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## INTRODUCTION

The procedures for executing INSTED®/Concentric Tubes program are presented in this section. The input file options, primary tasks, required data, and the output results are discussed, as are the online utilities that are available within the program environment.

INSTED/Concentric Tubes program performs a rating of concentric tubes heat exchangers. It also calculates the length of tube required to deliver a prescribed heat load. The program interfaces with INSTED/Internal Flow and Heat Transfer program to compute the heat transfer coefficient on the inside and the outside of the inner tube and with INSTED/Fin Analysis program to compute the heat transfer when there are fins.

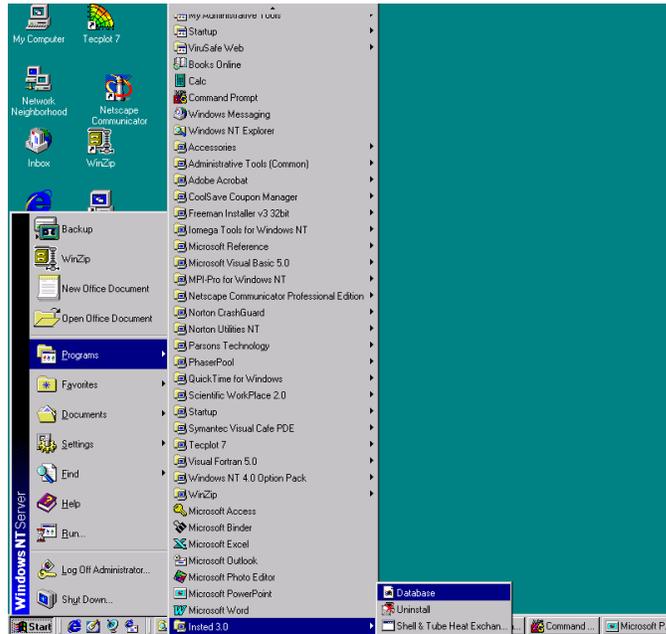
This manual also summarizes the procedure for carrying out a sample analysis with the Concentric Tubes program.

## RUNNING INSTED®/Concentric Tubes Program

### Starting the Program

Follow this procedure to execute INSTED®/Concentric Tubes Program:

1. Click on the Windows **Start** button
2. Select **Program**
3. Select **INSTED 3.0**
4. Select the **Concentric Tubes** icon



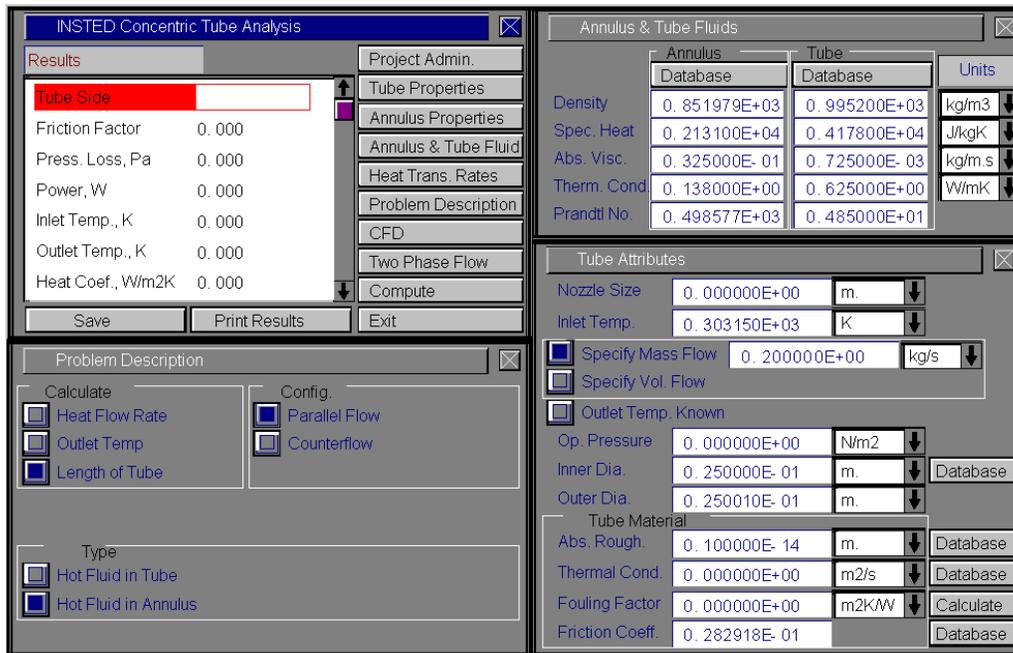
### The Restart File

The Concentric tubes program automatically loads the previous analysis if the program was terminated normally in the previous session. This is to allow interrupted sessions to continue naturally. However, to initialize all input fields, select the “New Project” option from the ‘Project Admin’ dialog box. This feature is explained in more details later in this manual.



