

PUMPCALC

Centrifugal Pump Performance

User Manual



www.systemek.us

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1. Introduction

PUMPCALC is a software program that is used to analyze the performance of centrifugal pumps. Several features are available for predicting pump performance from pump manufacturer's performance curves as follows:

- Single pump performance - Impeller size and speed changes
- Multiple Pump Performance - Series and Parallel Configuration
- Viscosity Corrected Pump Performance - Based on Hydraulic Institute method.
- Pump Head Curve versus Pipe System Head Curve - Operating point

Using Affinity Laws, the performance of a centrifugal pump at different impeller diameters, speeds and stages can be calculated from the manufacturer's pump curve data. For a given pump, the speed or diameter required to meet a specific design condition can also be calculated. Performance of pumps in series and parallel can be predicted. For high viscosity liquids, the water performance curve is used in conjunction with the Hydraulics Institute's charts to estimate the viscosity corrected pump performance. The resultant performance curves may be plotted on the screen as well as on a printer. For a pump-piping system, based on the pipeline diameter, length and elevations, the system head curves for the pipeline can be generated for given liquid properties at different flow rates. Using this data, the point of intersection of the pump head curve and the pipeline system curve can be determined. Minor pressure drops due to valves, fittings and other custom devices, such as meters, filters etc. may be included in the system head calculations. Screen graphics of the combined pump performance is also generated.

The input data for pump curves consist of selected capacity (flow rate), head, and efficiency points from the manufacturer's pump performance curve. For calculating the pipe system head curve, the pipeline data (distance, elevation, diameter, wall thickness) are input to create a data file. In addition, the liquid specific gravity, viscosity, pipe roughness, pump suction pressure, pipe delivery pressure and the maximum allowable pipe pressure are also input. Hydraulic calculations for pipe system head are based on isothermal flow conditions, using one of the selected pressure drop formulas, such as Hazen Williams or Colebrook-White equations.

Introduction

The output from the Pump Head Curve versus Pipe System Head Curve option consists of the pump operating flow rate, discharge pressure, efficiency and horsepower at the operating flow. In addition, the combined pump performance data and the individual pump flow rates and pressures are also output. Screen and printer graphics of the combined pump curve and system head curve are also generated.

English and SI-Metric units of calculation are available.

This software can be run on Pentium and Athlon based computers and compatibles with a minimum of 1 GB RAM running Microsoft Windows 2000/XP/Vista or Windows 7 operating systems. A minimum hard disk space of 20 MB is required for installing the program.

The software is licensed for use on one computer, at a time. Licensing employs an internet based authentication or use of a hardware key (dongle) known as KEYLOK. Network and multi-user licenses are available.

2. Getting Started

The software program is supplied on a CD-ROM that must be installed on your computer's hard disk as described below. If you purchased a USB dongle version (hardware key) follow the installation steps under section 2.1 below. However, if you have an internet authenticated version of the program that does not use a dongle follow the steps under section 2.2.

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.

2.1 Installation – USB dongle version

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. This dongle, shown in the figure below, *must* be in place for the software to operate properly. **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.

*The software will work **only** with the specific USB dongle included with the program CD. If this is an upgrade to the program, you will continue to use the original USB dongle when you first purchased the software. 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.

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.

Getting Started

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 CD 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.

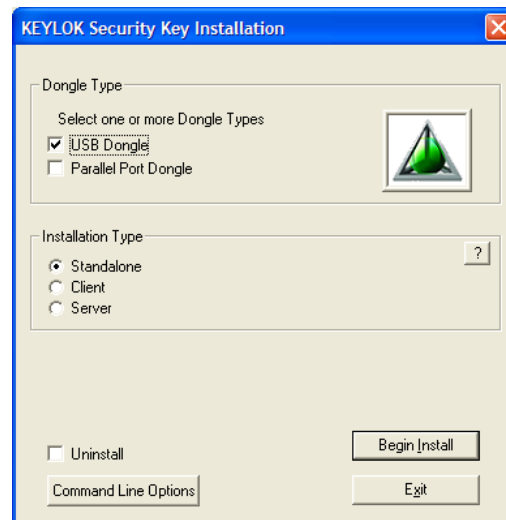
Follow the subsequent screen instructions to continue with the installation process.

Step-2:

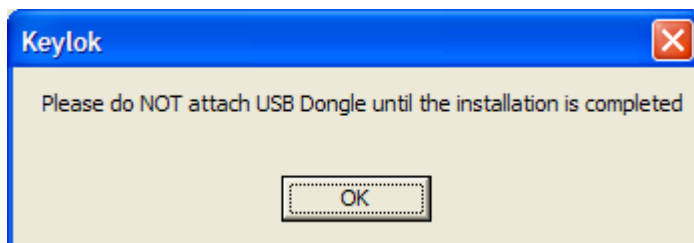
After the software is installed, the Dongle Installation will automatically start.

Do not attach the dongle until after the dongle installation step is completed.

Initially, the screen below is displayed:

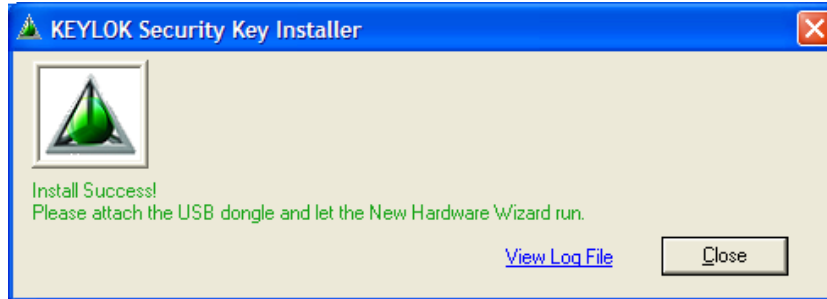


Choose the **USB Dongle** type and **Standalone** installation type as shown and click **Begin Install**. Next, the following screen is displayed. Click OK to confirm.



Getting Started

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 PUMPCALC 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 one year from the date of purchase. After this 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.

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.

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.

2.2 Installation – Internet Authenticated Version

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 CD 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.

2.3 Retaining/Releasing - Internet Authenticated Version

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 PUMPCALC folder.

2.4 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.**

2.5 Un-installation

Prior to uninstalling **PUMPCALC**, save all data files (TOT files), Liquid properties database, and simulation reports that you may need for later use. To **uninstall** the software from the hard disk, go to the Windows **Start button** and choose **Settings**. Next select the **Control Panel** and click on **Add/Remove** Programs. Follow subsequent instruction to uninstall **PUMPCALC**.

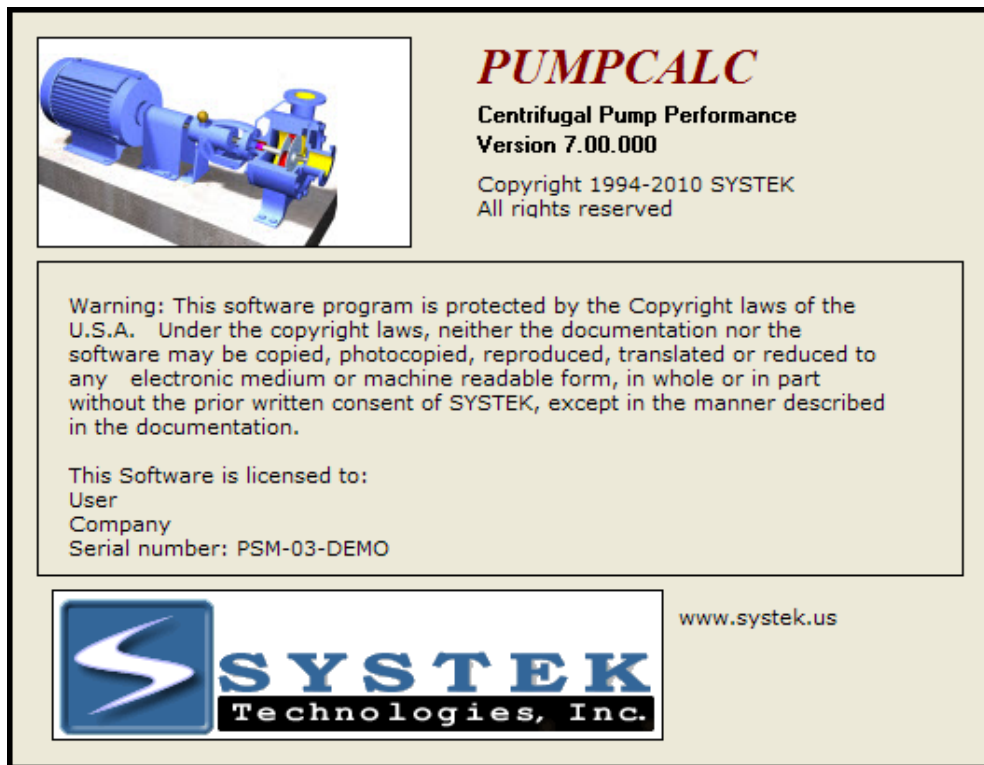
*You can no longer run the program, until you **re-install** it again as described in the Installation section.*

Put your original program disk away safely.

3. Running PUMPCALC

Start PUMPCALC by clicking on the program icon, or from the Start button choose Programs and select the PUMPCALC program.

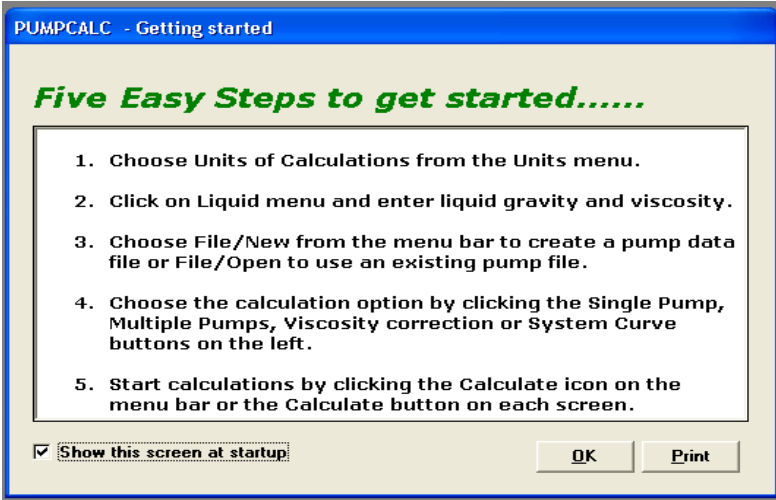
PUMPCALC will be loaded and the screen will display the main program window and licensed user information as shown below:



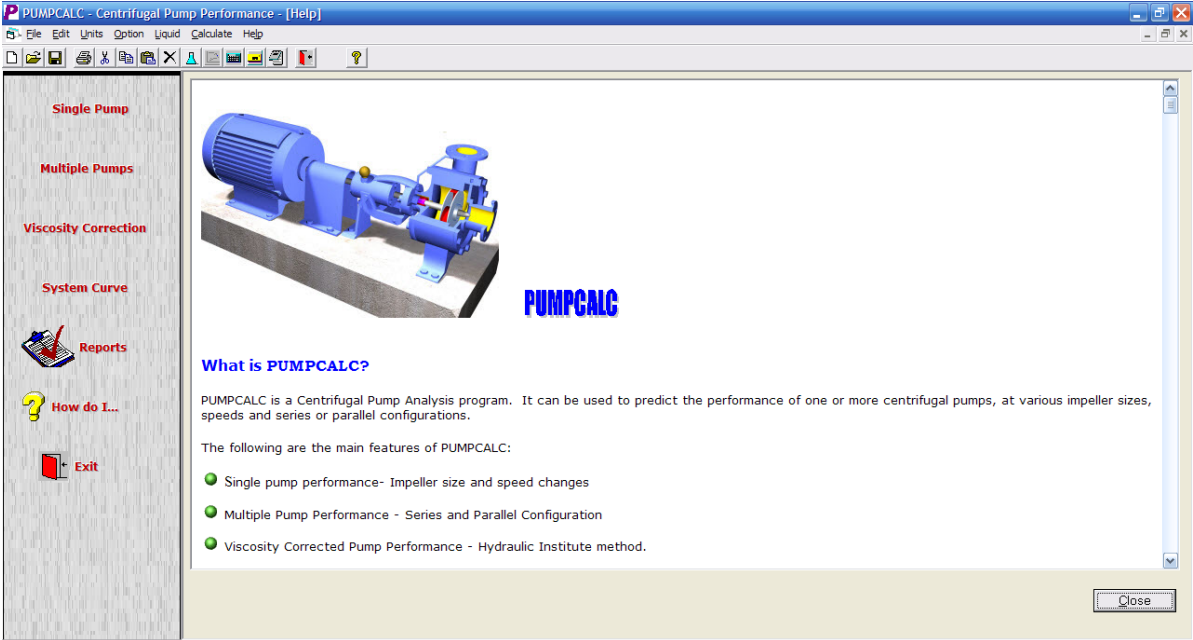
This screen shows the program version number, serial number and licensed user information. You may access this screen any time by choosing the pull down menu **Help/About** from the main program window.

Running PUMPCALC

After the **About** screen containing the program version and licensed user information is displayed, the main PUMPCALC window with **Five Easy Steps** will appear as shown below.



