Aspen B-JAC® 12.1

User's Guide

Version Number: 12.1
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Corporate

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Contents

Aspen B-JAC Overview

Aspen B-JAC Programs

The Aspen B-JAC software includes a number of programs for the thermal design, mechanical design, cost estimation, and drawings for heat exchangers and pressure vessels.

The major design programs are:

Aspen Hetran™	Thermal Design of Shell & Tube Heat Exchangers
Aspen Teams™	Mechanical Design, Cost Estimation, and Design Drawings of Shell &Tube Heat Exchangers and Pressure Vessels
Aspen Aerotran™	Thermal Design of Air Cooled Heat Exchangers, Flue Gas Heat Recuperators, and Fired Heater Convection Sections

In addition to the major design programs, these programs support the design programs:

Props	Chemical Physical Properties Databank
Priprops	Program to Build a Private Databank for Props
Metals	Metal Properties Databank
Primetals	Program to Build a Private Databank for Metals
Ensea	Tubesheet Layout Program
Qchex	Budget Cost Estimation Program
Draw	Graphics Interface Program for Drawings
Newcost	Program for Maintaining Labor & Material Databases
Defmats	Program for Establishing Default Materials

Aspen Plus Integration

The Aspen B-JAC Hetran and Aerotran programs are completely integrated with the Aspen Plus process simulation software. Users with licenses for both the Aspen B-JAC thermal analysis software and the Aspen Plus simulation software can use the Aspen B-JAC thermal models for shell and tube heat exchangers and air-cooled heat exchangers within the Aspen Plus flowsheet.

The models can be accessed from Aspen Plus by selecting the blocks Hetran or Aerotran for the heat transfer unit operations. Stream and property curve data for these blocks can be supplied to the Aspen B-JAC programs by Aspen Plus or from within the Aspen B-JAC input file, which is referenced in the Aspen Plus input for the block. All exchanger geometry data must be specified through the Aspen B-JAC input file.

During simulation the Aspen Plus simulator repetitively calls the Aspen B-JAC analysis programs to predict the outlet conditions of the heat transfer equipment. The results of the analysis are returned to Aspen Plus which then feeds them to subsequent blocks. A subset of the exchanger performance can be viewed from within the Aspen Plus environment. All results of the block can be viewed in detail through the Aspen B-JAC user interface.

Aspen Pinch Integration

The Aspen B-JAC Hetran program is completely integrated with the Aspen Pinch process synthesis software. Users with licenses for both the Aspen B-JAC thermal analysis software and the Aspen Pinch software can use the Aspen B-JAC thermal models for shell and tube heat exchangers within the Aspen Pinch flowsheet.

The models can be accessed from Aspen Plus by selecting the block Hetran for the heat transfer unit operations. Stream and property curve data for these blocks can be supplied to the Aspen B-JAC programs by Aspen Pinch or from within the Aspen B-JAC input file which is referenced in the Aspen Pinch input for the block. All exchanger geometry data must be specified through the Aspen B-JAC input file.

During simulation the Aspen Pinch simulator repetitively calls the Aspen B-JAC analysis programs to predict the outlet conditions of the heat transfer equipment. The results of the analysis are returned to Aspen Pinch which then feeds them to subsequent blocks. A subset of the exchanger performance can be viewed from within the Aspen Pinch environment. All results of the block can be viewed in detail through the Aspen B-JAC user interface.

Aspen Zyqad Integration

The Aspen B-JAC Hetran program is completely integrated with Aspen Zyqad. Aspen Zyqad is an engineering database tool used to capture process knowledge about the design, construction, or operation of a process plant. The database contains a number of data models to store information about the process streams, the process configuration, and the individual pieces of process equipment. The user can retrieve the information and generate specialized reports and equipment specification sheets from the data in the database.

License & Service Agreements

The use of the Aspen B-JAC software is governed by a "License Agreement" for licensed clients. These are legally binding contracts which have been signed and executed by your company and Aspen Technology, Inc.. Some of the points included in these contracts are shown below.

Access

Access to the programs is limited to the employees of the Customer in support of the Customer's business. Specifically excluded is access by persons other than the Customer's employees or use by the Customer's employees for any purpose outside the Customer's business.

License

The license authorizes the Customer to use the licensed program on the designated computers. Backup copies can be made.

The license is limited to the Customer, and may not be transferred or assigned, nor may it be extended to any subsidiaries or joint ventures except as agreed in writing between the Customer and Aspen Technology, Inc.

The licensed programs are the sole and exclusive property of Aspen Technology, Inc. The licensed Customer does not become the owner of the programs, but has the right to use the programs in accordance with the license agreement.

Warranty and Limitation of Liability

The licensed programs are offered as is, and it is the Customer's responsibility to determine if the programs are adequate for the Customer's requirements. The Customer understands that the programs are of such complexity that they may have inherent defects and that Aspen Technology, Inc. makes no warranty that all such defects will be corrected. Aspen Technology, Inc. will make a reasonable effort to correct or bypass properly reported and documented programming errors in regularly scheduled program updates.

In no event shall Aspen Technology, Inc., its agents, suppliers, or contractors be liable to the Customer or any third party for consequential damages arising from use of the Aspen B-JAC programs. It is the Customer's responsibility to check the results of all computer programs.

Technical Support

AspenTech customers with a valid license and software maintenance agreement can register to access the **Online Technical Support** Center at:

http://support.aspentech.com

This web support site allows you to:

- Access current product documentation
- Search for tech tips, solutions and frequently asked questions (FAQs)
- Search for and download application examples
- Search for and download service packs and product updates
- Submit and track technical issues
- Search for and review known limitations
- Send suggestions

Registered users can also subscribe to our Technical Support e-Bulletins. These e-Bulletins are used to proactively alert users to important technical support information such as:

- Technical advisories
- Product updates
- Service Pack announcements
- Product release announcements

Contacting Customer Support

Customer support is also available by phone, fax, and email for customers with a current support contract for this product. For the most up-to-date phone listings, please see the Online Technical Support Center at **http://support.aspentech.com**.

Hours

Support Centers	Operating Hours (Monday-Friday)
North America	8:00 – 20:00 Eastern Time
South America	9:00 – 17:00 Local time
Europe	8:30 – 18:00 Central European time
Asia and Pacific Region	9:00 – 17:30 Local time

Phone

Support Centers	Phone Numbers	
North America	1-888-996-7100	Toll-free from U.S., Canada, Mexico
	1-281-584-4357	North America Support Center
	(52) (55) 5536-2809	Mexico Support Center
South America	(54) (11) 4361-7220	Argentina Support Center
	(55) (11) 5012-0321	Brazil Support Center
	(0800) 333-0125	Toll-free to U.S. from Argentina
	(000) (814) 550-4084	Toll-free to U.S. from Brazil
	(0800) 100-2410	Toll-free to U.S. from Venezuela
Europe and Africa	(32) (2) 701-95-55	European Support Center
	Country specific toll-free numbers:	
	Austria	(0800) 111-900
	Belgium	(0800) 40-687
	Denmark	8088-3652
	Finland	(0) (800) 1-19127
	France	(0805) 11-0054
	Germany	(0800) 101-0068
	Ireland	(1) (800) 930-024
	Italy	(800) 905-826
	Netherlands	(0800) 023-2511
	Norway	(800) 13817
	South Africa	(0800) 996-852
	Spain	(900) 951846
	Sweden	(0200) 895-284
	Switzerland	(0800) 111-470
	UK	(0800) 376-7903
Asia and Pacific Region	(65) 6395-39-00	Singapore
	(81) (3) 3262-1743	Tokyo

Fax

Support Centers	Fax Numbers
North America	1-281-504-3999
South America	(54) (11) 4361-7220 (Argentina) (55) (11) 5012-4442 (Brazil)
Europe	(32) (2) 701-94-45
Asia and Pacific Region	(65) 6395-39-50 (Singapore) (81) (3) 3262-1744 (Tokyo)

E-mail

Support Centers	E-mail
North America	support@aspentech.com (Engineering Suite) support@hyprotech.com (Hyprotech products) atmdsupport@aspentech.com (Aspen ICARUS products) mimi.support@aspentech.com (Aspen MIMI products) pims.support@aspentech.com (Aspen PIMS products) aspenretail.support@aspentech.com (Aspen Retail products) ACS.Support@aspentech.com (Advanced Control products) AMS.Support@aspentech.com (Manufacturing Suite) Mexico.Support@aspentech.com (Mexico)
South America	LAsupport@aspentech.com Argentina.Support@aspentech.com (Argentina)
Europe	atesupport@aspentech.com (Engineering Suite) support@hyprotech.com (Hyprotech products) cimview@aspentech.com (CIMVIEW products) Metals.Support@aspentech.com (Metals products) AMS.Support@aspentech.com (All other suites)
Asia and Pacific Region	atasupport@aspentech.com (Singapore: Engineering Suite) support@hyprotech.com (Hyprotech products) mimi.support@aspentech.com (Singapore: Aspen MIMI) aspenretail.support@aspentech.com (Singapore: Aspen Retail) AMS.Support@aspentech.com (Singapore: All other suites) atjsupport@aspentech.com (Tokyo: Engineering Suite) TK_Support@aspentech.com (Tokyo: All other suites)

Aspen B-JAC User Interface

Version Control Utility (BJACVC.exe)

Aspen B-JAC provides a version control utility, BJACVC, which enables you to switch between versions of B-JAC. BJACVC.exe is located in the XEQ folder of the installed B-JAC program.

To run the BJACVC.exe utility, locate the file using Explorer, and then double click the file.

Selecting a B-JAC program version: Select which version you wish to run and the utility will update the MS Windows registry to allow you to run the selected B-JAC program version. BJACVC automatically executes when you open a B-JAC program version that is not registered properly.

Copying customized files: Select the source version where your existing customized database files are located. Next, select the target new version where you wish to copy the database files. Next, select the files you wish to transfer. Then select Copy to copy the customized files to the new version.

Copying program settings: To copy the program settings from an existing B-JAC version to a new version, select the source version. Next, select the target new program version. Then select Apply to copy the program settings to the new targeted version.

User Customized Database Files

There are a number of database files that you can change to customize the operation of the Aspen B-JAC programs, as well as alter the program answers. These customized database files are located in a default program folder or in a user specified directory. If you elect to use the default folder location, those database files must be copied from the previous B-JAC program default folder to the new Dat\PDA folder.

You can use the Version Control Utility, BJACVC, to copy your customized files from an existing version to the new B-JAC version.

Alternately, you can specify your own directory location for these customized files and the B-JAC program will access the database from your specified folder location. To specify your user customized database folder location, select Tools | Program Settings | Files and provide the folder location for the database files.

Note: If the update is installed into the directory for the previous version, the install program will not copy over the previous version's database files.

The following table contains a list of the database files that can be customized.

Database	Contents
D_FXPRIV.PDA	Private properties chemical databank properties
D_IDPRIV.PDA	Private properties chemical databank index
D_VAPRIV.PDA	Private properties chemical databank properties
G_COMPNA.PDA	Company name and address for drawings
G_PROFIL.PDA	Default headings, input, operation options
N_MTLDEF.PDA	Default materials for generic materials (ASME)
N_MTLDIN.PDA	Default materials for generic materials (DIN)
N_MTLCDP.PDA	Default materials for generic materials (AFNOR)
N_PARTNO.PDA	Part number assignment for bill of materials
N_PRIVI.PDA	Private properties materials databank index
N_PRIVP.PDA	Private properties materials databank properties
N_STDLAB.PDA	Fabrication standards, procedures, costs, etc.
N_STDMTL.PDA	Fabrication standards as function of materials
N_STDOPR.PDA	Fabrication operation efficiencies
N_STDWLD.PDA	Fabrication welding standards
N_STDPRC.PDA	Private materials prices

Accessing Aspen B-JAC Program Files

Most users will want their input and output files stored in a directory separate from the Aspen B-JAC programs. The input and output files are read from or written to the current directory on your PC. This allows you to organize your input and output files however you wish. We recommend that you run from a directory other than the directory in which the Aspen B-JAC programs are installed.

Filenames & Filetypes

Although the Aspen B-JAC software works on several different computers and operating systems, there is a high degree of similarity in the use of filenames and filetypes for input and output files.

The filename and filetype form the name under which the file is stored on the storage medium (usually disk).

Filenames

The filename can be up to 255 characters in length and may use the letters A-Z a-z, numbers 0-9, and special characters - _ & $.

Filetypes

The filetype (filename extension) is automatically established by the Aspen B-JAC software as follows:

Filetype	Description
BJT	Aspen B-JAC Input/Output File (Release 10.0 and greater)
BFD	Aspen B-JAC Drawing File
BDT	Aspen B-JAC Template file (user can save an existing *.BJT input file as a *.BDT template file, and then reuse the template to create other design input files, using the Windows Save As feature).
BJI	Aspen B-JAC Input File (previous versions)
BJO	Aspen B-JAC Output File (previous versions)
BJA	Aspen B-JAC Archive File (Input/Output data previous versions)

Whenever an Aspen B-JAC program requests a filename, it is expecting the name without the filetype. The program will append the filetype.

Alternate Filetypes

Filetype	Description
TAF	Aspen Hyprotech TASC Output file (for import into the Aspen Teams program
DBO	HTRI Output file (for impurt into the Aspen Teams program)
OUT	HTRI Output file (for impurt into the Aspen Teams program)

Importing/Exporting Design Data

AutomationX

The Aspen B-JAC input/results file may be exported to other OLE compliant systems for use with other programs via various automation utilities. An example automation file has been provided in the example sub-directory, XMP, of the installed B-JAC program.

Export Drawings

Drawings may be exported to a *.DXF CAD format file or to an Autocad inventor file.

Results

Aspen Hetran, Teams, and Aerotran results may be exported to a *.doc file format. Aspen Teams detailed results may also be exported to an *.rtf format file.

General Operating Procedures

Most of the Aspen B-JAC programs follow these general operating procedures.

1. Start Aspen B-JAC.

   On your desktop click the Aspen B-JAC shortcut icon *or* click **Start | Programs | AspenTech | Aspen Engineering Suite | Aspen B-JAC 12.1 | Aspen B-JAC Design System**.

2. Select the appropriate Aspen B-JAC program.

   On the **Aspen B-JAC Design System** dialog box, do one of the following:

   On the **New** tab, click the checkbox next to the B-JAC program you want to use and click **OK**.

   or

   Click the **Existing** tab and select the file you want to open and click **OK**.

3. Enter the required data.

   Use the Navigation Tree *or* click the Next button on the toolbar to display the required input forms and sheets, and enter the data.

4. Run the problem.

   On the toolbar click the **Run** button *or* on the menu bar click **Run | Run Program**.

5 Review the Results.

Use the Navigation Tree to display the results.

6 Save the input data at *any time*.

On the toolbar click the **Save** button *or* on the menu bar click **File | Save**.

7 Print a hard copy of the results, if desired.

On the toolbar click the **Print** button *or* on the menu bar click **File | Print**. In the dialog box, check the boxes next to the desired output, and click **Print**.

8 If appropriate, make changes to the input data and repeat steps 4 through 7 until you have the desired solution.

9 Update the file with current geometry.

On the menu bar click **Run | Update**.

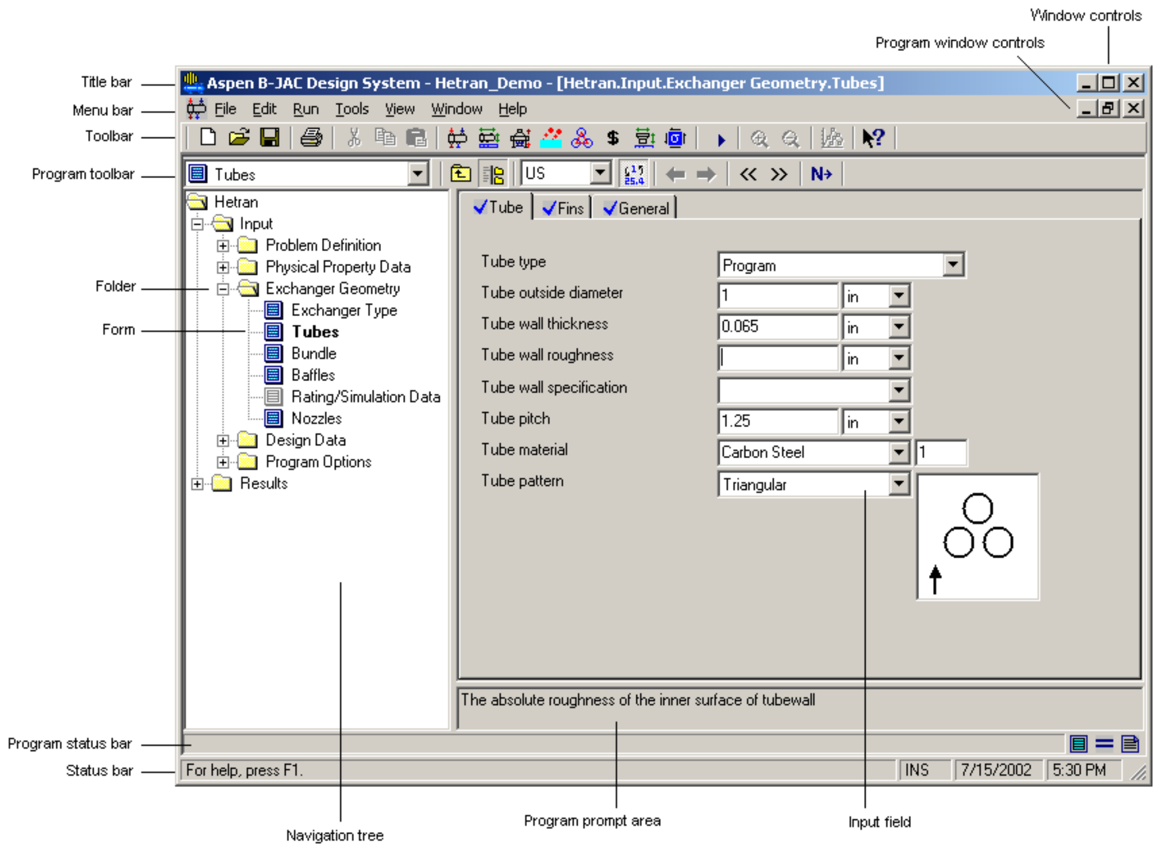
10 Transfer design information to other programs, if desired.

On the menu bar click **Run | Transfer**. In the dialog box, check the box next to the desired program and click **OK**.

11 Exit Aspen B-JAC.

On the menu bar click **File | Exit**. The program prompts you to save changes. Click the appropriate button.

The Aspen B-JAC Window



Title Bar

The bar at the top of the window displays the current program and file name.

Use the Minimize and Maximize and Restore screen control button to change the size of the program window and return the window to the original settings. The Close button closes the active program or file.

Navigation Tree, Forms and Sheets

Each Aspen B-JAC program has a Navigation Tree which appears in the left pane of the program window. The tree is organized by Input and Results folders that contain program-specific forms.

Expand the folders to display the forms. Use the scroll bar to scroll through the forms.

Each form contains one or more sheets for entering data in various input fields or for reviewing results. Tabs display the names of the different sheets. To display a sheet, click on the appropriate tab.

Prompt Area and Status Bar

This Prompt area in the Program window provides information to help you make choices or perform tasks. It contains a description about the current input field.

The Status bar at the bottom of the main Aspen B-JAC window displays information about the current program status and input field status. If value entered for an input field is outside the normal range, a warning will be display in the Status Bar with the recommend value limits.