## PROGRAM ORGANIZATION

The INSTED®/Concentric Tubes program is organized into six dialog boxes: the Main, Project Administration, Problem Description, Annulus & Tube Fluids, Heat Transfer Rates, Tube Properties, and the Annulus Properties dialog boxes. 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 below shows the program interface.



Concentric

## Tasks

Tasks that can be performed include:

- Rating (Performance) analysis
- Calculation of heat exchanger length

## Required Data

The minimum data required for analysis are:

- Inlet temperatures of both annulus and tube fluids
- Specification of whether the hot or cold fluid is in the annulus.
- Thermophysical properties (specific heat, density, absolute viscosity, thermal conductivity, and Prandtl number) for both annulus and tube fluids. These data may be specified directly or obtained seamlessly through the INSTED/Database program.
- Inner and outer diameter of the tube (also obtainable from the Database)
- Annulus inner diameter (can be obtained from Database)

## Other Data

- Fouling factor for tube side
- Fouling factor for annulus side
- Fin efficiency on the inner surface of tubes (can be obtained from INSTED/Fin Analysis program)
- Fin efficiency on the outer surface of tubes (can be obtained from INSTED/Fin Analysis program)

## Data that may be required

- Tube fluid mass flow rate
  - not required if tube outlet temperature is specified
- Annulus fluid mass flow rate
  - not required if annulus outlet temperature is specified
- Tube fluid outlet temperature
  - not required for the rating task

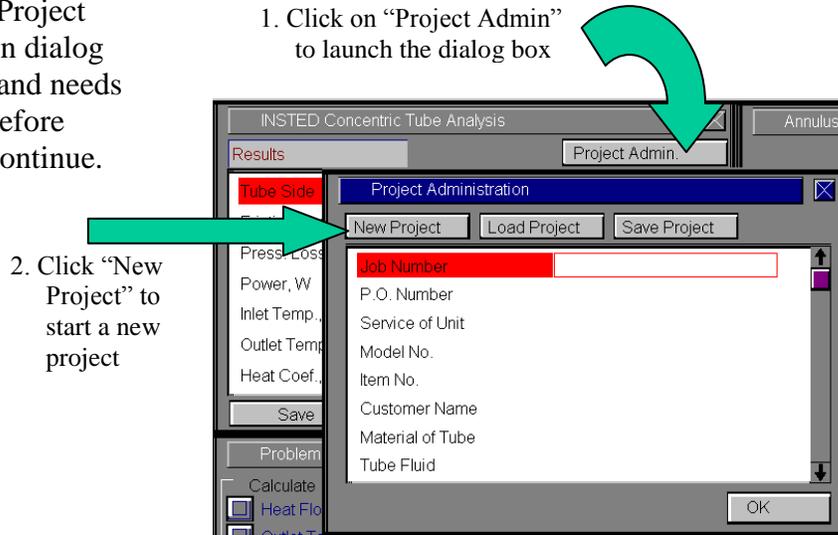
- Annulus fluid outlet temperature
  - not required for the rating task
- Film coefficient for inner surface of tubes
  - may be obtained from INSTED/Internal Flow and Heat Transfer program
  - not required if overall U can be specified
- Tube length
  - not required for the 'length of tube' task

## 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

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

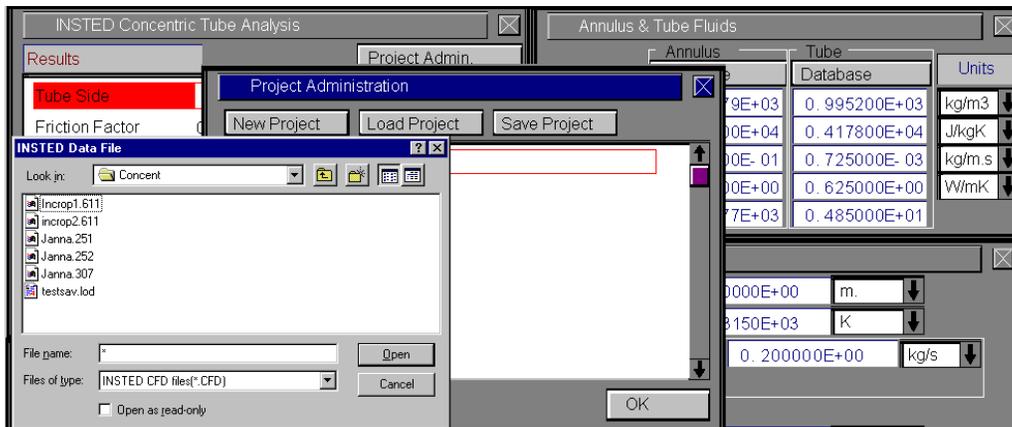


## Loading an Old Project

To load an old project:

1. Click on 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

5. Select the file you wish to open by locating it on the Windows file open dialog box. This dialog box is shown below.



## Saving a New Project

To save a new project:

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

## DESCRIPTION OF THE DIALOG BOXES

The following section describes the function of each dialog box in INSTED®/Concentric Tubes program.

