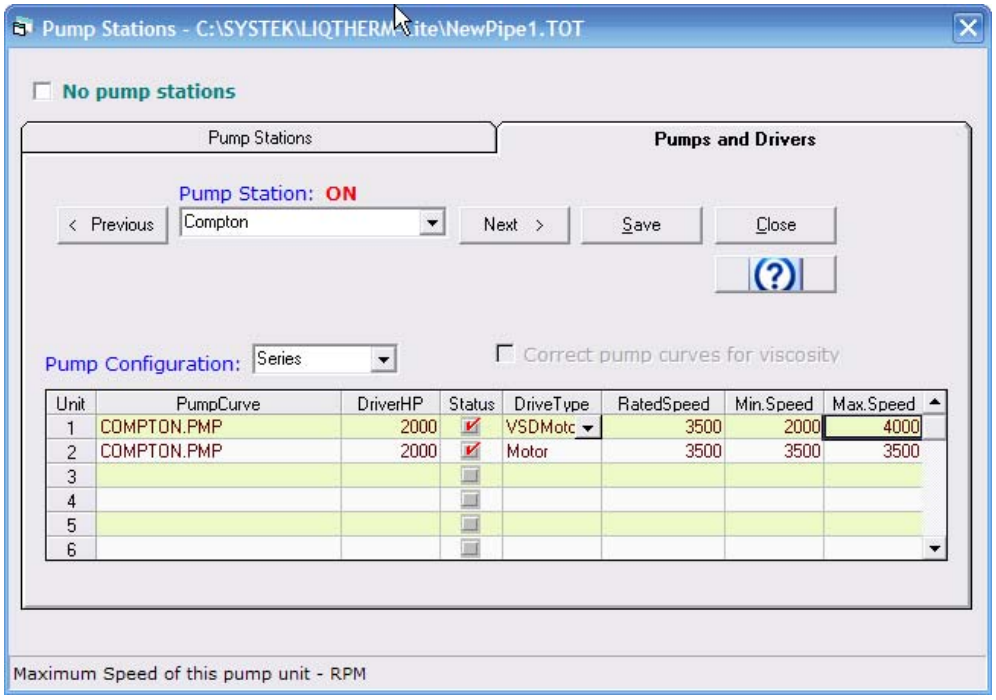
There may be instances where there are no pump stations at all, such as in a short pipeline with a tank at the origin or a connection to another pipeline. In such a case, check the box titled **No pump station**s in the screen above, and Click the **Update** button.

If there are no pump stations at all or the first pump station is not located at the origin (first milepost) of the pipeline, the program assumes that there is either a storage tank at the beginning of the pipeline or a connection to another pipeline that provides the pressure at the pipeline origin. In this case, upon clicking the **Update** button above, a screen is displayed for choosing a **Storage tank** or a **Connecting pipeline** at the first pipe node, as shown below.



For a storage tank, you must specify the tank head that will provide the starting pressure. For the connecting pipeline, the pipeline pressure must be specified.

In the **Pumps and Drivers** tab, enter the details of each pump station, pump configuration (series or parallel), pump curve data, driver HP and pump ON/OFF status. Press **F3** for available pump curve files, when in the cell containing pump curve data. Additional data, such as drive type (Motor, Engine, Gas turbine, and Variable Speed Drive Motor), the rated speed, minimum speed and maximum speed, if available, can be specified as well. If you choose Motor, all speeds (rated, minimum and maximum) will be the same, indicating constant speed electric motor. For Variable speed electric motor, choose VSD motor and enter the rated, minimum and maximum speeds.



Remember that for variable speed pumps, the pump curve data specified is assumed to be at the rated speed. LIQTHERM-Lite will calculate the pump performance at different speeds as needed, using the Affinity Laws for centrifugal pumps.

You may cycle through each pump station data using the **Previous** and **Next** buttons.

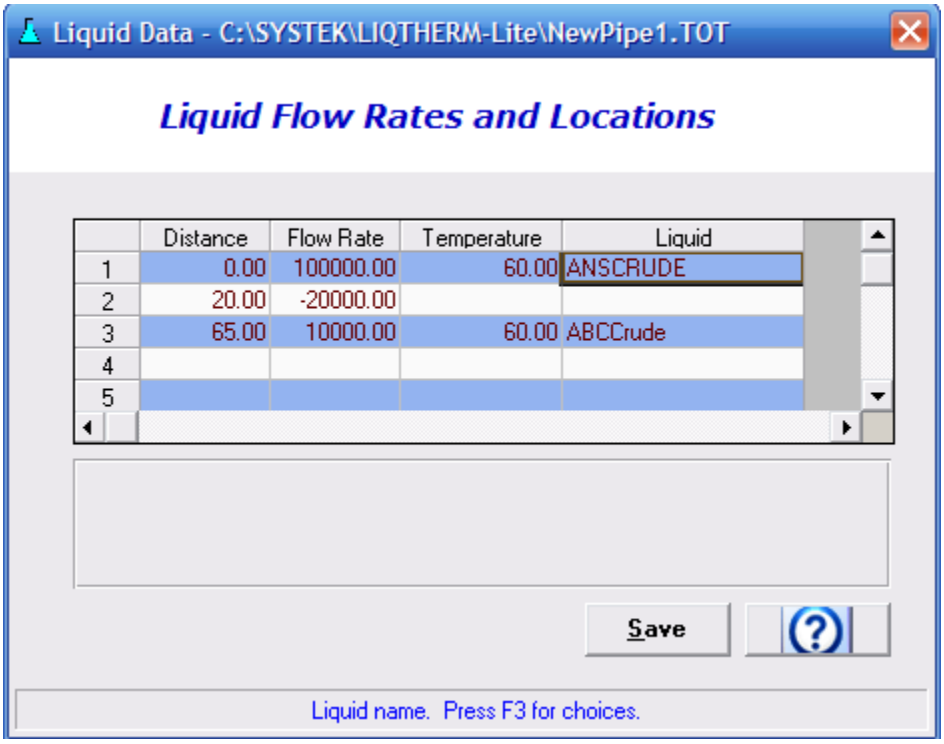
If you have not decided on the pump curves for a specific pump station, enter TBD under pump curve and specify a value for the driver HP. Make sure the Unit is ON. ***Do not enter any more TBD entries under pump curve data.***

When you run a case with no pump curves at all or TBD pumps at certain pump stations, LIQTHERM-Lite will create pump files suitable at the TBD pump stations. For example, if you have specified actual pump curves for Compton pump station but a TBD pump at Dimpton pump station, the simulation for a particular flow rate will create a new pump curve named **Dimpton_TBD.PMP**. This pump curve may then be inserted at Dimpton pump station and the simulation repeated. Note however, that each time a case is run for a particular flow rate with TBD pumps at some stations, corresponding new pump curves will be created automatically with the same name.

To view or edit a pump curve file, double click on the pump curve file name. A File open screen will be displayed, with the default pump curve name. Click **Open** and a screen containing the pump curve data will be displayed. From this screen, the pump performance at different speeds or impeller size and viscosity corrected performance can be calculated. Finally, click the **Save** button to save all pump station data and exit this screen.

Note that the pump curve data must be corrected for viscosity of the liquid, if appropriate. In the Pump Station screen, a check box is provided for *automatic* corrections for high viscosity. This means that the pump data files must contain head, flow rate and efficiency values for water and LIQTHERM-Lite will correct the performance for high viscosity liquids. You may also choose to input pump curve data that have already been corrected for viscosity using either the Hydraulic Institute Charts or SYSTEK's program **PUMPCALC.** Alternatively**,** use LIQTHERM-Lite's **Viscosity Correction** Option provided under **Pump Curves.** After opening a pump curve file, use the menu options for viscosity correction, described later.

The pull down menu under **Liquid** is used for entering the flow rates and their locations and also for reviewing and editing a database of liquid properties.



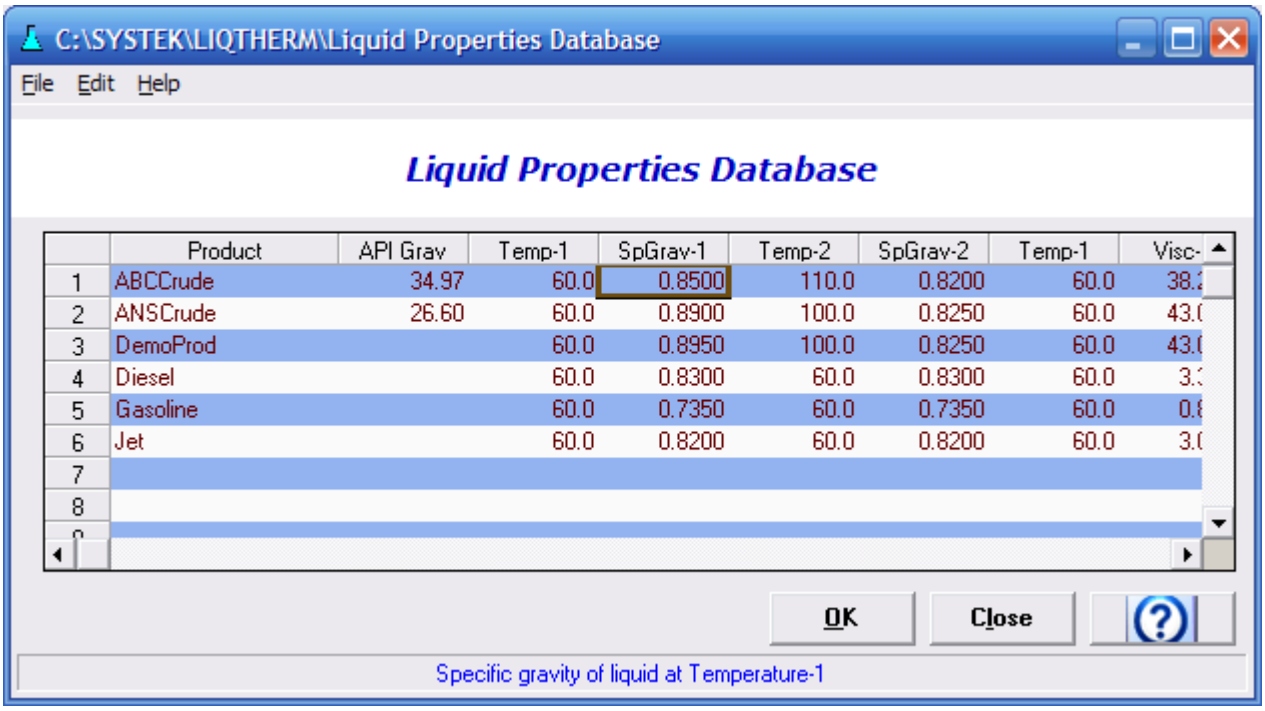
At the beginning of the pipeline, where the product enters the pipeline, a flow rate must be entered as a positive number such as 100,000 bbl/day shown above. If there is a *delivery* at a particular point on the pipeline, the flow rate in this column will have a *negative* value, as indicated above at location 20.0. At such locations where flow is *out* of the pipeline (negative), *do not* enter any temperature or product name.