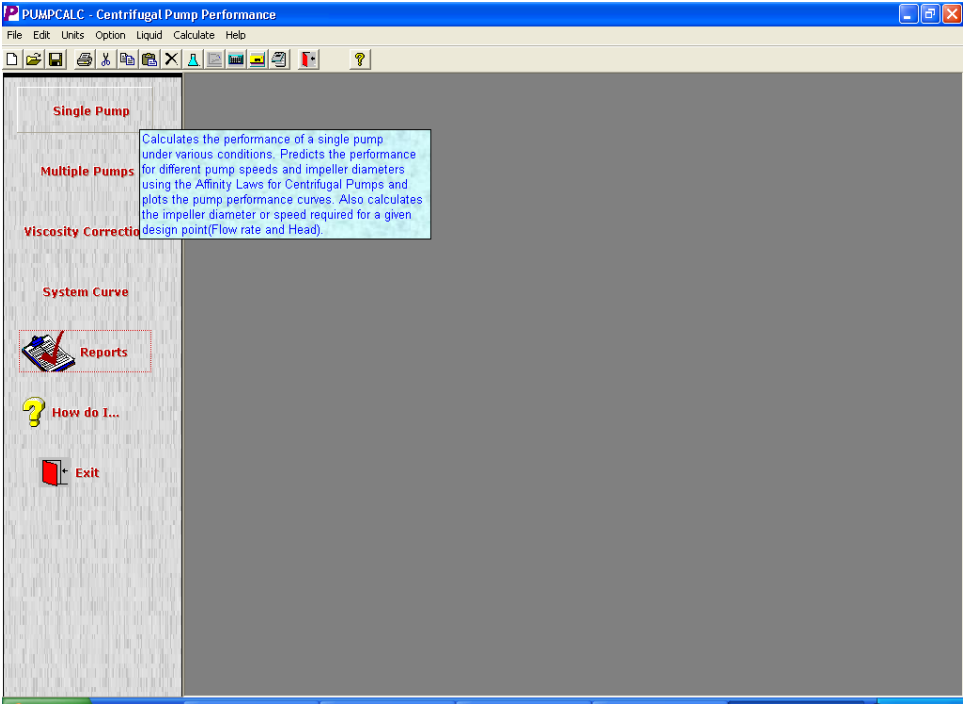
This is followed by the General Help screen.



Running PUMPCALC

In the screen above, the buttons titled **Single Pump**, **Multiple Pumps**, etc. are used to quickly access the calculation options. These same options are also available under the top menu bar item titled **Option**.

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



Running PUMPCALC

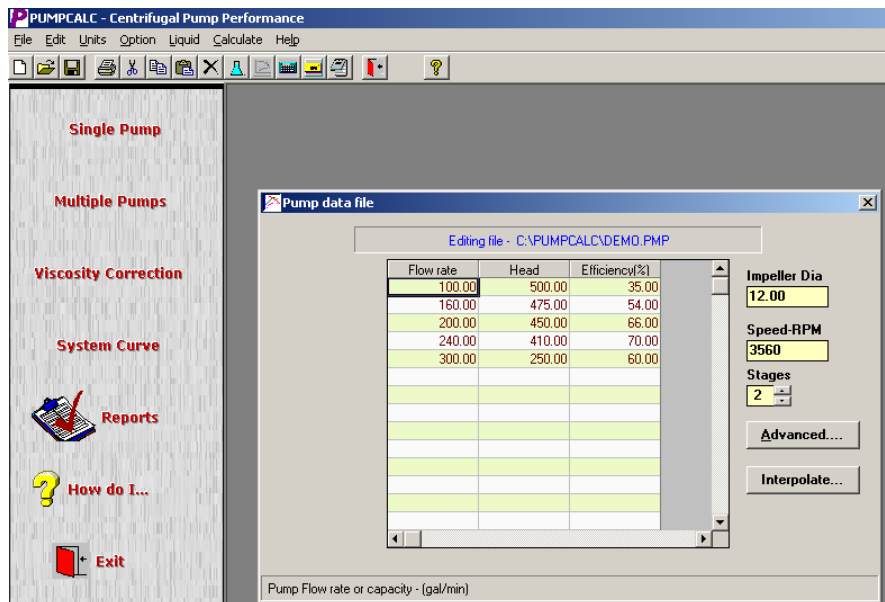
The pull down menu under **File** has the following options as shown below.

- New** - To create a pump data file.
- Open** - To open and edit an existing data file.
- View** - To view the results of a calculation
- Save** - To save a new or existing data file.
- Save As** - To save a data file under a new name.
- Close** - To close a data file.
- Plot** - To plot the pump curve data
- Print** - To print a data file.
- Exit** - Quit the program.

The pull down menu under **Edit** shown below, has the following choices:

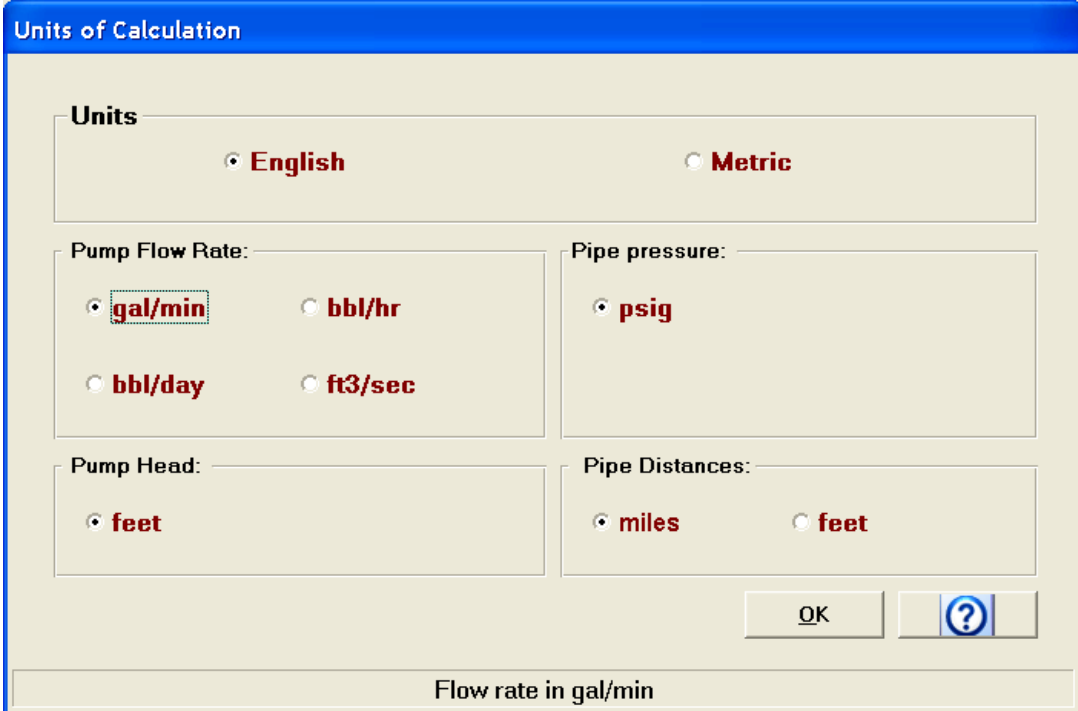
- Copy** - To copy data from file to Windows Clipboard.
- Cut** - To remove data from file to Clipboard.
- Paste** - To insert the data from Clipboard to file.
- Paste Special** - To paste from an Excel spreadsheet
- Insert row** - To insert a new row in the data file.
- Delete row** - To delete a row in the data file.

These choices under the **Edit** menu are used while editing the pump curve data in a spreadsheet as shown below:



Running PUMPCALC

The pull down menu under **Units** provides the following dialog box for specifying the units used in calculations.



The dialog box, titled "Units of Calculation", is used to specify units for calculations. It features a "Units" section with radio buttons for "English" (selected) and "Metric". Below this are four sections for specific units: "Pump Flow Rate" with options gal/min (selected), bbl/hr, bbl/day, and ft3/sec; "Pipe pressure" with the option psig (selected); "Pump Head" with the option feet (selected); and "Pipe Distances" with options miles (selected) and feet. At the bottom right are "OK" and "?" buttons. A status bar at the bottom indicates "Flow rate in gal/min".

This screen is used to choose English or SI-Metric units for calculations. In English units, pipeline distances have to be in either miles or feet. Flow rates for English units can be either gallons/minute, barrels/hour, barrels/day or cubic feet/second. *The pump curve data must match the flow units.* If gal/min is selected from the above screen, the pump curve information in the data files must also be in gal/min. The pipeline flow rate will also be gal/min.

Running PUMPCALC

For SI-Metric units, options for distance are kilometer or meter. Flow rates may be in cubic meter/hour or liter/second. Selection is made by clicking the mouse or using the cursor key to select the appropriate button.

Units of Calculation

Units

English Metric

Pump Flow Rate:

m3/hr litre/sec

Pipe pressure:

kPa MPa
 Bar kg/cm2

Pump Head:

metre

Pipe Distances:

km metre

OK ?

Pipe pressure in kPa

In English units, pipe pressures are input in psig.
In SI-Metric units, they are expressed in kilopascal (kPa), MegaPascal (MPa), Bar or Kg/cm²

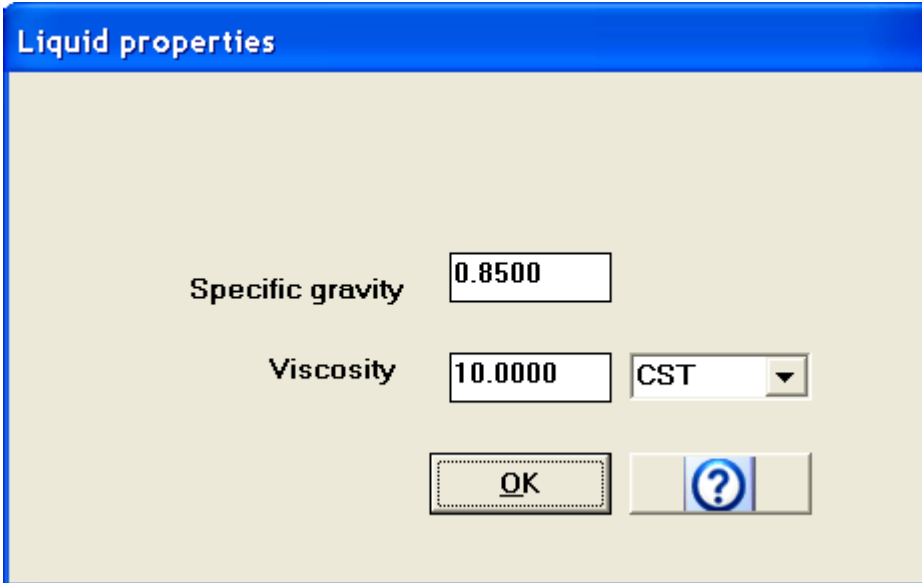
Running PUMPCALC

The pull down menu under **Option** has the following choices:

Single pump	- Single pump performance.
Multiple pumps	- Multiple pump performance.
Viscosity correction	- Viscosity corrected performance.
Pump curve-system head curve	- Pipe system head curves.

As mentioned earlier, the four buttons titled **Single Pump, Multiple Pumps,** etc on the main screen duplicate the function of the above menu items. These buttons are used to quickly access the Calculation options described above.

Clicking the "beaker" icon on the tool bar or choosing the menu bar item **Liquid**, displays the following screen for entering the liquid properties.



The screenshot shows a dialog box titled "Liquid properties". It contains two input fields: "Specific gravity" with the value "0.8500" and "Viscosity" with the value "10.0000". To the right of the viscosity field is a dropdown menu currently showing "CST". At the bottom, there are two buttons: "OK" and a help button with a question mark icon.

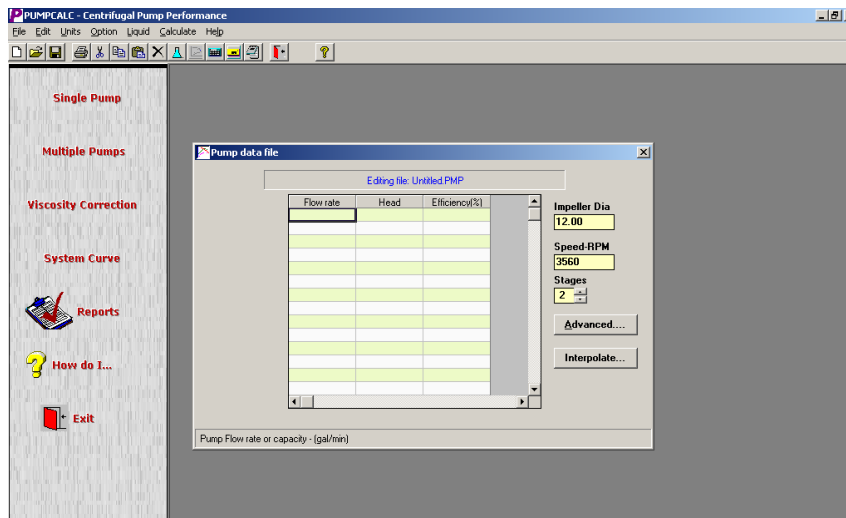
The specific gravity and viscosity of the liquid at flowing temperature are entered here. Specific gravity is always entered as decimal value and viscosity is input in centistokes, centipoise, SSU or SSF. Choose the viscosity units from the drop down list.

3.1 Creating and Editing Pump Data Files

Pump performance curve data and pipeline data are created and stored as ASCII Text files for subsequent use in PUMPCALC. These data files have to be created using the spreadsheet style data entry screens. The creating and editing of data files will be covered in this section.

Since the pump curve data file forms the central part of PUMPCALC, we will cover this first.

To create a new pump data file, choose **File/New** from the menu bar or click the **New file** icon on the toolbar. If you choose **Pump file** for File type from the next screen, a blank spreadsheet containing three columns is displayed, as shown below.



Enter the Capacity (flow rate), head and efficiency values from the manufacturer's pump performance curve. Make sure that you choose the full range of flow rates, beginning at the zero flow rate (shut-off head point) and extending all the way to the trailing end of the head curve. The total number of points cannot exceed 15 sets of data (15 rows of spreadsheet data). Also, the flow rate values in the first column should be sequential and in **ascending** order. In addition to the Flow rate, Head and Efficiency you may also specify the pump impeller size, speed and the number of stages in this pump. After entering all data, choose **File/Save** from the menu bar and save the pump curve data in a file name of your choice, such as Pump123. The filename extension **.PMP** is automatically appended.

Running PUMPCALC

The **Advanced...** button in the screen above is for entering a single design point data for a pump, in order to create a typical pump curve. For example, if the desired design point is at 1000 gal/min, 2500 ft head at 80% efficiency, you may enter this data for PUMPCALC to automatically create a pump curve based on this design point, as shown in screen below.

Flow rate: 1000

Head: 2500

Efficiency%: 80

File name: NewPump

Buttons: Browse, Create file, Cancel

Footer: Pump curve file name

After entering data for the design point as above, and selecting a name for the pump file, click the **Create file** button. PUMPCALC will automatically create a pump curve for the design point specified as indicated in the screen on the next page. It can be seen that the pump curve data have been created around the best efficiency point (BEP) specified above.

