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INTRODUCTION

The procedures for executing INSTED®/Series Piping System program are presented in this manual. The program is intended for the analysis of piping systems organized in series. Such a piping system in real applications usually consists of several components and several pipes. This program is useful in rating such systems.

INSTED®/Series Piping Systems is also useful for sizing, such as the estimation of the required pipe diameter to deliver a given load. In addition, the program calculates and displays the system curve and compares it with a prescribed pump curve. The program also assists in predicting cavitation.

Performing an analysis involves three main tasks:
(1) Definition of the pipe types that are included in the piping system to be analyzed. The pipe types are defined by the pipe diameter and roughness of the interior surfaces.
(2) Definition of the minor loss component types that are included in the piping system. Components are defined by the pressure loss factor for each type.
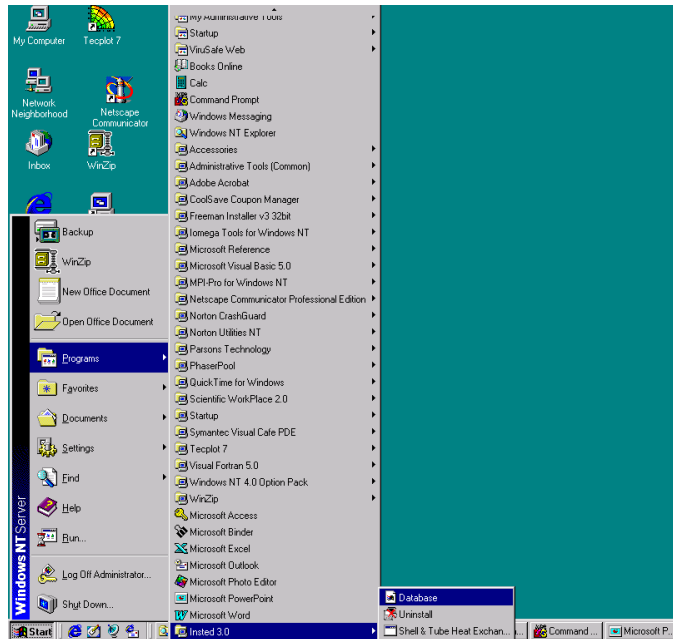(3) Definition of the entire piping system using the defined pipe types and loss types.

This section also includes a summary of the procedure for performing a sample analysis with the Series Piping program.

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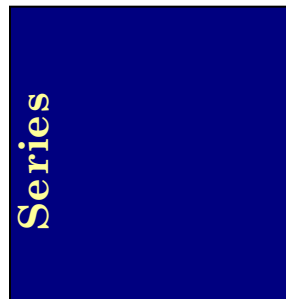# RUNNING INSTED®/Series Piping Systems Program

Starting the Program

Follow this procedure to execute INSTED®/Series Piping Systems Program:

1. Click on the Windows **Start** button.
2. Select **Program**
3. Select **INSTED 3.0**
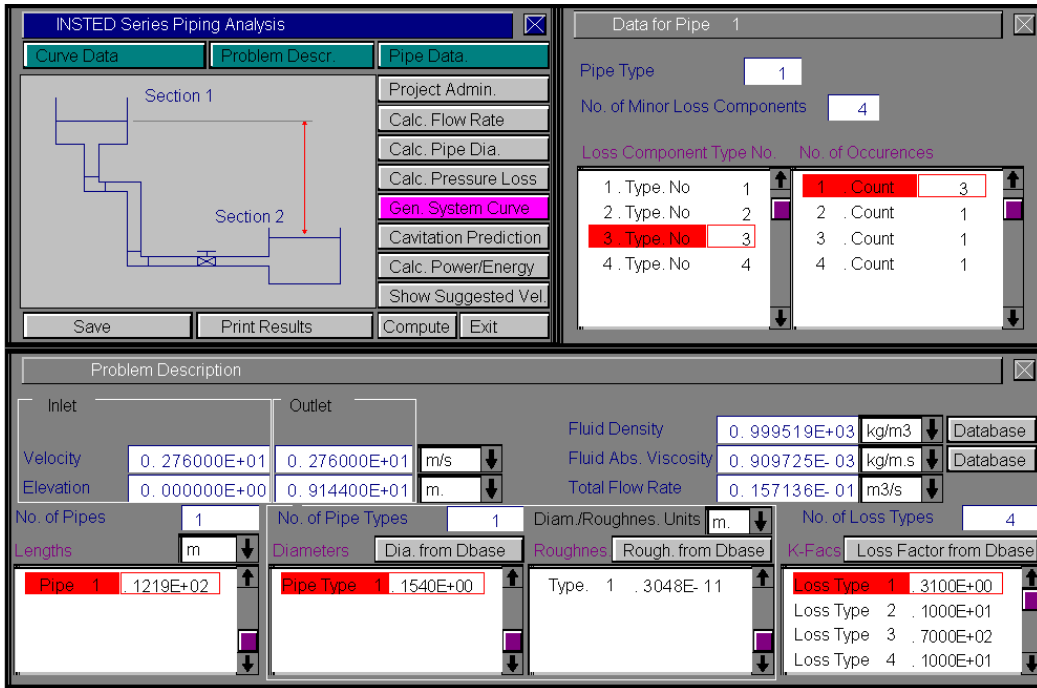4. Select the **Series Piping Systems** icon

The Restart File

The Series Piping Systems program automatically loads the previous analysis if the program was terminated normally in the previous session. This is to allow previous sessions to continue naturally. However, to initialize all input fields, select the "New Project" option as described elsewhere in this manual.
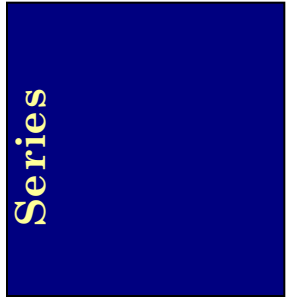
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PROGRAM ORGANIZATION

The INSTED®/Series Piping Systems Program is organized into six dialog boxes: the Main, Project Administration, Problem Description, Pipe Data, Curve Data and the Cavitation dialog boxes. The 'Curve Data' dialog box is available only if the required task is to compute the system curve. Also, the 'Cavitation' dialog box is also available only if the required task is to predict cavitation.

The dialog boxes are launched from the Main dialog box. Result presentation is done also via the Main dialog box. A detailed description of each dialog box is presented later in this manual. The figure above shows the program interface.

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Sketch of a Sample Series Piping System

Section 1 and Section 2 are terms used later in this manual and are labeled in the figure below.

Piping System

Section 1

Inlet

Section 2

Outlet

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Tasks and Input Requirements

INSTED®/Series Piping System Program performs the tasks shown in the table below.

Task	Input Requirements	Method of Solution
Calculation of flow rate (assumes one pipe)	Pressure at sections 1 and 2, velocity at sections 1 and 2, elevation (relative) at sections 1 and 2, length of pipe, K-factors for all minor losses, diameter and roughness of the pipe, density and absolute viscosity of fluid.	iterative
Calculation of pipe diameter (assumes one pipe)	Flow rate, pressure at sections 1 and 2, velocity at sections 1 and 2, elevation (relative) at sections 1 and 2, length of pipe, K-factors for all minor losses, roughness of the pipe, density and absolute viscosity of fluid.	iterative
Calculation of pressure loss	Flow rate, velocity at sections 1 and 2, elevation (relative) at sections 1 and 2, length of pipe, K-factors for all minor losses, diameter and roughness of all pipe types, density and absolute viscosity of fluid.	direct
Generation of the system curve and pump curve	Length of pipe, K-factors for all minor losses, diameter and roughness of all pipe types, density and absolute viscosity of fluid, minimum and maximum flow rate for system curve, pump curve data (if pump curve is required).	direct
Cavitation prediction	Pressure at sections 1 and 2, velocity at sections 1 and 2, elevation (relative) at sections 1 and 2, length of pipe, K-factors for all minor losses, diameter and roughness of pipes, density and absolute viscosity of fluid, required NPSH (Net Positive Suction Head), vapor pressure of liquid.	direct
Power/Energy calculation	Flow rate, pressure at sections 1 and 2, velocity at sections 1 and 2, elevation (relative) at sections 1 and 2, length of pipe, K-factors for all minor losses, diameter and roughness of pipes, density and absolute viscosity of fluid.	direct