Pressing the **F3** key with the cursor in the first column, titled **Distance** will display a screen showing all the available pipeline nodes. You may specify flow rate location, by choosing the pipe nodes as desired. If a desired flow location is not present in the list of pipe nodes, close the pipe node screen and enter the desired location in the Liquid screen. This additional pipe node will be automatically added to the pipe data file, after clicking the **Save** button above.

The third column is for the inlet temperature of the liquid. All injection points (positive flow rates) should have inlet *temperature and product name specified*. For delivery locations (negative flow rates) no temperature or product name entries are needed.

Pressing the **F3** key with the cursor in the last column, titled **Liquid** will display the Liquid Properties Database screen. Choose the product from the given list. You may also add a new product to the database.

The **Liquid Properties Database** screen shown below can also be accessed by choosing **Database** under the **Liquid** menu from the main screen.

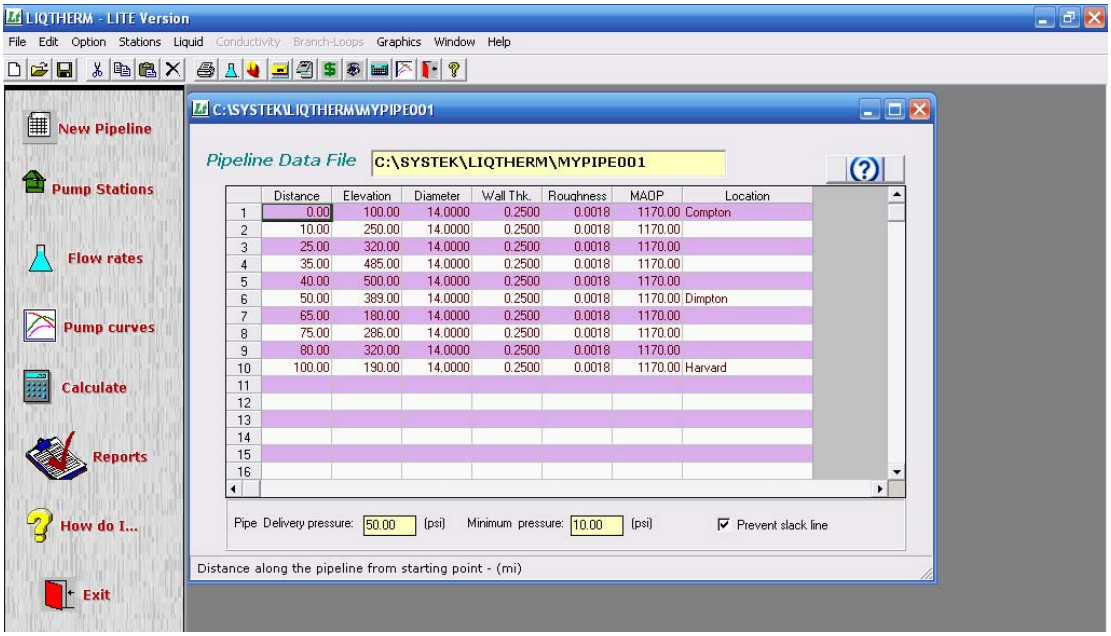


The screen above shows the liquid properties (specific gravity and viscosity) for several common liquids used. For isothermal hydraulics, properties at a single temperature will suffice. However, if the liquid temperature in the above Database screen is 60 F, whereas the liquid inlet temperature in the **Liquid Flow rate** screen is a different value, LIQTHERM-Lite will use the temperature in the above screen as the inlet temperature.

The liquid properties database can be saved under different file names such as *CrudeOilDatabase* containing all the crude oil properties or *RefinedProductDatabase* containing all the refined product properties. Create the database and save it, using File/SaveAs option to rename your file. Remember however, that you can use only one Database file at a time for picking the products. For example, while running Mypipe.TOT file, you have incoming and outgoing flows. All the products incoming and outgoing have to be from one database. In other words you CANNOT choose one product, say **Gasoline** from *RefinedProductDatabase* and another product **Diesel** from another file named *XYZProductDatabase*. Both products **Gasoline** and **Diesel** should be chosen from the same database. You are allowed to change the database association each time you make a run.

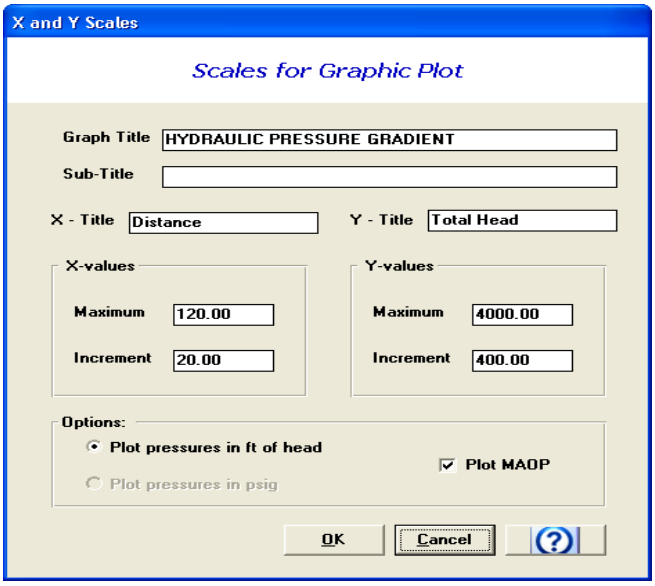
The lower portion of the main pipeline spreadsheet is used for entering **Pressure** information, such as the delivery pressure at the end of the pipeline and the minimum pipeline pressure (important in hilly terrain). If the pipeline must run packed and slack line conditions are to be avoided, check the option titled **Prevent Slack Line.**

In calculating the pressures along the pipeline, LIQTHERM-Lite makes allowance for peaks in the pipeline elevation profile. Hence the final pressure at the end of the pipeline may be higher than the minimum delivery pressure specified. This is true only if **Prevent slack line** option is chosen in the main pipe data screen. Obviously, a back pressure valve will be needed at the pipeline terminus to pack the line. However, if slack line conditions can be tolerated, this option may be unchecked and the desired delivery pressure would be forced. In the latter case, the last pump station segments will indicate slack line locations showing zero pressures. Please note that if a **Minimum pressure** is specified, the line must run packed to prevent slack line conditions.

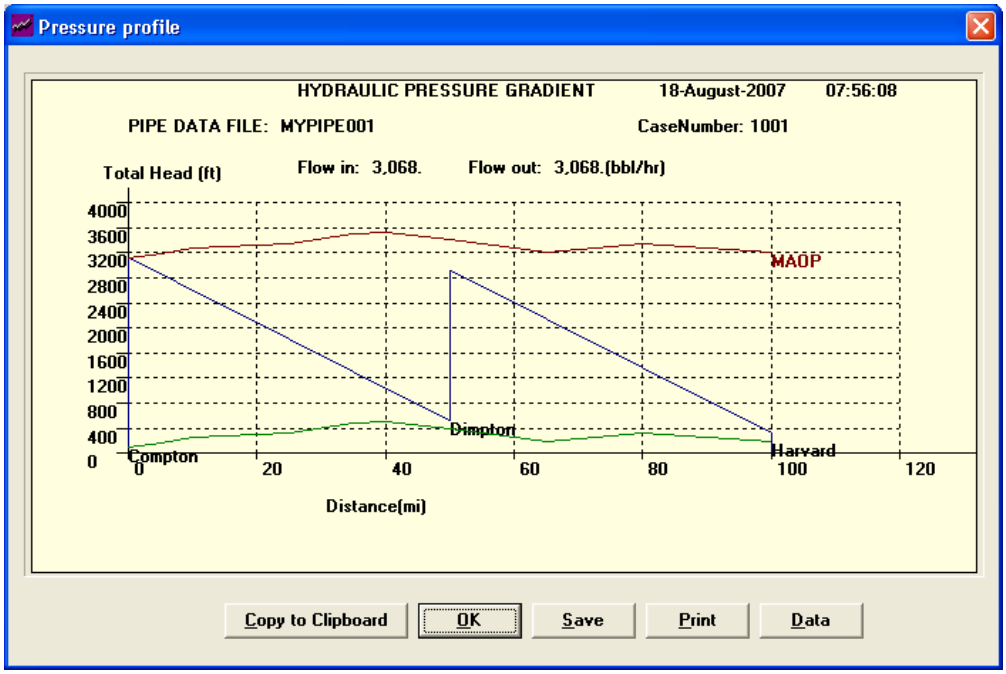


It must be noted that LIQTHERM-Lite is used as an isothermal model and all heat transfer effects are ignored. This means that the liquid inlet temperature specified at the beginning of the pipeline in the Liquid Flow rate screen is used as the ambient soil temperature in calculations. Also all liquid streams entering and leaving the pipeline must be at the same temperature. Isothermal calculations are generally performed for water pipelines, light crude oils and refined petroleum products such as gasoline and diesel. *If you anticipate modeling heavy crude oils with heating, thermal calculations must be performed using the full commercial program LIQTHERM.*

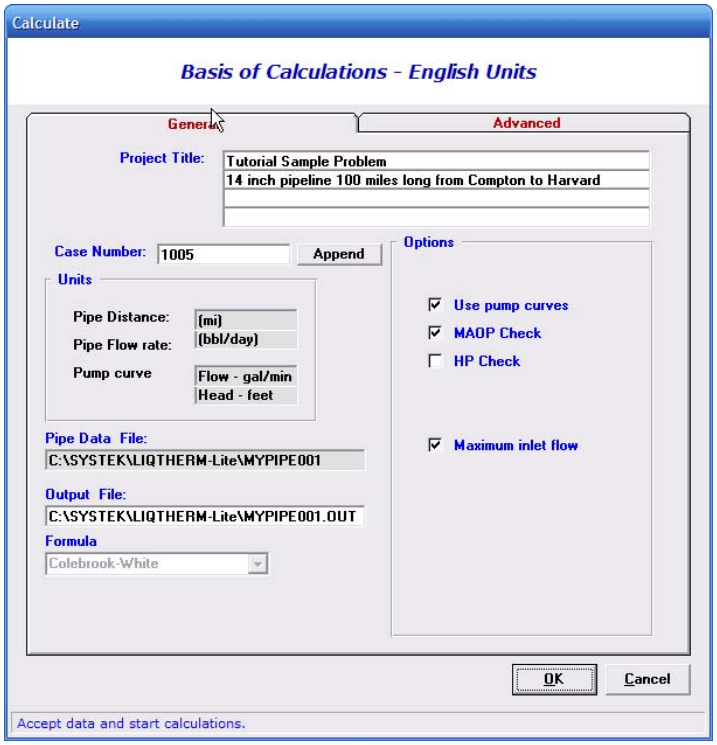
The **Graph** icon is used for selecting the scales for plotting Hydraulic Pressure Gradient along the pipeline. Choosing this option displays the following screen for selecting the labels and scales for the plot of the Hydraulic Pressure Gradient.