Key Functions

Key	Description
F1	Activates the Help system
Arrow Keys	Moves the location of the cursor within an input field and scrolls through the options in a given list
Delete Key	Deletes the character at the current cursor position and shifts the remainder of the input
Home Key	Returns the cursor to the beginning of the input field
End Key	Moves the cursor to the end of the input field
Forward Tab Key	Scrolls the user through the input fields of a form
Backward Tab Key	Move cursor back to previous field
Control + Delete Keys	Erases the characters from the cursor position to the end of the input field
Page Up/Page Down Keys	Scrolls the user through the forms of the Menu Tree
Backspace Key	Deletes the character to the left of the current cursor position in an input field

Mouse Functions

In the following descriptions, "click" means to place the mouse pointer on the item and press the left mouse-button.

Location	Action
Menu Bar	Click the appropriate menu to display the choices; then click the desired option
Toolbar	Click the desired toolbar button
Forms	Click the desired form in the Menu tree
Sheets	Click the desired tab at the top of the form to move between the sheets.
Input Fields	Click the desired input field. List items: click the arrow key to the right of the input field to display the items, then click the desired option on the list Checkbox: click the checkbox to toggle between selecting and clearing the checkbox.

Location	Action
Scroll Page Up	Click the up direction arrow
Scroll Page Down	Click the down direction arrow
Help	Click the input field that you need help, and then select the F1 key. For "What's This" help, click the "?" button on the toolbar. Then point to the input field that you need help on and click.

Menu Bar

The program has a number of additional features that can be accessed through a menu bar at the top of each screen. Using the left mouse button, click on a menu name to see the pull down options available. Click on a desired option or press the "Alt" key and the underscored character shown (some options can be accessed by a given "Ctrl" key + letter combination).

File Menu

Option	Description
New (Ctrl+N)	Opens new file for desired Aspen B-JAC program
Open (Ctrl+O)	Opens existing Aspen B-JAC program file
Close	Closes a chosen Aspen B-JAC program window
Add Application	Opens a chosen Aspen B-JAC program window
Remove Application	Removes a chosen Aspen B-JAC program window
Save (Ctrl+S)	Saves current file under chosen filename
Save As	Saves current file as a different filename
Export To	Export results to Excel, a DXF file, a RTF file, or a DOC file
Print Setup	Allows for change to printing options
Print (Ctrl+P)	Prints desired results sections from Aspen B-JAC program
Description	Displays the contents of the Description field in the input file
Exit	Exits Aspen B-JAC program and return user to Windows

Edit Menu

Option	Description
Undo	Undoes the last edit operation.
Cut (Ctrl+X)	Deletes the highlighted text.
Copy (Ctrl+C)	Saves a copy of the highlighted text.
Paste (Ctrl+V)	Paste inserts text from a copy to directed location

Run Menu

Option	Description
Run "Program"	Runs a chosen Aspen B-JAC program
Stop	Stops the run of a chosen Aspen B-JAC program
Transfer	Transfers design information into another BJAC program
Update	Updates file with final design information

Tools Menu

Option	Description
Data Maintenance	Provides access to units of measure, chemical database reference, material database, and Costing database.
Program Settings	Default units setting and headings for drawings
Security	Access to Aspen B-JAC security program.
Language	Sets language to English, French, German, Spanish, Italian (Chinese and Japanese to be offered in a later version).
Plot	Plots results functions.
Add Curve	Allows the addition of another curve to an existing plotted curve

View Menu

Option	Description
Tool Bar	Shows or hides the Tool Bar
Status Bar	Shows or hides the Status Bar
Zoom In	Enlarges sections of the Aspen B-JAC drawings
Zoom Out	Returns drawings to normal size
Refresh	Refreshes screen
Variable List	Displays variable list for form.

Window Menu

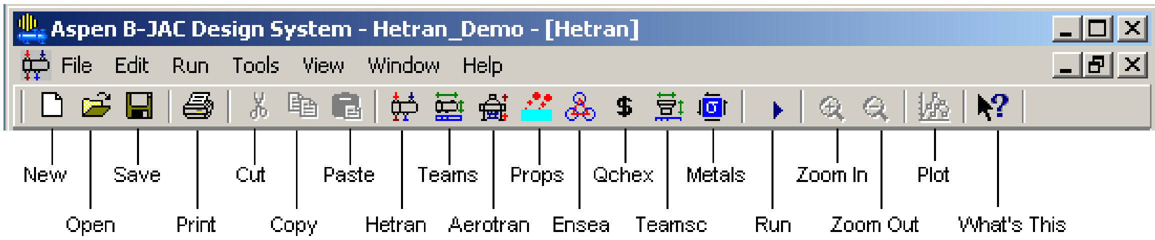
Name	Description
Cascade	Arranges program windows one behind the other
Tile Horizontal	Arranges program windows one on top another
Tile Vertical	Arranges program windows one besides the other
Arrange Icons	Automatically arranges icons
Create	Creates a window for a Aspen B-JAC program

Help Menu

Name	Description
Contents	Open Aspen B-JAC help table of Contents
Search for Help	Displays a list of topics for detailed help
What’s This Help	Allows the user to place "?" on desired item to receive information about the item
Training	Direct access to the AspenTech Training web site
Support	Direct access to the AspenTech Support web site
About B-JAC	Provides information on the current Aspen B-JAC release

Toolbars

Main Toolbar



Icon	**Description**
New	Creates a new Aspen B-JAC program file
Open	Opens an existing Aspen B-JAC program file
Save	Saves the current file data
Hetran	Opens the Hetran program window
Teams	Opens the Teams program window
Aerotran	Opens the Aerotran program window
Props	Opens the Props program window
Ensea	Opens the Ensea tube layout window
Qchex	Opens the Qchex budget costing window
Teamsc	Opens the Teams Component design window
Metals	Opens the Metals property database window
Run	Runs the chosen Aspen B-JAC Program
Zoom In	Enlarges sections of the Aspen B-JAC drawings
Zoom Our	Returns sections of drawings to normal size
Plot	Plot results functions
What's This?	Allows user to place "?" on desired item to display information about the item

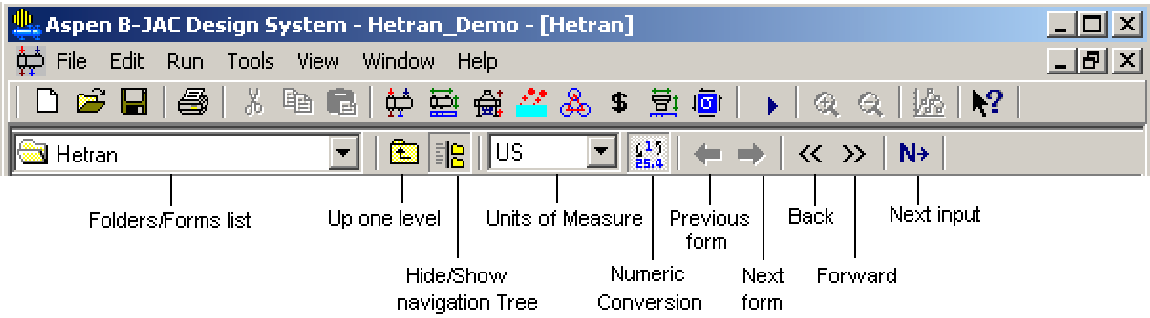
Zoom In/Zoom Out

You can Zoom In or Zoom Out on selected sections of the Aspen B-JAC drawings by selecting an area and drawing a frame around it.

To draw the frame, select a frame corner, press and hold down the left mouse button and drag the cursor diagonally to the opposite corner and then release the mouse button.

Click the Zoom In button to resize the framed section to the full window size.

Program Toolbar



Icon	Description
Navigator	Allows quick access to forms in the Menu Tree
One Level Up	Takes the user up one level in the Menu Tree
Hide Folder List	Hides Navigator Menu Tree
Units Box	Allow you to change globally the units of measure
Go Back	Takes the user to the most recently viewed form
Go Forward	Takes the user to the next form in the Menu Tree
Previous Form	Takes the user to the previous form in the Menu Tree
Next Form	Takes the user to the next form in the Menu Tree
Next	Takes the user to the next required input or result sheet

Next

The **Next** button guides you sequentially through the required input forms to complete the input for the problem. Note that subsequent steps are dependant upon your previous selections in the program. When you use the Next button, the program minimizes the input information required and uses program defaults.

Data Maintenance

Units of Measure

You can access the Units of Measure by selecting Tools in the Menu Bar and then selecting the Data Maintenance section. You can set the default units of measure to US, SI, or Metric and also set up your own customized set of units. In the Units Maintenance section you can customize the conversion factors used and the number of decimal point shown in the results.

Heat Exchanger Standards

This function allows you to create a database with your standard exchangers sizes that can reference from the B-JAC design programs.

Chemical Databank (B-JAC Props & Priprops)

This item provides access to the Aspen B-JAC Props, chemical databank, and Priprops, the user private property databases. The Priprops program allows you to build your own private property databank that can be accessed form the Hetran, Aerotran, and Props programs. Reference the Priprops section of this manual for additional information.

Materials Databank (B-JAC Databank & Primetals)

This item provides access to the Aspen B-JAC Metals, material databank, and Primetals, the private property metals databases. The Primetals program allows you to build your own private property databank that can be accessed from the Hetran, Aerotran, and Teams programs. Reference the Primetals section of this manual for additional information.

Materials Defaults (Defmats)

This item provides access to the B-JAC Defmats, material defaults database for metals in the databanks. The Defmats program allows you to change the specified material specifications to be used when the generic material references are specified.

Costing (Newcost Database)

This item provides access to the Newcost fabrication standards and material pricing databases. Labor, fabrication standards, and material pricing may be customized your applications. For more information, see the Newcost Database section of this manual.

Frequently Used Materials and Chemical Components

You can set a list of frequently used materials and/or chemical components for the databank search engines. This will allow to search for a material or component from your personalized list of items you use often.

Program Settings

You can specify global program settings, which all Hetran programs can use. These global settings are available from the **Tools** menu. They include:

- File Save Options

  Set the auto-save file functions. You can set the program to save your file information every few minutes or at the time the program is executed.

- Company Logo

  By providing the reference to a Bitmap file, you can add your company logo to the program results and drawings.

- Default Units of Measure

You can set the default units of measure to US, SI, or Metric. Note that the units may be changed at any time in the Aspen B-JAC program window.

- Headings / Drawing Title

  You can set up the default headings and title block information that appears on the printed output and drawings.

- Nozzle size specification on drawings

  You can set the units set basis for the nozzle sizes shown on the drawings. For example, US unit size nozzles can be shown even though the drawings are in SI or metric units.

- Folder for customized database files

  You can specify a folder location for your customized database files. The B-JAC programs will then reference your customized database files in the specified folder in lieu of the standard database files in the program PDA folder.

- Excel templates

  You can specify an Excel template file to use for each program as a default. When you select File | Export | Excel, the specified default template is used.

- Heat exchanger standards

  You can set which exchanger standards database file is to be referenced.

- Advanced

  You can enable variable attributes so they will be shown in the Aspen B-JAC program prompt area. For example, set drag-drop format to move data to Excel; set the maximum disk space for temporary files.

Program Input

Input Fields

Sheets are made up of input fields and their descriptions. For each field, the user (1) enters data, (2) chooses from a given list of options, or (3) checks the cell if appropriate. The cursor can be moved from one input field to another by using the Tab key, Enter key, arrow keys, or the mouse.

You can navigate through a input form by using the Tab key or Enter key which will take you to the next required input field or you can select the items with the mouse. To navigate through an input field grid, such as for physical properties, or nozzle connections, you can use the Enter key which will move the cursor down to the next field in a column, or you can use the arrow keys to direct the cursor, or you can use the mouse to select the input field.

The input fields consist of the following types:

- **User defined**. You enter the value such as a temperature or operating pressure.
- **User defined with suggested values**. You can input a value or select from a list of typical values for the input which are available in a drop down selection menu. You can access by the drop down menu by clicking on the input field with the mouse and then select the down arrow displayed. You can select an item in the drop down menu by using the up and down arrow keys or by selecting with the mouse.
- **Available program selections**. You select from a drop down menu list or options list displayed on the input form. You can select an item in the drop down menu by using the up and down arrow keys or by selecting with the mouse.
- **Many of the input fields have graphical support**. As you select from the available menu options, a sketch of the selection will appear next to the input field.

There are two types of data that can be entered: alphanumeric and numeric. Alphanumeric fields accept any printable character. Numeric fields accept only the digits zero through nine plus certain special characters such as: + - .

You can enter letters of the alphabet in either upper case or lower case. The letters are retained in the case entered for headings, remarks, and fluid names.

Whole numbers can be entered without a decimal point. Numbers over one thousand should not have punctuation to separate the thousands or millions. Decimal numbers less than 1 may be entered with or without the leading zero. Scientific notation (E format) can be used.

Examples of Valid Entries	**Examples of Invalid Entries**
125	15/16
289100	289,100
-14.7	
0.9375	

If an input field is identified as optional input (white background), you may leave the field blank and the program will use a default value. For physical properties where you want the program to retrieve the value from the physical properties databank (see Search a Databank), you should leave the input field blank. In many cases, you can get additional descriptive information on an item by pressing F1, the Help key.

Required input fields will be identified by a green background color for the input field. Optional input fields will have a white background. Any inputted value that exceeds a normal range limit will be highlighted with a red background. Note that the program will still accept and use a value outside the normal range. If a folder or tab is not complete, a red X will be shown on the respective folder in the Navigation Tree and on the Tab label.

Units of Measure - Field Specific

All of the Aspen B-JAC programs run in traditional U.S. units, SI units, and traditional metric units. The global setting for units is set in the Units Box located in the Tools Bar.

The programs allow you to dynamically change the system of measure used in the input or results sections. It is therefore possible to view and/or print the same solution in two different systems for easy comparison or checking.

Field specific units of measure control is also available. A specific set of units may be specified for each input data field by selecting from the units drop down menu next to the input field. The field specific units will override the global units set in the Units Box.

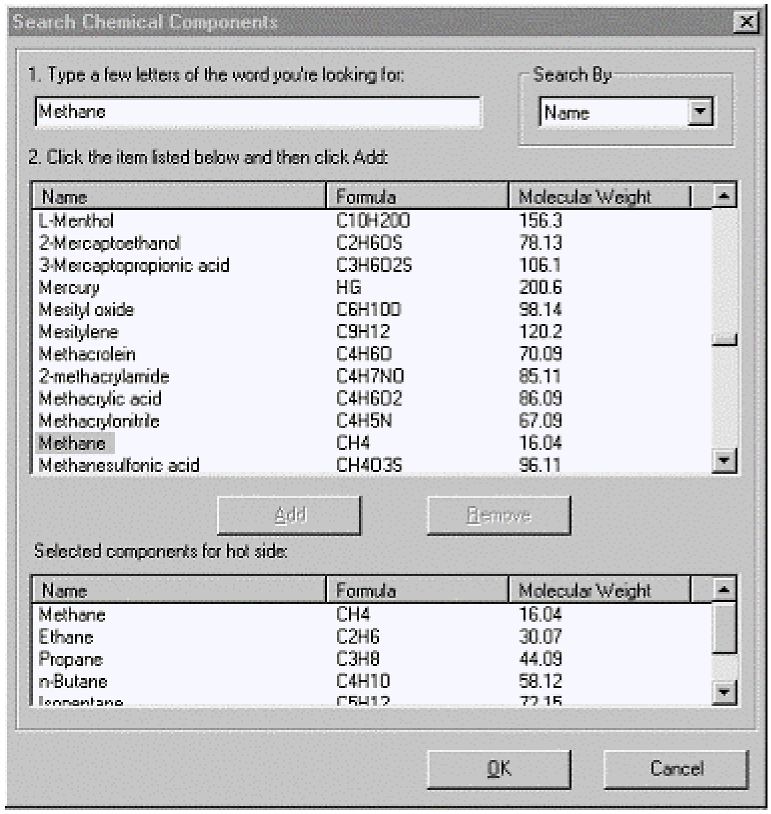
You can input the value in one set of units and then select an alternate unit from the drop down units menu, and the input value will be converted.

Please note that the solution of a design problem may be dependent upon the system of measure used in the input. This is due to differing standards in incrementing dimensions. This is especially true for the mechanical design programs.

Databank Reference

You can search for an item in the Chemical Component or Material of Construction Databanks. Click on the **Search** button located on databank reference form to open the search utility.

To find an item in the list, type in the first few letters of the material name. Or, scroll through the material list using the up and down arrows to the right of the field. You can also specify a search preference, database, material class and material type. Click on the desired material. In the Component list, click on the desired component and press Set to match it with the selected reference. You can also erase a reference from the component list by clicking on the component and pressing Clear.



The components in the databank have a component name which is up to 32 characters long, a chemical formula or material specification. You use these for the databank reference. We recommend that you do not use the chemical formula, because the formula may not be a unique reference. You should use the appropriate reference exactly as it appears in the databank directory.

Range Checks

After data is entered in an input field, the program will check the specified data against a high and low value range. If a value falls outside this range, the input field will turn red and a warning message will be displayed at the bottom left hand of the screen. This does not mean the program will not accept this data. It merely suggests that you should check the data for accuracy. If the data is correct, continue with data input.

Change Codes

Several of the programs have a form for change codes. You can use this form to insert four letter codes and numeric values to specify input data which is not included in the regular input screens. Refer to the Change Code section in the individual Program Guide. First type the change code, then an equals sign ("="), then the numeric value. For example: SENT=2.

It also possible to provide a **Super Change Code** by defining the change codes to be applied to a design in a separate ASCII file and referencing the file as follows in the Change Code input field: File="Filename"

The Database Concept

We suggest that you use the same input file for all Aspen B-JAC programs for a specific heat exchanger design problem. Save the input data in a convenient filename that can be accessed by all the Aspen B-JAC programs.

Using the Transfer function under the Run menu, you can add data to the input for use with other programs. For example, you can use Hetran to thermally design a shell and tube heat exchanger, and then request that the chosen design be transferred to another program such as Hetran into Aerotran, Hetran into Teams, or Teams into Ensea. In this way the appropriate design data is directly available to other programs.

This concept also makes it easy for you to compare design solutions in different types of heat exchangers. You can run Hetran to design a shell and tube heat exchanger and then, with very little additional input data, run Aerotran to design an air-cooled heat exchanger.

Program Output

The primary output formats of the Aspen B-JAC programs are:

- Display
- Print
- Drawings

Display

Scroll through the forms in the Results folder of the navigation tree to evaluate the results of the program output. Each form may have multiple sheets, which you can display by clicking on the different tabs.

Print

To print the results, choose Print from the File menu. On the Print dialog box, review the printing options, make any desired changes, and click OK.

Drawings

- 2D CAD

  The output of many Aspen B-JAC programs includes drawings. Drawings generated by the TEAMS program may be exported to CAD programs via a DXF file format.

- 3D Solid Model CAD

  Aspen Hetran Users can now create fully featured 3D solid models based on the Autodesk Inventor Tool, using the File | Export menu option. The interface allows the user to create models of individual components, groups of components, or the entire exchanger.

  Aspen Hetran 3D solid models provide a modern architecture from which the user can create sophisticated 2D drawings. Some dimensions used in the 3D Solid Model created from Aspen Hetran are estimated for example, tubesheet thickness. For a 3D Solid Model reflecting rigorous mechanical design calculations results and fabrication practices use Aspen Teams. Autodesk Inventor software can import and export both the STEP and IGES file formats as core functionality. It also supports the DWG, DXF™, and SAT (ACIS®) formats as well as 3D Studio VIZ®, and 3ds max™ for output only. The Inventor CAD program must be loaded on your system to generate the drawings.

Help Facility

Getting Help

The Aspen B-JAC software includes extensive help facilities, which have been designed to minimize the need for printed documentation.

You may access the help facility in the following ways:

- General Help

  This level includes information that applies to all of the Aspen B-JAC programs. You can access the general help index by selecting the Help button from the Menu Bar at any time in the program. You may select the Help Contents to select from the list of topics or you may search for Help on a specific topic.

- Field-specific general Help topic

  By selecting an input field with the mouse and then pressing the F1 key, the general help will open and display the information.