Running PUMPCALC

From this screen, you may interpolate the pump curve data for different flow rates. For example, at the flowrate of 600 and 1500 gpm, the interpolated head and efficiency are 3135.00 ft and 46.40 % for 600 gpm and 2939.91 ft and 76.22 % for 1500 gpm respectively. The brake horsepower for water is also calculated and displayed as indicated above.

Note the following when creating or editing pump curve files:

- A minimum of three sets of pump curve data (flow rate/head /efficiency) must be input.
- All values input from the pump curve shall be non-zero. Otherwise, an ERROR message will appear. For example, shut-off head should be input at some very low flow rate (such as 0.01 gpm).
- The various points selected from the pump curve as input data should include the full range of pump flow rates permissible, from shutoff head to the last point on the head curve.

3.2 Creating and Editing Pipe Data Files

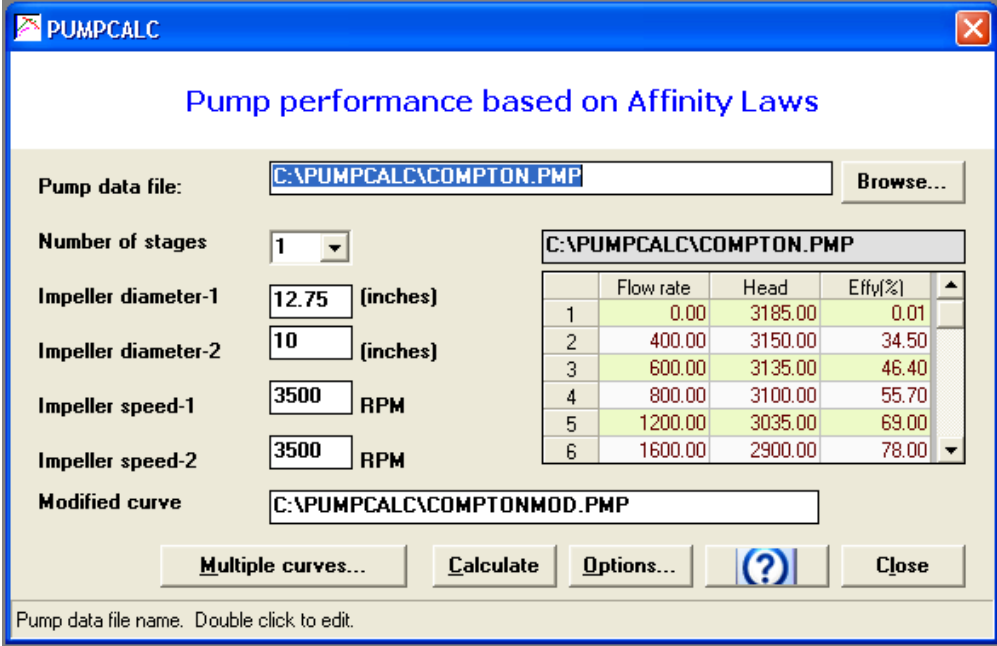
Pipe data files are used for the calculation of System Head Curves. The creation and editing of pipe data files will be described next. To create a new pipe data file, choose **System Curve** from the left panel. Next choose **Use Pipe Data** and double click on the filename, a spreadsheet containing five columns is displayed.

These five columns are for entering the pipe data. Enter the pipe line information such as distance, elevation, pipe diameter, wall thickness and pipe roughness (default = 0.002 inches) under appropriate columns. The total number of points cannot exceed 99 sets of data (99 rows of spreadsheet data). Also, the distance values in the first column should be sequential and in ***ascending*** order. Once the data points are entered, you may save the data using **File/Save As**.

The filename extension for pipe data file must be .DAT. As described above for pump files, the pipe data file name must be a valid file name with the DAT extension. Thus `Pipe123.dat` and `MyPipeline.dat` are both valid pipe file names.

3.3 Single Pump Performance

When the **Single pump** option is chosen, the following input screen is displayed. This is for entering the data necessary for analyzing the performance of a single pump at different speeds or impeller sizes.

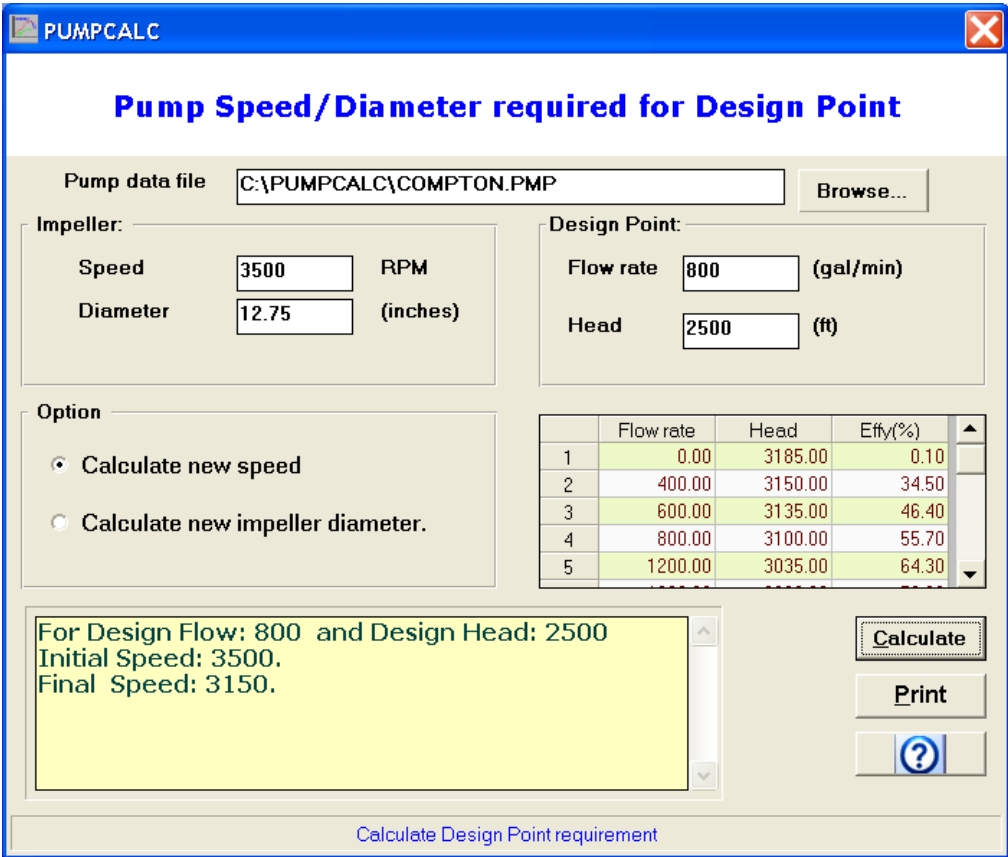


Using the **Single pump** option described earlier, the given pump performance data (flow rate, head and efficiency and pump impeller size, speed, stages, etc) from the pump manufacturer’s curve, the performance at different impeller speeds, diameter and stages are calculated, using Affinity Laws. The resultant pump performance data is saved in a file and can be plotted.

3.4 Design Point Option

Another calculation option for the **Single pump** option includes determining the pump speed or impeller size required to meet a specific design condition, such as flow rate and head.

By clicking on the **Options...** button in the previous screen, the following screen is displayed. This is for entering the data needed to calculate the requirements for a specific design point as shown below.



To satisfy a specific Design Point, such as 800 gal/min at 2500 ft head as seen in the screen above, the impeller diameter may be fixed and the corresponding pump speed calculated to meet the design requirements as shown above.

Running PUMPCALC

Alternatively, the pump speed may be fixed and the necessary impeller diameter calculated, by selecting the appropriate Option button as shown below.

The screenshot shows the PUMPCALC software window with the title "Pump Speed/Diameter required for Design Point". The interface includes a "Pump data file" field set to "C:\PUMPCALC\COMPTON.PMP" with a "Browse..." button. Below this are two main sections: "Impeller:" and "Design Point:".

Impeller:

- Speed: 3500 RPM
- Diameter: 12.75 (inches)

Design Point:

- Flow rate: 800 (gal/min)
- Head: 2500 (ft)

Option:

- Calculate new speed
- Calculate new impeller diameter.

A table displays performance data for various flow rates:

	Flow rate	Head	Effy(%)
1	0.00	3185.00	0.10
2	400.00	3150.00	34.50
3	600.00	3135.00	46.40
4	800.00	3100.00	55.70
5	1200.00	3035.00	64.30

At the bottom, a text box displays the results: "For Design Flow: 800 and Design Head: 2500", "Initial impeller diameter: 12.75", and "Final impeller diameter: 11.48". To the right of this box are buttons for "Calculate", "Print", and a help icon. The status bar at the bottom reads "Calculate Design Point requirement".

Running PUMPCALC

In addition, **Single pump** option has a **Multiple curves..** button. Clicking this button causes the following screen to be displayed.

Pump performance - Affinity Laws

Performance at Different Impeller Diameter/Speeds

Pump data file: C:\PUMPCALC\COMPTON.PMP

Impeller diameter: 12.75 (in) Number of stages: 1

Impeller speed: 3500 (RPM)

Select Option:

- At different impeller diameters
- At different impeller Speeds

	Diameter
1	12.75
2	10.00
3	14.00
4	

OK ? Close

Enter upto 4 impeller diameters to plot performance curves

This option lets you calculate, from a given pump curve data at a particular impeller diameter (or speed), the head versus capacity curves for different impeller diameters (or speeds).

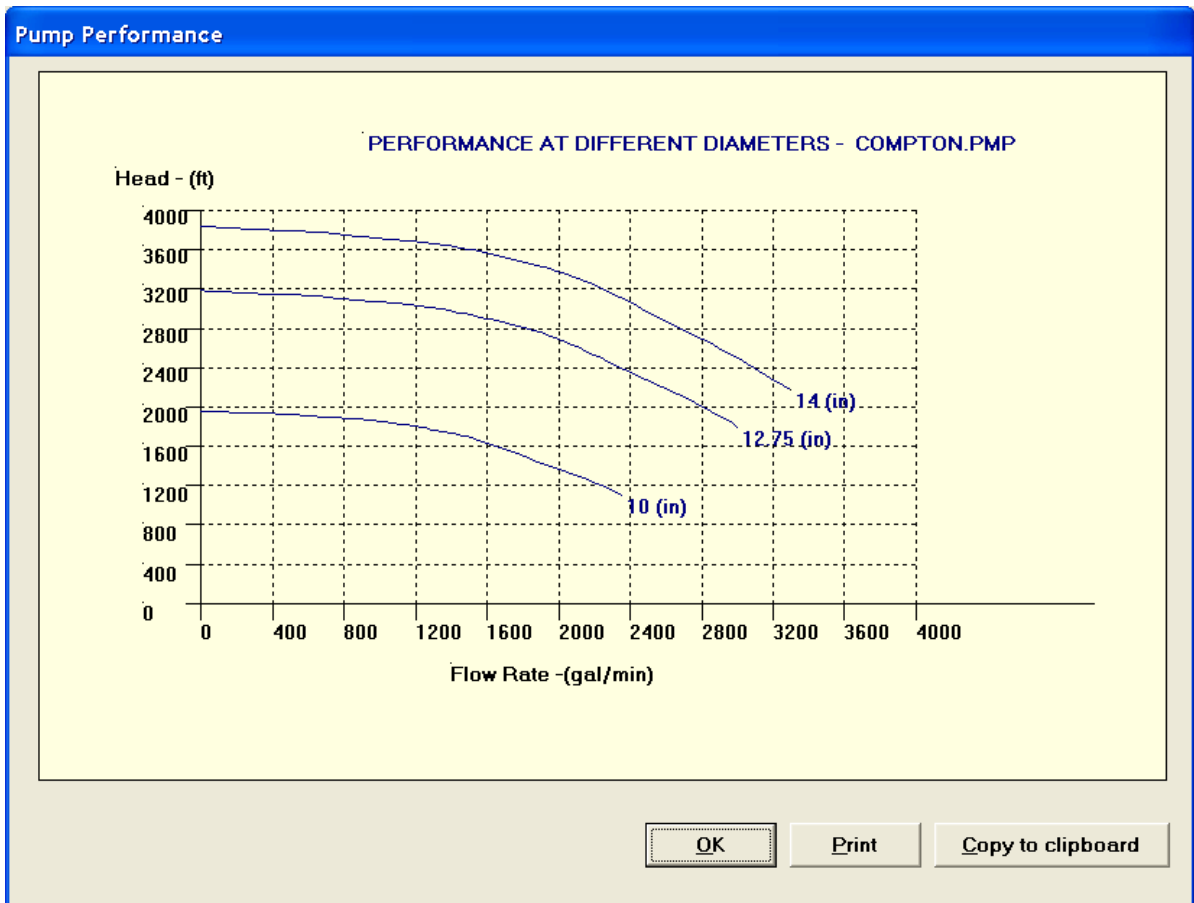
Enter the base impeller size and speed the pump curve is based on and specify up to four impeller sizes at which the pump performance is desired.

If the pump curve data is per stage, then enter the number of stages as well. Else, leave the pump stages at one.

Using Affinity Laws, the performance at the different impeller diameters (or speeds) will be calculated, saved and plotted.