On entering data and clicking the OK button, the hydraulic gradient will be plotted, as shown below:



The **Calculate** icon will display the following screen for specifying the format of the calculated results.



The project title may be a maximum of four lines. The calculated results are stored in an output file as shown above. You may rename this file when making multiple runs for the same pipeline system. For example, if the pipeline data file is named `MyPipe001` as in the sample above, the output file may be named `MyPipe001.001`, `MyPipe001.002`, etc.

It must be noted that LIQTHERM-Lite is used as an isothermal model and all heat transfer effects are ignored. This means that the liquid inlet temperature specified at the beginning of the pipeline is used as the ambient soil temperature. Isothermal calculations are generally performed for water pipelines and refined petroleum products pipelines such as gasoline and diesel.

Under the **Advanced** tab, the calculated accuracy may be selected. Generally medium accuracy will suffice.

Clicking the **OK** button initiates calculation.

The menu bar item **Window** lets you customize your screen.

The menu bar item on the extreme right titled **HELP** provides information about the program, such as version number, user registration information and General Help information on the program, in case the User Manual is not handy.

4. Tutorial

This section leads you through the program, using an illustrative example. See the **Reference** section for an explanation of the symbols and formulas used.

*If you are using the DEMO version of LIQTHERM Lite, the sample pipeline data file included with the DEMO is named `MyPipe001-Demo.TOT`. The following explanation **does not** apply to the DEMO version.*

Sample Problem:

Determine the pressure profile and HP for a pipeline transporting crude oil from Compton to Harvard with the following data:

Distance (miles)	**Elevation** (ft)	**Pipe dia.** (in)	**Wall Thk** (in)	**Rough** (in)	**MAOP** (psig)
0	100	14	0.25	.0018	1170
10	250	14	0.25	.0018	1170
25	320	14	0.25	.0018	1170
35	485	14	0.25	.0018	1170
40	500	14	0.25	.0018	1170
50	389	14	0.25	.0018	1170
65	180	14	0.25	.0018	1170
75	286	14	0.25	.0018	1170
80	320	14	0.25	.0018	1170
100	190	14	0.25	.0018	1170

The above pipeline data file is included with program disk as `MyPipe001.TOT`**.**

The pump stations, pump curve data and the pump configuration are as follows:

Pump station	**Distance** (mi)	**Suction Pressure** (psi)	**Drive Type**	**Installed HP**
Compton	0.0	25.0	Motor	2 - 2000
Dimpton	50.0	50.0	VSD	1 - 2000

The pump stations, pump curve data and the pump configuration are as follows:

Pump station	No. of pumps	Configuration	Pump curves (data file)
Compton	2	Parallel	Compton.pmp
Dimpton	1	Parallel	Dimpton.pmp

Pump curve: Compton.pmp

Flow (gpm)	Head (ft)	Efficiency (%)
0	3185	0.0
400	3150	34.5
600	3135	46.4
800	3100	55.7
1200	3035	64.3
1600	2900	78.0
2000	2690	81.2
2400	2350	79.3
2700	2100	76.0
3000	1800	72.0

Pump curve: Dimpton.pmp

Flow (gpm)	Head (ft)	Efficiency (%)
0.0	3140	0.0
400	3160	34.3
800	3120	57.5
1200	3140	72.0
1600	2820	79.0
1900	2560	80.0
2000	2460	79.8
2400	2060	76.0
3000	1680	65.7

The Variable Speed Drive (VSD) pump at Dimpton has the following speeds:

Rated speed: 3500 rpm
Minimum speed: 2000 rpm
Maximum speed: 4000 rpm

The liquid properties and other pipeline data are as follows:

Product Name	ANSCrude
Specific gravity at 60 deg. F	0.895
Specific gravity at 100 deg. F	0.825
Viscosity at 60 deg. F	43 centistokes
Viscosity at 100 deg. F	15 centistokes
Delivery pressure at Terminus	50 psi
Flow rate at inlet temperature	85,000 bbl/day
Liquid temperature at pipe inlet	100 deg F

The pump curve data must be corrected for viscosity of the liquid, if appropriate. **LIQTHERM-Lite** *does not include* corrections for high viscosity. This means that the pump data files must contain head, flow rate and efficiency values that have already been corrected for viscosity using either the Hydraulic Institute Charts or using the **PUMPCALC** program.

In calculating the pressures along the pipeline, LIQTHERM-Lite makes allowance for peaks and hence the final pressure at the end of the pipeline may be higher than the minimum delivery pressure specified. This is true only if **Prevent slack line** option is chosen in the main pipe data screen. However, if slack line conditions can be tolerated, this option may be unchecked and the desired delivery pressure would be forced. In the latter case, the last pump station segments will indicate slack line locations showing zero pressures. Please note that if a **Minimum pressure** is specified, the line must run packed to prevent slack line conditions. An example of a pipeline through a hilly terrain is also included.

Solution

In the main program window, choose **File** from the pull down menu. Choose **Open** to open an existing file. You are presented with the **File/Open** screen to choose the name of the pipe data file. All pipe data files are contained in an XML style file with a filename extension of **.TOT**. Similarly, pump curve data files are designated with a file extension of **.PMP.** For example, a pipeline data file may be **MYPIPE.TOT** whereas a pump curve data file may be shown as **DIMPTON.PMP.**

You may also click on the **Open file** icon on the toolbar to open a data file.
Type **MyPipe001.TOT** for the filename. The sample pipeline data file opens up. This data file contains the pipeline information for the sample problem.

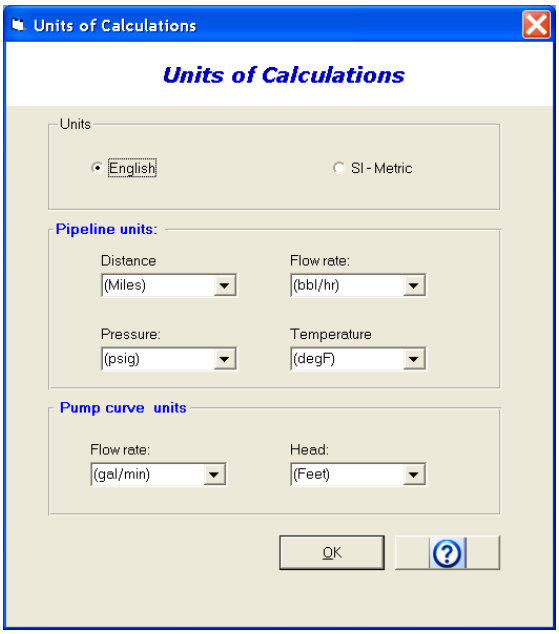
To create a new data file, choose **File** followed by **New.** A blank editing window (spreadsheet style) will be presented for inputting the data. Input the pipeline data similar to the sample problem.

To save changes, Select **File /Save** from the menu bar or click on the Toolbar icon.

For further explanation on creating data files, see the section, **Creating a Data File,** later on in this manual.

The pipe delivery pressure at the end of the pipeline and the minimum pipe pressure required for clearing any high elevation points are entered on the lower portion of the spreadsheet.

To proceed with the sample problem, choose the pull down menu item **Options** *followed by* **Units.** The following window opens up:



This screen is used to choose English or Metric units of calculation. Options are available for different sets of units for pipeline distance, pipeline flow rates, pressures and temperatures. For pump curve data you may choose the units for flow rate and head. Note that the pipeline flow rate units need not necessarily be the same as the pump curve flow rate units.

In English units, pipeline distances have to be in either miles or feet. Pipeline flow rates for English units can be in gallons/minute, barrels/hour or barrels/day. Pressures are input in psig and temperatures in deg F. For pump curve data - flow rates are input in gal/min or bbl/hr and head is input in either ft or psig.

For Metric units, distance options are kilometers or meters and flow rates may be in m^3/hr, liters/minute, tons/hr or Megatons/hr. Pressures can be input in kiloPascal, MegaPascal, Bar or kg/cm^2 Temperatures are input in deg C only. For pump curve data - flow rates are input in m^3/hr or liters/minute and head is input in meters only.

In both cases selections are made from the appropriate drop-down lists.

Choose English units of calculations for the sample problem. Also choose *miles* for units of distance, *bbl/day* for pipeline flow rate units, *psig* for pressures and *deg F* for temperature. For pump curves, choose the units of pump flow rate in *gal/min* and head in *feet*.

Click the **OK** button, after making your choice.

Next, choose **Options** *followed by* **Formula** and choose the default formula (Colebrook-White) for the sample problem.

If you choose **Hazen-Williams** formula, the Hazen-Williams C-value may either be specified or automatically calculated by the program. The two choices **Colebrook-White** and the **Moody friction factor** method are very similar. The original Moody method was modified based on US Bureau of Mines experiments and referred to as the **Modified Colebrook-White equation**. This latter equation for pressure drop is more conservative and results in a higher pressure drop per unit length of pipeline. Read the explanation of the pressure drop formulas in the **Reference** section of this manual.

Pump stations located along the pipeline are specified from the pull down menu titled **Stations** followed by **Pump Stations.**

Begin by inputting the pump station name, distance from the beginning of the pipeline (e.g. mile post location), the ON or OFF status of pump, pump efficiency and minimum suction pressure. If pump curve data is not available, LIQTHERM-Lite calculates the horsepower required at each pump station by using this hypothetical efficiency for each pump stations.
Note: A maximum of 5 pump stations can be specified.

With the cursor in the station name or distance column, press **F3** and a screen showing all the available pipeline nodes are displayed. You may specify pump station location, by choosing the pipe nodes as desired. If a desired pump station location is not present in the list of pipe nodes, close the pipe node screen and enter the desired location in the **Pump Stations** tab below. This additional pipe node will be automatically added to the pipe data file.

If there is no pump station at the beginning of the pipeline, a storage tank (with adequate liquid head) or connection to another pipeline (with sufficient pressure) must be specified. If the first pipe node is at milepost 0.0 and the first pump station is located at milepost 10.0 there must be a pressure source at m.p 0.0 to provide the necessary suction pressure to the first pump station. Another example is a storage tank at m.p 0.0 with a liquid head of 60 ft. and the first pump station located 500 ft away (m.p. 0.09).