- Field-specific "What's This?" Help

  You can obtain input field specific help by selecting the What's This ? button on the Tool Bar and then pointing to the input field and clicking the mouse to display the information.

- Training

  From the Help menu, you can directly access the AspenTech Training web site. The site provides the latest information on training sessions being offered. You can also access Computer-Based Training sessions available for the B-JAC programs.

- Support

  From the Help menu, you can directly access the AspenTech Support web site. You can report support issues that will be reviewed by our technical support team. You can also access our Knowledge Base support area, an information source full of technical tips on using the B-JAC programs and answers to frequently asked questions.

Aspen Hetran

Hetran Input

Problem Definition

TEMA Specification Sheet Descriptions

Use this sheet to specify the following optional descriptive information:

- **Headings**, which appear at the top of the TEMA specification sheet, Input Summary results, and the Title block of the drawings.

  Headings are 1 to 5 lines of up to 75 characters per line. Note that only the first 40 characters of each line appear on the drawings.
- **Fluid names**, which appear with other input items to help you identify to which fluid the data applies. These names also appear in the specification sheet output. Although optional, we recommend specifying meaningful fluid descriptions.

  Each fluid name can be up to 19 characters long and can contain multiple words.
- **Remarks**, which appear at the bottom of the specification sheet output.

  Each line can be up to 75 characters long.

You can also create global headings for use by any B-JAC program on the **Headings/Drawing** tab of **Program Settings** under Tools.

Application Options

Hetran Application Options Sheet

Use this sheet to specify these application options:

- Hot Side Application

  Select the application that describes the type of process condition that exists on the hot side. The selected application determines the required input data.

  For multi-component condensation applications, the program can calculate a **condensation curve**, or you can or specify the condensation heat release curve and properties.

  Most **condenser type**s have the vapor and condensate flow in the same direction. The Knockback (reflux) condenser, which is often used to separate high and low boilers with minimal subcooling, has vapor entering the bottom of the unit with condensate falling back against the incoming vapor. With this type of condenser, you should consider using the differential condensation option if the program calculates the condensation curve.

- Cold side application

  Select the application that describes the type of process condition that exists on the cold side. The selected application determines the required input data.

  For multi-component vaporization, the program can calculate a **vaporization curve**, or you can or specify the vaporization heat release curve and properties. For narrow range and multi-component vaporization applications, you must select a vaporizer type.

- Location of hot fluid

  This required input identifies on which side to put the hot fluid: the shell side or tube side. During execution of the Aspen Hetran program , you can change the location of the hot fluid to compare the two possibilities.

- Program mode

  In **design** mode, the program selects the geometry. In **rating** mode, the program determines if the unit is over/under surfaced. In **simulation** mode, the program predicts outlet conditions. You can also specify an exchanger size **standards file**, and the Hetran program will select an exchanger size that satisfies the performance requirements.

Hot side application

Select the application that describes the type of process condition that exists on the hot side:

- Liquid, no phase change

  This application covers a liquid phase fluid that does not change phase in the exchanger.

- Gas, no phase change

  This application covers a gas phase fluid that does not change phase in the exchanger.

- Narrow range condensation

  This application covers the cases where the condensing side film coefficient does not change significantly over the temperature range. Therefore, the calculations can be based on an assumed linear condensation profile. This class is recommended for cases of isothermal condensation and cases of multiple condensables without noncondensables where the condensing range is less than 6°C (10°F).

- Multi-component condensation

  This application covers the other cases of condensation where the condensing side film coefficient changes significantly over the condensing range. Therefore, the condensing range must be divided into several zones where the properties and conditions must be calculated for each zone. This class is recommended for all cases where noncondensables are present or where there are multiple condensables with a condensing range of more than 6°C (10°F).

  We recommend that you always use this application type when the Hetran file was created by Aspen Plus and condensation is occurring, even over a narrow range.

- Saturated steam

  This application covers the case where the hot side is pure steam, condensing isothermally.

- Falling film liquid cooler

  This application covers the case where the fluid is flowing downward and being cooled.

The selected application determines the required input data.

Cold side application

Select the application that describes the type of process condition that exists on the cold side:

- Liquid, no phase change

  This application covers a liquid phase fluid that does not change phase in the exchanger.
- Gas, no phase change

  This application covers a gas phase fluid that does not change phase in the exchanger.
- Narrow range vaporization

  This application covers the cases where the vaporizing side film coefficient does not change significantly over the temperature range. Therefore, the calculations can be based on an assumed linear vaporization profile. This class is recommended for cases of single components and cases of multiple components where the vaporizing range is less than 6°C (10°F).
- Multi-component vaporization

  This application covers the other cases of vaporization where the vaporizing side film coefficient changes significantly over the vaporizing range. Therefore, the vaporizing range must be divided into several zones where the properties and conditions must be calculated for each zone. This class is recommended for cases where there are multiple components with a vaporizing range of more than 6°C (10°F).

  We recommend that you always use this application type when the Hetran file was created by Aspen Plus and vaporization is occurring, even over a narrow range.

The selected application determines the required input data.

Vaporizer type

For narrow range and multi-component vaporization applications, select a vaporizer type:

- Pool boiling

  Pool boiling is restricted to the shell side and must be horizontal. It can be in a kettle or a conventional shell with a full bundle or a partial bundle where tubes are removed for disengagement space.

- Thermosiphon

  The thermosiphon can vaporize on the shell side (horizontal) or the tube side (vertical or horizontal). The hydraulics of the thermosiphon design are critical for proper operation.

  You can specify the relationship of the heat exchanger to the column and the associated piping in the input (see Thermosiphon Piping) or the program will select the piping arrangement and dimensions.

- Forced circulation

  Forced circulation can be on either shell or tube side. Here the fluid is pumped through and an allowable pressure drop is required input. This can be for a once through vaporizer.

- Falling film

  Falling film evaporation can be done only on the tube side in a vertical position where the liquid enters the top head and flows in a continuous film down the length of the tube. Part of the liquid is vaporized as it flows down the tube. Normally the vapor formed also flows down the tube due to the difference in pressure between the top head and the bottom head. This type of vaporizer helps minimize bubble point elevation and minimizes pressure drop.

Location of hot fluid

This required input identifies on which side to put the hot fluid. During the execution of the Aspen Hetran program, you can change the location of hot fluid to compare the two possibilities.

Consider these guidelines to decide which side to put the hot fluid:

On this side	Allocate these types of fluids
shell	more viscous fluid cleaner fluid lower flow rate fluid
Tube	more corrosive fluid higher pressure fluid higher temperature fluid dirtier fluid more hazardous fluid more expensive fluid

Program mode

Select a program mode:

- Design Mode

  In design mode, you specify the performance requirements, and the program searches for a satisfactory heat exchanger configuration.

- Rating Mode

  In rating mode, you specify the performance requirements and the heat exchanger configuration, and the program checks to see if that heat exchanger is adequate.

- Simulation Mode

  In simulation mode, you specify the heat exchanger configuration and the inlet process conditions, and the program predicts the outlet conditions of the two streams.

- Select from standard file

  You specify a exchanger size standards file, which contains a list of standard heat exchanger sizes available to the user, and the program selects an exchanger size from the list that satisfies the performance requirements.

  The standard files can be generated from the **Tools | Data Maintenance | Heat Exchanger Standards** menu option.

Process Data

Process Data Sheet

Use this sheet to specify the process data relevant to the hot side and/or cold side fluids. The selected application determines the required data.

- **Fluid quantity, total** - the total flow rates for the hot and cold side streams.
- **Vapor quantity** - the flow rates for the hot and cold side, inlet and outlet vapor streams.
- **Liquid quantity** - the flow rates for the hot and cold side, inlet and outlet liquid streams.
- **Temperature (in/out)** -hot and cold side inlet temperatures are required. Simple condensation applications require hot and cold side temperatures. For other applications the outlet temperature can be optional if sufficient data has been specified to calculate the heat load.
- **Dew / Bubble point** - the hot and cold side inlet dew point temperature and the hot and cold side outlet bubble point temperature, at a specified operating pressure.

- **Operating pressure (absolute)** - the absolute (not gauge) pressure. Depending on the application, the program may permit either inlet or outlet pressure to be specified. In most cases, it should be the inlet pressure.
- **Heat exchanged** - the total heat exchanged, which should be specified when designing to a specific heat duty.
- **Allowable pressure drop** - the maximum pressure drop permitted on the hot and cold sides.

  Where applicable, the allowable pressure drop is required. You can specify any value up to the operating pressure, although the allowable pressure drop should usually be less than 40% of the operating pressure.
- **Fouling resistance** - the hot and cold side fouling resistance.

  The fouling resistance defaults to zero if unspecified. You can specify any reasonable value. The program provides a list of typical values.

Fluid Quantity, Total

Specify the total flow rate for no phase fluid.

For **no phase change applications**: if flow rates are not specified, the program calculates the required flow rates to meet the specified heat load or the heat load on the opposite side. All temperatures *must* be specified if the flow rates are omitted.

For **phase change applications**: the total flow rate should be approximated. The program still calculates the total required flow rate to balance the heat loads.

Temperature (in/out)

You must specify the hot and cold side inlet/outlet temperatures.

Simple condensation applications require hot side outlet and cold side outlet temperatures. For other applications the outlet temperature can be optional if sufficient data has been specified to calculate the heat load.

For **no phase change applications**: specify the inlet temperature and flowrate. The program can calculate the outlet temperature based on the specified heat load or the heat load on the opposite side.

For **narrow condensation** and **vaporization applications**: specify an outlet temperature and associated vapor and liquid flows. This represents the second point on the VLE curve, which we assume to be a straight line. With this information, the program can determine the correct vapor/liquid ratio at various temperatures and correct the outlet temperature or total flow rates to balance heat loads.

Operating Pressure (absolute)

Specify the absolute (not gauge) pressure. Depending on the application, the program may permit specifying either inlet or outlet pressure. In most cases, it should be the inlet pressure.

For a **thermosiphon** reboiler, the operating pressure should reflect the pressure at the surface of the liquid in the column.

For **condensers** and **vaporizers**: in the case where you expect the pressure drop to significantly change the condensation or vaporization curves, you should use a pressure drop adjusted vapor-liquid equilibrium data. If the program calculates the curve, you can indicate adjusting the curve for pressure drop.

Heat Exchanged

Specify a value for the total heat exchanged when designing to a specific heat duty.

If the heat exchanged is specified, the program compares the hot and cold side calculated heat loads with the specified heat load. If they do not agree within 2%, the program corrects the flow rate, or outlet temperature.

If the heat exchanged is not specified, the program compares the hot and cold side calculated heat loads. If they do not agree within 2%, the program corrects the flow rate, or outlet temperature.

To determine how the program handles heat load imbalances, click the Heat Load Balance Options tab and set the heat load adjustment options to have the program change flow rate, outlet temperature, or to allow an unbalanced heat load.

Heat Load Balance Options Sheet

The heat load adjustment options determine how the program handles heat load imbalances.

Use this sheet to specify whether to adjust the total **flowrate** or the **outlet temperature** to balance the heat load against the specified heat load or the heat load calculated from the opposite side. The program calculates the required adjustment.

If you select **no adjustment**, the program designs the exchanger with the specified flows and temperatures, but with the highest of the specified or calculated heat loads.

Physical Property Data

Property Options

Databanks Sheet

Use this sheet to specify the source of the properties.

Properties from B-JAC Databank / User Specified properties / Interface properties from Aspen Plus

Selecting this option (default), allows you to reference the B-JAC Property Databank, specify your own properties in the Hot Side and Cold property sections, or have properties passed into the B-JAC file directly from an Aspen Plus simulation program.

Note: Any properties specified in the property sections override properties coming from a property databank.

The **B-JAC Property Databank** consists of over 1500 compounds and mixtures used in the chemical process, petroleum, and other industries. You can reference the database by entering the components for the Hot Side and/or Cold Side streams in the Composition sections. Click the **Search Database** button to locate the components in the database.

If you **specify properties** in the Hot Side and/or Cold Side property sections, do not reference any compounds in the Hot Side and/or Cold Side Composition sections unless you plan to use both the B-JAC Databank properties and specified properties.

Properties passed into the B-JAC file from the **Interface to an Aspen Plus simulation** run are displayed in the Hot Side and/or Cold Side Property sections. If you pass in properties from Aspen Plus, *do not* specify a reference to Aspen Plus to an Aspen Properties file, since properties are already provided by the Aspen Plus interface in the specified property sections.

Aspen Properties Databank

Aspen B-JAC provides access to the Aspen Properties physical property databank of compounds and mixtures.

If you are referencing the Aspen Properties databank, specify the **flash option** you want the Aspen Properties program to use with the VLE generation. The default is Vapor-Liquid. For more information see the *Aspen Properties Users Guide*.

To access the databank, first create an Aspen input file with stream information and physical property models. Run Aspen Plus and create the property file, xxxx.APPDF.

On the **Databanks** sheet specify the flash option and the name of the property file. If the file is not located in the same directory as your B-JAC input file, use the browse button to set the correct path to the *.APPDF file

Then specify the composition of the stream in the Property Composition section. When the B-JAC program is executed, the Aspen Properties program is accessed and the properties are passed back to the B-JAC design file.

Condensation Options Sheet

Use this sheet to specify the following options:

- Condensation curve calculation method

  The calculation method determines which correlations the program uses to determine the vapor-liquid equilibrium. The choice of method is dependent on the degree of non-ideality of the vapor and liquid phases and the amount of data available.

- Condensation curve calculation type

  For a condensing stream, you should determine if your case is closer to **integral** or **differential** condensation. The program defaults to integral.

- Effect of pressure drop on condensation

  The program defaults to calculating the condensing curve in isobaric conditions (constant operating pressure). If the B-JAC Property program generates the VLE curve, you may specify non-isobaric conditions. The program allocates the specified pressure drop based on temperature increments along the condensation/vaporization curve. The vapor/liquid equilibrium at various temperature points is calculated using an adjusted operating pressure.

- Estimated pressure drop for hot side

  Specify the estimated hot side pressure drop through the exchanger. If actual pressure varies more than 20 percent from this estimated pressure drop, adjust this value to the actual and rerun Hetran.

  If the B-JAC Property program generates the VLE curve, the program uses this pressure drop to adjust the VLE curve.

  The VLE calculation program does not permit the condensate to re-flash. If calculations indicate that this is happening, the program will suggest using a lower estimated pressure drop.

Condensation/Vaporization Curve Calculation Method

The calculation method determines which correlations the program will use to determine the vapor-liquid equilibrium. The choice of method is dependent on the degree of non-ideality of the vapor and liquid phases and the amount of data available.

The methods can be divided into three general groups:

- **Ideal** - correlations for ideal mixtures.

  The ideal method uses ideal gas laws for the vapor phase and ideal solution laws for the liquid phase. You should use this method when you do not have information on the degree of nonideality. This method allows for up to 50 components.

- **Soave-Redlich-Kwong, Peng-Robinson, and Chao-Seader** - correlations for non-ideal mixtures which do not require interaction parameters.

  The Soave-Redlich-Kwong and Peng-Robinson methods can be used on a number of systems containing hydrocarbons, nitrogen, carbon dioxide, carbon monoxide, and other weakly polar components. They can also be applied with success to systems which form an azeotrope, and which involve associating substances such as water and alcohols. They can predict vapor phase properties at any given pressure.

  The Chao-Seader method uses Redlich-Kwong equations for vapor phase non-ideality and an empirical correlation for liquid phase non-ideality. It is used with success in the petroleum industry. It is recommended for use at pressures less than 68 bar (1000 psia) and temperatures greater than -18°C (0°F). The program uses the original Chao-Seader correlation with the Grayson-Streed modification. There is no strict demarcation between these two methods since they are closely related. These methods allow for up to 50 components.

- **Uniquac, Van Laar, Wilson, and NRTL** - correlations for non-ideal mixtures which require interaction parameters.

  These methods are limited to ten components. The Uniquac, Van Laar, Wilson, and NRTL methods require binary interaction parameters for each pair of components. The Uniquac method also requires a surface parameter and volume parameter, and the NRTL method requires an additional Alpha parameter.

  The Wilson method is particularly suitable for strongly non-ideal binary mixtures, for example, solutions of alcohols with hydrocarbons. The Uniquac method is applicable for both vapor-liquid equilibrium and liquid-liquid equilibrium (immiscibles). It can be used for solutions containing small or large molecules, including polymers. In addition, Uniquac interaction parameters are less temperature dependent than those for Van Laar and Wilson.

Condensation Curve Calculation Type

For a condensing stream, you should determine if your case is closer to integral or differential condensation.

Integral condensation assumes that the vapor and liquid condensate are kept close enough together to maintain equilibrium, and that the condensate formed at the beginning of the condensing range is carried through with the vapor to the outlet. Vertical tube side condensation is the best case of integral condensation. Other cases which closely approach integral condensation are: horizontal tube side condensation, vertical shell side condensation, and horizontal shell side crossflow condensation (X-shell).

In **differential condensation** the liquid condensate is removed from the vapor, thus changing the equilibrium and lowering the dew point of the remaining vapor. The clearest case of differential condensation is seen in the knockback reflux condenser, where the liquid condensate runs back toward the inlet while the vapor continues toward the outlet.

Shell side condensation in a horizontal E or J shell is somewhere between true integral condensation and differential condensation. If you want to be conservative, treat these cases as differential condensation. However, the industry has traditionally designed them as integral condensation.

More condensate will be present at any given temperature with integral condensation versus differential condensation. In the heat exchanger design, this results in a higher mean temperature difference for integral condensation compared to differential condensation.

The program defaults to integral.

Vaporization Options Sheet

Use this sheet to specify the following options:

- Vaporization curve calculation method

  The calculation method determines which correlations the program uses to determine the vapor-liquid equilibrium. The choice of method is dependent on the degree of non-ideality of the vapor and liquid phases and the amount of data available.

- Effect of pressure drop on vaporization

  The program defaults to calculating the vaporization curve in isobaric conditions (constant operating pressure). If the B-JAC Property program generates the VLE curve, you may specify non-isobaric conditions. The program allocates the specified pressure drop based on temperature increments along the condensation/vaporization curve. The vapor/liquid equilibrium at various temperature points is calculated using an adjusted operating pressure.

- Estimated pressure drop for cold side

  Specify the estimated cold side pressure drop through the exchanger. The program uses this pressure drop to adjust the VLE curve. If actual pressure varies more than 20% from this estimated pressure drop, adjust this value to the actual and rerun Hetran.

Property Methods Sheet

Use this sheet to specify the following methods:

- Property Method Hot & Cold Sides

  Select the property method you wish to be used in the Aspen Properties program. Several property methods are available:

  - Ideal gas law
  - Equation of state
  - Interactive parameter
  - For additional information, please reference the Aspen Properties User Guide. B-JAC calls and executes the Aspen Properties program and applies the selected property method to generate the VLE and physical property data required to design the exchanger.

- Free Water Method Hot & Cold Sides

  Lets you specify the property method for the free-water phase. Steam tables are recommended. For additional information, please reference the Aspen Properties User Guide. B-JAC calls and executes the Aspen Properties program and applies the selected property method to generate the VLE and physical property data needed to design the exchanger.

- Solubility Hot & Cold Sides

  Specify the solubility factor to be used. For additional information, please reference the Aspen Properties User Guide. B-JAC calls and executes the Aspen Properties program and applies the selected property method to generate the VLE and physical property data needed to design the exchanger.

- Flash Options Hot & Cold Sides

  Specify which flash phase option is to be used. For additional information, please reference the Aspen Properties User Guide. B-JAC calls and executes the Aspen Properties program and applies the selected property method to generate the VLE and physical property data needed to design the exchanger.

Hot Side Composition

Composition Sheet

If the stream physical properties are being accessed from the Aspen B-JAC databank or if the program is calculating a vapor/liquid equilibrium curve (B-JAC Props or Aspen Properties); use this sheet to define the stream composition.