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Results

- Flow rate
- Pressure loss
- Power/energy required
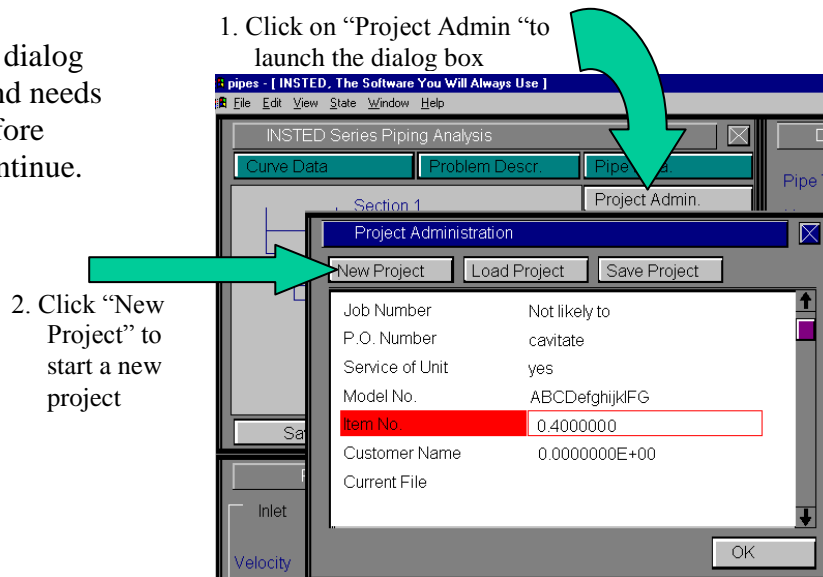- Likelihood of occurrence of cavitation
- System curve

Graphs

- Plots of system curve
- Plots of the pump curve, if you supply the pump characteristics. The intersection of the system and pump curves is calculated and displayed

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Starting a New Project

To start a new project:
1. Click the "Project Admin." button on the Main dialog box
2. Click "New Project" on the 'Project Administration' dialog box
3. Fill in the administrative data for the editbox on the Project Administration dialog box as needed

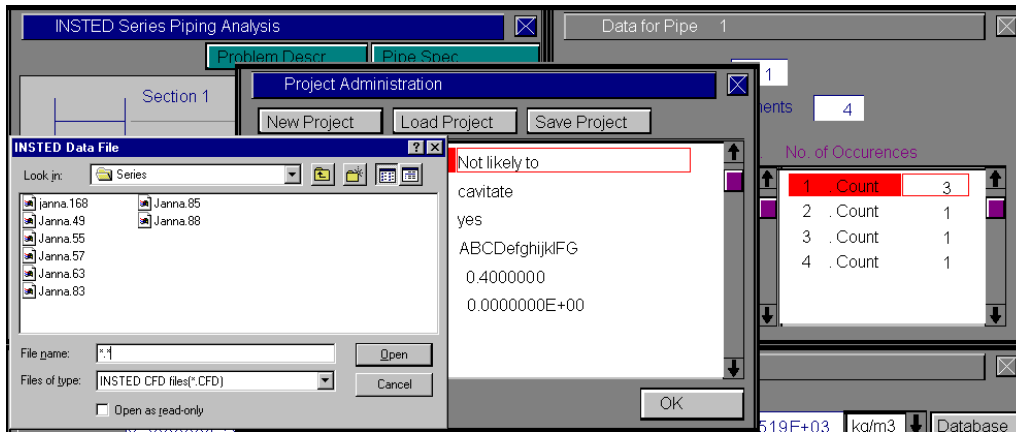The Project Administration dialog box is modal and needs to be closed before analysis can continue.