After clicking Update, choose the **Pumps and Drivers** tab; enter the details of each pump station, pump configuration (series or parallel), pump curve data, driver HP and pump ON/OFF status. Press **F3** for available pump curve files, when in the cell containing pump curve data. Additional data, such as drive type (Motor, Engine, Gas turbine, and Variable Speed Drive Motor), the rated speed, minimum speed and maximum speed, if available, can be specified as well. If you choose Motor, all speeds (rated, minimum and maximum) will be the same, indicating constant speed electric motor. For Variable speed electric motor, choose VSD motor and enter the rated, minimum and maximum speeds.

Remember that for variable speed pumps, the pump curve data specified is assumed to be at the rated speed. LIQTHERM-Lite will calculate the pump performance at different speeds as needed, using the Affinity Laws for centrifugal pumps.

If you have not decided on the pump curves for a specific pump station, enter TBD under pump curve and specify a value for the driver HP. Make sure the Unit is ON. ***Do not enter any more TBD entries under pump curve data.***

Solution

To view or edit a pump curve file, double click on the pump curve file name. A File open screen will be displayed, with the default pump curve name. Click **Open** and a screen containing the pump curve data will be displayed. From this screen, the pump performance at different speeds or impeller size and viscosity corrected performance can be calculated.

You may cycle through each pump station data using the **Previous** and **Next** buttons.

As mentioned before, a maximum of 5 pump data files can be specified for each pump station. Each pump data file may have up to 15 sets of data points (flow rate, head and efficiency values).

When entering pump curve data, make sure that the first column containing flow rates are in increasing order, with each subsequent value larger than the previous value.

Please refer to the **Pump Curve Data File** for further details on How to Create, Edit and Save Pump Data file.

After the sample problem data is input, save data and close the screen.

Next, click on the beaker icon or choose the pull down menu item **Liquid** followed by **Flow Rates**. This screen is used to enter the location, the liquid flow rate, the temperature and product name such as ANSCrude, gasoline, diesel etc.

At the beginning of the pipeline, where the product enters the pipeline, a flow rate must be entered as a positive number such as 85,000 bbl/day for the sample problem. If there is a *delivery* at a particular point on the pipeline, the flow rate in this column will have a *negative* value.

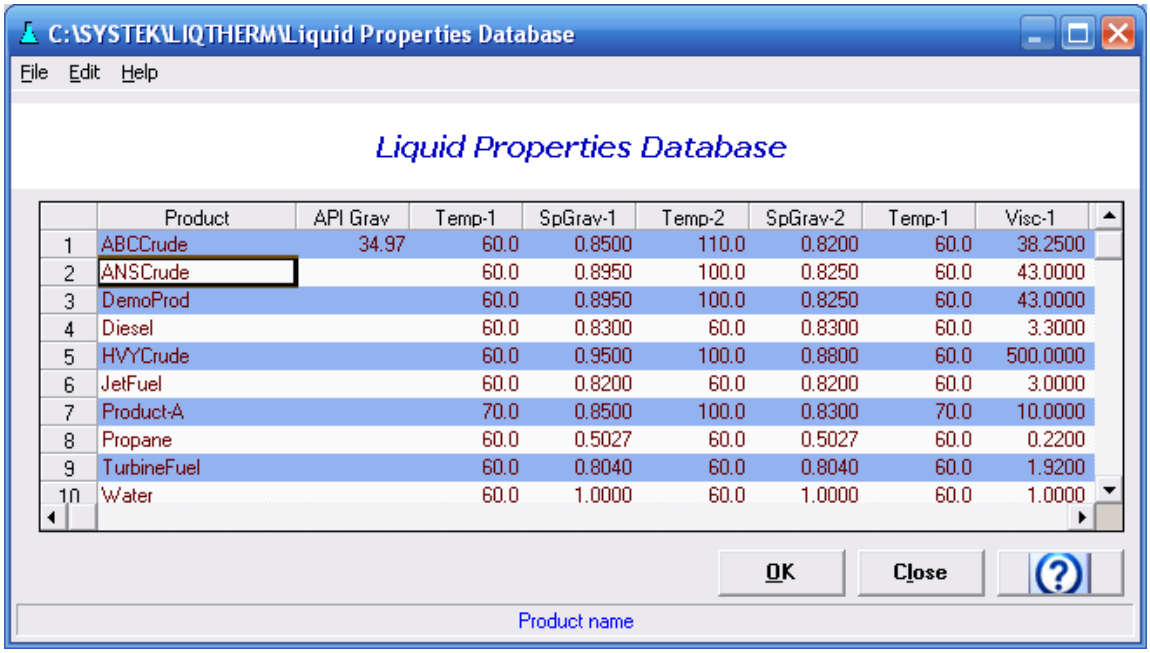
The third column is for the inlet temperature of the liquid. All injection points should have inlet *temperature and product name specified*. For delivery locations no temperature or product name entries are needed.

The last column is for selecting the product transported. Choose from available product names (PRODUCT-A, ANSCrude etc.) from the database by pressing **F3**. At locations where flow is *out* of the pipeline (negative), *do not* enter any product name.

No entry is needed at the last milepost location, for delivery out of the pipeline at the pipeline terminus.

The status bar at the bottom of the spreadsheet window briefly describes the expected data in each cell. In English units, the pipeline flow rate may be *gal/min, bbl/day or bbl/hr*. If a different unit such as bbl/hr is desired, enter the data in the spreadsheet as above, go to the pull down menu for **Units** under **Options** and select the appropriate units, *before initiating calculations.*

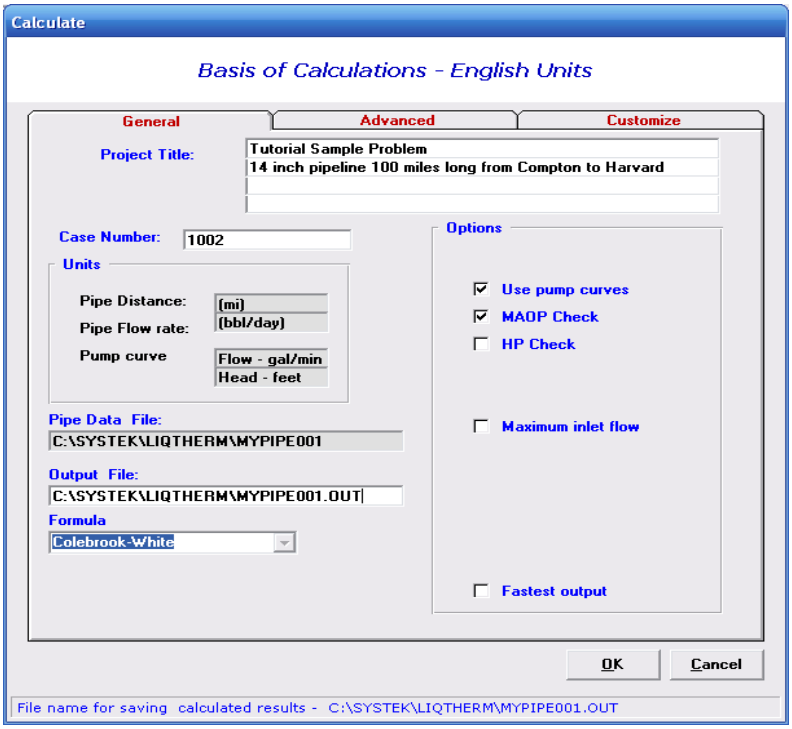
To add new liquid property data to the Liquid property database screen, open the database from **Liquid** on the menu bar and click on **Database**. The following screen opens up.



This is a simple database of liquid properties such as API gravity, Specific gravity and viscosities at different temperatures and units such as centistokes, centipoise, SSU and SSF. You may add new products, edit the data above and save changes as needed. Double clicking on a cell containing Specific gravity, API gravity or Viscosity will open up conversion screens to convert from one set of units to another.

The liquid properties database can be saved under different file names such as *CrudeOilDatabase* containing all the crude oil properties or *RefinedProductDatabase* containing all the refined product properties. Create the database and save it, using File/SaveAs option to rename your file. Remember however, that you can use only one Database file at a time for picking the products. For example, while running Mypipe.TOT file, you have incoming and outgoing flows. All the products incoming and outgoing have to be from one database. In other words you CANNOT choose one product, say **Gasoline** from *RefinedProductDatabase* and another product **Diesel** from another file named *XYZProductDatabase*. Both products **Gasoline** and **Diesel** should be chosen from the same database. You are allowed to change the database association each time you make a run.

Next, click on the **Calculator** icon on the toolbar to start calculations. In the resulting screen, enter the project title, case number and name of the output file name.



The project title may be a maximum of four lines. Press the **Tab** key to move from each line to the next to enter the additional lines for the project title. The calculated results are stored in an output file as shown above. You may rename this file when making multiple runs for the same pipeline system. For example, if the pipeline data file is named MyPipe001.TOT as in the sample above, the output file may be named **MyPipe001.001, MyPipe001.002**, etc. Clicking the **OK** button initiates calculation.