Select the **composition specification** - weight flow rate or %, mole flow rate or %, volume flow rate or % - to determine the basis of the mixture physical properties calculations. Then use the table to define the stream composition:

- Components

  List the components in the stream here if you want to access the B-JAC database for properties. Component names must match the compound name listed in the B-JAC database. Click the **Search Databank** button to scan and select compounds from the databank. If you are supplying the stream physical properties and VLE (for phase change) in the Hot Side and/or Cold Side properties section, do not list any components here.

  When the program is calculating a vapor/liquid equilibrium curve, you can specify individual component physical properties by selecting **User** in the **Source** field. In this case the component field is used to identify the component in the results.

- Vapor in, Liquid in, Liquid out

  These fields identify the composition of the stream in each phase and is dependant on the Composition Specification. You must specify the inlet compositions if referencing the databank for physical properties. If outlet compositions are not specified, the program assumes the same composition as the inlet. The data for each column is normalized to calculate the individual components fraction.

- Component Type

  Use this field to specify noncondensables and immiscible components in the stream for all complex condensing applications. If a component does not condense any liquid over the temperature range in the exchanger, it is best to identify it as a noncondensable. If a component is immiscible with the other stream components, it needs to be identified so the condensation VLE can be adjusted. If the field is left blank, the program attempts to determine if a component is a noncondensable but does not try to identify any immiscibles.

- Source

  This field is currently available for components only when the program is calculating vapor/liquid equilibrium curves. **Databank** indicates that all component properties will be retrieved from one of the B-JAC databanks. **User** indicates that the physical properties for this component are specified by the user.

Component Properties Sheet

This sheet is used only for calculating condensing/vaporization curves within the program, allowing you to override databank properties or to specify properties of components that are not in the databank.

These physical properties are required for various applications:

Reference temperature	Density vapor
Viscosity vapor	Specific heat vapor
Thermal conductivity vapor	Latent heat
Vapor pressure	Density liquid
Viscosity liquid	Specific heat liquid
Thermal conductivity liquid	Surface tension liquid
Molecular volume	Molecular weight
Critical pressure	Critical temperature

Interaction Parameters Sheet

The Uniquac, Van Laar, Wilson, and NRTL methods require binary interaction parameters for each pair of components. This data is not available from the databank and must be provided by the user.

NRTL Method --Example with 3 components (Reference Dechema)

NRTL "A" Interactive Parameters -Hetran input parameters

	1	2	3
1	--	A21	A31
2	A12	--	A32
3	A13	A23	--

NRTL "Alpha" Parameters –Hetran input parameters

	1	2	3
1	--------	Alpha21	Alpha31
2	Alpha12	--------	Alpha32
3	Alpha13	Alpha23	--------

Alpha 12 = Alpha 21

Alpha 13 = Alpha 31

Alpha 23 = Alpha 32

NRTL – Conversion from Aspen Properties parameters to Hetran parameters:

Aspen Properties NRTL Parameters – The parameters AIJ, AJI, DJI, DIJ, EIJ, EJI, FIJ, FJI, TLOWER, & TUPPER in Aspen Properties (not shown in the following example) are not required for the Hetran NRTL method.

Aspen Properties NRTL Interactive Parameters

Component I	Component 1	Component 1	Component 2
Component J	Component 2	Component 3	Component 3
BIJ	BIJ12	BIJ13	BIJ23
BJI	BJI12	BJI13	BJI23
CIJ	CIJ12	CIJ13	CIJ23

"A" Interactive Parameters – Conversion from Aspen Properties to Hetran

	1	2	3
1	--	A21=BJI12*1.98721	A31=BJI13*1.98721
2	A12=BIJ12*1.98721	--	A32-BJI23*1.98721
3	A13=BIJ13*1.98721	A23=BIJ23*1.98721	--

"Alpha" Parameters – Conversion from Aspen Properties to Hetran

	1	2	3
1	--	Alpha21=CIJ12	Alpha31=CIJ13
2	Alpha12= CIJ12	--	Alpha32=CIJ23
3	Alpha13=CIJ13	Alpha23=CIJ23	--

NRTL - Alpha parameters

The NRTL method requires binary interaction parameters for each pair of components and an additional Alpha parameter. This data is not available from the databank.

Uniquac - Surface & Volume parameters

The Uniquac method requires binary interaction parameters for each pair of components and also needs a surface parameter and volume parameter. This data is not available from the databank.

Hot Side Properties

Hot Side Properties

Use these sheets to specify the physical properties that are required for the hot side fluids:

- VLE
- Vapor
- Liquid
- Noncondensable

Properties specified here override data coming from the B-JAC Property Database or Aspen Properties programs.

VLE Properties Sheet

If you are entering a **vapor-liquid equilibrium curve**, you must specify multiple **temperature** points on the curve encompassing the expected inlet and outlet temperatures of the exchanger. The dew and bubble points of the stream are recommended.

Condensation curves require the dew point and vaporization curves require the bubble point. The first point on the curve does not have to agree with the inlet temperature, although it is recommended. For simulation runs, it is best to specify the curve down to the inlet temperature of the opposite side.

You can specify one temperature point or as many as 13 temperature points. The temperatures entered for no phase change fluids should at least include both the inlet and outlet temperatures. The inlet temperature of the opposite side fluid should also be included as a third temperature point for viscous fluids. Multiple temperature points, including the inlet and outlet, should be entered when a change of phase is present.

For each temperature point you must specify a parameter defining the **heat load**. For heat load specify **cumulative** heat load, **incremental** heat load, or **enthalpies**.

For each temperature point you must also specify a parameter defining the **vapor/liquid composition**. For the composition, you may specify **vapor flow rate**, **liquid flow rate**, **vapor mass fraction**, or **liquid mass fraction**.

The program calculates the other parameters based on the entry and the total flow specified under process data. Vapor and liquid mass fractions are recommended because they are independent of flow rates. For complex condensers, the composition should be the total vapor stream including noncondensables.

Liquid and Vapor Properties Sheets

The type of application determines the required properties. Most properties are self-explanatory.

If you are referencing the databank for a fluid, you do not need to enter any data on the corresponding physical properties input sheets. However, even if you are referencing the databank, you can also specify any property. The specified property overrides the value from the databank.

Specific Heat

Specify the specific heat for the component at the referenced temperature.

Thermal Conductivity

Specify the thermal conductivity for the component at the referenced temperature.

Viscosity

The viscosity requested is the dynamic (absolute) viscosity in centipoise or mPa*s (note that centipoise and mPa*s are equal). To convert kinematic viscosity in centistokes to dynamic viscosity in centipoise or mPa*s, multiply centistokes by the specific gravity.

The program uses a special logarithmic formula to interpolate or extrapolate the viscosity to the calculated tube wall temperature. However, when a liquid is relatively viscous, say greater than 5 mPa*s (5 cp), and especially when it is being cooled, the accuracy of the viscosity at the tube wall can be very important for calculating an accurate film coefficient. In these cases, you should specify the viscosity at a third point, which extends the viscosity points to encompass the tube wall temperature. This third temperature point may extend to as low (if being cooled) or as high (if being heated) as the inlet temperature on the other side.

Density

Be sure to specify density and not specific gravity. Convert specific gravity to density by using the appropriate formula:

density, lb/ft3 = 62.4 * specific gravity
density, kg/m3 = 1000 * specific gravity

The density can also be derived from the API gravity, using this formula:

density, lb/ft3 = 8829.6 / (API + 131.5)

Surface Tension

Surface tension is required for vaporizing fluids. If you do not have surface tension information available, the program estimates a value.

Latent Heat

Provide latent heat for change of phase applications.

Molecular Weight

Provide the molecular weight of the vapor for change of phase applications.

Diffusivity

The diffusivity of the vapor is used in the determination of the condensing coefficient for the mass transfer method. Therefore, provide this property if data is available. If not known, the program estimates a value.

Noncondensable Sheet

Noncondensables are those vapor components in a condensing stream, which do not condense in any significant proportions at the expected tube wall temperature. Examples include hydrogen, CO_2, Air, CO.

Noncondensables require the following properties:

- Specific Heat
- Thermal Conductivity
- Viscosity
- Density
- Molecular Weight
- Molecular Volume

These properties can be specified or referenced from the database.

The **noncondensable flow rate** is required if it has not been defined in the databank composition input.

Cold Side Composition

Cold Side Composition Sheet

If the stream physical properties are being accessed from the Aspen B-JAC databank or if the program is calculating a vapor/liquid equilibrium curve (B-JAC Props or Aspen Properties); use this sheet to define the stream composition.

Select the **composition specification** - weight flow rate or %, mole flow rate or %, volume flow rate or % - to determine the basis of the mixture physical properties calculations. Then use the table to define the stream composition:

- Components

  List the components in the stream here if you want to access the B-JAC database for properties. Component names must match the compound name listed in the B-JAC database. Click the **Search Databank** button to scan and select compounds from the databank. If you are supplying the stream physical properties and VLE (for phase change) in the Hot Side and/or Cold Side properties section, do not list any components here.

  When the program is calculating a vapor/liquid equilibrium curve, you can specify individual component physical properties by selecting User in the Source field. In this case the component field is used to identify the component in the results.

- Liquid in, Vapor in, Vapor out

  These fields identify the composition of the stream in each phase and is dependant on the Composition Specification. You must specify the inlet compositions if referencing the databank for physical properties. If outlet compositions are not specified, the program assumes the same composition as the inlet. The data for each column is normalized to calculate the individual components fraction.

- Component Type

  Use this field to specify any **inert** in the stream. If the field is left blank, the program attempts to determine if a component is an inert.

- Source

  This field is currently available for components only when the program is calculating vapor/liquid equilibrium curves. **Databank** indicates that all component properties will be retrieved from one of the B-JAC databanks. **User** indicates that the physical properties for this component are specified by the user.

Component Properties Sheet

This sheet is used only for calculating condensing/vaporization curves within the program, allowing you to override databank properties or to specify properties of components that are not in the databank.

These physical properties are required for various applications:

Reference temperature	Density vapor
Viscosity vapor	Specific heat vapor
Thermal conductivity vapor	Latent heat
Vapor pressure	Density liquid
Viscosity liquid	Specific heat liquid
Thermal conductivity liquid	Surface tension liquid
Molecular volume	Molecular weight
Critical pressure	Critical temperature

Interaction Parameters Sheet

The Uniquac, Van Laar, Wilson, and NRTL methods require binary interaction parameters for each pair of components. This data is not available from the databank and must be provided by the user.

NRTL Method --Example with 3 components (Reference Dechema)

NRTL "A" Interactive Parameters -Hetran input parameters

	1	2	3
1	--	A21	A31
2	A12	--	A32
3	A13	A23	--

NRTL "Alpha" Parameters –Hetran input parameters

	1	2	3
1	--------	Alpha21	Alpha31
2	Alpha12	--------	Alpha32
3	Alpha13	Alpha23	--------

Alpha 12 = Alpha 21

Alpha 13 = Alpha 31

Alpha 23 = Alpha 32

NRTL – Conversion from Aspen Properties parameters to Hetran parameters:

Aspen Properties NRTL Parameters – The parameters AIJ, AJI, DJI, DIJ, EIJ, EJI, FIJ, FJI, TLOWER, & TUPPER in Aspen Properties (not shown in the following example) are not required for the Hetran NRTL method.

Aspen Properties NRTL Interactive Parameters

Component I	Component 1	Component 1	Component 2
Component J	Component 2	Component 3	Component 3
BIJ	BIJ12	BIJ13	BIJ23
BJI	BJI12	BJI13	BJI23
CIJ	CIJ12	CIJ13	CIJ23

"A" Interactive Parameters – Conversion from Aspen Properties to Hetran

	1	2	3
1	--	A21=BJI12*1.98721	A31=BJI13*1.98721
2	A12=BIJ12*1.98721	--	A32-BJI23*1.98721
3	A13=BIJ13*1.98721	A23=BIJ23*1.98721	--

"Alpha" Parameters – Conversion from Aspen Properties to Hetran

	1	2	3
1	--	Alpha21=CIJ12	Alpha31=CIJ13
2	Alpha12= CIJ12	--	Alpha32=CIJ23
3	Alpha13=CIJ13	Alpha23=CIJ23	--

NRTL - Alpha parameters

The NRTL method requires binary interaction parameters for each pair of components and an additional Alpha parameter. This data is not available from the databank.

Uniquac - Surface & Volume parameters

The Uniquac method requires binary interaction parameters for each pair of components and also needs a surface parameter and volume parameter. This data is not available from the databank.

Cold Side Properties

Cold Side Properties Form

Use these sheets to specify the physical properties that are required for the cold side fluids:

- VLE
- Liquid
- Vapor
- Pressure Correction

Properties specified here override data coming from the B-JAC Property Database or Aspen Properties programs.

VLE Properties Sheet

If you are entering a **vapor-liquid equilibrium curve**, you must specify multiple **temperature** points on the curve encompassing the expected inlet and outlet temperatures of the exchanger. The dew and bubble points of the stream are recommended.

Condensation curves require the dew point and vaporization curves require the bubble point. The first point on the curve does not have to agree with the inlet temperature, although it is recommended. For simulation runs, it is best to specify the curve down to the inlet temperature of the opposite side.

You can specify one temperature point or as many as 13 temperature points. The temperatures entered for no phase change fluids should at least include both the inlet and outlet temperatures. The inlet temperature of the opposite side fluid should also be included as a third temperature point for viscous fluids. Multiple temperature points, including the inlet and outlet, should be entered when a change of phase is present.

For each temperature point you must specify a parameter defining the **heat load**. For heat load specify **cumulative** heat load, **incremental** heat load, or **enthalpies**.

For each temperature point you must also specify a parameter defining the **vapor/liquid composition**. For the composition, you may specify **vapor flow rate**, **liquid flow rate**, **vapor mass fraction**, or **liquid mass fraction**.

The program calculates the other parameters based on the entry and the total flow specified under process data. Vapor and liquid mass fractions are recommended because they are independent of flow rates. For complex condensers, the composition should be the total vapor stream including noncondensables.

Liquid and Vapor Properties (Cold Side)

The type of application determines the required physical properties. Most properties are self-explanatory.

If you are referencing the databank for a fluid, you do not need to enter any data on the corresponding physical properties input sheets. However, you can specify any property, even if you are referencing the databank. The specified property overrides the value from the databank.

Specific Heat

Provide the specific heat for the component at the referenced temperature.

Thermal Conductivity

Provide the thermal conductivity for the component at the referenced temperature.

Viscosity

The viscosity requested is the dynamic (absolute) viscosity in centipoise or mPa*s (note that centipoise and mPa*s are equal). To convert kinematic viscosity in centistokes to dynamic viscosity in centipoise or mPa*s, multiply centistokes by the specific gravity.

The Aspen Hetran program uses a special logarithmic formula to interpolate or extrapolate the viscosity to the calculated tube wall temperature. However when a liquid is relatively viscous, say greater than 5 mPa*s (5 cp), and especially when it is being cooled, the accuracy of the viscosity at the tube wall can be very important to calculating an accurate film coefficient. In these cases, you should specify the viscosity at a third point, which extends the viscosity points to encompass the tube wall temperature. This third temperature point may extend to as low (if being cooled) or as high (if being heated) as the inlet temperature on the other side.

Density

Be sure to specify density and not specific gravity. Convert specific gravity to density by using the appropriate formula:

density, lb/ft3 = 62.4 * specific gravity
density, kg/m3 = 1000 * specific gravity.

The density can also be derived from the API gravity, using this formula:

density, lb/ft3 = 8829.6 / (API + 131.5)

Surface Tension

Surface tension is required for vaporizing fluids. If you do not have surface tension information available, the program estimates a value.

Molecular Weight

Specify the molecular weight of the vapor for change of phase applications.

Pressure Correction Properties Sheet

Use this sheet to make these pressure corrections:

- Vaporization curve adjustment for pressure

  For certain applications (e.g., thermosiphon reboilers, pool boilers), it is advisable to adjust the vaporization curve for pressure changes during the analysis of the exchanger. This input specifies the type of adjustment to be made.

- Reference pressure

  For vaporization applications, a second reference pressure with the corresponding bubble and/or dew point(s) is recommended. Using this data, the program can determine the change in bubble point temperature with the change in pressure. This is used to correct the vaporization curve for pressure changes.

- Bubble point at reference pressure

  For vaporization applications, a bubble point at reference pressure may be optionally specified. The bubble point at reference pressure and bubble point at operating pressure are used to determine the change in bubble point temperature with change in pressure. This is used to correct the vaporization curve for pressure changes.

- Dew point at reference pressure

  For vaporization applications, a dew point at reference pressure may be optionally specified. The dew point at reference pressure and dew point at operating pressure are used to determine the change in dew point temperature with change in pressure. This is used to correct the vaporization curve for pressure changes.

Exchanger Geometry

Exchanger Type

Shell/Heads Sheet

Use this sheet to specify the shell and head types and exchanger position.

- Front head type

  The front head type should be selected based on the service needs for the exchanger. A full access cover provided in the A, C, and N type heads may be needed if the tube side of the exchanger must be cleaned frequently. Type B (default) is generally the most economical type head.

- Shell type

  The shell type determines the shell side flow arrangement and the place of the shell side nozzles. The default is type E (except K type shell side pool boilers).

- Rear head type

  The rear head type affects the thermal design, because it determines the outer tube limits and therefore the number of tubes and the required number of tube passes. Type U is the default for kettle shells; for all others, M.

- Exchanger position

  Specify whether the exchanger is to be installed in the horizontal or vertical position. The default is vertical for tube side thermosiphon; for all others, horizontal.

Shell type

The shell type determines the shell side flow arrangement and the place of the shell side nozzles.

Type	Description
E	Generally provides the best heat transfer but also the highest shell side pressure drop. Used for temperature cross applications where pure counter current flow is needed.
F	This two pass shell can enhance shell side heat transfer and also maintain counter current flow if needed for temperature cross applications.
G	Will enhance the shell side film coefficient for a given exchanger size.

Type	Description
H	A good choice for low shell side operating pressure applications. Pressure drop can be minimized. Used for shell side thermosiphons.
J	Used often for shell side condensers. With two inlet vapor nozzles on top and the single condensate nozzle on bottom, vibration problems can be avoided.
K	Used for kettle type shell side reboilers.
X	Good for low shell side pressure applications. Units is provided with support plates which provides pure cross flow through the bundle. Multiple inlet and outlet nozzles or flow distributors are recommended to assure full distribution of the flow along the bundle.
V	This type is not currently part of the TEMA standards. It is used for very low shell side pressure drops. It is especially well suited for vacuum condensers. The vapor belt is an enlarged shell over part of the bundle length.

Default: E type (except K type shell side pool boilers)

Covers Exchanger Type

Use this sheet to specify the type of covers.

- Front cover type

  The front cover type appears only when you specify a B type front head. A flat bolted cover is assumed for the other front head types. This is included for the accuracy of the cost estimate and a more complete heat exchanger specification. The default is ellipsoidal.

- Cover welded to a cylinder

  The cover welded to a cylinder option determines if there is a cylinder between the front head flange (or tubesheet in the case of a hemispherical cover) and the attached cover. This is included for the accuracy of the cost estimate and a more complete heat exchanger specification. The default is yes, except when the cover is hemispherical.

- Rear cover type

  The rear cover type is based on the selected rear head type. The flat bolted cover is for L, N, P and W type rear heads. The flat welded and form covers (except for the dished cover) are available on the M type rear heads. The dished and ellipsoidal is available on the S and T rear heads. This is included for accuracy of the cost estimate and a more complete heat exchanger specification. The defaults are: flat bolted for L, N, P, or W types; ellipsoidal for M type; dished for S or T type.