1. Click on "Project Admin "to launch the dialog box

2. Click "New Project" to start a new project

Loading an Old Project

To load an old project:
1. Click the "Project Admin." button on the Main dialog box
2. Click on the "Load Project" button
3. Type "*.* in the file name text box on the Windows file menu which comes up
4. Press the Enter key

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5. Select the file you wish to open on the Windows file open dialog box, which is shown below

Saving a New Project

To save a new project:
1. Click the "Project Admin." button on the Main dialog box
2. Click on the "Save Project" button
   ⇒ A Windows 'File Save' dialog box will appear
3. Select the path where you wish to save the file
4. Type a name for the new project file

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DESCRIPTION OF THE DIALOG BOXES

The following section describes the function of each dialog box in INSTED®/Series Piping Systems program.
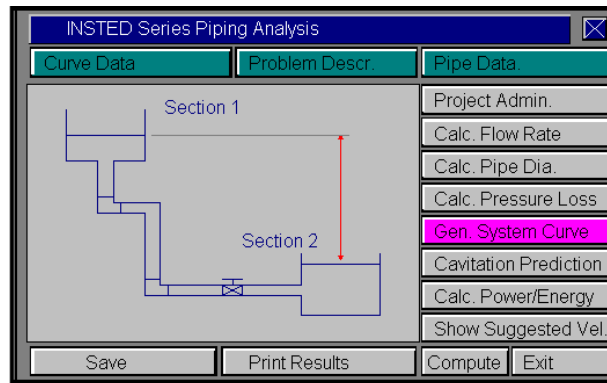
The Main Dialog Box

The activities involved in the analysis of Series Piping systems with INSTED are organized around fifteen buttons whose functions are described below.

Project Admin

This button opens the 'Project Administration' dialog box, which performs administrative functions including loading and saving the session data and initializing all data fields for starting a new session.

Task Buttons

The buttons for selecting the tasks are also located in the Main dialog box. This includes the "Calc. Flow Rate", "Calc. Pipe Dia.", "Calc. Pressure Loss", "Gen. System Curve", "Cavitation Prediction" and "Calc. Power/Energy" buttons.

The tasks supported by this program and the required inputs have been presented in a previous section of this manual.

Show Suggested Velocity

Press this button to open the 'Suggested Velocity' module of INSTED/Database. It provides estimates of the optimum velocities for the flow of fluids in a pipe.

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Problem Description

This button opens the 'Problem Description' dialog box, which contains a description of the problem including the pipe types, loss types, thermophysical properties of fluids, number and length of pipes, and the flow conditions at inlet.

Pipe Data

Press the "Pipe Data" button to open the 'Pipe Data' dialog box where the pipes are described in terms of the type, number of components, and the component types.

Compute

The Compute button tells INSTED to compute the results. This assumes that all required input data for the task have been specified. If this is not the case, the computation may be unsuccessful and the missing input is indicated, via a (warning) message box.

To Save

Click on the "Save" button, which is conveniently situated on the Main dialog box. To safeguard work done in the session, it is advisable to intermittently perform a save operation. Note that an error occurs if no project has been loaded and previously saved using the "Save Project" button in the 'Project Administration' dialog box. The procedure for saving a new project has been described in a previous section of this manual.

Print Results

Click on the "Print Results" button to plot the system curve and pump curves (if pump characteristics are specified). When both the system curve and pump curve are presented, the point of intersection is also displayed. The plot may be printed from the File/Print menu at the top of the plot screen. Clicking on any area of the plot screen returns you to the Main program.