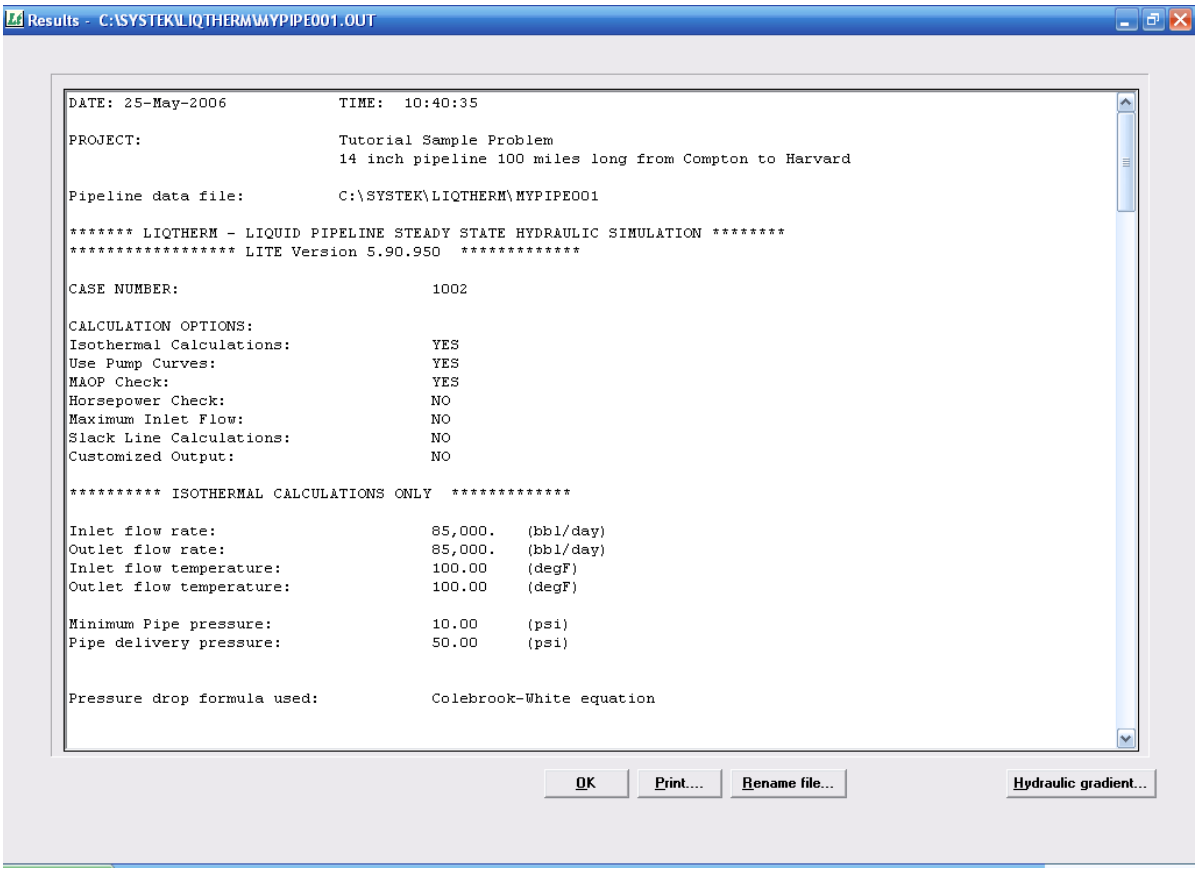
Notice that the pipe data file name and the corresponding output file names are shown as **MyPipe001** and **MyPipe001.OUT** respectively. If the input pipe data file were **ABCPipeline**, the corresponding results of calculation will be stored in a file named **ABCPipeline.OUT.** Change the output file name as desired.

By clicking the **Customize….** tab on the above screen, you may select portions of output in any order desired. The default output will consist of all sections of output as shown in the **Sample Output** section of this User Manual. The calculation accuracy can be improved by increasing the sub-divisions in the **Advanced** tab. However, this may result in extraordinarily long program execution time.

Please pay special attention to the check boxes on the right side of the screen. Ensure that the **Use Pump curves and MAOP check** categories are checked for the sample problem,

indicating that pump curves are to be used and calculated pressures have to be checked against MAOP values. If all information above is correct, press **OK** to initiate calculations. After a pause, varying from a few seconds to several minutes depending on the computer, the results of the calculation are displayed in a scrollable window.

The calculated results are also saved on disk. If the input pipe data file is `MyPipe001.TOT` the corresponding output file will be saved under the name `MyPipe001.OUT`. After viewing the results of the calculations on screen, click the **Print** button to print the results on the printer. The button titled **Hydraulic gradient** is for plotting the hydraulic pressure gradient. **Rename File...** can be used to rename the output file.



The calculated results are included at the end of this User Manual under the heading **Sample Output.**

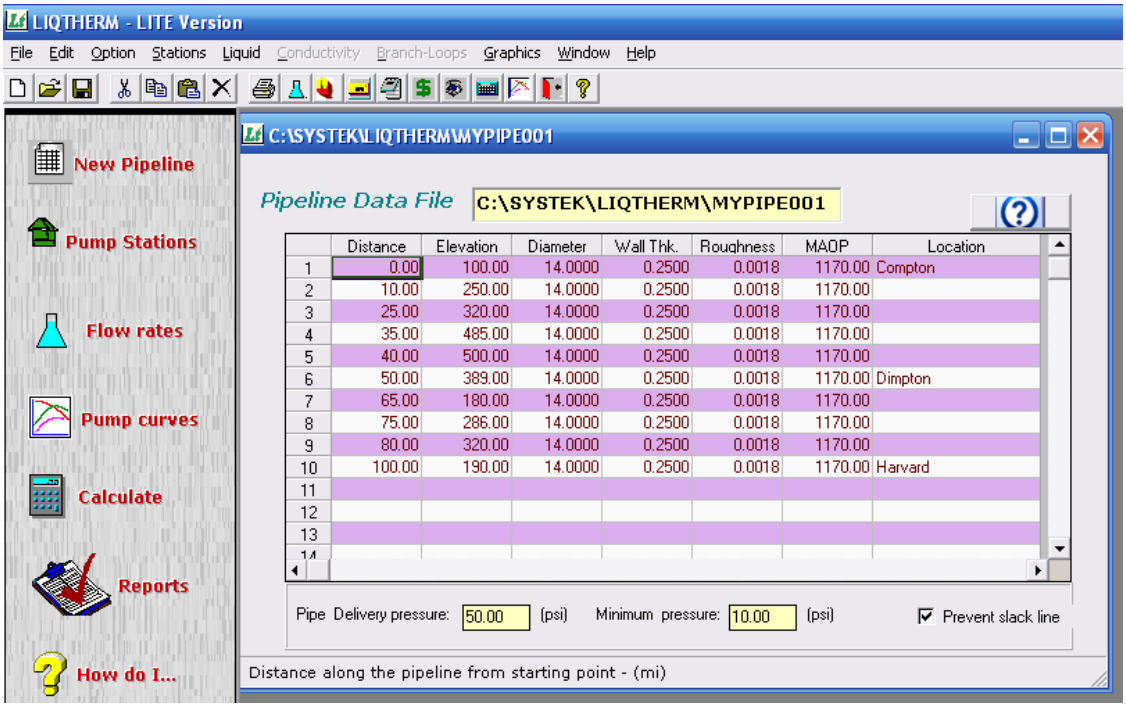
See next section on making changes to the data file, for running different cases.

File Format for Pipe Data File

The screen below shows a sample pipe data file used with LIQTHERM-Lite. It is displayed in a spreadsheet when you use the pull down menu **File|Open.** *The status bar located at the bottom of the spreadsheet window briefly describes the expected data in each cell.*

Creating a pipe data file

Since the pipeline data file is the most important data that is needed for running LIQTHERM-Lite, it is appropriate to describe the creation and editing of the data file.



Most data are entered in Microsoft Excel compatible spreadsheet that results in easy editing and cut and paste operations via the Windows clipboard. The spreadsheets are saved in a proprietary file format compared to the familiar .XLS file extension for Microsoft Excel. For the sample problem, pipeline profile data (distance, elevation, pipe diameter and wall thickness, pipe roughness, MAOP) is saved in a file designated as MyPipe001.TOT. *Do not edit this file using a text editor or Word Processor.* To edit the input data file, use only the LIQTHERM-Lite spreadsheet editor described here. You may export files to or import files from an Excel Spreadsheet, via the Windows Clipboard.

The pipeline data file name can be a long filename (max 255 characters) with a 3-letter extension, such as ACME 16-INCH PIPELINE.TOT. *The file name extension must be TOT and if not specified, is automatically appended by the program.* The calculated results are automatically saved under the same name, with file extension of OUT. Thus, if the input pipe data file is named **`MyPipeline.TOT`**, the results of the calculations are stored in the output file **`MyPipeline.OUT`** in the same sub-directory or folder.

Creating a pipe data file

The screen shot on the previous page shows the spreadsheet editor with a sample file already typed in. Initially, when creating a brand new pipe data file, the title above the spreadsheet will be blank, but once data is entered and the file saved, the name of the sub-directory and data file are shown on the title panel just above the spreadsheet as seen on the previous page.

Each column in the spreadsheet is for a specific data for the pipeline. Each row represents a specific location along the pipeline. The first column is for the distance *measured from the origin* of the pipeline, such as *mile post*. Each subsequent location of the pipeline is measured from the beginning of the pipeline and hence the first column is the *cumulative length* of each point on the pipeline measured from the beginning, also designated as mile post location (m.p.).

Unlike other hydraulic simulation models, the distances are cumulative and not pipe segment lengths.

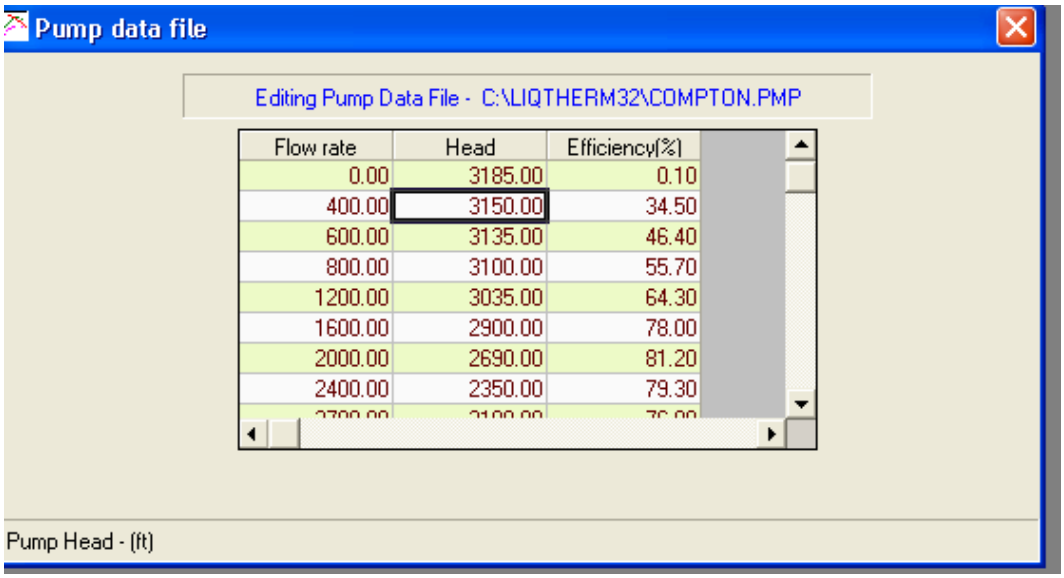
The second column is for the elevation of the pipe at that mile post location, measured above some datum, such as sea level. The third, fourth and fifth columns represent the pipe *outside* diameter, pipe wall thickness and pipe roughness at this location. The pipe diameter, wall thickness and roughness entered at a specific location represent those for the pipe segment *downstream* of that milepost location. Thus, if the first two milepost locations are 0.0 and 10.0, the diameter, wall thickness and roughness entered at 0.0 milepost are for the pipe segment from 0.0 to the 10.0 location. The diameter, wall thickness and roughness entered at milepost 10.0 are for the *next* pipe segment starting at milepost 10.0. Finally, for the very last milepost location (the last data row of the spreadsheet) the diameter, wall thickness and roughness entered should be a duplicate of the *immediately previous location*, since there is no pipe segment downstream of the last milepost.