- Cover welded to a cylinder

  The cover welded to a cylinder option only applies to M type rear heads. For other cases it is ignored. It determines if there is a cylinder between the rear head flange (or tubesheet in the case of a hemispherical cover) and the attached cover. This is included for the accuracy of the cost estimate and a more complete heat exchanger specification. The default is yes, except when the cover is hemispherical.

- Shell cover type

  A shell cover type should be specified for a U-tube, S, or T type rear head exchangers. Shell cover may be welded directly to shell cylinder or bolted to the shell cylinder with a pair of mating body flanges. The default is Ellipsoidal for U-tube, S, T type rear heads.

Tubesheets/Expansion Joints Sheet

Use this sheet to specify:

- Tubesheet type

  The tubesheet type has a very significant effect on both the thermal design and the cost.

- Tube to tubesheet joint

  The tube to tubesheet joint does not affect the thermal design, but it does have a small effect on the mechanical design and sometimes a significant effect on the cost.

- Expansion joint

  The specification of an expansion joint does not affect the thermal design calculations, but does have a significant effect on the cost. This item only applies to fixed tubesheet heat exchangers; it is ignored for all other types. The default is program, based on the estimated differential expansion.

  Note that the calculations required to determine the need for an expansion joint are quite complex and are beyond the scope of the Hetran program. These calculations are part of the Teams program. However the Hetran program will estimate the differential expansion between the tubes and the shell and make a simple determination on the need for an expansion joint if you use the program default.

Tubesheet type

The tubesheet type has a very significant effect on both the thermal design and the cost. The default is normal single tubesheet(s).

Double tubesheets are used when it is extremely important to avoid any leakage between the shell and tube side fluids. Double tubesheets are most often used with fixed tubesheet exchangers, although they can also be used with U-tubes and outside packed floating heads.

Double tubesheets shorten the length of the tube which is in contact with the shell side fluid and therefore reduce the effective surface area. They also affect the location of the shell side nozzles and the possible baffle spacings.

The gap type double tubesheet has a space, usually about 150 mm (6 in.), between the inner (shell side) and outer (tube side) tubesheets. The integral type double tubesheet is made by machining out a honeycomb pattern inside a single thick piece of plate so that any leaking fluid can flow down through the inside of the tubesheet to a drain. This type is rare, since it requires special fabrication tools and experience.

Tube to tubesheet joint

The tube to tubesheet joint does not affect the thermal design, but it does have a small effect on the mechanical design and sometimes a significant effect on the cost.

The most common type of tube to tubesheet joint is expanded only with 2 grooves. Although TEMA Class C allows expanded joints without grooves, most fabricators will groove the tube holes whenever the tubes are not welded to the tubesheet.

For more rigorous service, the tube to tubesheet joint should be welded. The most common welded joints are expanded and seal welded with 2 grooves and expanded and strength welded with 2 grooves.

For normal service the default is expanded only with 2 grooves; for lethal service the default is expanded and strength welded with 2 grooves.

Flanges Sheet

The body flange type refers to the type of flanges that are attached to the shell cylinder for the shell side and the head cylinder(s) for the tube side. This item can have a significant effect on the cost. The shell side body flange type (applicable to removable bundle designs only) also can have an effect on the thermal design, since the choice will determine how close the shell side nozzles can be to the tubesheet and therefore, where the first and last baffles can be located.

If the cylinder is carbon steel, the program defaults to a ring type body flange. If the cylinder is alloy, the program defaults to a lap-joint type flange.

Default: Ring if attached to a carbon steel cylinder and not TEMA R Hub if attached to a carbon steel cylinder, and TEMA R Lap joint if attached to an alloy cylinder

Tubes

Tube Exchanger Geometry Sheet

Use this sheet to specify:

- Tube type

  The program covers plain tubes (default) and external integral circumferentially finned tubes.
- Tube outside diameter

  You can specify any size for the tube outside diameter. Correlations have been developed based on tube sizes from 10 to 50 mm (0.375 to 2.0 inch). For integral finned tubes, this is the outer diameter of the fins.
- Tube wall thickness

  The tube wall thickness should be based on considerations of corrosion, pressure, and company standards. Tube wall thickness can be specified or calculated by the program.
- Tube wall specification

  The tube wall specification is average or minimum.
- Tube pitch

  The tube pitch is the center-to-center distance between two adjacent tubes
- Tube pattern

  The tube pattern is the layout of the tubes in relation to the direction of the shell side crossflow, which is normal to the baffle cut edge. The one exception to this is pool boiling in a kettle type reboiler where the tube supports are sometimes baffles with a vertical cut.
- Tube material

  Select the construction material of the tubes. The default is Carbon Steel (CS).
- Tube Surface

  The tube surface finish affects the tube side pressure drop. Depending on the surface finish, the appropriate relative roughness factor is applied to the calculations to get a reliable tube side pressure drop.

- Tube wall roughness

  The relative roughness of the inside tube surface affects the calculated tube side pressure drop. A commercial grade pipe has a relative roughness of 1.97 x 10-3 inch. The program defaults to a relatively smooth tube surface (5.91 x 10-5 inch).

Tube type

The program covers plain tubes (default) and external integral circumferentially finned tubes.

Externally finned tubes become advantageous when the shell side film coefficient is much less than the tube side film coefficient. However there are some applications where finned tubes are not recommended. They are not usually recommended for cases where there is high fouling on the shell side or for condensation where there is a high liquid surface tension.

The dimensional standards for Wolverine and High Performance finned tubes are built into the program. These standard finned tubes are available in tube diameters of 12.7, 15.9, 19.1, and 25.4 mm or 0.5, 0.625, 0.75, and 1.0 inch.

Tube outside diameter

You can specify any size for the tube outside diameter. However, the correlations have been developed based on tube sizes from 10 to 50 mm (0.375 to 2.0 inch). The most common sizes in the U.S. are 0.625, 0.75, and 1.0 inch. In many other countries, the most common sizes are 16, 20, and 25 mm.

If you do not know what tube diameter to use, start with a 20 mm diameter (ISO standards) or a 0.75 inch diameter (American standards). This size is readily available in nearly all tube materials. The primary exception is graphite, which is made in 32, 37, and 50 mm, or 1.25, 1.5, and 2 inch outside diameters.

For integral low fin tubes, the tube outside diameter is the outside diameter of the fin.

Default: 19.05 mm or 0.75 inch

Tube wall thickness

The tube wall thickness should be based on considerations of corrosion, pressure, and company standards. If you work with ANSI standards, the thicknesses follow the BWG standards.

The program defaults are a function of material per TEMA recommendations and a function of pressure. The Aspen Hetran program checks the specified tube wall thickness for internal pressure and issues a warning if it is inadequate. For low fin tubes, the tube wall thickness specified will be maintained below the fins.

Defaults:	carbon steel	0.065 in. or 1.6 mm
	titanium	0.028 in. or 0.7 mm
	graphite	0.180 in. or 5 mm
	other materials	0.049 in. or 1.2 mm

Note: The values are not limited to those listed, which are provided as a convenience.

Tube wall specification

In many countries, the tube wall thickness is specified as either average or minimum.

Average (default) means the average wall thickness will be at least the specified thickness; typically the thickness may vary up to 12%.

With **minimum** wall thickness, all parts of the tube must be at least the specified thickness.

The program does not adjust the tube wall thickness based upon this average or minimum wall specification. This option only sets a tubing requirement specification on the data sheet.

In the U.S., most heat exchanger tubes are specified as average wall thickness. In other countries, for example, Germany, the standard requires minimum wall thickness.

This item has a small effect on tube side pressure drop and a moderate effect on heat exchanger cost.

Tube pitch

The tube pitch is the center-to-center distance between two adjacent tubes. Generally, the tube pitch should be approximately 1.25 times the tube OD. It some cases, it may be desirable to increase the tube pitch in order to better satisfy the shell side allowable pressure drop. Increasing the tube pitch beyond 1.5 times the tube OD is not recommended.

Minimum tube pitches are suggested by TEMA as a function of tube OD, tube pattern, and TEMA class. The program defaults to the TEMA minimum tube pitch, if you are designing to TEMA standards.

The DIN standards also cover tube pitch. The DIN tube pitches are a function of tube OD, tube pattern, and tube to tubesheet joint. The program defaults to the DIN standard if you are designing to DIN standards.

Tube Pattern

The tube pattern is the layout of the tubes in relation to the direction of the shell side crossflow, which is normal to the baffle cut edge. The one exception to this is pool boiling in a kettle type reboiler, where the tube supports are sometimes baffles with a vertical cut.

Use **triangular** when you want to maximize the shell side film coefficient and maximize the number of tubes, and shell side cleaning is not a major concern. If you must be able to mechanically clean the shell side of the bundle, then choose square or rotated square.

Square is recommended for pool boilers to provide escape lanes for the vapor generated.

Rotated square will give the higher film coefficient and higher pressure drop, but it will usually have fewer tubes than a square layout.

Rotated triangular is rarely the optimum, because it has a comparatively poor conversion of pressure drop to heat transfer.

Defaults: triangular for fixed tubesheet exchangers; square for pool boilers

Tube Surface

The tube surface finish primarily affects the tube side pressure drop. With a ‘smooth’ surface, a low relative roughness factor is used in the calculations resulting in a lower tube side pressure drop. With a commercial finished tube, the relative roughness is higher and results in a higher tube side pressure drop compared to the smooth surface tube.

If pipe material is used for the tubing, it is advisable to switch to a commercial finish or to specify the relative roughness. The program default is a smooth tube surface.

Fins Sheet

If the specified tube type is finned tubes, use this sheet to specify:

- **Fin density**, which is the number of fins per inch or per meter depending on the system of measure.
- **Fin height**, which is the height above the root diameter of the tube.
- **Fin thickness**, which is the average fin thickness.
- **Surface area per unit length**, which is outside tube surface area per unit length of tube.
- **Outside/Inside surface area ratio**, which is the ratio of the developed outside surface area of the tube divided by the inside surface area of the tube per unit length.

Standard fin dimensions:

Fin Density	16-30 fins/in	630-1181 fins/m
Fin Height	0.0625-0.032 in	1.59-0.81 mm
Fin Thickness	0.011-0.012 in	0.28-0.31 mm

Typical average outside surface area / unit length:

Tube O.D.	0.750 in	0.406-0.500 ft2/ft
Tube O.D.	19.05 mm	0.124-0.152 m2/m

Fin density

If you specify fin tubes as the tube type, then you must specify the desired fin density (i.e., the number of fins per inch or per meter depending on the system of measure). Since the possible fin densities are very dependent on the tube material, you should be sure that the desired fin density is commercially available.

The dimensional standards for finned tubes made by Wolverine, and High Performance Tube are built into the program. If you choose one of these, the program will automatically supply the corresponding fin height, fin thickness, and ratio of tube outside to inside surface area. If you do not choose one of the standard fin densities, then you must also supply the other fin data.

The following table lists the standard fin densities for various materials.

Material	**Fin density**
Carbon Steel	19
Stainless Steel	16, 28
Copper	19, 26
Copper-Nickel 90/10	16, 19, 26
Copper-Nickel 70/30	19, 26
Nickel Carbon Alloy 201	19
Nickel Alloy 400 (Monel)	28
Nickel Alloy 600 (Inconel)	28
Nickel Alloy 800	28
Hastelloy	30
Titanium	30
Admiralty	19, 26
Aluminum-Brass Alloy 687	19

Surface area per unit length

Specify the outside tube surface area per unit length of tube.

Average outside surface area / Unit length:

Tube O.D.	0.750 in	0.406-0.500 ft2/ft
Tube O.D.	19.05 mm	0.124-0.152 m2/m

Standard fin dimensions:

Fin Density	16-30 fins/in	630-1181 fins/m
Fin Height	0.0625-0.032 in	1.59-0.81 mm
Fin Thickness	0.011-0.012 in	0.28-0.31 mm

General Exchanger Geometry

Use this sheet to specify these parameters, when using twisted tapes:

- Twisted tap insert ratio

  Provide the ratio of the length of tape required to make a 180 degree twist to the width of the tape. The smaller the ratio, the tighter the twist.
- Twisted tape insert width

  Specify the width of twisted tape insert.
- Tapered tube ends for knockback condensers

Tapered tube ends at the inlet tubesheet can be specified for knockback condensers applications. Tapered tube ends promote better condensate drainage from the tubes, reduce the potential for flooding, and allow a higher allowable tube velocity to be utilized in the design.

Bundle

Shell Inlet/Outlet Sheet

Use this sheet to specify:

- Shell entrance and exit construction options

  The shell entrance construction specification affects the shell and bundle entrance velocities. The shell exit construction specification affects the shell and bundle exit velocities. These specifications may affect the tube count.

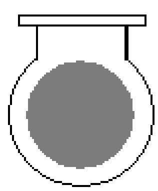
- Pool boiler options

  If specified, the **shell diameter** will be increased to **provide disengagement space** for the vapor generated. If a kettle shell is specified, the program always provides the disengagement space. You can specify the **percentage of disengagement space** needed.

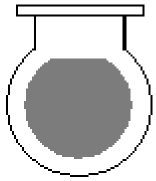
  The disengagement space for kettle type pool boilers will be adjusted based on the specified exit entrainment ratio. If the specified exit quality requires less than 5% entrained liquid, additional separation devices, such as demister pads, are recommended.

Shell Entrance and Exit Construction Options

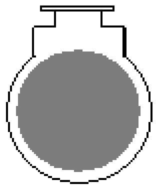
These are the shell entrance and exit construction options:



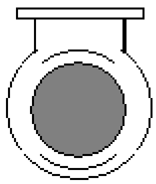
Normally, it is advantageous to use a **full tube layout**; that is, to place as many tubes as possible within the outer tube limits. This maximizes the surface area within a given shell diameter and minimizes bypassing. However, when this results in excessive velocities entering the shell, it is recommended that some tubes near the inlet nozzle be removed or a dome or distributor belt be installed.



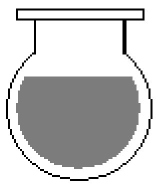
If you **remove tubes within the nozzle projection**, the program eliminates any tubes that would extend beyond the lowest part of the nozzle cylinder. In many cases, using this option will have no effect since nozzles, which are relatively small in comparison to the shell diameter (say smaller than 1/4 the shell diameter) will not extend to the first row of tubes anyway.



A **nozzle dome with a full layout** reduces the velocity entering the shell, but does not effect the velocity entering the bundle.



A **distributor belt with a full layout** is the most effective way to reduce entrance velocities, but it is usually the most expensive.



If you **remove tubes so that the shell entrance area equals the inlet nozzle area**, the tube layout is the same as when installing an impingement plate on the bundle, although the presence of the impingement plate is determined by another input item described next. This is usually a very effective way of decreasing entrance velocities.

Defaults:

Entrance Normal with full layout if no impingement plate

Nozzle dome with full layout if impingement plate in nozzle dome

Remove tubes so that shell entrance area equals inlet nozzle area if impingement plate on bundle

Exit Same as shell entrance construction if inlet and outlet nozzles are at the same orientation; otherwise, normal with full layout

Impingement Sheet

Use this sheet to specify these impingement parameters:

- Protection type

  The purpose of impingement protection is to protect the tubes directly under the inlet nozzle, by deflecting the bullet shaped flow of high velocity fluids or the force of entrained droplets.

- Plate diameter

  The program will use this input to determine the position and the dimension of the impingement plate This input is not required if you have already specified the shell inlet nozzle OD. The default is the shell inlet nozzle O.D.

- Plate length and width

  Specify the length and width (parallel to a tube axis) of the rectangular impingement plate. The default is the shell inlet nozzle O.D. for length and width (square plate).

- Plate thickness

  The thickness is required if you specify there is an impingement field. You can specify any thickness for the impingement plate. The default is 3 mm or 0.125 inch.

- Distance from shell ID

  You can specify the distance from the shell inside diameter to the impingement plate. The default is the top row of tubes.

- Clearance to tube edge

  You can specify the distance from the impingement plate to the first row of tubes.

- Plate perforation area %

  If you are using a perforated type impingement plate, you can specify the percent of area that the plate is perforated.

Impingement protection type

TEMA recommends that inlet impingement protection be installed under the following conditions:

- When the rho*V2 through the inlet nozzle exceeds 2232 kg/(m*s2) or 1500 lb/(ft*s2) for non-corrosive, non-abrasive, single phase fluids
- When the rho*V2 through the inlet nozzle exceeds 744 kg/(m*s2) or 500 lb/(ft*s2) for corrosive or abrasive liquids
- When there is a nominally saturated vapor
- When there is a corrosive gas

- When there is two phase flow at the inlet

If you choose a **plate on the bundle**, the program automatically removes tubes under the inlet nozzle so that the shell entrance area equals the cross-sectional area of the nozzle. This is approximately equal to removing any tubes within a distance of 1/4 the nozzle diameter under the center of the nozzle. For purposes of calculating the bundle entrance velocity, the program defaults to an impingement plate that is circular, unperforated, equal in diameter to the inside diameter of the nozzle, and approximately 3 mm or 1/8 in. thick.

An alternative is to put a **plate in a nozzle dome**, which means suspending the impingement plate in an enlarged nozzle neck, which may be a dome or a cone.

Both types have their advantages and disadvantages. If the plate is on the bundle, the flow is more widely distributed, and there is neither the expense for the enlarged nozzle neck nor the increased potential of fabrication problems when cutting a large hole in the shell (as can often happen with vapor inlet nozzles). However, since tubes are removed, it may require larger diameter shell, tubesheets, flanges, etc. Especially in cases where the tubesheets and/or shell are made of alloy and the inlet nozzle is not large, the impingement plate in the nozzle dome may be significantly less expensive.

For some special applications, the plate may be perforated. The primary advantage being that the perforations will help reduce the velocity into the bundle. The main concern with perforated plates is that flow through the holes could cause localized erosion for certain tube materials.

Default: circular plate on bundle if condensation or vaporization is occurring on the shell side; otherwise, none

Layout Options Sheet

Use this sheet to specify these layout options:

- Pass layout

  The type of required pass layout.
- Design symmetrical tube layout

  When selected, the program makes the tube pattern as symmetrical as possible for the top to bottom.
- Maximum % deviation in tubes per pass

  This determines the acceptable deviation from the median number of tubes per pass. This value is used in the tubesheet layout subroutine to determine the maximum number of tubes.

- Number of tie rods

  The tie rods hold the spacers, which hold segmental baffles in place.
- Tie rod diameter and spacer diameter
- Number of sealing strip pairs

  Sealing strips are used to reduce bypassing of the shell side flow around the bundle.
- Minimum u-bend diameter

  This is the minimum distance from tube center to tube center that a U-tube can be bent.
- Pass partition lane width

  The pass partition lane is the opening between passes as measured from the outermost edge of the tube of one pass to the outermost edge of a tube in the next pass. This necessary distance is a function of the thickness of the pass partition plate and, in the case of U-tubes, the minimum U-bend diameter.

  The program default equals the thickness of the pass partition plate plus 3 mm or 0.125 in. The thickness of the pass partition plate is determined according to the TEMA standards.
- Percent of pass partition lane blocked from flow

  If the shell side cross flow direction is parallel to the pass partition lanes, fluid bypasses the bundle through the open lane and reduces the heat transfer efficiency. As a default, Hetran assumes that 20% of the pass lane flow area is blocked by dummy tubes or seal strips. You can adjust the percent blocked here.
- Location of center tube in 1st row

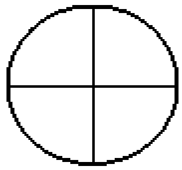
  You can select the tube position in the first row to be on the center line or off center. If program will optimize is selected, the tube position is set to maximize the number of tubes in the layout.
- Outer tube limit diameter

  The outer tube limit (OTL) is the diameter of the circle beyond which no portion of a tube will be placed. This input only applies to rating mode. In design mode, the program ignores this entry. An alternative means of controlling the OTL, in both rating and design mode, is to specify the Shell ID to Baffle OD and the Baffle OD to outer tube limit on the **Clearances** sheet. The program calculates this by default.
- Spacer diameter

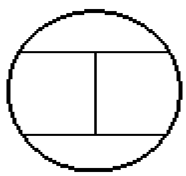
  The spacers slide over the tie rods to secure the baffles at the correct distance apart. Tubes are generally used for spaces. For example, a 3/8 inch OD tie rod would have a 5/8 inch OD tube used as a spacer.