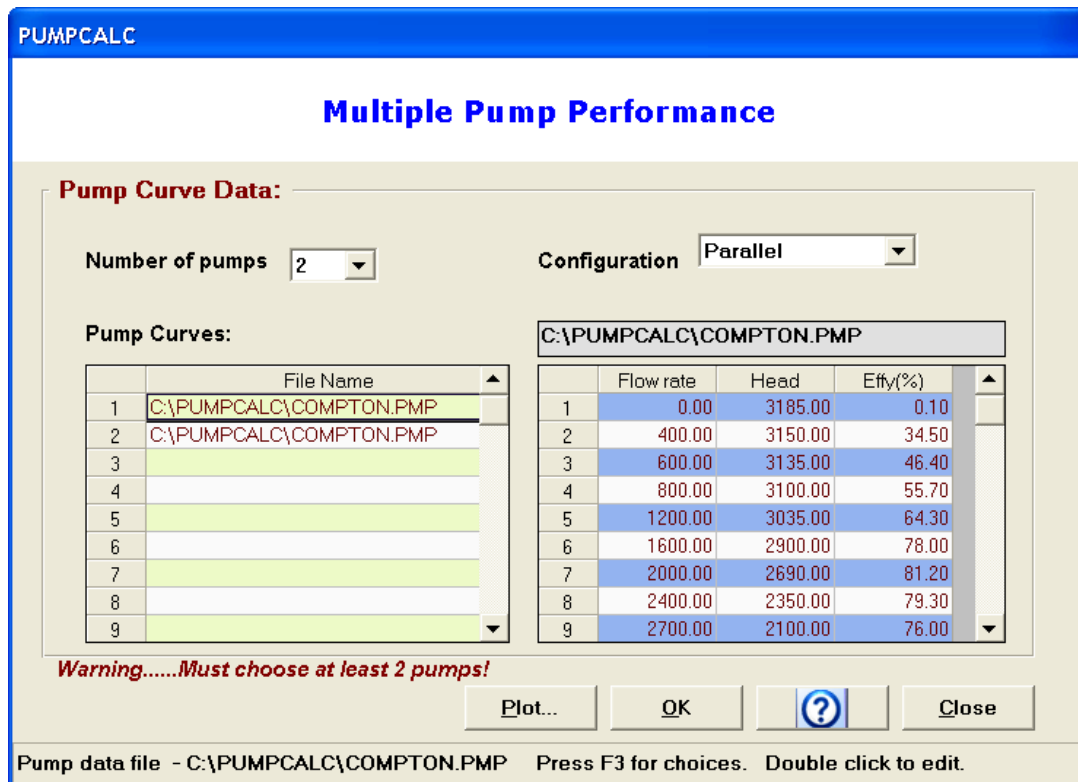
Running PUMPCALC

Click on OK and the following screen displays the results.



3.5 Multiple Pump Performance

Clicking the button titled **Multiple Pumps** on the main screen or the corresponding pull down menu item under **Option** displays the screen below for entering data needed for calculation of Multiple Pump Performance.



PUMPCALC

Multiple Pump Performance

Pump Curve Data:

Number of pumps: 2 Configuration: Parallel

Pump Curves: C:\PUMPCALC\COMPTON.PMP

	File Name	Flow rate	Head	Effy(%)
1	C:\PUMPCALC\COMPTON.PMP	0.00	3185.00	0.10
2	C:\PUMPCALC\COMPTON.PMP	400.00	3150.00	34.50
3		600.00	3135.00	46.40
4		800.00	3100.00	55.70
5		1200.00	3035.00	64.30
6		1600.00	2900.00	78.00
7		2000.00	2690.00	81.20
8		2400.00	2350.00	79.30
9		2700.00	2100.00	76.00

Warning.....Must choose at least 2 pumps!

Plot... OK ? Close

Pump data file - C:\PUMPCALC\COMPTON.PMP Press F3 for choices. Double click to edit.

Using this option, the performance of two or more pumps in series or parallel can be calculated. In the above screen, enter the file names for the pump curves. To choose the pump files, press the F3 key as indicated in the status bar of the screen above. After entering all data and choosing the pump configuration (series or parallel), click the **OK** button.

One important consideration with multiple pumps is that they should be fairly matched in performance. For pumps in series, since the flow rate through each pump will be the same, there should be a common flow range for all curves. Similarly, for parallel pumps, there must be a common range of head values to operate properly. PUMPCALC checks this before starting calculations and warns if there is a mismatch.

3.6 Viscosity Corrected Performance

Clicking the button titled **Viscosity Correct** on the main screen or the corresponding pull down menu item under **Option** displays the screen below. This is for entering data needed for calculating the viscosity corrected performance of a centrifugal pump.

The screenshot shows a software dialog box titled "PUMPCALC" with a blue header. The main title is "Viscosity Corrected Pump Performance". The dialog is divided into several sections:

- Pump Data File:** Contains two text input fields. The first is labeled "Water curve" and contains the path "C:\PUMPCALC\PUMPXYZ.PMP". To its right is a "Browse..." button. The second is labeled "Viscous curve" and contains "C:\PUMPCALC\PUMPXYZVSC.PMP".
- Liquid properties:** Contains two input fields. "Specific gravity" has the value "0.9". "Viscosity" has the value "1000" and a dropdown menu set to "SSU".
- Best Eff. Point:** Contains three input fields. "Flow" has the value "750" with the unit "(gal/min)". "Head" has the value "100" with the unit "(ft)". "Efficiency" has the value "82" with the unit "(%)". Below these is a checkbox labeled "Calculate BEP".
- At the bottom left, there is a label "If pump curve data is not per stage enter number of stages:" followed by a dropdown menu set to "1".
- At the bottom right, there are three buttons: "Calculate", a help button with a question mark icon, and "Close".
- The status bar at the very bottom reads: "File name - C:\PUMPCALC\PUMPXYZ.PMP Press F3 for choices. Double-click to view".

Enter the file name of the water performance curve and the file name for storing the viscosity corrected performance data. Click the **Browse** button for available pump data files, as indicated in the status bar of the screen above. The file name for the viscous curve, by default, has the three letters VSC added to the water performance curve file name as seen from above. For example if the water curve is Pump123.PMP then the viscous curve will be shown as Pump123vsc.pmp. You may also specify another valid filename, with a PMP extension.

The viscous performance calculated requires the use of the best efficiency point (BEP) from the water curve. This is defined as the point on the water performance curve with the best (maximum) efficiency. The flow rate, head and efficiency at this point on the curve is used as the starting point for viscosity corrected performance calculations. The BEP values may be specified in the appropriate fields shown in the above screen or you may have PUMPCALC calculate the BEP by interpolation.

Running PUMPCALC

After entering all data, click the **Calculate** button to start calculations. Based on the Hydraulic Institute Charts, the water performance curve will be corrected for the given liquid viscosity and both water and viscous performance results will be shown side by side in spreadsheets as shown below.

The screenshot shows the 'Water and Viscous Performance' window. It is divided into two main sections: 'Water Performance' and 'Viscous Performance'. Each section has a header with 'SpGrav' and 'Viscosity' values, and a file path. Below these are two tables with columns for Flow rate, Head, Efficiency, and BHP. The 'Water Performance' table shows data for flow rates 450.00 to 900.00. The 'Viscous Performance' table shows data for flow rates 426.24 to 852.49. An 'Interpolate' section at the bottom has a text box with '620' and '(gal/min)'. At the very bottom are buttons for 'Calculate', 'Print', 'Plot', a help icon, and 'Close'.

Water Performance					Viscous Performance				
SpGrav: 1.00 Viscosity: 1.00 cSt					SpGrav: 0.9 Viscosity: 1000.00 SSU				
C:\PUMPCALC\PUMPXYZ.PMP					C:\PUMPCALC\PUMPXYZVSC.PMP				
	Flow rate	Head	Efficiency	BHP		Flow rate	Head	Efficiency	BHP
1	450.00	114.00	72.50	17.87	1	426.24	109.37	46.08	22.99
2	600.00	108.00	80.00	20.45	2	568.32	101.49	50.84	25.78
3	750.00	100.00	82.00	23.10	3	710.41	92.12	52.12	28.54
4	900.00	86.00	79.50	24.59	4	852.49	76.67	50.53	29.40
5					5				
6					6				
7					7				
8					8				
9					9				
10	620.00	107.11	80.50	20.83	10	620.00	98.56	51.75	26.83
11					11				
12					12				
13					13				

Interpolate

Flow rate: (gal/min)

Buttons: Calculate, Print, Plot, Help, Close

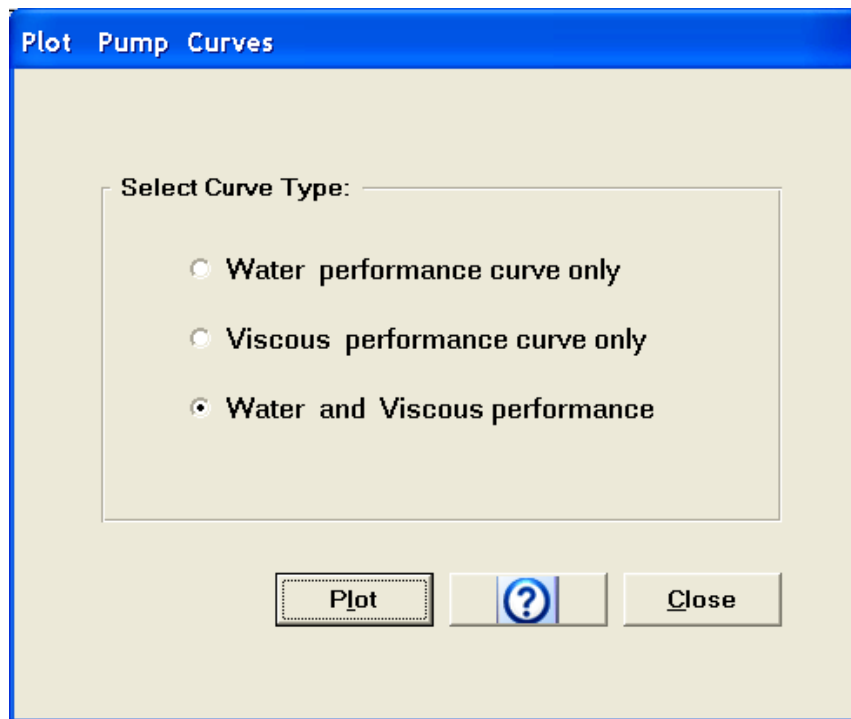
Once the viscous performance is determined, additional points on the water curve and the viscous curve can be determined by interpolation, as shown above for 525 gal/min flow rate.

Please note that the Hydraulic Institute method is based on predicting the pump performance at 60%, 80%, 100% and 120% of the BEP flow rate. Therefore, even if the original water curve had a flow rate range of 0 – 2500 gpm with a BEP flow rate of 2000 gpm, the viscosity corrected curves will be based on a flow rate range of 1200 gpm (60% BEP flow rate) to 2400 gpm (120% BEP flow rate) for the water curve.

Running PUMPCALC

Note that extrapolating beyond the limits of the performance curve in the previous screen, though feasible, may be inaccurate. Due to the nature of the Spline Interpolation method used, *extrapolation* may yield incorrect results in some case. However *interpolation* is generally quite accurate. The calculated viscous performance curve is saved in a data file. This curve information may then be used with the **Single Pump performance** option to determine other performance characteristics using Affinity Laws.

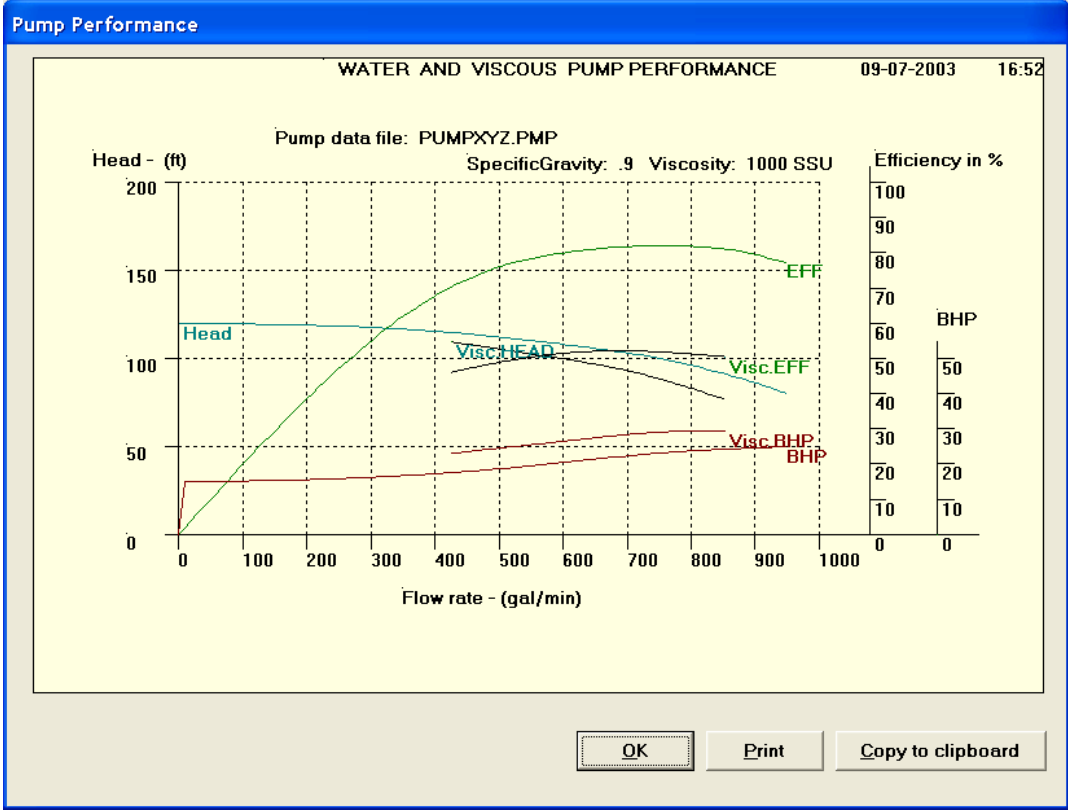
In the previous screen, clicking on the **Plot** button displays another screen for choosing the type of plot as shown below. The calculated water performance and viscous performance curves can be plotted by clicking on one of the Option buttons below.



From the screen above, you may choose to plot the water performance curve, viscous performance curve or both curves.