The next column entry is the Maximum Allowable Operating Pressure (MAOP) for the pipe at that milepost location. If you double-click or press Enter with the cursor in the cell containing the MAOP, a new screen opens up. This screen can be used to verify or calculate the MAOP of the pipe. From this screen, you may also calculate the hydrostatic test pressures for pipe hoop stresses of 90% and 100% of the specified minimum yield strength (SMYS) of pipe material.

Note: A maximum of 100 points are allowed in the pipe data file and a maximum of 5 pump stations can be specified in the Lite version.

Creating a pump curve file

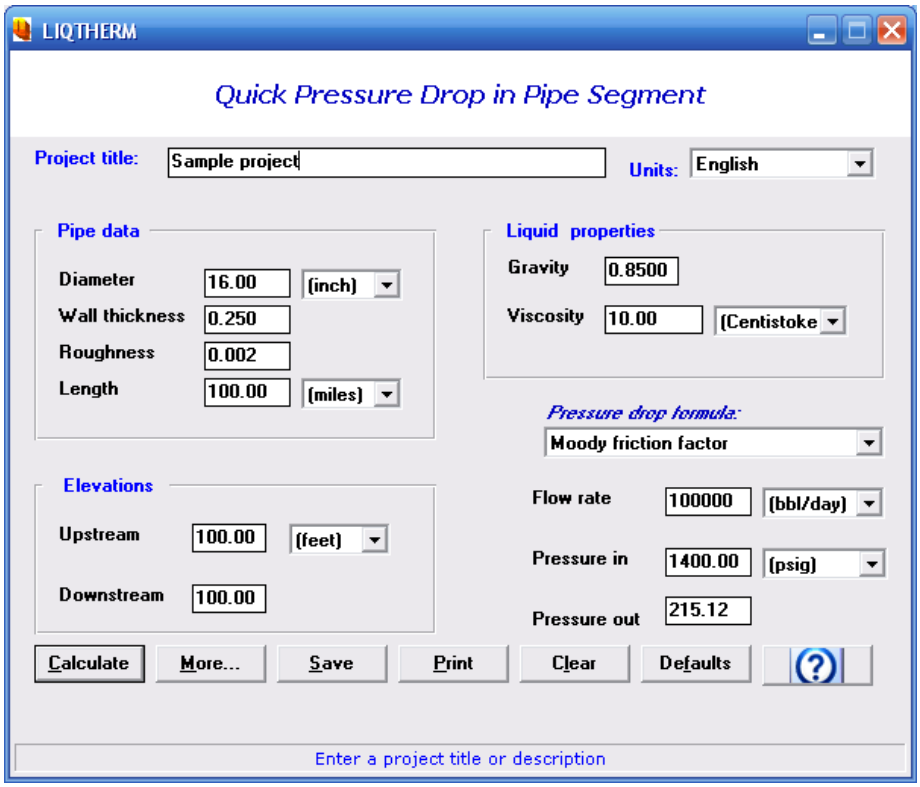
A pump curve file is created by entering the flow rates, heads and efficiencies of the pump at several points from the pump manufacturer's performance curve. From the **Stations** menu, under **Pump stations**, double clicking on the cell containing the pump curve name opens up a spreadsheet that will help edit or create a pump file. Choosing **Open** will show the pump curve data in a spreadsheet. To create a new pump curve, open an existing pump data file, make changes to the data and use the **Save As** option from the **File** menu to save under the new file name.



Pump curve data are ASCII text files that can be edited easily. As a convention, all pump curve data files are designated with the .PMP extension, such as DEMO.PMP. The maximum set of data points allowed on a pump curve is 15 sets. The minimum sets of data points are three. For each pump station, a maximum of 5 pumps either in series *or* parallel can be specified. Therefore 5 pump curve data files can be specified per pump station on the spreadsheet describing the pump station data.

Quick Pressure Drop

Upon clicking the icon with the letter **Q**, the **Quick Pressure Drop** option screen shown below opens up.



This is for quick calculation of *isothermal pressure drop* in a pipe segment. For a given flow rate, pipe diameter, pipe length, elevations, specific gravity and viscosity, the Quick Pressure Drop Option calculates the inlet or outlet pressure, given one of the two pressures. If the outlet pressure is specified, the inlet pressure is calculated and vice versa. Alternatively, the flow rate can be calculated for a given inlet and outlet pressure. You may also choose the pressure drop formula (such as Colebrook-White, Hazen-Williams etc.) to be used. Liquid viscosity may be specified in centistokes, centipoise, SSU etc.

5. Reference

This section provides an explanation of formulas and variable names used.

Hydraulic Formulas

The following symbols are used in the equations below:

Q - Pipeline flow rate, gal/min .

Cfact - Hazen Williams C Factor

D - Inside diameter of pipe, inches.

S - Specific gravity of liquid at flowing temperature, dimensionless.

V - Viscosity of liquid at flowing temperature, centistokes (cSt)

R - Reynold's number, dimensionless.

K - Absolute roughness of pipe, inches.
(use 0.0018 inch for new steel pipe).

F - Transmission factor, dimensionless.

Pm - Pressure drop due to friction, psi/mile.

L(I) - Pipeline mile post, I = 1,2,3.....100 (max).

H(I) - Pipeline elevation, ft.

P(I) - Pipeline pressure, psi.

P9 - Pipe delivery pressure, psi.

PD(J) - Pump station discharge pressure, psi.
J = 1,2,3.....5 (max).

E - Pump efficiency, percent.

DeltaH - Pump differential head, ft

1. Velocity Vel = $\frac{0.408Q}{D^2}$

2. Reynold's number R = $\frac{3162.5Q}{VD}$

3. Pressure drop Pm = $\frac{284.6(Q/F)^2 S}{D^5}$ (Darcy-Weisbach equation)

4. Discharge Pressure PD(J) = PM(L(I)-L(I-1)) + (H(I)-H(I-1))S/2.31+P9

5. Horsepower HP = $\frac{DeltaH \times Q \times S}{39.60 \times E}$

The pressure drop equation 3 above uses the *Transmission factor* F instead of a *friction factor.* These two parameters have a reciprocal relationship as follows:

Transmission factor $F = \frac{2}{\sqrt{f}}$

Darcy or Moody friction factor $f = \frac{4}{F^2}$

Where F is the transmission factor and f is referred to as the *Darcy or Moody friction factor.* There is another friction factor called the *Fanning friction factor* which is related to the Moody friction factor as follows:

Fanning friction factor = $\frac{f}{4}$

The Transmission factor F used in the pressure drop equation 3 on this page is calculated as follows:

Colebrook-White Equation:

$F = \frac{\sqrt{R}}{4}$ for laminar flow (R <= 2100)

$F = \frac{1}{\sqrt{(R-2100)/1277500 + 0.008}}$ for transition flow (R <= 4555)

$F = -4Log_{10}\left(\frac{K}{3.7D} + \frac{1.4125F}{R}\right)$ for turbulent flow (R > 4555)

Moody friction factor method:

$$F = \frac{\sqrt{R}}{4}$$ for laminar flow (R <= 2100)

$$F = \frac{1}{\sqrt{(R-2100)/1277500 + 0.008}}$$ for transition flow (R <= 4555)

$$F = -4Log_{10}\left(\frac{K}{3.7D} + \frac{1.25F}{R}\right)$$ for turbulent flow (R > 4555)

MIT Equation:

$$F = \frac{\sqrt{R}}{4}$$ for laminar flow (R <= 2100)

$$F = \frac{1}{\sqrt{0.0018 + 0.159/R^{0.355}}}$$ for turbulent flow (R > 2100)

Several other pressure drop formulas are discussed below. These do not use a friction factor or transmission factor. They either use an experience factor or some modified form of calculating pressure drop from the flow rate.

Miller Equation:

BConst1 = 0.1692

BConst2 = 4.35

$$BConst3 = \frac{(Q/24)^2 S}{BConst1^2 \times D^5}$$

$$BConst4 = \frac{D^3 S}{(V \times S)^2}$$

$$Pm = \frac{BConst3}{\left(Log_{10}(BConst4 \times Pm) + BConst2\right)^2}$$

Hazen-William Equation:
This pressure drop equation is widely used in the water industry as well as in calculating pressure drop in pipelines transporting products such as gasoline and diesel. This equation uses a C factor to calculate the flow rate in bbl/day from a given pressure drop Pm in psi/mi as follows:

$$Q = 0.1482 CfactD^{2.63}\left(\frac{Pm}{S}\right)^{0.54}$$

The C factor is usually a number between 100 and 200, based on experience with different products. Typical values in the range 120 to 160 are used for petroleum products.

In the absence of data, the C factor may be approximated by the following viscosity related equation:

$$Cfact = \frac{146.59}{V^{0.08}}$$

6. Troubleshooting

LIQTHERM-Lite is a powerful hydraulic simulation program for liquid pipelines under steady state flow. Despite the complexity of the program it is very user friendly. Online HELP is available for most data entry screens and the program has extensive error checking features. However, there is always a possibility that some extraneous or invalid data was entered and the program may hang up. In such cases, try quitting the program by using the **File/Exit** menu item or click on the **Exit** icon on the toolbar. If this does not work, you have no choice but to perform a hard re-boot and re-start the **LIQTHERM-Lite** program.

If you cannot get **LIQTHERM-Lite** to run properly even after following the steps outlined in the *Getting Started* section of this manual, please check the following *before* you call Technical Support. Have your program disk serial number and program version number handy to facilitate quick response.

Error Messages:

The following are some errors that you may encounter while running **LIQTHERM-Lite**:

Divide by zero error
This is generally due to some data input value that is zero. Check all input data for zero values. The pump efficiencies, specific gravity, viscosity are usually suspect.

Illegal Function call
This is generally due to some illegal mathematical operation such as trying to extract the square root of a negative value. Ensure that there are no inadmissible negative values, such as a negative value for viscosity or specific gravity.

File not found
A common error when a file specified cannot be located on the hard disk or does not exist. When specifying pump curves, make sure the file is present in the sub-directory or folder containing LIQTHERM-Lite. Otherwise, ensure that the file name is typed in correctly, including the full path.

Input past end of file
This happens when the program reads a data file and looks for *more* information than present in the file. For example, it tries to read 10 sets of pump curve data (flow, head and efficiency values) from a data file where only 9 sets of data exist. In such a case, first load the pump data file in an ASCII or text editor, such as the Windows Notepad. Review the data file to ensure that the number of data sets specified in the first line matches the data below. If there are less number of rows of data as compared to the sets specified, correct the data file and save the information. If any of the rows of data shows a string of zero values, make corrections and save the data file.

If the above problems persist or you cannot successfully install the software on your hard disk, contact Technical Support.

7. Technical Support

Please read the Troubleshooting section of this manual before you call us for technical support.