### The Main Dialog Box

This dialog box contains twelve buttons which are described below.

#### Project Admin

Click on this button to open 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.

#### Tube Properties

Click on this button to open the 'Tube Properties' dialog box.

#### Annulus Properties

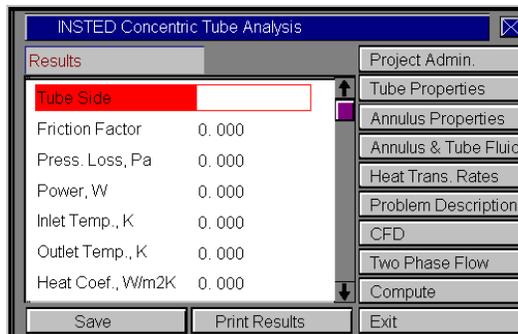
Click on this button to open the 'Annulus Properties' dialog box.

#### Annulus & Tube Fluid

Click on this button to open the 'Annulus & Tube Fluid' dialog box.

#### Heat Transfer Rates

Click on this button to open the 'Heat Transfer Rates' dialog box.



## **Problem Description**

This button opens the 'Problem Description' dialog box.

## **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 not be successful 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 previously and 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**

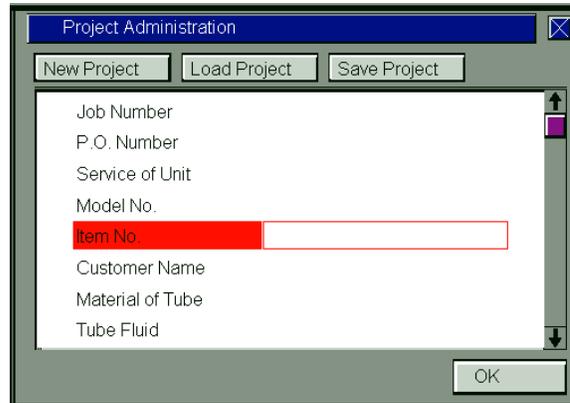
The "Print Results" button presents the results in a TEMA Sheet format. This report may be printed from the File/Print menu at the top of the report screen. Clicking on any point on the screen will exit the TEMA Sheet and return you to the main program.

## **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.

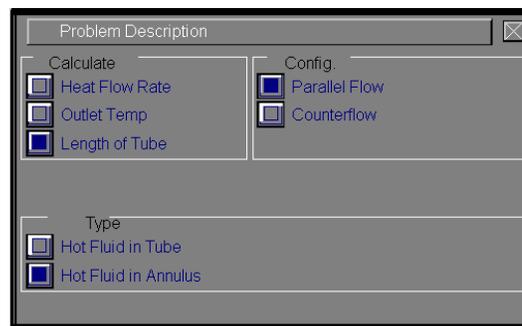
## The Project Administration Dialog Box

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 Problem Description Dialog Box

You specify the type of analysis desired in this dialog box. There are two basic options for analysis: rating and tube length determination.



In this dialog box, you also specify the flow configuration (parallel or counter-current) and indicate which stream (hot or cold) is located in the shell.

## Tube Attributes Dialog Box

This dialog box contains the input field for the process and flow conditions inside the tube. The inlet and outlet temperatures, flow rate, and the diameter of the tubes may be entered in this dialog box. Standard tube sizes are available in the Pipe Schedules module of INSTED/Database, which can be accessed by clicking on the “Database” button beside each input.

The screenshot shows the 'Tube Attributes' dialog box with the following fields and values:

Field	Value	Unit	Action
Nozzle Size	0.000000E+00	m.	
Inlet Temp.	0.303150E+03	K	
<input checked="" type="checkbox"/> Specify Mass Flow	0.200000E+00	kg/s	
<input type="checkbox"/> Specify Vol. Flow			
<input type="checkbox"/> Outlet Temp. Known			
Op. Pressure	0.000000E+00	N/m2	
Inner Dia.	0.250000E-01	m.	Database
Outer Dia.	0.250010E-01	m.	
Tube Material			
Abs. Rough.	0.100000E-14	m.	Database
Thermal Cond.	0.000000E+00	m2/s	Database
Fouling Factor	0.000000E+00	m2KW	Calculate
Friction Coeff.	0.282918E-01		Database

The tube inner surface roughness and the material thermal conductivity may also be specified in this dialog box.