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Curve Data

This button is visible only if the "Gen. System Curve" button is selected. This button opens up the dialog box in which the curve data is specified. The range of flow rate for which the system curve is desired should also be specified in this dialog box. The corresponding pump head loss data for the range of flow rate should also be specified if you require that the program display the pump curve.
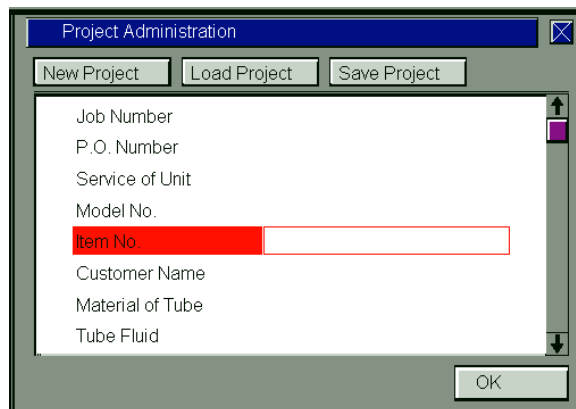
Cavitation Data

Click on the "Cavitation Prediction" button to open the 'Cavitation Data' dialog box where cavitation data whould be specified. The cavitation data include the vapor pressure and the required Net Positive Suction Head (NPSH).

Exit

Press this button to close the program and end the current session. All session data are stored and are automatically retrieved on restarting the program.
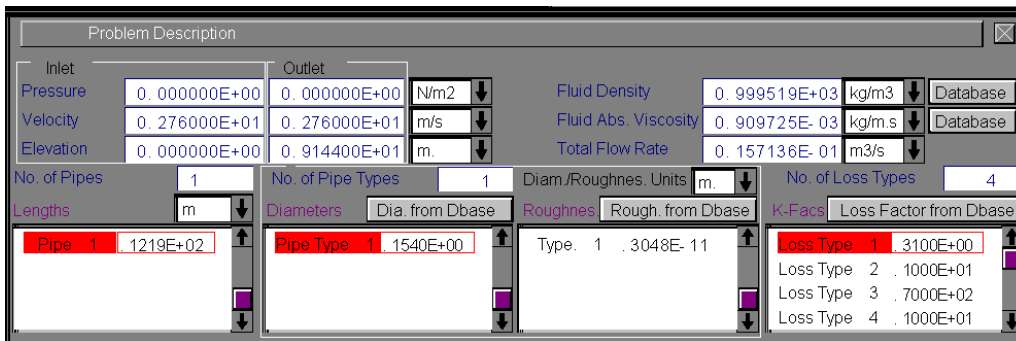
The Project Administration Dialog Box

In previous sections, we covered the functions of the Project Administration dialog box, including loading an existing project, saving a new project, or starting a new project.

The Project Administration dialog box contains a description of the project, including job number, customer names, etc.

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The Problem Description Dialog Box

This dialog box contains a description of the problem. Enter the inlet and exit conditions in this dialog box. A complete description of the end conditions requires the pressure, velocity and elevation. The required end conditions depend on the selected task. For instance, if pressure loss is to be calculated, the end pressure conditions is not a required input data. The required input data for the different tasks have been presented earlier in this manual.
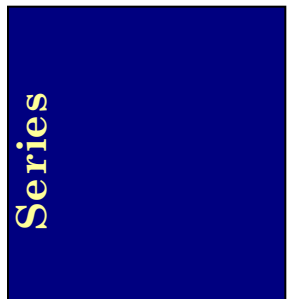

The number of pipes and the length of each pipe should be specified in this dialog box.

Pipe Types

A piping system may be composed of several pipe types, in terms of diameter and roughness. Grouping pipes into types saves on input data specification. Pipes of the same type have the same diameter and roughness.

The pipe types should be specified in the 'Problem Description' dialog box. The required input is the pipe diameter and the pipe roughness. Pipes can be selected from the INSTED/Database. Roughness data can also be obtained from

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INSTED/Database. Please refer to the database manuals for instructions on how to find specific data.