Free Technical Support is provided for registered users of this software for a period of sixty (60) days from the initial purchase date. *After that period, Technical Support can be provided only if an annual software maintenance and support plan has been purchased. Contact SYSTEK for details.*

In order to facilitate quick response, please have your disk serial number and program version available when you call us.

How to contact us:

You may contact SYSTEK in any of the following ways:

Phone/Fax: (928) 453-9587

E-mail: techsupport@systek.us

Web site: www.systek.us

Mail: SYSTEK Technologies, Inc.
3900 Chickasaw Drive
Lake Havasu City, AZ 86406 USA

Consulting Services:

If you would like SYSTEK to perform consulting work, such as pipeline feasibility studies, hydraulic analysis, surge or transient studies, please contact us at the above address.

We can also put together the first pipeline model using your pipeline data in LIQTHERM-Lite at a very reasonable fee. This will save you considerable time, if you find yourself short of time or do not have the staff to perform the work.

Sample Problems

Sample Problem –1

This is similar to the sample problem MyPipe001.TOT discussed in the **Tutorial** section of this manual. Some changes have been made to a include VSD motor at the second pump station.

Determine the pressure profile and HP required for a 14" pipeline transporting crude oil (ANSCrude)with the following data:

Specific gravity at 60 deg. F	0.895
Specific gravity at 100 deg. F	0.825
Viscosity at 60 deg. F	43 centistokes
Viscosity at 100 deg. F	15 centistokes
Pipe delivery pressure	50 psi
Flow rate at inlet temperature	85,000 bbl/day
Pipe Inlet temperature	100 deg F

The pipeline data file is provided on the program disk as MyPipe001.TOT**.**

The pump stations, pump curve data and the pump configuration are as follows:

Pump station	**Distance** (mi)	**Suction Pressure** (psi)	**Drive Type**	**Installed HP**
Compton	0.0	25.0	Motor	2 - 2000
Dimpton	50.0	50.0	VSD	1 - 2000

Pump station	**No. of pumps**	**Configuration**	**Pump curves**
Compton	2	Parallel	Compton.pmp
Dimpton	1	Series	Dimpton.pmp

DATE: 25-May-2006 TIME: 10:53:15

PROJECT: Tutorial Sample Problem
14 inch pipeline 100 miles long from Compton to Harvard

Pipeline data file: C:\SYSTEK\LIQTHERM\MYPIPE001

******* LIQTHERM - LIQUID PIPELINE STEADY STATE HYDRAULIC SIMULATION ********
****************** LITE Version 5.90.950 *************

CASE NUMBER: 1003

CALCULATION OPTIONS:
Isothermal Calculations: YES
Use Pump Curves: YES
MAOP Check: YES
Horsepower Check: NO
Maximum Inlet Flow: NO
Slack Line Calculations: NO
Customized Output: NO

********** ISOTHERMAL CALCULATIONS ONLY *************

Inlet flow rate: 85,000. (bbl/day)
Outlet flow rate: 85,000. (bbl/day)
Inlet flow temperature: 100.00 (degF)
Outlet flow temperature: 100.00 (degF)

Minimum Pipe pressure: 10.00 (psi)
Pipe delivery pressure: 50.00 (psi)

Pressure drop formula used: Colebrook-White equation

********** LIQUID PROPERTIES **********

PRODUCT: ANSCrude
Specific gravity: 0.8950 at 60.0(degF)
0.8250 at 100.0(degF)

Viscosity: 43.00 CST at 60.0(degF)
15.00 CST at 100.0(degF)

********** LIQUID FLOW RATES AND LOCATIONS **********

Location (mi)	Flow rate (bbl/day)	Inlet Temp. (degF)	Product
0.00	85,000.	100.0	ANSCrude

********** PUMP STATIONS **********

Pump station	Distance (mi)	Pump suct pressure (psi)	Pump disch pressure (psi)	Sta. disch pressure (psi)	Throttled pressure (psi)	BHP Reqd by pump	TotHPinst. (Active)
Compton	0.00	25.00	1105.50	1105.50	0.00	2388.	4000.
Dimpton	50.00	71.91	909.31	909.31	0.00	1580.	2000.
					TOTAL Power:	3967.	6000.

********** PUMP AND DRIVER DATA **********

PumpSta.	Config.	Pump Curves	Status	Driver	RPM	Pump BHP	HPInstalled
Compton	Parallel	COMPTON.PMP	ON	Motor	3,500.	1,193.84	2000
		COMPTON.PMP	ON	Motor	3,500.	1,193.84	2000
Dimpton	Parallel	DIMPTON.PMP	ON	VSDMotor	3,694.	1,579.80	2000

Pump Station: Compton
Pump curve file: C:\SYSTEK\LIQTHERM\COMPTON.PMP
Constant Speed Pumps: 3,500. RPM
Pump curve: C:\SYSTEK\LIQTHERM\COMPTON.PMP Pump Status:ON

Flow rate (gal/min)	Head (ft)	Efficiency% (%)
0	3185	0.1
400	3150	34.5
600	3135	46.4
800	3100	55.7
1200	3035	64.3
1600	2900	78
2000	2690	81.2
2400	2350	79.3
2700	2100	76
3000	1800	72

Combined Pump Curve: Compton Pump station
Constant Speed Pumps: 3,500. RPM

Flow rate (gal/min)	Head (ft)	Efficiency (%)
0.01	3185.00	0.01
800.00	3150.00	34.50
1200.00	3135.00	46.40
1600.00	3100.00	55.70
2400.00	3035.00	64.30
3200.00	2900.00	78.00
4000.00	2690.00	81.20
4800.00	2350.00	79.30
5400.00	2100.00	76.00
6000.00	1800.00	72.00

Pump Station: Dimpton
Rated Pump speed:3500 RPM
Minimum speed: 2000 RPM
Maximum speed: 4000 RPM
Pump curve: C:\SYSTEK\LIQTHERM\DIMPTON.PMP Pump Status:ON

Flow rate (gal/min)	Head (ft)	Efficiency% (%)
0	3140	0.01
400	3160	34.3
800	3140	57.5
1200	3120	72
1600	2820	79
1900	2560	80
2000	2460	79.8
2400	2060	76
3000	1680	65.7

Combined Pump Curve: Dimpton Pump station
Pump speed required: 3,694. RPM
Percentage of rated speed: 105.55%
Percentage of Maximum speed: 92.35%

Flow rate (gal/min)	Head (ft)	Efficiency (%)
0.01	3497.86	0.01
422.18	3520.14	34.30
844.36	3497.86	57.50
1266.54	3475.58	72.00
1688.71	3141.39	79.00
2005.35	2851.76	80.00
2110.89	2740.36	79.80
2533.07	2294.77	76.00
3166.34	1871.47	65.70

********** PIPELINE PROFILE DATA **********

Distance (mi)	Elevation (ft)	Diameter (in)	Wall Thk. (in)	Roughness (in)	MAOP (psi)	Location
0.0000	100.00	14.000	0.250	0.0018	1170.	Compton
10.0000	250.00	14.000	0.250	0.0018	1170.	
25.0000	320.00	14.000	0.250	0.0018	1170.	
35.0000	485.00	14.000	0.250	0.0018	1170.	
40.0000	500.00	14.000	0.250	0.0018	1170.	
50.0000	389.00	14.000	0.250	0.0018	1170.	Dimpton
65.0000	180.00	14.000	0.250	0.0018	1170.	
75.0000	286.00	14.000	0.250	0.0018	1170.	
80.0000	320.00	14.000	0.250	0.0018	1170.	
100.0000	190.00	14.000	0.250	0.0018	1170.	Harvard

********** ISOTHERMAL CALCULATIONS ONLY - THERMAL EFFECTS IGNORED **********

********** VELOCITY, REYNOLD'S NUMBER AND PRESSURE DROP **********

Distance (mi)	Diameter. (in)	FlowRate (bbl/day)	Velocity (ft/sec)	Reynolds number	Press.drop (psi/mi)	Location
0.00	14.00	85,000.00	5.55	38,716.	18.61	Compton
10.00	14.00	85,000.00	5.55	38,716.	18.61	
25.00	14.00	85,000.00	5.55	38,716.	18.61	
35.00	14.00	85,000.00	5.55	38,716.	18.61	
40.00	14.00	85,000.00	5.55	38,716.	18.61	
50.00	14.00	85,000.00	5.55	38,716.	18.61	Dimpton
65.00	14.00	85,000.00	5.55	38,716.	18.61	
75.00	14.00	85,000.00	5.55	38,716.	18.61	
80.00	14.00	85,000.00	5.55	38,716.	18.61	
100.00	14.00	85,000.00	5.55	38,716.	18.61	Harvard

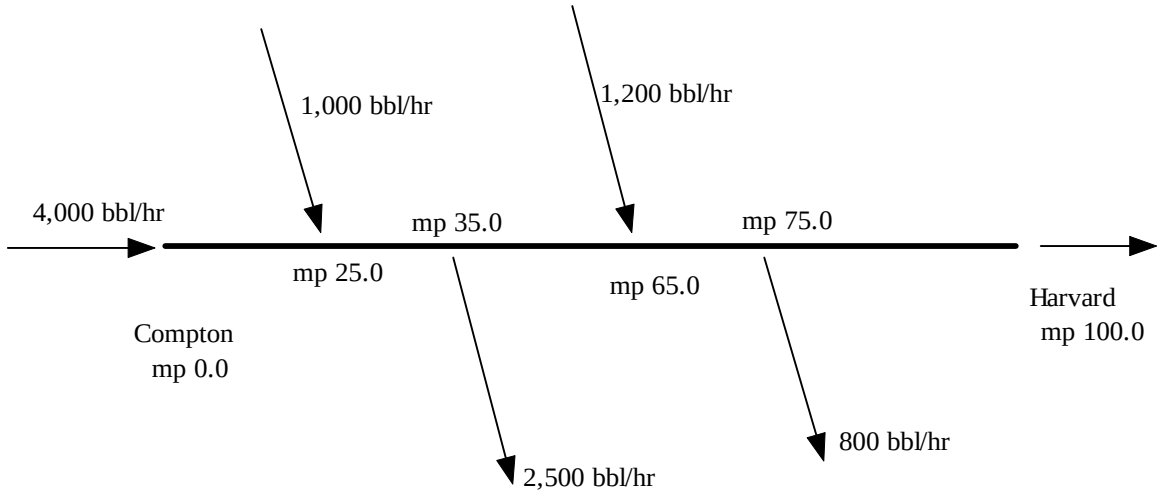
********** TEMPERATURE AND PRESSURE PROFILE **********