Pass layout

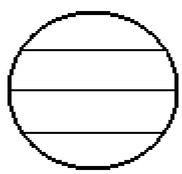
There are several possible ways to layout tubes for four or more passes. The primary effect on the thermal design is due to the different number of tubes that are possible for each type.



Quadrant layout has the advantage of usually (but not always) giving the highest tube count. It is the required layout for all U-tube designs of four or more passes. The tube side nozzles must be offset from the centerline when using quadrant layout. The program automatically avoids quadrant layout for shells with longitudinal baffles and 6, 10, or 14 pass, to avoid having the longitudinal baffle bisect a pass.



Mixed layout has the advantage of keeping the tube side nozzles on the centerline. It often gives a tube count close to quadrant and sometimes exceeds it. The program automatically avoids mixed layout for shells with longitudinal baffles and 4, 8, 12, or 16 passes.



Ribbon layout nearly always gives a layout with fewer tubes than quadrant or mixed layout. It is the layout the program always uses for an odd number of tube passes. It is also the layout preferred by the program for X-type shells. The primary advantage of ribbon layout is the more gradual change in operating temperature of adjacent tubes from top to bottom of the tubesheet. This can be important when there is a large change in temperature on the tube side, which might cause significant thermal stresses in mixed and quadrant layouts.

Default: program will optimize

Maximum % deviation in tubes per pass

This input determines the acceptable deviation from the median number of tubes per pass. This value is used in the tubesheet layout subroutine to determine the maximum number of tubes.

Ideally, it is desirable to have the same number of tubes in each pass when there is no change of phase on the tube side. However, for most layouts of more than two passes, this would require removing tubes which would otherwise fit within the outer tube limit. Since it is preferable to maximize the surface area within a given shell and minimize the possible shell side bypassing, a reasonable deviation in tubes per pass is usually acceptable.

It is recommended that you avoid large deviations since this gives significantly different velocities in some passes and wastefully increases the pressure drop due to additional expansion and contraction losses. Since the Aspen Hetran program bases the tube side calculations on an average number of tubes per pass, such aberrations are not reflected in the thermal design.

Default: 5 %

Number of tie rods

The tie rods hold the spacers, which hold segmental baffles in place. TEMA has recommendations for a minimum number of tie rods, which is a function of the shell diameter. Additional tie rods are sometimes desirable to block bypassing along pass partition lanes or to better anchor double or triple segmental baffles.

This input has no meaning in the case of grid baffles (rod and strip baffles).

The Aspen Hetran program first tries to locate the tie rods so that they do not displace any tubes. If this is not possible, the program then displaces tubes as necessary. The program only locates tie rods around the periphery of the bundle, not in the middle of the bundle.

After you have finalized your exchanger design, you can add, delete, and relocate the tie rods interactively on the **Tube Layout** in the **Rating/Simulation Data** section.

Default: TEMA Standards

Number of sealing strip pairs

Sealing strips are used to reduce bypassing of the shell side flow around the bundle.

In fixed tubesheet type exchangers, the clearance between the bundle and shell is very small and seal strips are generally not required.

With floating head type units, such as S & T type rear heads, the open space around the bundle is larger and requires seal strips to avoid the fluid bypassing around the bundle.

After you have finalized your exchanger design, you can add, delete, and relocate the tie rods interactively on the **Tube Layout** in the **Rating/Simulation Data** section.

Default: LMNU, W type – No seal strips
S, T & P – One pair every 5 tube rows

Minimum u-bend diameter

This is the minimum distance from tube center to tube center that a U-tube can be bent. The program defaults to a generally safe minimum of three times the tube O.D. The true minimum is a function of the material, the tube wall thickness, and the bending process.

This has a significant effect on the thermal design, because it determines the number of tubes in a U-tube layout.

You can also use this input to force the program to simulate a U-tube layout where the innermost U-tubes are installed at an angle other than the normal vertical plane (for 2 passes) or horizontal plane (for 4 or more passes). However, when doing this, the program will over-predict the number of tubes by one for each pass.

Default: three times the tube outside diameter

Layout Limits Sheet

Use this sheet to specify:

- Open space between shell ID and outermost tube

  You can control where the program will place tubes by specifying limits at the top of the bundle, bottom of the bundle, and/or both sides of the bundle. The tubesheet layout is always symmetrical left to right, but it can be asymmetrical top to bottom. You can specify each limit as either a percentage of the shell inside diameter or as an absolute distance. The default is limited by the outer tube limit.
- Distance from tube center

  You can control the distances between the center tube rows and the horizontal / vertical centerlines. The program optimizes by default.

Clearances Sheet

Use this sheet to specify diametric clearances:

For **shell ID to baffle OD** and **baffle OD to out tube limit** clearances, it is recommended that you choose the program defaults for diametrical clearances that are in accordance with the TEMA standards. If you want to override any of the default values, specify the desired diametrical clearance (two times the average gap).

Note that the tolerance on the **baffle hole to tube** clearance is highly dependent on the drilling equipment used. Therefore, be careful when specifying a baffle hole to tube clearance less than 0.8 mm or 0.03125 in.

Default: TEMA Standards

Baffles

Hetran Baffles Sheet

Use this sheet to specify:

- Baffle type
- Baffle cut as a percentage of the shell inside diameter
- Baffle cut orientation

Baffle Type

Baffle types can be divided up into two general categories:

- **Segmental baffles** are pieces of plate with holes for the tubes and a segment that has been cut away for a baffle window. Single, double, triple, and no tubes in window are examples of segmental baffles.
- **Grid baffles** are made from rods or strips of metal, which are assembled to provide a grid of openings through which the tubes can pass.

Segmental baffles are the most common type of baffle, with the single segmental baffle being the type used in a majority of shell and tube heat exchangers. The single segmental baffle gives the highest shell film coefficient but also the highest pressure drop. A double segmental baffle at the same baffle spacing will reduce the pressure drop dramatically (usually somewhere between 50% - 75%) but at the cost of a lower film coefficient. The baffles should have at least one row of overlap and therefore become practical for a 20 mm or 0.75 in. tube in shell diameters of 305 mm (12 in.) or greater for double segmental and 610 (24 in.) or greater for triple segmental baffles. (Note: the B-JAC triple segmental baffle is different than the TEMA triple segmental baffle.)

Full Supports are used in K and X type shells where baffling is not necessary to direct the shell side flow.

No Tubes In Window is a layout using a single segmental baffle with tubes removed in the baffle windows. This type is used to avoid tube vibration and may be further enhanced with intermediate supports to shorten the unsupported tube span. The standard abbreviation for no tubes in the window is NTIW.

The program covers two types of grid baffles: rod baffles and strip baffles. Both are used in cases where the allowable pressure drop is low and the tube support is important to avoid tube vibration.

Rod Baffle design is based on the construction and correlations developed by Phillips Petroleum. Rod baffles are limited to a square tube pattern. The rods are usually about 6 mm (0.25 in.) in diameter. The rods are placed between every other tube row and welded to a circular ring. There are four repeating sets where each baffle is rotated 90 degrees from the previous baffle.

Strip Baffles are normally used with a triangular tube pattern. The strips are usually about 25 mm (1 in.) wide and 3 mm (0.125 in.) thick. The strips are placed between every tube row. Intersecting strips can be notched to fit together or stacked and tack welded. The strips are welded to a circular ring. Strip baffles are also sometimes referred to as nest baffles.

Default: single segmental except X shells; full support for X shell

Baffle cut (% of diameter)

The baffle cut applies to **segmental baffles** and specifies the size of the baffle window as a percent of the shell inside diameter.

For **single segmental baffles**, the program allows a cut of 15% to 45%. Greater than 45% is not practical because it does not provide for enough overlap of the baffles. Less than 15% is not practical, because it results in a high pressure drop through the baffle window with relatively little gain in heat transfer (poor pressure drop to heat transfer conversion). Generally, where baffling the flow is necessary, the best baffle cut is around 25%.

For **double and triple segmental baffles**, the baffle cut pertains to the most central baffle window. The program automatically sizes the other windows for an equivalent flow area.

Defaults:	single segmental	45% for simple condensation and pool boiling; 25% for all others

double segmental	28% (28/23)
triple segmental	14% (14/15/14)

Baffle cut orientation

The baffle orientation applies to the direction of the baffle cut with segmental baffles. It is very dependent on the shell side application.

For horizontal, shell side condensation applications, the cut should be oriented vertically. This will facilitate condensate drainage. For all other applications, the cut orientation is not as critical. The program defaults to vertical cut for horizontal condensers and horizontal cut for all other applications.

For a single phase fluid in a horizontal shell, the preferable baffle orientation of single segmental baffles is horizontal, although vertical and rotated are usually also acceptable. The choice will not affect the performance, but it will affect the number of tubes in a multipass heat exchanger. The horizontal cut has the advantage of limiting stratification of multicomponent mixtures, which might separate at low velocities.

The rotated cut is rarely used. Its only advantage is for a removable bundle with multiple tube passes and rotated square layout. In this case the number of tubes can be increased by using a rotated cut, since the pass partition lane can be smaller and still maintain the cleaning paths all the way across the bundle. (From the tubesheet, the layout appears square instead of rotated square.)

For horizontal shell side condensers, the orientation should always be vertical, so that the condensate can freely flow at the bottom of the heat exchanger. These baffles are frequently notched at the bottom to improve drainage. For shell side pool boiling, the cut (if using a segmental baffle) should be vertical. For shell side forced circulation vaporization, the cut should be horizontal in order to minimize the separation of liquid and vapor.

For double and triple segmental baffles, the preferred baffle orientation is vertical. This provides better support for the tube bundle than a horizontal cut which would leave the topmost baffle unsupported by the shell. However this can be overcome by leaving a small strip connecting the topmost segment with the bottommost segment around the baffle window between the O.T.L. and the baffle OD.

Defaults: vertical for double and triple segmental baffles
vertical for shell side condensers
vertical for F, G, H, and K type shells
horizontal for all other cases

Tube Supports Sheet

Use this sheet to specify the **number of intermediate supports** at the inlet, outlet, center spacing, and at the U-bends. The default is none.

Intermediate supports are support plates or grids, which give additional support to the tubes to avoid tube vibration. Grid supports can be used with any type of baffle between baffles, at the inlet or outlet, or at the U-bend.

With standard type segmental baffles, grid type intermediate supports should be used. Plate type supports should be used only for No Tubes In the Window (NTIW) type baffles. Intermediate supports are assumed to have an insignificant effect on the thermal performance. Their presence will however be considered in the vibration analysis.

One or more **supports** can be placed **at the U-bend** to give additional support to the tubes to avoid tube vibration. The default is full support at U-bend.

Specify the **distance from the nearest support or baffle to the tangent point of the U-bends**. Normally this clearance is a minimum of 3 inches.

If you specify two **partial supports at U-bend**, you can specify the **distance** between those supports. The default is 6-inch spacing between the partial supports.

The **U-bend mean radius** determines the unsupported tube span for the U-bends used in the tube vibration calculations. If not provided, the program determines the mean radius based upon the actual tube layout.

Multi-Segmental Baffles Sheet

When check rating existing equipment with multi-segmental baffles, it may be necessary to specify the inner and outer baffle cuts. If only a nominal baffle cut is specified on the Baffles tab, it should reflect the baffle cut in the inner window (the inner cut height as a percent of the shell diameter).

When only the nominal baffle cut is specified, the program will calculate the outer cut heights that will result in approximately the same window flow areas.

Use this sheet to override the program calculated outer cuts by specifying the actual inner and outer cuts.

Deresonating Baffles Sheet

Use this sheet to specify the location of the deresonating baffle, using the distance from centerline of baffle to the shell ID. If the distance specified is less than ½ the shell diameter, the program will add multiple parallel baffles spaced by the distance specified.

Rod Baffles Sheet

Use this sheet to specify the **inside** and **outside ring diameters** and **support rod diameter** for rod type baffles. If left blank, the program determines the dimensions based on the shell diameter.

You can also specify the **total length of support rods per baffle** so that the available flow area can be determined for heat transfer and pressure drop calculations. The program calculates this by default.

If there are **open areas** where tubes have been removed for rod baffle applications, you can specify to block these open flow areas with plates. Hetran adjusts the performance and pressure drop calculations accordingly.

Rating/Simulation Data

Rating/Simulation Data

If you specified on the **Application Options** sheet that you want to perform a check rating or simulation of an existing exchanger, you must provide the exchanger mechanical information. Other geometry parameters such as shell type and tube size will be set at defaults, unless they are specified on the Geometry sheet in this section.

Geometry Sheet

Use this sheet to specify:

- Shell outside and inside diameters

  Specify the actual shell outside diameter (OD) and inside diameter (ID). If the shell OD is specified we recommend leaving the ID blank.

For pipe size exchangers, we recommend specifying a shell OD rather than an ID, since the program references standard pipe schedules. For exchangers made of rolled and welded plate materials, the shell OD or ID may be specified. For kettles, the shell diameter is for the small cylinder near the front tubesheet, not the large cylinder.

- Baffle spacing center-center

  Specify the center-to-center spacing of the baffles in the bundle.

- Baffle spacing at inlet and outlet

  Specify the inlet baffle spacing at the entrance to the bundle and the outlet baffle spacing at the exit of the bundle. For G, H, J, and X shell types, this is the spacing from the center of the nozzle to the next baffle. These types should have a full support under the nozzle.

  If the inlet baffle spacing is not specified, the program calculates the space based on the center-to-center spacing and the outlet spacing. If the outlet spacing is not provided, the program will determine the remaining tube length not used by the center to center spacing and provide equal inlet and outlet spacings.

- Baffle number

  The number of baffles is optional input. The number of baffles for G, H, and J type shells should include the baffle or full support under the nozzle.

  If you do not know the number of baffles, inlet spacing, or outlet spacing, you can approximate the number of baffles by dividing the tube length by the baffle spacing and subtracting 1. However, it is best to let the program calculate it, because the program also considers the tubesheet thickness and nozzle sizes.

- Tube length

  Specify the tube length, which should include the length of tubes in the tubesheets. For U-tube exchangers, specify the straight length to the U-bend tangent point.

- Tube number

  Specify the number of tube holes in the tubesheet. This is the number of straight tubes or the number of straight lengths for a U-tube. If you specify the number, the program checks to make sure that number of tubes can fit into the shell. If not specified, the program calculates the number of tubes using the tubesheet layout subroutine.

- Tube passes

  Specify the number of tube passes in the exchanger.
- Shells in series, shells in parallel

  If you have multiple exchangers for a rating case, be sure to specify the appropriate number in parallel and/or series. Remember that the program requires that both shell side and tube side be connected in the same way (both in parallel or both in series). You can specify multiple exchangers in both parallel and series; for example you can have two parallel banks of three in series for a total of six heat exchangers.
- Tube layout option

  You can select to have the Hetran program generate a new tube layout every time the program runs (default), or you can select to use an existing layout. For the second option, you must first run Hetran to establish a layout and then select the option to use the existing layout for all subsequent runs.

Kettle/Vapor Belt Sheet

Use this sheet to specify the following rating/simulation data:

- Kettle outside and inside diameters

  Specify the actual kettle outside diameter (OD) and inside diameter (ID). If the kettle OD is specified, we recommend leaving the ID blank.

  For pipe size exchangers, we recommend specifying a kettle OD rather than an ID, since the program references standard pipe schedules. For exchangers made of rolled and welded plate materials, the kettle OD or ID may be specified.
- Vapor belt outside and inside diameters

  Specify the actual vapor belt outside diameter for a V type shell.

  For pipe size exchangers, we recommend specifying a vapor belt OD rather than an ID, since the program references standard pipe schedules. For exchangers made of rolled and welded plate materials, the vapor belt OD or ID may be specified.
- Vapor belt length

  The length of the vapor belt is approximately two thirds the length of the V type shell. The length specified will affect the entrance area pressure drop.

Thicknesses Sheet

Use this sheet to specify:

- Shell cylinder thickness

  Specify the actual shell cylinder thickness. If the shell OD is specified, the program uses the cylinder thickness to calculate a shell ID and establish the OTL and tube count for the exchanger.
- Front head cylinder thickness

  Specify the actual front head cylinder thickness.
- Front and rear tubesheet thickness

  Specify the actual front tubesheet thickness and rear tubesheet thickness. The program uses the tubesheet thickness to determine the effective tube length for effective surface area calculations.
- Baffle thickness

  Specify the actual baffle thickness.

If not specified, the program will estimate the thicknesses per the applicable code.

Tube Layout Sheet

Once you have a specified an exchanger geometry and executed the Hetran in the Rating Mode, you can interactively make modifications to the tube layout.

Tubes: To remove a tube, click on the tube (tube is highlighted in red) and select the red X on the menu. If you want to designate a tube as a plugged tube or as a dummy tube, click on the tube (tube is highlighted in red) and click the plugged tube icon or dummy tube icon on the menu.

Tie Rods: To remove a tie rod, click on the tie rod (tie rod is highlighted in red) and select the red X on the menu. To add a tie rod, click the add a tie rod icon on the menu and specify the location for the tie rod.

Sealing Strips: To remove a sealing strip, click on the sealing strip (sealing strip is highlighted in red) and select the red X on the menu. To add a sealing strip, click the add a sealing strip icon on the menu and specify the location for the sealing strip.

Nozzles

Nozzles Sheet

Use this sheet to specify nozzle specifications for the **hot/cold side**, **inlet/outlet**, and **hot side condensate**.

For the nozzle diameter specification you can select **nominal diameter**, **actual OD**, or **actual ID**. If left blank, the program sizes the nozzle based on nozzle mass velocity limits per TEMA and the allowable pressure drop.

The logical **orientation of the nozzles** follows the laws of nature, that is, fluids being cooled should enter the top and exit the bottom, and fluids being heated should enter the bottom and exit the top. Normally, the program should determine the orientation. If you specify the orientation, make sure that it is compatible with the baffle cut and the number of baffles. For example, if your design has an odd number of single segmental baffles with a horizontal cut, the inlet and outlet must be at the same orientation.

For standard pipe schedule sizes, specify the **nominal dome diameter**. For larger formed head domes, specify the actual outside diameter.

The specification of the **nozzle flange rating** does not affect the thermal design calculations or the cost estimate. It is included in the input to make the specification of the heat exchanger more complete (e.g., on the TEMA specification sheet output). The pressure-temperature charts are built into the program. By default the program determines the rating based on the design pressure and design temperature. The values are not limited to those listed, but you should select a rating that is consistent with the desired standard (ANSI, ISO, or DIN).

By default the program selects a **slip on type nozzle flange**. If your application requires one of the alternate types, select it from the list, and it will be passed on to the Teams mechanical design program to provide a more accurate equipment cost.

For a single pass shell/single pass tube or a two pass shell/two pass tube exchanger arrangement, you can set the tube and shell side **flow direction** to be **counter current** or **co-current**. For multi passes on the tube side, setting the flow direction for the first pass will locate the inlet shell nozzle accordingly.

The program default **location of the nozzle** near the U-bends is between the U-bend support and the first baffle. By locating the nozzle at this location, you can avoid the passing of the fluid across the U-bends that could result in vibration.

Generally, the U-bend surface area is not considered as effective a heat transfer area as the rest of the tube bundle due to the non-uniformity of the tube spacing. If you want the U-bend surface area to be included, you can set the percentage effective on the Process sheet of the Thermal Analysis form in the Program Options folder.

Thermosiphon Piping Sheet

Use this sheet to specify the height of liquid level and outlet piping above the top tubesheet of a vertical thermosiphon reboiler or vessel centerline of a or horizontal thermosiphon reboiler and equivalent length of inlet/outlet piping.