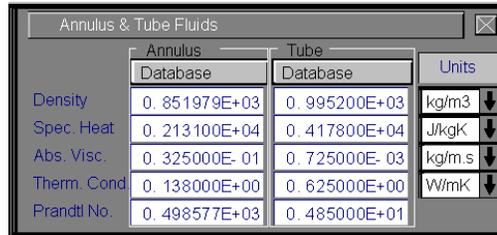
The friction coefficient for the tube flow may be specified or computed in INSTED/Database using the Reynolds number calculated from the flow rate and density input. You may also choose to obtain estimates of the surface roughness for the given tube material from the database.

## Annulus Attributes Dialog Box

This dialog box is similar to the ‘Tube Attributes’ dialog box. It receives the input data for the process and flow conditions in the annulus.

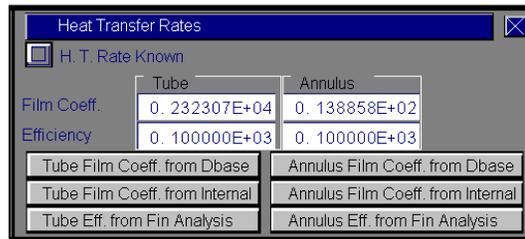
## Annulus & Tube Fluids Dialog Box

Enter the thermophysical properties of the fluids in the annulus and in the tube in this dialog box. These properties are density, specific heat, thermal conductivity, and absolute viscosity. The properties of many fluids can be obtained from INSTED/Database. For fluids not included in the Database, you may enter their properties in the Database using the custom data capabilities of INSTED/Database.



## Heat Transfer Rates Dialog Box

Enter the heat transfer coefficient in the inner and the outer surfaces of the tube in this dialog box. The heat transfer coefficient may be obtained from a calculation performed in INSTED/Internal Flow and Heat Transfer program. Very rough estimates for this variable may also be obtained from INSTED/Database.



If the surface of the tubes are finned, the heat transfer coefficients may be obtained from INSTED/Fin & Fin Array program. These programs are easy to use. However, you may refer to the particular manuals for the procedures on how to perform the required tasks.

## RUNNING A SAMPLE PROBLEM

This section illustrates the use of the INSTED/Concentric Tubes program. A sample problem best illustrates the procedure.

### Problem Statement

In a facility where electricity is generated, condensed (distilled) water is to be cooled by means of a shell and tube heat exchanger. Distilled water enters the exchanger at 110°F at a flow rate of 170,000 lbm/hr. Heat will be transferred to raw water (from a nearby lake) which is available at 65°F and 150,000 lb/hr. Preliminary calculations indicate that it may be appropriate to use a heat exchanger that has a 17¼ in. inside diameter shell, and ¾ in. OD, 18 BWG tubes that are 16 ft. long. The tubes are laid out on a 1 in. triangular pitch, and the tube fluid will make two passes. The exchanger contain baffles that are spaced 1 ft. apart. Analyze the proposed heat exchanger to determine its suitability.

### Source

William S. Janna. "Design of Thermal Systems". PWS-Kent Publishing. Boston. Page 275.

### Comments and Procedural Details

- In INSTED, choose the 'outlet temperature' or the 'rating' task
- Hot fluid (distilled water) is in the shell. Raw water is in the tubes
- In addition to the data above, it is also stated that the number of tubes is 196, the number of shell passes is 1, and the number of baffles is 15. From 2 tube passes and 196 total number of tubes, the total number of tubes per pass is 98
- Specify triangular pitch, 2 tube passes
- The mass flow rates of both tube and shell fluids are known
- Use online conversion to convert all British units to SI
- Use thermophysical properties given in source. Obtain absolute viscosity,  $\mu$ , from the  $\rho$  and  $\nu$  provided in the source, where  $\nu$  is the kinematic viscosity

- Overall U is not known apriori. Both the inner and outer film coefficients of the inner tube were obtained from internal flow analysis.
- To obtain the inner film coefficient of the inner tube, click the “Compute Tube Film Coeff.” button on the 'Heat Transfer Rates' dialog box.
- The friction factor calculation for the annulus flow is calculated as 0.2774, the Nusselt number for is 126.8, and calculated film coefficient is 4429 W/m<sup>2</sup>K.
- The problem is solved without specifying a fouling factor. For fouling factor, a fouling factor of 0.00015 m<sup>2</sup>K/W is assumed at both the inner and outer surfaces of tubes.

### Name of Data

The input data for the present sample problem are contained in the file  
\insted30\concentric\samples\janna.275.

### Instructions for running a sample file

Sample files for INSTED/Concentric Tubes program are located in the installation drive. To run the sample file 'janna.275', follow these procedures:

1. From the 'Project Admin' dialog box, click on the “Load Project” button
2. Locate the directory \insted30\concentric\samples\ on the installation drive
3. Type " \*.\* " in the filename position and press Enter  
→ A list of the files present in the directory is displayed
4. Select the file 'janna.275' and click on the 'Ok' button
5. Click "Compute" on the Main dialog box to view the results