Running PUMPCALC

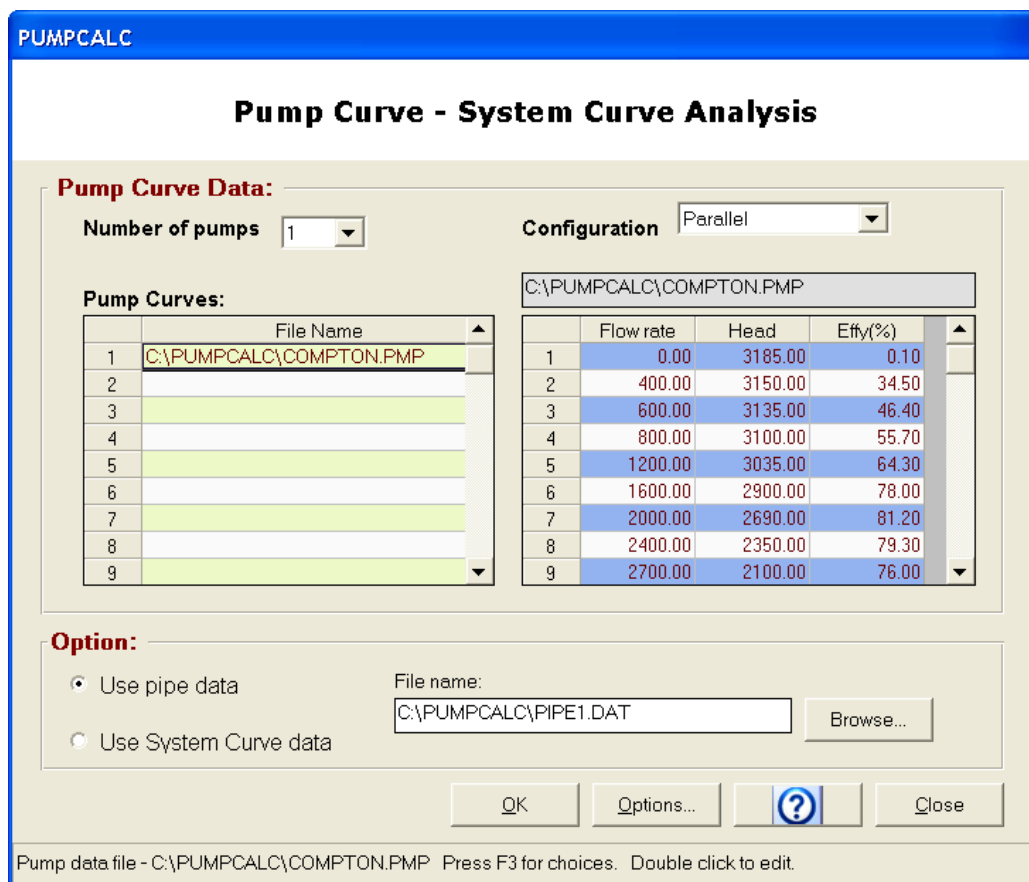
The combined water and viscosity corrected pump curves for a sample problem are as shown.



For a hard copy of the graphics plot, click the **Print** button. You may click the **Copy to clipboard** button to copy the plot to the Windows clipboard. The graphic can then be inserted in a Microsoft Word document as part of a report, if desired.

3.7 Pump curve - System head curve

Clicking the button titled **System Curve** on the main screen or the pull down menu item **Pump curve-system head curve** under **Option** displays the screen below. This is for entering the pump station data, consisting of the number of pumps, their configuration (series or parallel) and the actual pump data file names. Press F3 key to choose from available pump files. Double-click the file name to view the pump data.



Pump Curve Data:

Number of pumps: 1 Configuration: Parallel

Pump Curves:

	File Name	Flow rate	Head	Effy(%)
1	C:\PUMPCALC\COMPTON.PMP	0.00	3185.00	0.10
2		400.00	3150.00	34.50
3		600.00	3135.00	46.40
4		800.00	3100.00	55.70
5		1200.00	3035.00	64.30
6		1600.00	2900.00	78.00
7		2000.00	2690.00	81.20
8		2400.00	2350.00	79.30
9		2700.00	2100.00	76.00

Option:

Use pipe data File name: C:\PUMPCALC\PIPE1.DAT

Use System Curve data

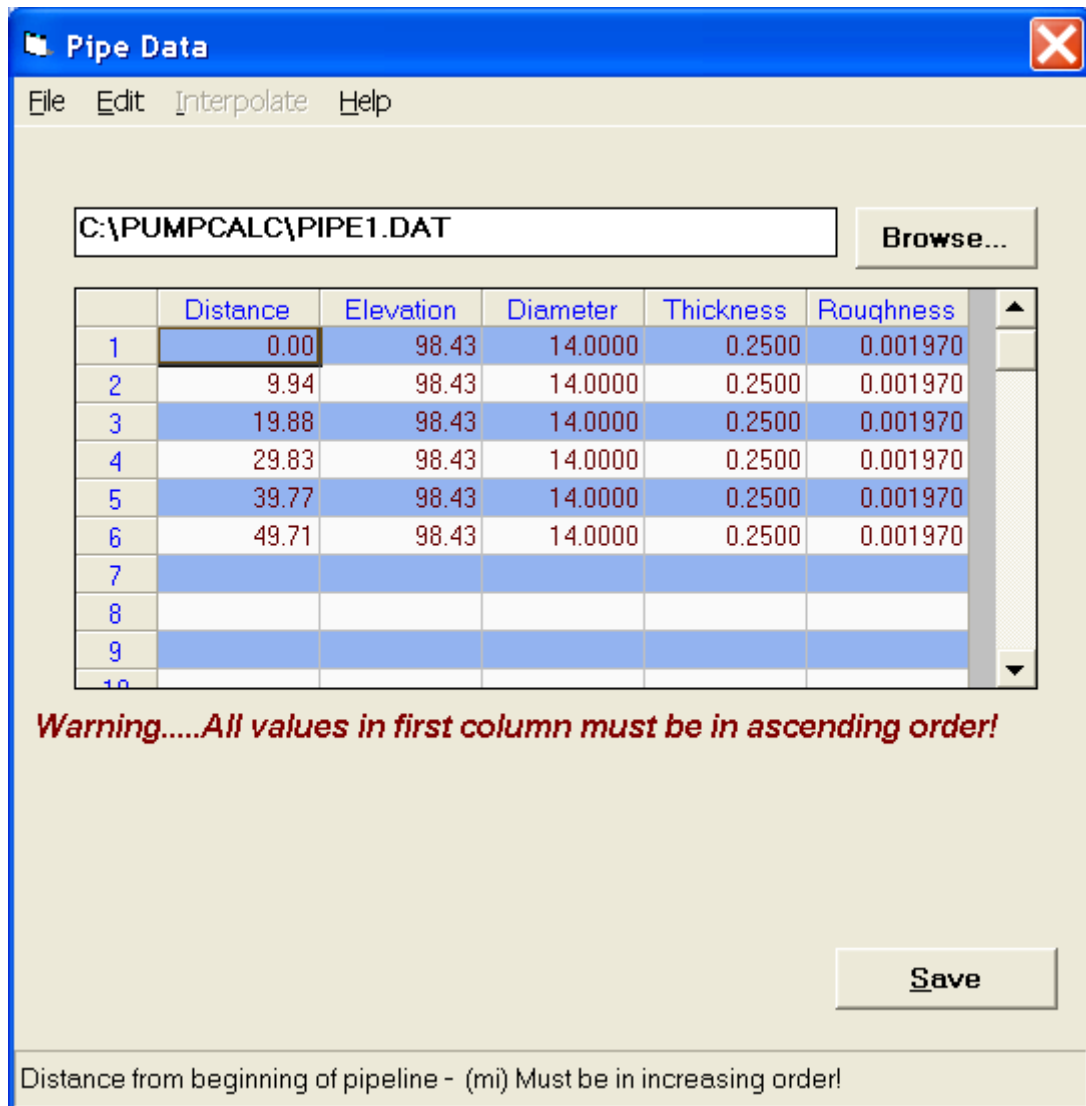
OK Options... ? Close

Pump data file - C:\PUMPCALC\COMPTON.PMP Press F3 for choices. Double click to edit.

If you selected **Use System Curve Data** option from above screen, there is no need to click the Options button to enter the pressure details. The option **Use System Curve Data** implies that you have a ready-made system head curve data, consisting of the heads required for various flow rates, or you intend to create a system curve data file by directly inputting the flow rate/head values.

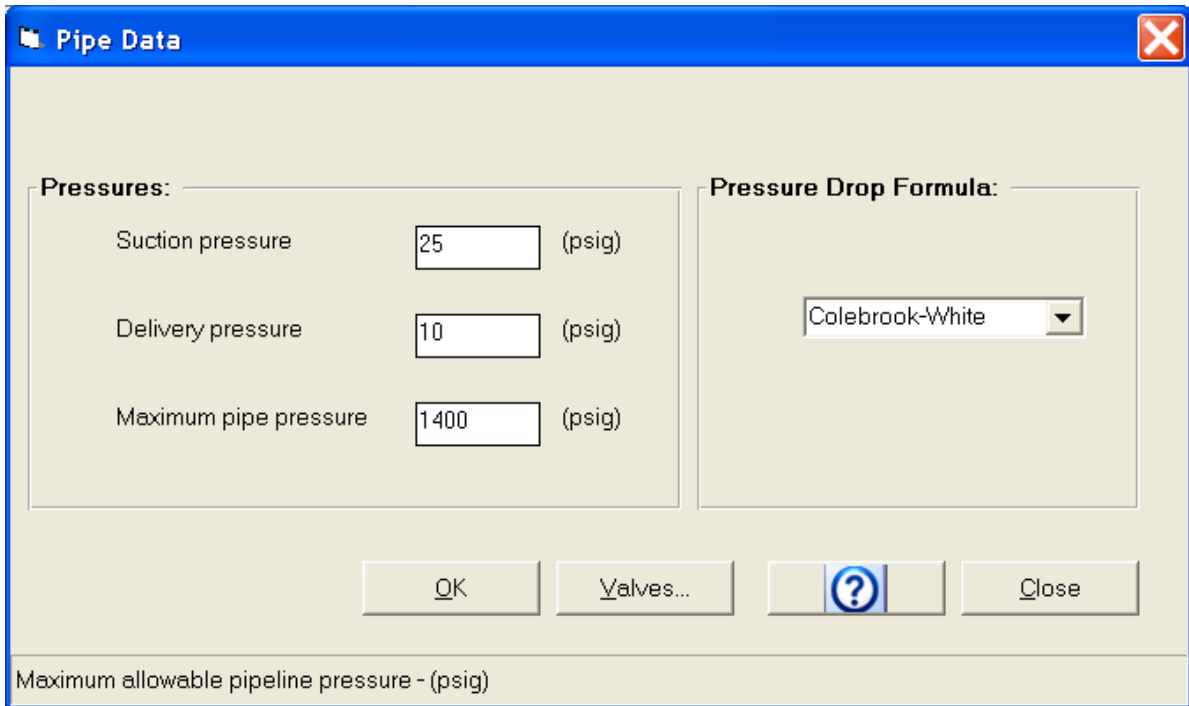
Running PUMPCALC

You may double-click the file name above to open a screen for editing the pipe data file or the System Head Curve data, as shown below.



Running PUMPCALC

Clicking the **Options...** button displays the screen for inputting the suction pressure, pipe delivery pressure and the maximum pipeline pressure, for creating the System Head Curve.



The screenshot shows the "Pipe Data" dialog box with the following fields and controls:

Field	Value	Unit
Suction pressure	25	(psig)
Delivery pressure	10	(psig)
Maximum pipe pressure	1400	(psig)

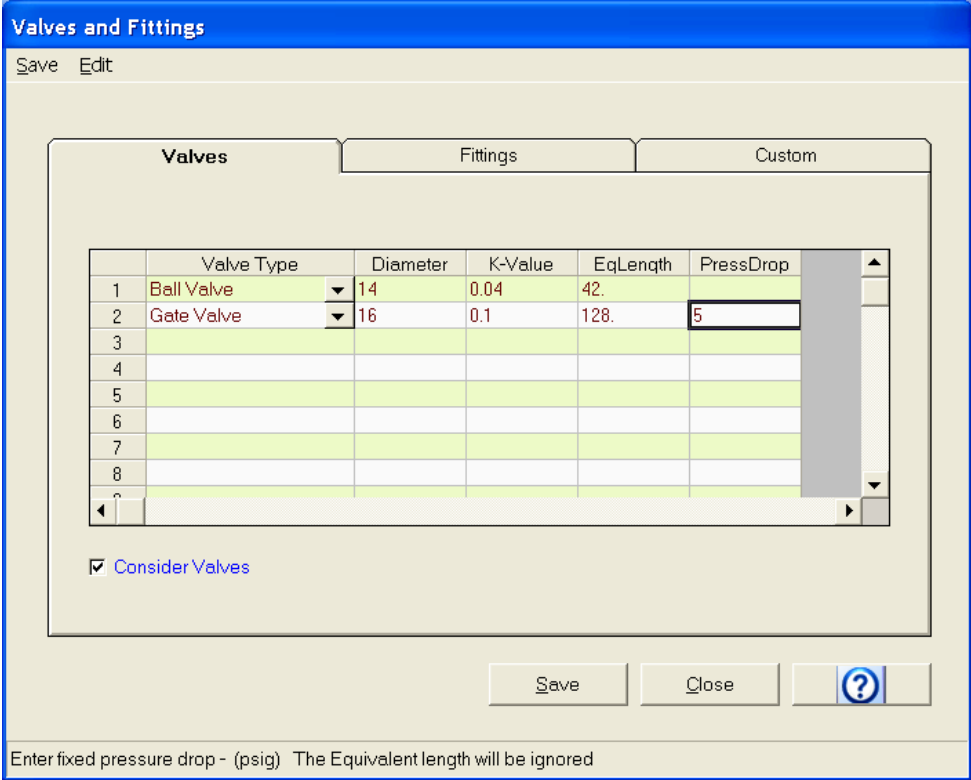
Pressure Drop Formula: Colebrook-White

Buttons: OK, Valves..., Help (?), Close

Maximum allowable pipeline pressure - (psig)

In calculating the system head curve, you may simulate the pressure drop through a restriction, such as a control valve, a gate valve or a fitting such as an elbow.

Click the **Valves..** button to enter information on valves, pipe fittings and other pressure drop devices, such as meters, strainers, etc.



Under tabs marked Valves and Fittings, enter the data on valves and fittings along the pipeline.