The **height above the top tubesheet of the liquid level in the column and the outlet piping back to** column are important for the calculation of the hydraulics of the reboiler, in that the data is used to determine the static head.

For **vertical thermosiphons**, the reference point is the top face of the top tubesheet. The level of the return connection to the column is at the centerline of the connection. For the **liquid level** in the column specify a positive (+) height if above the tubesheet, a negative (-) height if below the tube sheet. By default the program starts with the level at the top tubesheet and then increases as necessary to obtain the needed static head. For the **outlet piping back to the column** the default level of return connection is one shell diameter above the top tubesheet.

For **horizontal thermosiphons** the reference point is the centerline of the vessel. The level of the return connection to the column is at the centerline of the connection. For the **liquid level** specify a positive (+) height if above the vessel centerline, a negative (-) height if below the vessel centerline. The default is even with the vessel center line. For the **outlet piping back to the column** the default level of return connection is one shell diameter above vessel centerline.

Equivalent length is a method of specifying a length of piping that accounts for the pressure drop of pipe as a ratio of length to diameter and the effect of valves, bends, tees, expansions, contractions, etc. Refer to a piping handbook for more details.

If these items are not specified the program calculates an equivalent length for the column to the inlet based on a pipe equal in diameter to the inlet nozzle and one 90 degree elbow. The default for the outlet to the column is based on a horizontal pipe equal in diameter to the outlet nozzle without any bends.

Thermosiphon Piping Specs Sheet

In lieu of specifying the equivalent lengths of piping on the **Thermosiphon Piping** sheet, you can specify the inlet/outlet piping details - **inside diameter**, **vertical and horizontal pipe straight lengths**, **number of 90 degree elbows**, and **valve type** - and the program will calculate the equivalent length of piping. For

TEMA H, J, X shells you can specify the inlet/outlet manifold inside diameter.

By default the program will use equivalent length defaults, if no piping specs are given.

Design Data

Design Constraints

Shell/Bundle Design Constraints Sheet

Use this sheet to specify these design mode constraints.

- Shell diameter

  The program uses the **increment** specified here when it increases the shell diameter of a shell made of plate in design mode. The default is 2 in or 50 mm. If the shell is made of pipe, this parameter is ignored.

  The program considers the **minimum/maximum shell diameter** specified here in design mode. For pipe shells, this refers to the outside diameter. Acceptable values are a lower limit of 2 in. or 50 mm and no upper limit. The input specification for shell and front head reference for plate shells in the shell design constraints section determines if this is for the outside or inside diameter of a shell made from plate. The minimum diameter default is 6 in. or 150 mm; the maximum is 72 in. or 2000 mm. The maximum must be greater or equal to the minimum.

- Tube length

  The program uses the **increment** specified here when it increases or decreases the tube length in design mode. The default is 2 ft. or 500 mm.

  The program considers the **minimum/maximum tube length** specified here in design mode. For U-tubes it is straight length. The minimum default is 4 ft. or 1000 mm; the maximum is 20 ft. or 6000 mm. The maximum must be greater or equal to the minimum.

- Tube passes

  This applies to the selection of tube passes in design mode.

- Baffle spacing

  The program considers the minimum baffle spacing specified here in design mode. TEMA recommends that segmental baffles should not be placed:

  - Closer than a distance equal to 20% of the shell ID or 50 mm (2 in), whichever is greater. This is the minimum default.
  - Further apart than a distance equal to the shell ID or 1/2 the maximum unsupported span, whichever is less (except

NTIW and grid baffles). The maximum default is the greater of the shell ID or 610 mm (24 in).

- Shell design constraints

  Constraints include using shell ID or OD as reference, using pipe or plate for small shells, the minimum shells in series or parallel.

- Baffles design constraints

  Constraints include the allowable number of baffles, allowing baffles under nozzles, and using a proportional baffle cut.

Tube Passes

This applies to the selection of tube passes in design mode. Choices are **odd** (1,3,5,7,...), **even** (1,2,4,6,...), or **all** (1,2,3,4,...). The default is even. The normal progression of tube passes is 1, 2, 4, 6, 8, 10, 12, 14, 16. However, there are times when an odd number of passes above 1 may be desirable.

One possible case is when 4 passes results in enough surface, but the pressure drop is too high and 2 passes results in an acceptable pressure drop, but the surface is inadequate. Since pressure drop is increased by about 8 times when going from 2 to 4 passes, a 3 pass design may be the optimum compromise.

Another case is when a 2 or 4 pass design is controlled by a low MTD correction factor (say 0.75), but the 1 pass design has too low a velocity or requires too much surface. Since a 3 pass heat exchanger can have 2 counter-current passes to only 1 co-current pass; the F factor can be significantly higher than other multipass designs.

The program considers **minimum/maximum number of tube passes** specified here in design mode. The actual number of tube passes tried is also a function of the shell diameter. The program will not try the higher tube passes if they are inappropriate for the shell diameter.

Acceptable minimum/maximum values are 1 to 16. Minimum defaults are 1 for straight tubes, 2 for U-tubes. Maximum default values are 8 for single phase in tubes; 2 for two-phase in tubes. The maximum must be greater than or equal to the minimum.

Shell Design Constraints

You can specify these shell design constraints:

- Use shell ID or OD as reference

  This determines whether the references to shell diameter in input and output are to the outside or inside diameter. When you specify outside diameter (default), both the shell and front head cylinders will have the same outside diameter. Likewise, the shell and front head cylinders will have equal inside diameters when you specify inside diameter.

  When the required thickness for the front head is significantly greater than the shell, it is usually preferable to specify that the inside diameters be equal, to avoid an increased gap between the shell ID and the OTL

- Use pipe or plate for small shells

  This applies to shell diameters up to 24 in. or 610 mm. It determines if the shell incrementing should follow the standard pipe sizes (default) or go in exact increments as specified with the input value for **Shell Diameter Increment**.

- Minimum shells in series

  Use this item to force the program to evaluate multiple shells in series. The default is 1.

- Minimum shells in parallel

  Use this item to force the program to evaluate multiple shells in parallel. The default is 1.

Baffles Design Constraints

You can specify these baffles design constraints:

- **Allowable number of baffles**, which controls how the program determines the number of baffles in design mode.

  This is of special importance for single segmental baffles in a horizontal heat exchanger. An even number of single segmental baffles means that the nozzles will be at opposite orientations (usually 0 and 180 degrees for horizontal cut baffles); an odd number means they will be at the same orientation.

  Nozzles at opposite orientations have the advantage of being self-venting on startup and self-draining on shutdown. If nozzles are installed at the same orientation, it is important to have couplings opposite the nozzles to facilitate venting and draining.

For multi-segmental baffles and grid baffles, the number of baffles does not dictate the nozzle orientation. To improve flow distribution at the inlet and outlet, double and triple segmental baffles should have an odd number of baffles. The first and last multi-segmental baffle should be the one with the centermost segment.

Defaults are **even** number for horizontal exchangers with single segmental baffle, **odd** number for multi-segmental baffles, and **any** number for all other cases.

- **Allow baffles under nozzles**, which controls whether baffles are allowed to be placed under the nozzle in design mode.

  Normally baffles should not be placed under nozzles, because it will lead to poor flow distribution in the inlet or outlet zone, thus decreasing the efficiency of the heat transfer surface there. However when there is a very large inlet or outlet nozzle, which would force the tube span to exceed the maximum unsupported span, or when tube vibration is probable, it may be necessary to place a baffle or support under the nozzle. This is reasonable when using multi-segmental baffles or grid baffles.

  Defaults are **no** for single segmental baffles; **yes** for other baffles, if no other solution

- **Use proportional baffle cut**, which applies only to single segmental baffles.

  Normally in design mode, the program chooses the baffle cut based on the baffle type and the shell side application. However, with single segmental baffles, it is sometimes desirable to maintain a reasonable balance between crossflow velocity and window velocity.

  By choosing to make the baffle cut proportional to the baffle spacing, the program will increase the baffle cut as the baffle spacing is increased. The logic behind this is based on maximizing pressure drop to heat transfer conversion. If pressure drop is controlling, it may be counter-productive to take an inordinate amount of pressure drop through a small baffle window where the heat transfer is less effective than in crossflow. The default is not proportional.

Process Design Constraints Sheet

Use this sheet to specify these process design constraints:

- Allowable pressure drop

  Where applicable, the allowable hot side/cold side pressure drop is required input. You can specify any value up to the operating pressure, although the allowable pressure drop should usually be less than 40 percent of the operating pressure. Typical values are listed for convenience.

- Minimum fluid velocity

  This is the lowest velocity the program will accept in design mode. The program may not find a design that satisfies this minimum. If the chosen design does not satisfy the minimum, the program issues a warning.

  The program tries to maximize the velocities within the allowable pressure drops and the maximum allowable velocities. Therefore, this constraint does not enter into the design mode logic. On the shell side, this refers to the crossflow velocity. For two phase flow it is the vapor velocity at the point where there is the most vapor.

  Note that since there is usually significant bypassing in baffled exchangers, the crossflow velocities, which can be attained, are usually below the velocities you would expect on the tube side.

- Maximum fluid velocity

  This is the highest velocity the program will accept in design mode. The optimization logic is controlled by this item. On the shell side, this refers to the crossflow velocity. For two phase flow it is the vapor velocity at the point where there is the most vapor.

  The default value calculated by the program for maximum allowable velocity is equal to the following appropriate constant divided by the square root of the density (kg/m3 in SI units or lb/ft3 in US units).

  Vmax = k / (Density)0.5

	k in SI units	**k in US units**
Shell Side Fluid:	60.9	50.0
Tube Side Fluid:	93.8	77.0

- Maximum % of allowable pressure drop for each nozzle

  By default, Hetran limits the pressure drop taken in a nozzle to 10% of the operating pressure. You can override this default by specifying the maximum pressure drop limit.

- Minimum % excess surface area required

  The program will optimize the design with the minimum percent excess surface area specified.

- Percent of tubes to be plugged

  It is possible to model existing units with plugged tubes. By specifying the percentage of tubes that have been plugged, Hetran adjusts the tube side performance and pressure drop calculations.

Materials

Vessel Materials

Use this sheet to select the material of construction for these items:

Cylinder - hot side	Select a generic material, a general material class for the hot side components. The list includes all items except tubesheets, tubes, and baffles.
Cylinder - cold side	Select a generic material, a general material class for the cold side components. The list includes all items except tubesheets, tubes, and baffles.
Tubesheet	Select a generic material, a general material class for the tubesheet.
Double tubesheet (inner)	Select a generic material, a general material class for the inner tubesheet(s).
Baffles	Select a generic material, a general material class for the baffles, which are generally of the same material type as the shell cylinder.
Tubes	Select a generic material, a general material class for the tubes.

For all items the default is carbon steel. To specify a material grade, click the **Databank Search** button.

If you specify a material designator for the tube material, the program retrieves the thermal conductivity of the tube from its built-in databank. However, if you have a tube material that is not in the databank, you can specify the **thermal conductivity of the tube material** here.

Cladding/Gaskets Sheet

Use this sheet to select the generic material for:

- Hot/cold side tubesheet cladding, if cladding is required
- Hot/cold side gaskets

To specify a specific material grade for the hot/cold side gaskets, click the **Databank Search** button.

The program asks for gasket materials on both sides; although in the case of a fixed tubesheet type heat exchanger, there will be gaskets on only one side. You can specify either the generic material designators or the four digit material designators listed in the METALS databank or the Help facility.

If you do not specify a value, the program uses compressed fiber as the material for the mechanical design and cost estimate. The heat exchanger specification sheet will not show a gasket material, if unspecified.

Specifications

Design Specifications Sheet

Use this sheet to specify these design specifications:

- **Design code** - ASME (American), CODAP (French), or AD-Merkblatter (German) - is used to tell the program which basic mechanical design calculations to follow and also to make the heat exchanger specification more complete.
- Service class

  If you select low temperature (design temperature less than -50°F) or lethal service (exchanger contains a lethal substance), the program selects the corresponding Code requirements for that class, such as full radiography for butt welds and PWHT for carbon steel construction. The default is normal service class.
- TEMA class

  If you want the heat exchanger to be built according to TEMA standards, select the appropriate TEMA class: B (Default), C, or R. If TEMA is not a design requirement, then specify Code only, and program will use only the design code to determine the mechanical design.
- **Material standard** - ASTM, AFNOR, or DIN - determines the selection of materials listed in the input for materials of construction. By default the program uses the standards defined in the Program Settings under Tools.
- **Dimensional standard**- ANSI (American), ISO (International), or DIN (German) - applies to such things as pipe cylinder dimensions, nozzle flange ratings, and bolt sizes. DIN also encompasses other construction standards such as standard tube pitches.

  This selection is included primarily to make the heat exchanger specification complete, although it does have some subtle effects on the thermal design through the basic mechanical design. By default the program uses the standards defined in the Program Settings under Tools.

- **Design pressure**

  Used in the mechanical design calculations, the specified design pressure influences the shell, head, and tubesheet required thicknesses, and therefore affects the thermal design. If you do not specify a value, the program defaults to the operating pressure plus 10% rounded up to a logical increment. This is in gauge pressure, which is one atmosphere less than the equivalent absolute pressure.
- **Design temperature**

  Used in the mechanical design calculations, the design temperatures influence the shell, head, and tubesheet required thicknesses, and therefore affect the thermal design and cost. If you do not specify a value, the program defaults to the highest operating temperature plus 33ºC (60ºF) rounded down to a logical increment.
- **Vacuum design pressure**

  By default vacuum design pressure is not calculated for vacuum service. However, if the heat exchanger is going to operate under a full or partial vacuum, you should specify a vacuum service design pressure.

  The basic mechanical design calculations do not consider external pressure; therefore, this item will have no effect on the thermal design from the program.
- **Test pressure** is the pressure at which the manufacturer will test the heat exchanger. This has no effect on the thermal design, but is included to make the heat exchanger specification more complete. The default is Code.
- **Corrosion allowance** is included in the thickness calculations for cylinders and tubesheets, and therefore has a subtle effect on thermal design. The default is 0.125 in. or 3.2 mm for carbon steel; 0 for other materials

Design Code

The **design code** is used to tell the program which basic mechanical design calculations to follow and also to make the heat exchanger specification more complete. Choices are:

- ASME (American)
- CODAP (French)
- AD-Merkblatter (German)

The program defaults to the design code specified in the Program Settings under Tools.

The design code has a subtle, but sometimes significant effect on the thermal design. This is because the design code determines the :

- Required thicknesses for the shell and heads, therefore affecting the number of tubes
- Thickness of the tubesheet, therefore affecting the effective heat transfer area
- Dimensions of the flanges and nozzle reinforcement, therefore affecting the possible nozzle and baffle placements

Due to the fact that the mechanical design calculations themselves are very complex, the Aspen Hetran program only includes some of the basic mechanical design calculations. The full calculations are the function of the Aspen B-JAC TEAMS program.

Program Options

Thermal Analysis

Thermal Analysis Process Sheet

Use this sheet to specify:

- Heat transfer coefficient

  Normally, the film coefficients are two of the primary values you want the program to calculate. However, there may be cases where you want to force the program to use a specific coefficient, perhaps to simulate a situation that the program does not explicitly cover. You can specify neither, either, or both.
- Heat transfer coefficient multiplier

  You can specify a factor that becomes a multiplier on the film coefficient, which is calculated by the program. You may want to use a multiplier greater than 1 if you have a construction enhancement that is not covered by the program, for example tube inserts or internally finned tubes. You can use a multiplier of less than 1 to establish a safety factor on a film coefficient. This would make sense if you were unsure of the composition or properties of a fluid stream.
- Pressure drop multiplier

  Similar to the multipliers on the film coefficients, you can also specify a factor that becomes a multiplier on the bundle portion of the pressure drop, which is calculated by the program. It does not affect the pressure drop through the inlet or outlet nozzles or heads. These multipliers can be used independently or in conjunction with the multipliers on film coefficients.
- Percent of u-bend area used for heat transfer

  Since the shell side fluid does not usually flow over the U-bends in the same way as it flows over the straight portion, the effectiveness of the area in the U-bends is limited. The Aspen Hetran program assumes that there is a full support at the end of the straight length, which will limit flow over the U-bends, except in the case of kettle-type reboilers. Defaults are 100% effective for kettle-type reboiler; 0% effective for all other cases.

- Maximum rating for thermosiphons

  You may specify that the program vary flows to balance pressure for thermosiphon applications. Hetran must be set to the **Rating Mode** on the **Application Options** sheet before you can select to balance hydraulics & surface area or to balance hydraulics only.

Delta T Sheet

Use this sheet to specify:

- Mean temperature difference

  Usually you rely on the program to determine the MTD, however you can override the program calculated corrected (or weighted) MTD by specifying a value for this item.

- Minimum allowable temperature approach

  You can limit the minimum approach temperature. The program increases the number of shells in series and/or limit the exchanger to a one pass-one pass countercurrent geometry to meet the minimum approach temperature. The default is 3-5 degrees F, depending on the application.

- Minimum allowable MTD correction factor

  Most of the correction factor curves become very steep below 0.7, which is why the Aspen Hetran program defaults to 0.7 as the minimum F factor before going to multiple shells in series in design mode. The only exception is the X-type shell, where the program allows the F factor to go as low as 0.5 in design mode. In rating mode, the default is 0.5. With this input item, you can specify a lower or higher limit.

- Maximum allowable heat flux

  For vaporizing applications, it is often important to limit the heat flux (heat exchanged per unit area) to avoid the generation of too much vapor so quickly as to blanket the tube surface, resulting in a rapid decline in the film coefficient. The Aspen Hetran program has built in limits on the heat flux, but you can also establish your own limit by specifying a value here.

- Flow direction for first tube pass

For a single pass shell/single pass tube or a two pass shell/two pass tube exchanger arrangement, you can set the tube and shell side flows to be in counter current or co-current flow directions. For multi passes on the tube side, setting the flow direction for the first pass locates the inlet shell nozzle accordingly.

Calculation Options Sheet

Use this sheet to specify these calculation options:

- Maximum number of design mode iterations

  In the Design Mode the program will reiterate through the specified design parameters to converge on the lowest cost solution. You may set the maximum number of iterations for the optimization.

- Simulation mode convergence tolerance

  Specify the convergence tolerance for the simulation mode of the program. Note that a very low convergence tolerance may result in a longer calculation time.

- Number of calculation intervals

  The program does an interval analysis by dividing the heat exchanger into sections. Specify how many interval sections are to be considered. The program default is 21 sections.

- Type of interval calculation

  The program does an interval analysis by dividing the heat exchanger into sections. Select whether the program is to use equal heat load or equal temperature increments for the sectional analysis of the exchanger. The program default is equal heat load increments.

- Fouling calculation options

  You can adjust how the program allocates the excess fouling (extra fouling that is available due to excess surface area) for the **Maximum Rating** case reported in the **Thermal Resistance Analysis** report located in the **Thermal Summary Results** section.

  You can apply a different fouling ratio, Hot side to cold side, from the specified fouling factors or apply all the excess fouling to the Hot or Cold sides. Note that if you select to apply all excess fouling to the Hot or Cold Sides, any Hot / Cold ratio specified will be ignored.

Correlations

General Sheet

The Stream Flow Model options are listed below:

- Shell side flow analysis calculation method

  You can select which shell side stream analysis should be applied. By default, the Hetran program method is selected.

- Nozzle flow model to be used

  The Hetran default for two phase flow in the nozzle is to calculate the vapor volume available. The vapor velocity is determined and the corresponding pressure drop of the vapor. If you select to use the homogeneous model, the program determines a weighted liquid/vapor density and the corresponding mixture velocity and pressure drop.