Loss Types

In INSTEAD, the minor losses in piping systems are grouped in terms of the loss (or K) factors to save on input data specification. A piping system may contain several loss types with some loss types occurring several times in the assembly. The Series Piping program allows you to define the loss type once and reuse this loss type as many times as necessary.

The required input for defining a loss type is the loss factor, which you may specify or obtain from INSTED/Database.
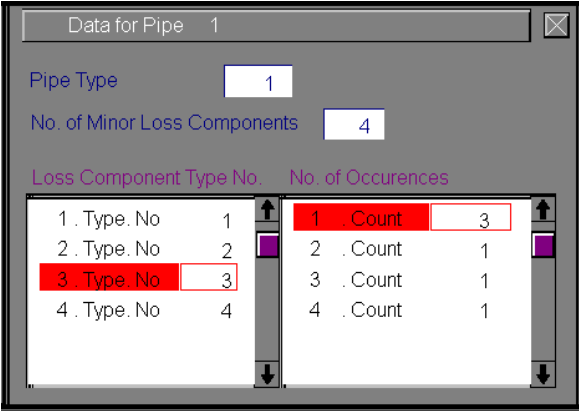
Fluid Properties

Specify fluid thermophysical properties in this environment. You could also obtain them from the Database.

Total Flow Rate

The total flow rate through the piping system is also entered in the 'Problem Description' dialog box.
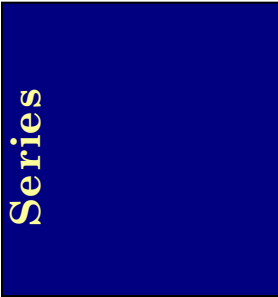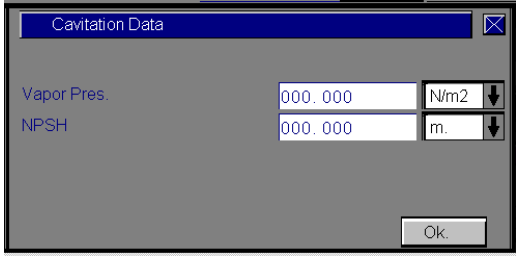
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Pipe Data Dialog Box

This dialog box contains a description of each pipe section. The required input data is the pipe type used in the section and the number and type of loss components in the pipe.
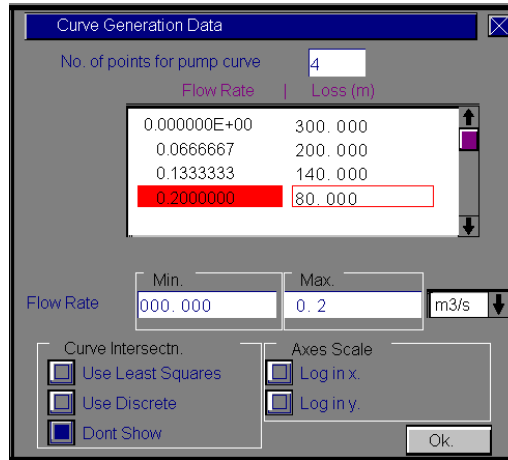

Cavitation Dialog Box

Enter the required input data for predicting cavitation in this dialog box. The input data are the vapor pressure and the required Net Positive Suction Head (NPSH).
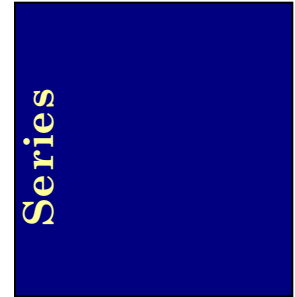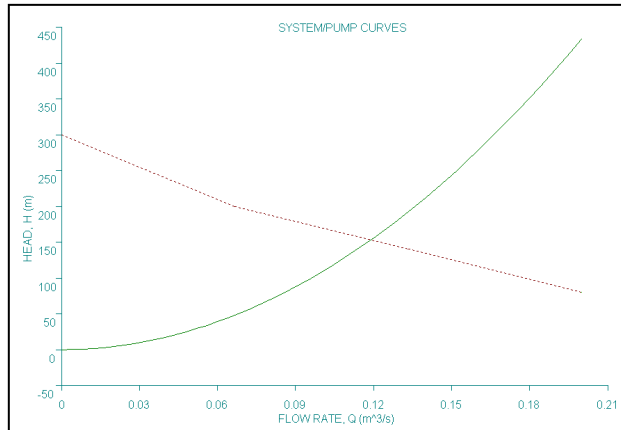