The valve and fitting data consists of the valve or fitting type (gate, check, elbow etc), its diameter, resistance coefficient K, the equivalent length and the actual pressure drop across the device. If pressure drop is not specified, the K-value or equivalent length will be used to calculate the pressure drop. If a pressure drop value is entered, the K-value and equivalent length will be ignored in the calculations. Similarly for custom pressure drop devices such as a filter, strainer etc. you may enter data for pressure drop under the Tab marked Custom.

Remember to check the appropriate box on the bottom left of each Tab to take into account the pressure drop for the device. If left unchecked, the valve, fitting or custom device data will be ignored and no pressure drops for these devices will be included in the calculations.

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

- Output Format** - For entering date, project title, case number, output file name and whether printer output is required.
- Go!** - This initiates calculations for all options, except Viscosity correction.
- Extrapolate curve data** - For extrapolating pump curve data.

The menu item on the extreme right titled **Help** provides general help information, data limitations of the DEMO version, if applicable and Program Version number and Licensed User Information.

Default values shown in the input screens correspond to the sample problem data in most cases.

To proceed with the program, turn to the **TUTORIAL** section.

4. Tutorial

This section leads you through the program, using illustrative examples. See the **REFERENCE** section for an explanation of variable names and formulas used. English and Metric Units examples are included below.

4.1 Sample Problems

(a) Single Pump Performance

Using Affinity Laws, determine the total flow rate, head and HP required for a centrifugal pump with the following performance data:

Pump data file: DEMO.PMP

Flow rate (gpm)	Head (ft)	Efficiency (%)
100	500	56.0
120	490	63.0
150	449	67.0
190	380	70.0
300	120	69.0

Number of stages	= 2
Initial impeller diameter	= 12.5 inches.
Final impeller diameter	= 12.75 inches
Initial speed	= 3500 rpm.
Final speed	= 3600 rpm.
Liquid specific gravity	= 0.85
Liquid viscosity	= 10.0 cSt

Also, determine the impeller size required for the above pump operating at 3500 RPM, to meet the following design condition:

Design point Flow rate:	165 gpm
Design point Head:	400 ft

(b) Multiple Pump Performance

- (1). Determine the total flow, head and horsepower for two pumps in series:

Pump file name: PUMP1.PMP

Flow rate (gpm)	Head (ft)	Efficiency (%)
200	325	52.0
400	306	79.0
600	270	86.0
800	210	70.0

Pump file name: PUMP2.PMP

200	308	50.0
400	280	77.0
600	235	85.0
800	170	68.0

- (2). Determine the total flow, head and horsepower for the above two pumps in parallel.

In both cases above, use liquid properties from part (a)

(c) Viscosity Corrected Pump Performance

Using The Hydraulic Institute method, calculate the viscosity corrected performance of a centrifugal pump based on the following water performance curve:

Pump file name: PUMPXYZ.PMP

Flow rate (gpm)	Head (ft)	Efficiency (%)
0	120	0.0
450	114	72.5
600	108	80
750	100	82
900	86	79.5
950	80	77.0
Number of stages		= 1
Liquid specific gravity		= 0.9
Viscosity		= 1000 SSU
Best efficiency point:		750 gpm 100 ft 82 % efficiency

Determine the water curve and viscosity corrected pump performance curve values for a capacity of 500 gpm.

(d) System head curve versus Pump head curve

(1) A pipeline 100 miles long described below, has a pump station located at the beginning of the pipeline with one pump, defined below. Calculate the flow rate, pressure, efficiency and horsepower at the operating point of the pump curve with the following data:

Pump file name: PUMP3.PMP

Flow rate (gpm)	Head (ft)	Efficiency (%)
0.01	660	0.1
400	650	52.0
800	612	79.0
1200	540	86.0
1600	420	70.0
Number of stages		= 1
Liquid specific gravity		= 0.85
Viscosity		= 10.0 cSt
Pipe roughness		= 0.002 in
Suction pressure		= 25.0 psi
Delivery pressure		= 50.0 psi
Maximum pipe pressure		= 1000 psi

The pipeline data file is defined as follows:

Pipe data file name: PIPE1

Distance (miles)	Elevation (ft)	Diameter (in)	Thickness (in)
0.0	100	14.0	0.25
10.0	200	16.0	0.25
50.0	120	16.0	0.25
100.0	300	16.0	0.25

(2) Repeat the above analysis using two identical pumps above in series.

(e) Single Pump Performance – SI-Metric Units

Using Affinity Laws, determine the total flow rate, head and Kwatts required for a centrifugal pump with the following performance data:

Pump data file: MetricPump1.PMP

Flow rate (m ³ /hr)	Head (metre)	Efficiency (%)
0	296	0.0
20	293	34
30	291	46
40	288	56
62	282	64
83	269	78
103	250	81
124	218	79
140	195	76
155	167	72

Number of stages	= 1
Initial impeller diameter	= 400 mm.
Final impeller diameter	= 350 mm.
Initial speed	= 3500 rpm.
Final speed	= 3600 rpm.
Liquid specific gravity	= 0.85
Liquid viscosity	= 10.0 cSt

Also, determine the impeller size required for the above pump operating at 3500 RPM, to meet the following design condition:

Design point Flow rate:	100 m ³ /hr
Design point Head:	240 metre

(f) Multiple Pump Performance – Metric Units

- (1). Determine the total flow, head and Kwatts power for two identical pumps in series:

Pump file name: MetricPump1.PMP

Flow rate (m ³ /hr)	Head (meter)	Efficiency (%)
0	296	0.0
20	293	34
30	291	46
40	288	56
62	282	64
83	269	78
103	250	81
124	218	79
140	195	76
155	167	72

- (2). Determine the total flow, head and power for the above two pumps in parallel.

Liquid specific gravity = 0.962
 Liquid viscosity = 15.0 centistokes

(g) Viscosity Corrected Pump Performance – Metric Units

Using The Hydraulic Institute method, calculate the viscosity corrected performance of a centrifugal pump based on the following water performance curve:

Pump file name: MetricPump2.PMP

Flow rate (liters/sec)	Head (metre)	Efficiency (%)
0	37	0
28	35	72.5
38	33	80
47	30	82
57	26	79.5

Number of stages = 1
Liquid specific gravity = 0.9
Viscosity = 1000 SSU
Best efficiency point: To be calculated

Determine the water curve and viscosity corrected pump performance curve values for a capacity of 32 liters/sec.

(h) System head curve versus Pump head curve – Metric Units

A pipeline 80 km long described below, has a pump station located at the beginning of the pipeline with one pump, defined below. Calculate the flow rate, pressure, efficiency and horsepower at the operating point of the pump curve with the following data:

Pump file name: ComptonMetric.PMP

Flow rate (m ³ /hr)	Head (m)	Efficiency (%)
0	970	0.0
90	960	34.5
136	955	46.4
182	945	55.7
272	925	64.3
363	884	78.0
454	820	81.2
545	715	79.3
613	640	76
681	549	72

Number of stages	= 1
Liquid specific gravity	= 1.0
Viscosity	= 1.0 cSt
Pipe roughness	= 0.05 mm
Suction pressure	= 1.0 kg/cm ²
Delivery pressure	= 1.0 kg/cm ²
Maximum pipe pressure	= 100 kg/cm ²
Formula used	= Colebrook-White

The pipeline data file is defined as follows:

Pipe data file name: MetricPipe1

Distance (km)	Elevation (m)	Diameter (mm)	Thickness (mm)
0.0	30	355.6	6.35
16.0	30	355.6	6.35
32	30	355.6	6.35
48	30	355.6	6.35
64	30	355.6	6.35
80	30	355.6	6.35

4.2 Solution

Start PUMPCALC by clicking on its icon. From the main window, choose **Units**. Select English units of calculations for the sample problem. Make sure the flow rate is in gal/min and distances are in miles. Click **OK**.

(a) Single Pump Performance

Next, choose **Liquid** from the pull down menu bar and input the values of 0.85 for specific gravity and 10 cSt for viscosity.

Then, from the **Option** menu choose **Single pump** or click the Single pump button on the left of the main screen. Enter the sample problem data. For the pump curve, you may double-click on the file name and edit the values in the resulting window. Generally, to create a new pump curve file, open any existing pump file, make changes and save under the new name.

After entering all data click the OK button to close the window and start calculations.

The calculated results are shown in an output window. The result is included in the **Sample Output** section of this manual.

To determine the impeller size required for 165 gpm at 400 ft head, click the **Single pump** button and after entering the Part (a) data, click the **Options..** button. In the resulting screen, enter the design point and other data and click the **Calculate** button, after choosing the option for **Fix speed. Calculate new impeller diameter** option. The calculated results are shown in the text area below.

(b) Multiple Pump Performance

Click the **Multiple Pumps** button and enter data for the two pumps in series. As before, you may create the pump files by editing an existing data file. Click OK to start calculations.

The calculated results are shown in an output window. The result is included in the **Sample Output** section of this manual.

Repeat above for the same two pumps in parallel.

(c) Viscosity Corrected Pump Performance

Click the **Viscosity Correct** button and enter data for the water performance curve, the filename for the viscous curve, liquid specific gravity and viscosity and the best efficiency point for the water curve. You may also let PUMPCALC calculate the best efficiency point, by checking that option.

Click the **Calculate** button to start calculations. The water curve and the viscosity corrected performance curves are displayed, side by side. The combined plots may also be obtained. The result is included in the **Sample Output** section of this manual.

(d) System head curve versus Pump head curve

Click the **System Curve** button and enter data for the pump PUMP3.PMP and the pipeline PIPE1.DAT along with suction, delivery pressure etc. The latter data is entered by clicking the **Options** button. Choose Colebrook equation for the pressure drop calculations.

Click OK to start calculations. The calculated results are shown in an output window. The result is included in the **Sample Output** section of this manual.

5. Reference

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

5.1 Formulas

$$\text{factor} = (D2/D1)(N2/N1)$$

For pumps in series:

1. Total capacity:

$$Q = (\text{capacity/pump})(\text{factor})$$

2. Total head:

$$H = (\text{head/stage/pump})(\text{factor})^2 (\text{pumps})(\text{stages/pump})$$

For pumps in parallel:

3. Total capacity:

$$Q = (\text{capacity/pump})(\text{factor})(\text{pumps})$$

4. Total head:

$$H = (\text{head/stage/pump})(\text{factor})^2 (\text{stages/pump})$$

5. Pump power required: (BHP in English. kW in SI-Metric)

$$\text{BHP} = (\text{feet head})(\text{gpm})(\text{spgr})/[(3960)(\text{efficiency})]$$

$$\text{Power(kW)} = (\text{meters})(\text{m}^3/\text{h})(\text{spgr})/[367.46(\text{efficiency})]$$

Efficiency is expressed as a decimal value, less than 1.0

6. Reynolds number $R = 3162.51(Q)/(VD)$

7. Transmission factor, based on the Modified Colebrook-White equation:

$$F = \text{SQR}(R)/4 \quad \text{for laminar flow } (R \leq 2100)$$

$$F = 1/\text{SQR}((R-2100)/1277500 + 0.008) \\ \text{for critical flow } 2100 < R \leq 4555$$

$$F = -4\text{Log}(K/(3.7D) + 1.4125F/R) \\ \text{for turbulent flow } (R > 4555)$$

8. Darcy Friction factor $f = 4/F^2$

9. Pressure drop/mi $P_3 = 284.59(Q/F)^2 (S/D^5)$

10. Pump horsepower $HP = (P_d - P_s)Q / (17.14SE)$

$$HP = (\text{GPM})(\text{HEAD})(\text{Spgr}) / [(3960)(\text{Efficiency})]$$

Viscosity correction calculations are based on the Hydraulic Institute charts. Refer to the Hydraulic Institute Handbooks for more information.

5.2 Symbols

D1, D2- Initial and final impeller diameters

N1,N2 - Initial and final pump speeds

Q - Flow rate or capacity of pump/ Pipeline flow rate

H - Differential head of pump at Q

S - Specific gravity of liquid pumped

BHP - Brake horsepower of pump at Q (In SI-Metric: Power in kW)

D - Inside diameter of pipe, inches.

D0 - Outside diameter of pipe, inches.

T - wall thickness, inches.

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

R - Reynolds number, dimensionless

K - Absolute pipe roughness, inches.

F - Colebrook-White transmission factor, dimensionless

P3 - Pressure drop due to friction, psi/mile.

L - Pipeline length, miles.

Pd - Pump discharge pressure, psi.

Ps - Pump suction pressure, psi.

E - Pump efficiency, percent.

HP - Brake horsepower of pump at flow rate Q

6. Troubleshooting

PUMPCALC is a powerful centrifugal pump analysis program with many features. 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 choosing 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 shut down the program from the Windows Task Manager.

If you cannot get **PUMPCALC** to run properly even after following the instructions 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

Here are some errors that you may encounter while running PUMPCALC:

1. 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.

2. 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.

3. 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 PUMPCALC. Otherwise, ensure that the file name is typed in correctly, including the full path.