Distance (mi)	Elevation (ft)	FlowRate (bbl/day)	Temperature (degF)	SpGrav --	Viscosity CST	Pressure (psi)	MAOP (psi)	Location Name
0.00	100.00	85,000.00	100.00	0.8250	15.00	25.00	1170.00	Compton
0.00	100.00	85,000.00	100.00	0.8250	15.00	1105.50	1170.00	Compton
10.00	250.00	85,000.00	100.00	0.8250	15.00	865.85	1170.00	
25.00	320.00	85,000.00	100.00	0.8250	15.00	561.74	1170.00	
35.00	485.00	85,000.00	100.00	0.8250	15.00	316.74	1170.00	

40.00	500.00	85,000.00	100.00	0.8250	15.00	218.34	1170.00	
50.00	389.00	85,000.00	100.00	0.8250	15.00	71.91	1170.00	Dimpton
50.00	389.00	85,000.00	100.00	0.8250	15.00	909.31	1170.00	Dimpton
65.00	180.00	85,000.00	100.00	0.8250	15.00	704.84	1170.00	
75.00	286.00	85,000.00	100.00	0.8250	15.00	480.90	1170.00	
80.00	320.00	85,000.00	100.00	0.8250	15.00	375.72	1170.00	
100.00	190.00	85,000.00	100.00	0.8250	15.00	50.00	1170.00	Harvard

Sample Problem–2

This is similar to the previous problem. All pipeline and pump station data remain the same. Instead of a single inlet flow of 85,000 bbl/day, the following liquid flow injections and deliveries are present along the pipeline:



Location Milepost	Flow rate bbl/hr	Type	Temperature deg F	Product
0.0	4,000	injection	60	ANSCrude
25.0	1,000	injection	60	XYZCrude
35.0	2,500	delivery		
65.0	1,200	injection	60	Product-A
75.0	800	delivery		

Determine the pressure profile and HP required for the pipeline above. The liquid properties for XYZCrude and Product-A are found in the **Liquid Database screen**.

```
DATE: 25-May-2006            TIME:  11:04:19

PROJECT:                     Sample Problem-2
                             14 inch pipeline 100 miles long from Compton to Harvard
                            With Injection and deliveries

Pipeline data file:          C:\SYSTEK\LIQTHERM\MYPIPE001

******* LIQTHERM - LIQUID PIPELINE STEADY STATE HYDRAULIC SIMULATION ********
****************** LITE Version 5.90.950  *************

CASE NUMBER:                           1005

CALCULATION OPTIONS:
Isothermal Calculations:               YES
Use Pump Curves:                       YES
MAOP Check:                            YES
Horsepower Check:                      NO
Maximum Inlet Flow:                    NO
Slack Line Calculations:               NO
Customized Output:                     NO

********** ISOTHERMAL CALCULATIONS ONLY  *************

Inlet flow rate:                       3,221.    (bbl/hr)
Outlet flow rate:                      2,121.    (bbl/hr)
Inlet flow temperature:                60.00     (degF)
Outlet flow temperature:               60.00     (degF)

Minimum Pipe pressure:                 10.00     (psi)
Pipe delivery pressure:                50.00     (psi)


Pressure drop formula used:            Colebrook-White equation


********** LIQUID PROPERTIES **********

PRODUCT:                     ANSCrude
Specific gravity:            0.8950 at  60.0(degF)
                             0.8250 at  100.0(degF)

Viscosity:                   43.00 Centistokes at 60.0(degF)
                             15.00 Centistokes at 100.0(degF)


PRODUCT:                     XYZ Crude
Specific gravity:            0.8000 at  70.0(degF)
                             0.7500 at  100.0(degF)

Viscosity:                   25.00 Centistokes at 60.0(degF)
                             10.00 Centistokes at 100.0(degF)



PRODUCT:                     Product-A
Specific gravity:            0.8500 at  70.0(degF)
                             0.8300 at  100.0(degF)

Viscosity:                   10.00 Centistokes at 70.0(degF)
                             5.00 Centistokes at 100.0(degF)
```

********** LIQUID FLOW RATES AND LOCATIONS **********

Location (mi)	Flow rate (bbl/hr)	Inlet Temp. (degF)	Product
0.00	3,221.	60.0	ANSCrude
25.00	1,000.	60.0	XYZ Crude
35.00	-2,500.	60.0	
65.00	1,200.	60.0	Product-A
75.00	-800.	60.0	

****** INLET FLOW RATE REDUCED DUE TO PUMP LIMITS AND/OR PIPE MAOP LIMITS ****

********** PUMP STATIONS **********

Pump station	Distance (mi)	Pump suct pressure (psi)	Pump disch pressure (psi)	Sta. disch pressure (psi)	Throttled pressure (psi)	BHP Reqd by pump	TotHPinst. (Active)
Compton	0.00	25.00	1206.68	1169.00	37.68	2481.	4000.
Dimpton	50.00	70.81	454.60	454.60	0.00	305.	2000.
				TOTAL Power:		2786.	6000.

********** PUMP AND DRIVER DATA **********

PumpSta.	Config.	Pump Curves	Status	Driver	RPM	Pump BHP	HPInstalled
Compton	Parallel	COMPTON.PMP	ON	Motor	3,500.	1,240.66	2000
		COMPTON.PMP	ON	Motor	3,500.	1,240.66	2000
Dimpton	Parallel	DIMPTON.PMP	ON	VSDMotor	2,124.	304.61	2000

Pump Station: Compton
Pump curve file: C:\SYSTEK\LIQTHERM\COMPTON.PMP
Constant Speed Pumps: 3,500. RPM
Pump curve: C:\SYSTEK\LIQTHERM\COMPTON.PMP Pump Status:ON

Flow rate (gal/min)	Head (ft)	Efficiency% (%)
0	3185	0.1
400	3150	34.5
600	3135	46.4
800	3100	55.7
1200	3035	64.3
1600	2900	78
2000	2690	81.2
2400	2350	79.3
2700	2100	76
3000	1800	72

Combined Pump Curve: Compton Pump station
Constant Speed Pumps: 3,500. RPM

Flow rate (gal/min)	Head (ft)	Efficiency (%)
0.01	3185.00	0.01
800.00	3150.00	34.50
1200.00	3135.00	46.40
1600.00	3100.00	55.70
2400.00	3035.00	64.30
3200.00	2900.00	78.00
4000.00	2690.00	81.20
4800.00	2350.00	79.30
5400.00	2100.00	76.00
6000.00	1800.00	72.00

Pump Station: Dimpton
Rated Pump speed:3500 RPM
Minimum speed: 2000 RPM
Maximum speed: 4000 RPM
Pump curve: C:\SYSTEK\LIQTHERM\DIMPTON.PMP Pump Status:ON

Flow rate (gal/min)	Head (ft)	Efficiency% (%)
0	3140	0.01
400	3160	34.3
800	3140	57.5
1200	3120	72
1600	2820	79
1900	2560	80
2000	2460	79.8
2400	2060	76
3000	1680	65.7

Combined Pump Curve: Dimpton Pump station
Pump speed required: 2,124. RPM
Percentage of rated speed: 60.70%
Percentage of Maximum speed: 53.11%

Flow rate (gal/min)	Head (ft)	Efficiency (%)
0.01	1156.56	0.01
242.77	1163.93	34.30
485.52	1156.56	57.50
728.29	1149.20	72.00
971.05	1038.70	79.00
1153.11	942.93	80.00
1213.82	906.10	79.80
1456.56	758.76	76.00
1820.72	618.80	65.70

********** PIPELINE PROFILE DATA **********

Distance (mi)	Elevation (ft)	Diameter (in)	Wall Thk. (in)	Roughness (in)	MAOP (psi)	Location
0.0000	100.00	14.000	0.250	0.0018	1170.	Compton
10.0000	250.00	14.000	0.250	0.0018	1170.	
25.0000	320.00	14.000	0.250	0.0018	1170.	
35.0000	485.00	14.000	0.250	0.0018	1170.	
40.0000	500.00	14.000	0.250	0.0018	1170.	
50.0000	389.00	14.000	0.250	0.0018	1170.	Dimpton
65.0000	180.00	14.000	0.250	0.0018	1170.	
75.0000	286.00	14.000	0.250	0.0018	1170.	
80.0000	320.00	14.000	0.250	0.0018	1170.	
100.0000	190.00	14.000	0.250	0.0018	1170.	Harvard

********** ISOTHERMAL CALCULATIONS ONLY - THERMAL EFFECTS IGNORED **********

********** VELOCITY, REYNOLD'S NUMBER AND PRESSURE DROP **********

Distance (mi)	Diameter. (in)	FlowRate (bbl/hr)	Velocity (ft/sec)	Reynolds number	Press.drop (psi/mi)	Location
0.00	14.00	3,220.55	5.05	12,281.	21.94	Compton
10.00	14.00	3,220.55	5.05	12,281.	21.94	
25.00	14.00	4,220.55	6.61	18,410.	33.35	
35.00	14.00	1,720.55	2.70	7,505.	6.99	
40.00	14.00	1,720.55	2.70	7,505.	6.99	
50.00	14.00	1,720.55	2.70	7,505.	6.99	Dimpton
65.00	14.00	2,920.55	4.58	20,189.	15.47	
75.00	14.00	2,120.55	3.32	14,659.	8.82	
80.00	14.00	2,120.55	3.32	14,659.	8.82	
100.00	14.00	2,120.55	3.32	14,659.	8.82	Harvard

********** TEMPERATURE AND PRESSURE PROFILE **********

Distance (mi)	Elevation (ft)	FlowRate (bbl/hr)	Temperature (degF)	SpGrav --	Viscosity CST	Pressure (psi)	MAOP (psi)	Location Name
0.00	100.00	3,220.55	60.00	0.8950	43.00	25.00	1170.00	Compton
0.00	100.00	3,220.55	60.00	0.8950	43.00	1169.00	1170.00	Compton
10.00	250.00	3,220.55	60.00	0.8950	43.00	891.50	1170.00	
25.00	320.00	4,220.55	60.00	0.8766	37.59	535.31	1170.00	
35.00	485.00	1,720.55	60.00	0.8766	37.59	139.22	1170.00	
40.00	500.00	1,720.55	60.00	0.8766	37.59	98.58	1170.00	
50.00	389.00	1,720.55	60.00	0.8766	37.59	70.81	1170.00	Dimpton
50.00	389.00	1,720.55	60.00	0.8766	37.59	454.60	1170.00	Dimpton
65.00	180.00	2,920.55	60.00	0.8685	23.72	429.07	1170.00	
75.00	286.00	2,120.55	60.00	0.8685	23.72	234.50	1170.00	
80.00	320.00	2,120.55	60.00	0.8685	23.72	177.60	1170.00	
100.00	190.00	2,120.55	60.00	0.8685	23.72	50.00	1170.00	Harvard