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Curve Data Dialog Box

Enter the range of flow rate for the system curve in this dialog box. This input is relevant only if the system curve task is selected. The program calculates the head loss across the range of flow rate and displays a graph of the result.

If you require INSTED to compare this system curve to a pump curve, enter the pump head loss over the same range of flow rate. The number of points for plotting the pump curve should be specified; the program provides a template for entering the pump data over this range and calculates the intersection of the pump and system curves.

The figure on the right shows a system curve for a piping system for the range of flow rate specified in the 'Curve Data' dialog box shown above.

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RUNNING A SAMPLE FILE

This section presents procedural details for using INSTED to analyze series piping systems.

Procedure for a series piping system calculation

1. Select the task of interest e.g. 'Calculate flow Rate' or 'Calculate Power/Energy'
2. In the 'Problems Description' dialog box, enter the number of pipe types in the system
   → The diameter and roughness listboxes are automatically formatted to receive input for the number of pipe types entered
3. Enter the diameter and roughness of each pipe type in the appropriate listboxes You may select these from INSTED/Database by clicking the appropriate button
4. Enter the number of minor loss types
5. Enter the K-factor for each loss type in the 'K-facs' listbox or select this from the database
6. Enter the number of pipes in the system. (Note that this number is always 1 for Tasks 1 and 2.)
7. Enter the length of each pipe in the 'Lengths' listbox.
8. Select each pipe in the 'Lengths' listbox by clicking on it in the listbox. For each pipe:
   (a) Enter the pipe type in the 'Data for Pipe' dialog box
   (b) Enter the number of minor loss components
   (c) For each loss component, enter its type and number of occurrence in the pipe
9. Click on the "Compute" button

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A sample problem best illustrates the procedure.

Problem Statement

Chloroform flows at a rate of 0.05 m^3/s through a 4-nominal schedule 40 wrought iron pipe. The pipe is laid out horizontally and is 250 m long. Calculate the pressure drop of the chloroform.

For chloroform, density, ρ = 1.47 kg/m^3, absolute viscosity, μ = 0.53 x 10^{-3} Ns/m^2.

For 4-nominal schedule 40 pipe, the internal diameter is 10.23 cm, flow area is 82.19 cm^2 (this pipe type is also available in INSTED/Database).

Source

William @. Janna. "Design of Fluid Thermal Systems". PWS-Kent Publishing, Boston, Page 49.

Comments

- The task is to calculate pressure
- Input data are provided in source as shown above
- There are no minor losses in this problem.

Name of Data

The input data for the present sample problem are contained in the file \insted30\pipes\samples\janna.49.

Instructions for running a sample file

Sample files for INSTED/Series Piping Systems program are located in the installation drive. To run the sample file 'janna.49', follow these procedures:

1. Click "Project Admin" on the Main dialog box.
2. Click the "Load Project" button.

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3. Go to the subdirectory 'Samples' by double-clicking on the 'Samples' folder.
4. Type " *.* " in the filename position and press Enter
   → A list of the files present in the directory is displayed.
5. Select the file '*janna.49*' and click on the "Open" button.
6. Close the Project Admin dialog by clicking its "Ok" button
7. Click "Compute" on the Main dialog and wait for computation to end.

Results

Variable	Janna (SI)	INSTED (SI)	Difference
Pressure loss	0.11 MPa	0.111 MPa	< 1%
Friction	0.0165	0.0167	< 1%
Re	1.73×10^6	1.73×10^6	< 1%

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