4. 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 and run the software, contact SYSTEK 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 one year 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 program CD 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: +1 (928) 453-9587

E-mail: support@systek.us

Web site: www.systek.us

8. Sample Output

Problem (a) – Single Pump Performance

***** PUMPCALC - CENTRIFUGAL PUMP PERFORMANCE *****

***** SINGLE PUMP PERFORMANCE *****

Project: Global Pumping System
Case number: 1001

Liquid Specific gravity: 0.8500
Number of stages: 2
Initial pump speed: 3500. RPM
Final pump speed: 3600. RPM
Initial impeller diameter: 12.5000 (in)
Final impeller diameter: 12.7500 (in)

ORIGINAL PUMP CURVE DATA: C:\PUMPCALC\DEMO.PMP

Sets of data points: 5

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
100.00	1000.00	56.00	38.33
120.00	980.00	63.00	40.07
150.00	898.00	67.00	43.15
190.00	760.00	70.00	44.28
300.00	240.00	69.00	22.40

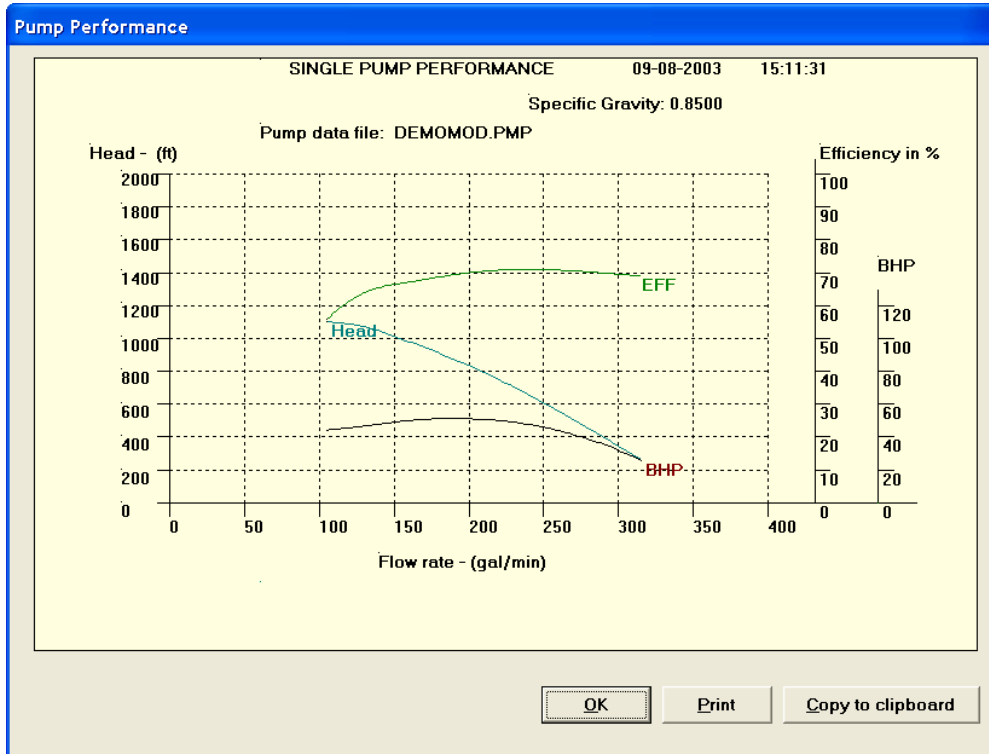
CALCULATED PUMP CURVE DATA BASED ON AFFINITY LAWS:

Modified Pump curve data file: C:\PUMPCALC\DEMOMOD.PMP

Sets of data points: 5

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
104.91	1100.70	56.00	44.26
125.90	1078.69	63.00	46.27
157.37	988.43	67.00	49.83
199.34	836.53	70.00	51.13
314.74	264.17	69.00	25.86

The plot of the pump performance is shown below:



The impeller diameter required to achieve the design point of 165 gpm at 400 ft head is shown in the result screen below:

PUMPCALC

Pump Speed/Diameter required for Design Point

Pump data file: C:\PUMPCALC\DEMO.PMP [Browse...]

Impeller:
 Speed: 3500 RPM
 Diameter: 12.5 (in)

Design Point:
 Flow rate: 165 (gal/min)
 Head: 400 (ft)

Option:
 Calculate new speed
 Calculate new impeller diameter.

	Flow rate	Head	Effy(%)
1	100.00	500.00	56.00
2	120.00	490.00	63.00
3	150.00	449.00	67.00
4	190.00	380.00	70.00
5	300.00	120.00	69.00

For Design Flow: 165 and Design Head: 400
 Initial impeller diameter: 12.5
 Final impeller diameter: 12.23

Buttons: Calculate, Print, ?

Calculate Design Point requirement

Problem (b) - Multiple Pumps in Series

***** PUMPCALC - CENTRIFUGAL PUMP PERFORMANCE *****

***** MULTIPLE PUMP PERFORMANCE *****

Project: Global Pumping System
Case number: 1001

Number of pumps: 2
Pump configuration: Series

Liquid Specific gravity: 0.8500

Pump curve data files: C:\PUMPCALC\PUMP1.PMP
C:\PUMPCALC\PUMP2.PMP

Pump curve data file: C:\PUMPCALC\PUMP1.PMP

Sets of data points: 4

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
200.00	325.00	52.00	26.83
400.00	306.00	79.00	33.26
600.00	270.00	86.00	40.43
800.00	210.00	70.00	51.52

Pump curve data file: C:\PUMPCALC\PUMP2.PMP

Sets of data points: 4

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
200.00	308.00	50.00	26.44
400.00	280.00	77.00	31.22
600.00	235.00	85.00	35.61
800.00	170.00	68.00	42.93

Combined Pump Curve:

Sets of data points: 10

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
260.00	620.57	51.08	67.80
320.00	607.16	58.31	71.52
380.00	591.75	64.55	74.77
440.00	573.38	69.32	78.12
500.00	551.35	72.29	81.86
560.00	525.10	73.26	86.15
620.00	494.12	72.04	91.28
680.00	458.64	68.77	97.35
740.00	420.08	64.09	104.10
800.00	380.00	58.73	111.11

Problem (b) - Multiple Pumps in Parallel

***** PUMPCALC - CENTRIFUGAL PUMP PERFORMANCE *****
 ***** MULTIPLE PUMP PERFORMANCE *****

Project: Global Pumping System
 Case number: 1001
 Number of pumps: 2
 Pump configuration: Parallel
 Liquid Specific gravity: 0.8500
 Pump curve data files: C:\PUMPCALC\PUMP1.PMP
 C:\PUMPCALC\PUMP2.PMP

Pump curve data file: C:\PUMPCALC\PUMP1.PMP

Sets of data points: 4

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
200.00	325.00	52.00	26.83
400.00	306.00	79.00	33.26
600.00	270.00	86.00	40.43
800.00	210.00	70.00	51.52

Pump curve data file: C:\PUMPCALC\PUMP2.PMP

Sets of data points: 4

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
200.00	308.00	50.00	26.44
400.00	280.00	77.00	31.22
600.00	235.00	85.00	35.61
800.00	170.00	68.00	42.93

Combined Pump Curve:

Sets of data points: 9

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
602.02	308.00	56.58	70.34
661.25	298.20	59.28	71.40
777.11	288.40	64.60	74.47
874.86	278.60	68.20	76.71
958.76	268.80	70.46	78.51
1033.34	259.00	71.71	80.11
1100.92	249.20	72.17	81.59
1279.18	219.80	70.20	85.97
1334.13	210.00	68.73	87.50

Problem (c) - Viscosity Correction

Water and Viscous Performance

Water Performance

SpGrav: 1.00 Viscosity: 1.00 cSt

C:\PUMPCALC\PUMPXYZ.PMP

	Flow rate	Head	Efficiency	BHP
1	450.00	114.00	72.50	17.87
2	600.00	108.00	80.00	20.45
3	750.00	100.00	82.00	23.10
4	900.00	86.00	79.50	24.59
5				
6				
7				
8				
9				
10	500.00	112.20	75.96	18.65
11				
12				
13				

Viscous Performance

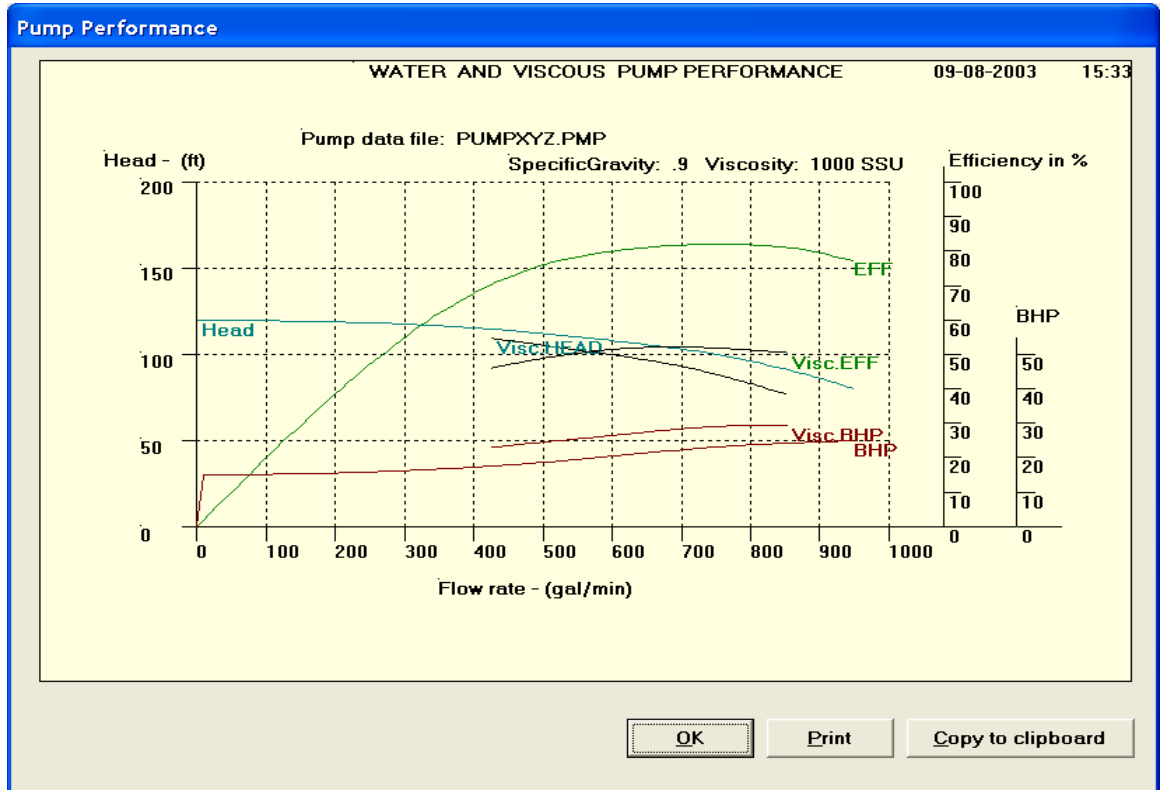
SpGrav: 0.9 Viscosity: 1000.00 SSU

C:\PUMPCALC\PUMPXYZVSC.PMP

	Flow rate	Head	Efficiency	BHP
1	426.24	109.37	46.08	22.99
2	568.32	101.49	50.84	25.78
3	710.41	92.12	52.12	28.54
4	852.49	76.67	50.53	29.40
5				
6				
7				
8				
9				
10	500.00	105.28	48.83	24.50
11				
12				
13				

Interpolate

Flow rate: (gal/min)



Problem (d) –System Head Curve versus Pump Head Curve

***** PUMPCALC - PUMP CURVE SYSTEM CURVE INTERSECTION *****

Project: Global Pumping System
Case number: 1001

***** PUMP STATION DATA *****

Number of pumps: 1
Pump configuration: One pump

Pump curve data file: C:\PUMPCALC\PUMP3.PMP

Pump curve data file: C:\PUMPCALC\PUMP3.PMP

Sets of data points: 5

Flow rate (gal/min)	Head (ft)	Efficiency (%)	BHP
0.01	660.00	0.10	1.42
400.00	650.00	52.00	107.32
800.00	612.00	79.00	133.03
1200.00	540.00	86.00	161.73
1600.00	420.00	70.00	206.06

***** PIPE LINE DATA *****

Specific gravity: 0.85000
Viscosity: 10.0000 CST
Pump suction pressure: 25.000 (psig)
Pipe delivery pressure: 50.000 (psig)
Maximum pipe pressure: 1000.000 (psig)

Pressure drop formula: Colebrook-White Equation

Pipe data file: C:\PUMPCALC\PIPE1.DAT

Sets of data points: 4

Distance (mi)	Elevation (ft)	Diameter (in)	Thickness (in)	Roughness (in)
0.00	100.00	14.000	0.250	0.002000
10.00	200.00	16.000	0.250	0.002000
50.00	120.00	16.000	0.250	0.002000
100.00	300.00	16.000	0.250	0.002000

***** PIPE PRESSURE PROFILE *****

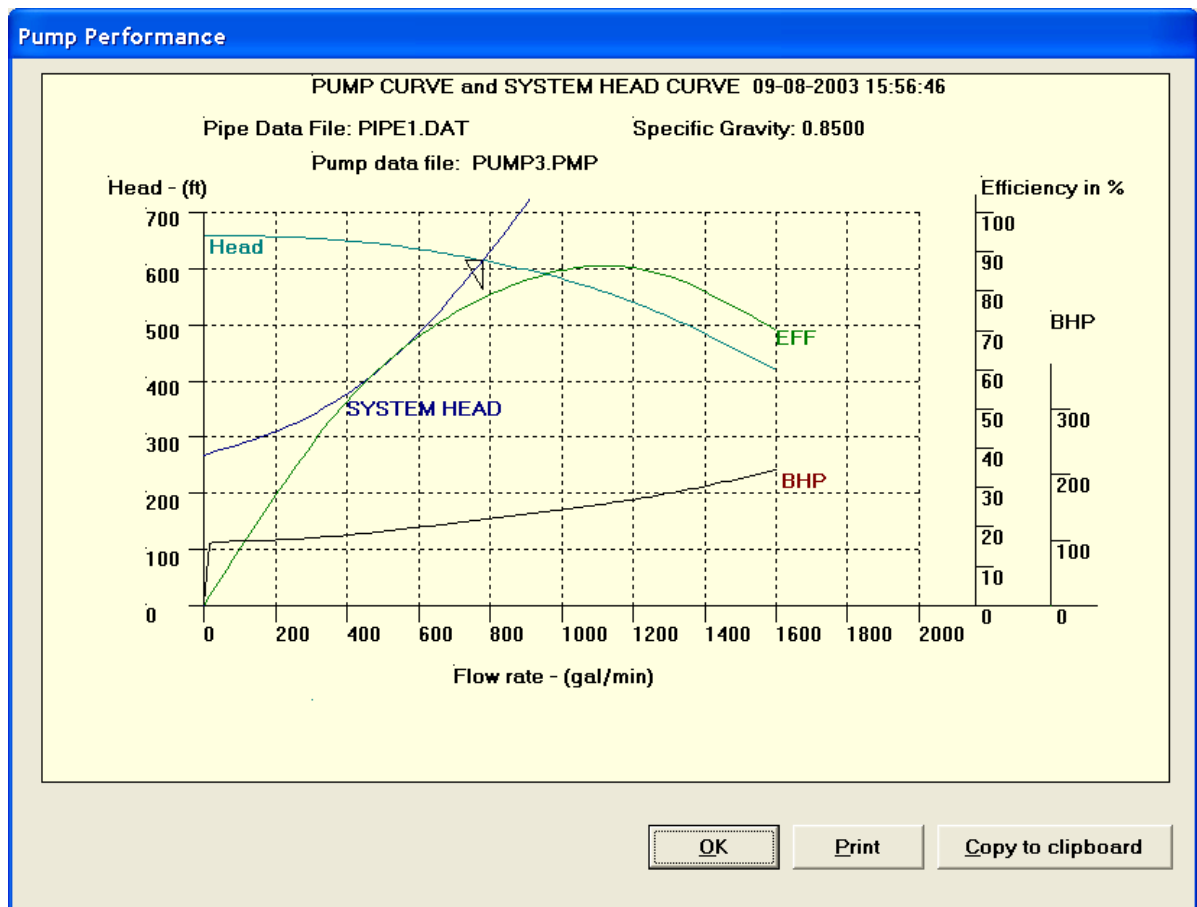
Segment number	Diameter (in)	Velocity (ft/sec)	Reynolds number	Pressure drop (psi/mi)
1	14.000	1.744	18241.76	2.254
2	16.000	1.323	15887.98	1.167
3	16.000	1.323	15887.98	1.167

Distance (mi)	Elevation (ft)	Diameter (in)	Pressure (psig)
0	100.00	14.000	251.20
10	200.00	16.000	191.86
50	120.00	16.000	174.60
100	300.00	16.000	50.00

***** SUMMARY *****

Pipeline Flow rate: 778.82 (gal/min)
 Pipeline discharge pressure: 251.20 (psig)
 Total Horsepower required: 131.60

Pump differential pressure: 614.74 (ft)
 Combined Pump efficiency: 78.09 (%)
 Pump discharge pressure: 251.20 (psig)
 Total Pump horsepower: 131.60



Problem (e) –Single Pump Performance – SI-Metric Units.

***** PUMPCALC - CENTRIFUGAL PUMP PERFORMANCE *****

***** SINGLE PUMP PERFORMANCE *****

Project: 1001
Case number:

Liquid Specific gravity: 0.8500
Number of stages: 1
Initial pump speed: 3500. RPM
Final pump speed: 3600. RPM
Initial impeller diameter: 400.0000 (mm)
Final impeller diameter: 350.0000 (mm)

ORIGINAL PUMP CURVE DATA: C:\PUMPCALC\METRICPUMP1.PMP

Sets of data points: 10

Flow rate (m3/hr)	Head (m)	Efficiency (%)	KWatts
0.00	296.00	0.01	0.00
20.00	293.00	34.00	39.87
30.00	291.00	46.00	43.90
40.00	288.00	56.00	47.59
62.00	282.00	68.00	59.48
83.00	269.00	78.00	66.21
103.00	250.00	81.00	73.54
124.00	218.00	79.00	79.15
140.00	195.00	76.00	83.09
155.00	167.00	72.00	83.16

CALCULATED PUMP CURVE DATA BASED ON AFFINITY LAWS:

Modified Pump curve data file: C:\PUMPCALC\METRICPUMP1MOD.PMP

Sets of data points: 10

Flow rate (m3/hr)	Head (m)	Efficiency (%)	KWatts
0.00	239.76	0.01	0.00
18.00	237.33	34.00	29.06
27.00	235.71	46.00	32.00
36.00	233.28	56.00	34.69
55.80	228.42	68.00	43.36
74.70	217.89	78.00	48.27
92.70	202.50	81.00	53.61
111.60	176.58	79.00	57.70
126.00	157.95	76.00	60.57
139.50	135.27	72.00	60.62

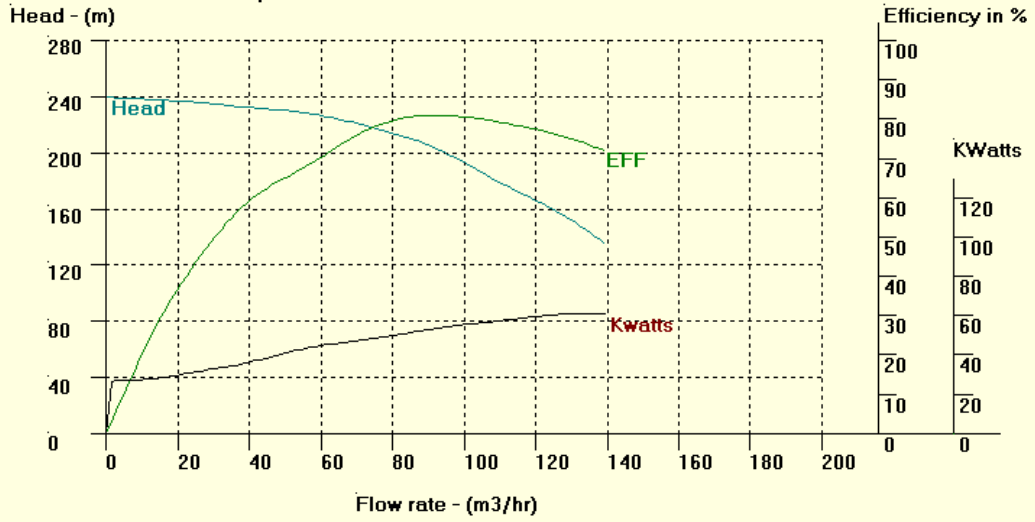
Pump Performance

PUMP CURVE and SYSTEM HEAD CURVE 09-08-2003 16:19:34

Pipe Data File: PIPE1.DAT

Specific Gravity: 0.8500

Pump data file: METRICPUMP1MOD.PMP



OK

Print

Copy to clipboard

Problem (f) – Multiple Pump Performance – SI-Metric Units

***** PUMPCALC - CENTRIFUGAL PUMP PERFORMANCE *****
***** MULTIPLE PUMP PERFORMANCE *****

Project: 1001
Case number:

Number of pumps: 2
Pump configuration: Series

Liquid Specific gravity: 0.9620

Pump curve data files: METRICPUMP1.PMP
METRICPUMP1.PMP

Pump curve data file: METRICPUMP1.PMP

Sets of data points: 10

Flow rate (m3/hr)	Head (m)	Efficiency (%)	KWatts
0.00	296.00	0.01	0.00
20.00	293.00	34.00	45.12
30.00	291.00	46.00	49.68
40.00	288.00	56.00	53.86
62.00	282.00	68.00	67.31
83.00	269.00	78.00	74.94
103.00	250.00	81.00	83.23
124.00	218.00	79.00	89.58
140.00	195.00	76.00	94.04
155.00	167.00	72.00	94.12

Combined Pump Curve:

Sets of data points: 10

Flow rate (m3/hr)	Head (m)	Efficiency (%)	KWatts
0.01	592.00	0.01	154.98
20.00	586.00	34.00	90.24
30.00	582.00	46.00	99.37
40.00	576.00	56.00	107.71
62.00	564.00	68.00	134.62
83.00	538.00	78.00	149.88
103.00	500.00	81.00	166.45
124.00	436.00	79.00	179.16
140.00	390.00	76.00	188.08
155.00	334.00	72.00	188.24

Problem (g) –Viscosity Correction – SI-Metric Units

Water and Viscous Performance

Water Performance

SpGrav: 1.00 Viscosity: 1.00 cSt

C:\PUMPCALC\METRICPUMP2.PMP

	Flow rate	Head	Efficiency	KWatts
1	28.04	34.99	72.56	13.25
2	37.39	33.16	79.74	15.23
3	46.74	30.10	82.00	16.81
4	56.09	26.37	79.83	18.15
5				
6				
7				
8				
9				
10	32.00	34.35	76.57	14.06
11				
12				
13				

Viscous Performance

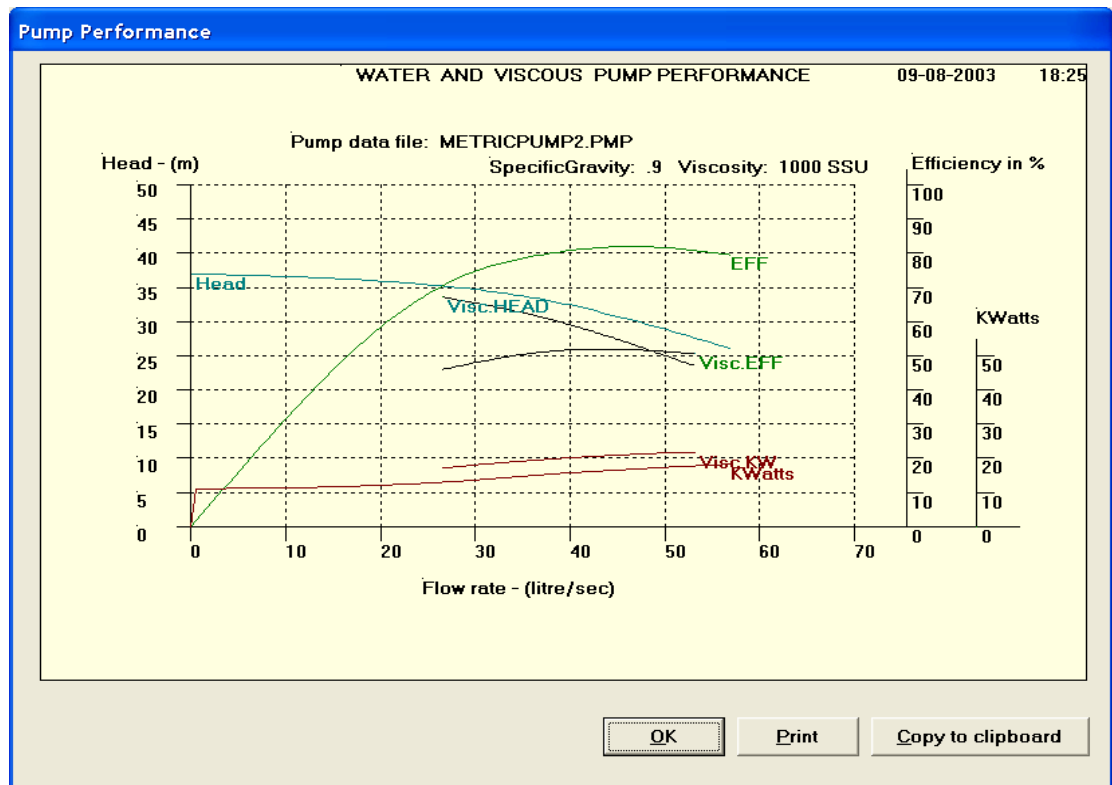
SpGrav: 0.9 Viscosity: 1000.00 SSU

C:\PUMPCALC\METRICPUMP2VSC.PMP

	Flow rate	Head	Efficiency	KWatts
1	26.56	33.57	45.98	17.09
2	35.41	31.15	50.54	19.25
3	44.26	27.71	51.97	20.81
4	53.12	23.49	50.59	21.75
5				
6				
7				
8				
9				
10	32.00	32.17	49.03	18.51
11				
12				
13				

Interpolate

Flow rate: (litre/sec)



Problem (h) –System Head Curve/Pump Head Curve – SI-Metric Units

***** PUMPCALC - PUMP CURVE SYSTEM CURVE INTERSECTION *****

Project:
Case number:

***** PUMP STATION DATA *****

Number of pumps: 1
Pump configuration: One pump

Pump curve data file: C:\PUMPCALC\COMPTONMETRIC.PMP

Pump curve data file: C:\PUMPCALC\COMPTONMETRIC.PMP

Sets of data points: 10

Flow rate (m3/hr)	Head (m)	Efficiency (%)	KWatts
0.00	970.00	0.01	0.00
90.00	960.00	34.50	681.53
136.00	955.00	46.40	761.75
182.00	945.00	55.70	840.30
272.00	925.00	68.00	1006.91
363.00	884.00	78.00	1119.57
454.00	820.00	81.20	1247.68
545.00	715.00	79.30	1337.27
613.00	640.00	76.00	1404.80
681.00	549.00	72.00	1413.11

***** PIPE LINE DATA *****

Specific gravity: 1.00000
Viscosity: 1.0000 CST
Pump suction pressure: 1.000 (kg/cm2)
Pipe delivery pressure: 1.000 (kg/cm2)
Maximum pipe pressure: 100.000 (kg/cm2)

Pressure drop formula: Colebrook-White Equation

Pipe data file: C:\PUMPCALC\METRICPIPE1.DAT

Sets of data points: 6

Distance (km)	Elevation (m)	Diameter (mm)	Thickness (mm)	Roughness (mm)
0.00	30.00	355.600	6.350	0.050000
16.00	30.00	355.600	6.350	0.050000
32.00	30.00	355.600	6.350	0.050000
48.00	30.00	355.600	6.350	0.050000
64.00	30.00	355.600	6.350	0.050000
80.00	30.00	355.600	6.350	0.050000

***** PIPE PRESSURE PROFILE *****

Segment number	Diameter (mm)	Velocity (m/sec)	Reynolds number	Pressure drop (kg/cm2/km)
1	355.600	1.885	646902.54	.778
2	355.600	1.885	646902.54	.778
3	355.600	1.885	646902.54	.778
4	355.600	1.885	646902.54	.778
5	355.600	1.885	646902.54	.778

Distance (km)	Elevation (m)	Diameter (mm)	Pressure (kg/cm2)
0	30.00	355.600	63.24
16	30.00	355.600	50.79
32	30.00	355.600	38.34
48	30.00	355.600	25.90
64	30.00	355.600	13.45
80	30.00	355.600	1.00

***** SUMMARY *****

Pipeline Flow rate: 627.23 (m3/hr)
 Pipeline discharge pressure: 63.24 (kg/cm2)
 Total Pump KWatts: 1412.86

Pump differential pressure: 622.41 (m)
 Combined Pump efficiency: 75.20 (%)
 Pump discharge pressure: 63.24 (kg/cm2)
 Total Pump KWatts: 1412.86