- MTD correction factor for stream bypassing

  An MTD correction factor correlation is used to correct the overall MTD for the unit, based on the amount of stream bypassing that is occurring. This correction factor acts as an additional safety factor in predicting the required heat transfer surface area requirements. By default, BJAC does not apply this factor.

Condensation Options

These are the Hetran transfer condensation options:

- Desuperheating heat transfer method

  The program defaults to determining the tube wall temperature at the hot side inlet. If this option is enabled, the program assumes a desuperheating zone exists from the specified inlet temperature down to the dew point.

  The program defaults to determining the tube wall temperature at the hot side inlet. If the wall temperature is below the dew point, the program assumes that the tube wall is "wet" with condensation and uses a condensing coefficient for heat transfer. If the tube wall temperature is above the dew point, the program determines at what hot side gas temperature the tube wall temperature falls below the dew point. This hot side gas temperature would represent the low temperature for the desuperheating zone.

- Condensation heat transfer model

  The **Mass transfer film model**, is based on a Colburn-Hougen correlation for condensable(s) with noncondensable(s) and a Colburn-Drew correlation for multiple condensables. The **Modified proration model** is an equilibrium method based on a modification of the Silver-Bell correlation.

Researchers have developed several different methods of predicting the film coefficient for a condensing vapor. Each has its strengths and weaknesses. If the composition of the vapor is well known, the mass transfer method is the most accurate.

- Shell side dry gas heat transfer correlation

  The dry gas heat transfer correlation is used when condensation occurs on the shell side of the exchanger. By default, the stream analysis method is selected.

- Shell side two phase heat transfer correlation

  The three major two phase condensing correlations to determine shell side film coefficients referenced in the industry are the Taborek (default), McNaught, and Chen methods.

- Tube side two phase heat transfer correlation

  The two major two phase condensing correlations to determine tube side film coefficients referenced in the industry are the Taborek (default) and the Chen methods.

- Liquid subcooling heat transfer method

  Select the calculation method to determine the liquid subcooling coefficient for a condensing application. For most applications, the larger of the free or forced convection should be considered.

Vaporization Options

These are the Hetran transfer vaporization options:

- Suppress nucleate boiling coefficient

  If selected the program suppresses the nucleate boiling coefficient when determining the overall film coefficient. This option should be considered for very large temperature differences or with very viscous fluids.

- Minimum temperature difference for nucleate boiling

  You may specify a minimum temperature difference requirement for nucleate boiling to be considered.

- Shell side two phase heat transfer correlation

  The major two phase vaporization correlations to determine shell side film coefficients referenced in the industry are the Steiner-Taborek (default), Polley, and the Dengler-Addoms methods.

- Tube side two phase heat transfer correlation

  The major two-phase vaporization correlations to determine tube side film coefficients referenced in the industry are the

Steiner-Taborek (default), Collier-Polley, Chen, Dengler-Addoms, and the Guerrieri-Talty methods.

- Mist flow heat transfer calculation method

  When a stream approaches total vaporization, a condition of mist flow may be encountered. In this regime heat transfer coefficient may drop dramatically to that of a pure vapor flowing. Although the BJAC two phase correlation reduces the heat transfer coefficient down to that of pure vapor as it approaches total vapor, this approach is not the most conservative.

  If mist flow is predicted, you can reduce the coefficient immediately to that of pure vapor, which is the most conservative approach, or prorate the coefficient between the two phase and pure vapor based on the vapor fraction.

Pressure Drop Correlations Sheet

Use this sheet to specify these pressure drop correlations:

- Shell side pressure drop calculation method

  You can select the shell side stream analysis method for pressure drop to be applied: ESDU, VDI Heat Atlas, or B-JAC (default).

- Shell side two phase pressure drop correlation

  You can select the shell side two phase pressure drop correlation to be applied: Lochart-Martinelli (default) or Grant-Chisholm.

- Tube side two phase pressure drop correlation

  You can select the tube side two phase pressure drop correlation to be applied: Lochart-Martinelli, Friedel, Chisholm, McKetta, or Nayyar. If not specified, the program selects the one most appropriate for the application.

You can enter the **velocity heads for pressure drop** to be applied to the flow entering and exiting the tube and to each of the nozzles. The program default is ½ of a velocity head for each entrance and each exit of the tubes and ½ velocity head for each of the nozzles.

Change Codes

Change Codes Sheet

Use the Change Codes sheet to specify those items that can be specified only with a change code. Change codes are processed after all of the other input and override any previously set value.

One of the best uses of the Change Codes sheet is to provide a visual path of the various changes made during program execution.

For this purpose, we recommend that changes for a particular alternative design be placed on a separate line.

The format for change code entries is: CODE=value

For instance, if you specify the tube outside diameter as 20 mm in the regular input screens, then enter the change code TODX=25, the 25 will override the 20. If you enter the same change code more than once, the last value will prevail.

Another good use of the Change Codes sheet is to "chain" to another file containing only change codes. This is especially convenient if you have a line of standard designs, which you want to use after you have found a similar solution in design mode.

To do this, use the FILE= change code, followed by the name of the file containing the other change codes with the file type, for example, ABC-1.BJI. The other file must also have a .BJI filetype. You can create this change code file with a standard edit program.

For example, the entry FILE=S-610-2 would point to a file named S-610-2.BJI, containing the following data:

MODE=2,SODX=610,TLNG=5000,TNUM=458,TPAS=2,BSPA=690,TODX=20,TPAT=1

Design Mode Change Codes

These are the design mode change codes that are available in the Aspen Hetran program.

MODE = program mode: 1 = design, 2 = rating

SDMN = shell diameter, minimum

SDMX = shell diameter, maximum

TLMN = tube length, minimum

TLMX = tube length, maximum

TPMN = tube passes, minimum

TPMX = tube passes, maximum

BSMN = baffle spacing, minimum

BSMX = baffle spacing, maximum

PAMN = shells in parallel, minimum

SEMN = shells in series, minimum

EXMN = excess surface, minimum

POSI = exchanger position: 1 = horizontal, 2 = vertical

Rating Mode Change Codes

These are the rating mode change codes that are available in the Aspen Hetran program.

MODE = program mode: 1 = design, 2 = rating

SODX = shell outside diameter

SIDX = shell inside diameter

BSPA = baffle spacing center-center

BSIN = baffle spacing at inlet

BSOU = baffle spacing at outlet

BNUM = number of baffles

TLNG = tube length

TNUM = number of tubes

TPAS = tube passes

PNUM = number of shells in parallel

SNUM = number of shells in series

KODX = kettle outside diameter

KIDX = kettle inside diameter

VODX = vapor belt outside diameter

VIDX = vapor belt inside diameter

VLNG = vapor belt length

Shell & Head Types Change Codes

These are the shell and head types change codes that are available in the Aspen Hetran program.

FTYP = front head type: 1=A 2=B 3=C 4=N 5=D

STYP = shell type: 1=E 2=F 3=G 4=H 5=J   6=K   7=X   8 =V

RTYP = rear head type: 1=L 2=M 3=N 4=P 5=S 6=T 7=U 8=W

Baffle Change Codes

These are the baffle change codes that are available in the Aspen Hetran program.

BTYP = baffle type:

1 = single   2 = double   3 = triple   4 = full   5 = NTIW   6 = rod   7 = strip

BORI = baffle orientation: 1 = H   2 = V   3 = R

BCUT = baffle cut

Tube Change Codes

These are the tube change codes that are available in the Aspen Hetran program.

TODX = tube outside diameter

TWTK = tube wall thickness

TTYP = tube type: 1 = plain, 2 = finned

FDEN = fin density (fins/in or fins/m)

FHGT = fin height

FTKS = fin thickness

AOAI = ratio of outside area to inside area

Tubesheet Layout Change Codes

These are the tubesheet layout change codes that are available in the Aspen Hetran program.

TPAT = tube pattern:

30 = triangular   60 = rotated triangular   90 = square   45 = rotated square

TPIT = tube pitch

PTYP = pass type: 1 = quadrant   2 = mixed   3 = ribbon

IIMP = impingement plate: 1 = none   2 = on bundle   3 = in nozzle dome

Miscellaneous Change Codes

These are the miscellaneous change codes that are available in the Aspen Hetran program.

TSTK = tubesheet thickness

STRH = Strouhal number used for vibration analysis

FILE = filename for additional file containing change codes

Hetran Results

The Results section is divided into these basic sections:

- Design Summary
- Thermal Summary
- Mechanical Summary
- Calculation Details

Design Summary

The Design Summary Section is subdivided into four sections:

- Input Summary
- Optimization Path
- Recap of Designs
- Warnings & Messages

Input Summary

This section provides you with a summary of the information specified in the input file. It is recommended that you request the input data as part of your printed output so that it is easy to reconstruct the input, which led to the design.

Optimization Path

This part of the output is the window into the logic of the program. It shows some of the heat exchangers the program has evaluated in trying to find one, which satisfies your design conditions. These intermediate designs can also point out the constraints that are controlling the design and point out what parameters you could change to further optimize the design.

To help you see which constraints are controlling the design, the conditions that do not satisfy your specifications are noted with an asterisk (*) next to the value. The asterisk will appear next to the required tube length if the exchanger is undersurfaced, or next to a pressure drop if it exceeds the maximum allowable.

In design mode, the Hetran program will search for a heat exchanger configuration that will satisfy the desired process conditions. It will automatically change a number of the geometric parameters as it searches. However Hetran will not automatically evaluate all possible configurations, and therefore it may not necessarily find the true optimum by itself. It is up to the user to determine what possible changes to the construction could lead to a better design and then present these changes to the program.

Hetran searches to find a design that satisfies the following:

(1) enough surface area to do the desired heat transfer

(2) pressure drops within the allowable

(3) physical size within acceptable limits

(4) velocities within an acceptable range

(5) mechanically sound and practical to construct

In addition to these criteria, Hetran also determines a budget cost estimate for each design and in most cases performs a vibration analysis. However cost and vibration do not affect the program's logic for optimization.

There are over thirty mechanical parameters which directly or indirectly affect the thermal performance of a shell and tube heat exchanger. It is not practical for the program to evaluate all combinations of these parameters. In addition, the acceptable variations are often dependent upon process and cost considerations which are beyond the scope of the program (for example the cost and importance of cleaning). Therefore the program automatically varies only a number of parameters which are reasonably independent of other process, operating, maintenance, or fabrication considerations.

The parameters which are automatically optimized are:

shell diameter	baffle spacing	pass layout type
tube length	number of baffles	exchangers in parallel
number of tubes	tube passes	exchangers in series

The design engineer should optimize the other parameters, based on good engineering judgment. Some of the important parameters to consider are:

shell type	tube outside diameter	impingement protection
rear head type	tube pitch	tube pattern
nozzle sizes	tube type	exchanger orientation
tubesheet type	baffle type	materials
baffle cut	fluid allocation	tube wall thickness

Optimization Path Items

Optimization of Shell Diameter: The highest priority variable in design mode is the shell diameter. The program attempts to find the smallest diameter shell which will satisfy surface area, pressure drop, and velocity requirements. The diameter is incremented based on the shell diameter increment and is limited by the minimum shell diameter, and the maximum shell diameter. Each of these can be specified in the input. This is the shell outside or inside diameter depending upon the input specification to use shell ID or shell OD as the reference.

Optimization of Tube Length: Once the smallest shell diameter has been found, the program optimizes the tube length to the shortest standard length, within the allowable range, which will satisfy surface area, pressure drop, and velocity requirements. The length is incremented or decremented based on the tube length increment and is limited by the minimum tube length and maximum tube length. Each of these can be specified in the input. The **actual tube length** will be shown which is the length of the straight tubes or the straight length to the tangent for U-tubes. This includes the portion of the tube, which is in the tubesheet. This length will be compared to the **required tube length** calculated by the program to achieve the desired heat transfer duty. This length will also include the portion of the tube in the tubesheet, which is ineffective for heat transfer.

Pressure Drop – Shell side and Tube side: These are the calculated pressure drops. For a single phase applications, it is based on the actual tube length. For a two phase application, if the exchanger is oversurfaced it is based on the actual tube length; if it is undersurfaced it is based on the required tube length.

Optimization of Baffle Spacing: The program seeks the minimum reasonable center to center baffle spacing which gives a pressure drop and velocity within the maximums allowed. The program wants to maximize the shell side velocity thereby maximizing the shell side film coefficient and minimizing any velocity dependent fouling.

The minimum baffle spacing is usually equal to 20% of the shell inside diameter or 50 mm (2 in.), whichever is larger. The maximum baffle spacing is usually equal to one half the maximum unsupported span, as suggested by TEMA, for segmental baffles, and one times the maximum unsupported span for grid baffles or no tubes in the window construction. You can override these default values by specifying the minimum and/or maximum baffle spacing in the input.

Optimization of Number of Baffles: The program attempts to find the maximum number of baffles that will fit between the inlet and outlet nozzles. Since the exact locations of the inlet and outlet nozzles are very much dependent upon the mechanical design, the program attempts to locate the nozzles by estimating the thickness of the tubesheet, the thickness of any shell or backing ring flanges, the maximum reinforcement pad diameters, and the necessary clearances. This is the number of baffles and/or support plates. For G, H, and J shells it includes the full support under the nozzle.

Optimization of Tube Passes: The program seeks the maximum reasonable number of tube passes that gives a pressure drop and velocity within the maximums allowed. The program wants to maximize the tube side velocity thereby maximizing the tube side film coefficient and minimizing any velocity dependent fouling. This is the number of tube passes in one shell.

The maximum reasonable number of tube passes is usually a function of the shell diameter and the tube outside diameter, although it can also be a function of the tube side application (e.g., a tube side condenser is usually limited to one pass and should never be more than two passes) or a function of the rear head type (e.g., the W type head is limited to two passes).

The tube passes for tubes with an outside diameter up to 25.4 mm (1.00 in) are limited by shell diameter as follows:

Shell O.D., mm	Shell O.D., in	Maximum tube passes
102-168	**4-6**	**4**
169-610	**7-24**	**8**
611-914	**25-36**	**12**
915-3000	**37-120**	**16**

The maximum number of tube passes are further restricted for tubes with an outside diameter larger than 25.4 mm (1.00 in).

Optimization of Tube Count: The HETRAN program contains the same tube count subroutine which is in the ENSEA tubesheet layout program. Therefore it determines an exact number of tubes and their location for each design. The program will try different tube pass layout types (quadrant, mixed, and ribbon) when appropriate and choose the layout giving the highest number of tubes. This is the number of straight tubes or the number of straight lengths for a U-tube exchanger (twice the number of U-s). This is also the number of tube holes in one tubesheet.

Optimization of Exchangers in Parallel: The program will automatically increase the number of exchangers in parallel when it reaches the maximum allowable shell diameter and minimum allowable tube length and still is unable to satisfy the allowable pressure drop. This is the number of exchangers in parallel. Note that both the shell side streams and tube side streams are considered to be flowing in parallel.

Optimization of Exchangers in Series: The program will automatically increase the number of exchangers in series when it reaches the maximum allowable shell diameter and tube length and still is unable to find a design with enough heat transfer area. It will also go to exchangers in series when the correction factor on the MTD falls below 0.7 (or the minimum allowable correction factor specified in the input). This is the number of shells in series. Note that both the shell side stream and the tube side stream are considered to be flowing in series.

Total Price: This is the estimated budget price for the total number of heat exchangers in series and parallel. It is the price determined using the QCHEX program subroutines

Recap of Designs

The recap of design cases summarizes the basic geometry and performance of all designs reviewed up to that point. The side by side comparison allows you to determine the effects of various design changes and to select the best exchanger for the application. As a default, the recap provides you with the same summary information that is shown in the Optimization Path. You can customize what information is shown in the Recap by selecting the Customize button. You can recall an earlier design case by selecting the design case you want from the Recap list and then select the Select Case button. The program will then regenerate the design results for the selected case.

Warnings & Messages

Aspen B-JAC provides an extensive system of warnings and messages to help the designer of heat exchanger design. Messages are divided into five types. There are several hundred messages built into the program. Those messages requiring further explanation are described here.

Warning Messages: These are conditions, which may be problems, however the program will continue.

Error Messages: Conditions which do not allow the program to continue.

Limit Messages: Conditions which go beyond the scope of the program.

Notes: Special conditions which you should be aware of.

Suggestions: Recommendations on how to improve the design.

Thermal Summary

The Thermal Summary Section is subdivided into four sections:

- Performance
- Coefficients & MTD
- Pressure Drop
- TEMA Sheet

Performance

Performance

This section provides a concise summary of the thermal process requirements, basic heat transfer values, and heat exchanger configuration on the following sheets:

- General
- Thermal Resistance Analysis

General Performance

In the general performance section, flow rates, **Gases (in/out) and Liquids (in/out)**, for the shell and tube sides are shown to summarize any phase change that occurred in the exchanger.

The **Temperature (in/out)** for both side of the exchanger are given along with **Dew point and bubble poin**t temperatures for phase change applications.

Film coefficients for the shell and tube sides are the weighted coefficients for any gas cooling/heating and phase change that occurred in the heat exchanger.

Velocities for single phase applications are based on an average density. For condensers, the velocity is based on the inlet conditions. For vaporizers, it is based on the outlet conditions. Shell side velocities are the crossflow velocity at the diametric cross-section.

Overall performance parameters are given, such as **Heat exchanged**, **MTD** with any applied **correction factor** and the **effective total surface area**. For single phase applications on both sides of the shell, a MTD correction factor will be applied in accordance with TEMA standards. For multi-component phase change applications, the MTD is weighted based upon a heat release curve. The effective surface area does not include the U-bend area for U-tubes unless it was specified to do so.

The **exchanger geometry** provided in the summary includes: TEMA type, exchanger position, number of shells in parallel and in series, exchanger size, number of tubes and tube outside diameter, baffle type, baffle cut, baffle orientation, and number of tube passes.

Thermal Resistance Analysis

This portion gives information to help you evaluate the surface area requirements in the clean, specified fouled (as given in the input), and the maximum fouled conditions.

The **clean condition** assumes that there is no fouling in the exchanger, in the new condition. The overall coefficient shown for this case has no fouling resistance included. Using this clean overall coefficient, the excess surface area is then calculated.

The **specified foul condition** summarizes the performance of the exchanger with the overall coefficient based upon the specified fouling.

The **maximum fouled condition** is derived by taking the specified fouling factors and increasing them (if the exchanger is oversurfaced) or decreasing them (if undersurfaced), proportionately to each other, until there is no over or under surface.

The **distribution of overall resistance** allows you to quickly evaluate the controlling resistance(s). You should look in the "Clean" column to determine which film coefficient is controlling, then look in the "Spec. Foul" column to see the effect of the fouling resistances. The difference between the excess surface in the clean condition and the specified fouled condition is the amount of surface added for fouling.

You should evaluate the applicability of the specified fouling resistances when they dictate a large part of the area, say more than 50%. Such fouling resistances often increase the diameter of the heat exchanger and decrease the velocities to the point where the level of fouling is self-fulfilling.

Coefficients & MTD

This output section shows the various components of each **film coefficient.** Depending on the application, one or more of the following coefficients are shown:

- desuperheating
- condensing
- vapor sensible
- liquid sensible
- boiling
- liquid cooling

The **Reynolds number** is included so that you can readily evaluate if the flow is laminar (under 2000), transition (2000-10000), or turbulent (over 10000).

The **fin efficiency factor** is used in correcting the tube side film thermal resistance and the tube side fouling factor resistance.

The **mean metal temperature** of the shell is the average of the inlet and outlet temperatures on the shell side. The mean metal temperature of the tube wall is a function of the film coefficients on both sides as well as the temperatures on both sides. These two temperatures are intended for use in the mechanical design in order to determine the expansion joint requirements in a fixed tubesheet heat exchanger.

The calculated corrected MTD (**Mean Temperature Difference**) for no phase change applications is the product of the LMTD (Log Mean Temperature Difference), the correction factor (F), and the longitudinal baffle efficiency factor (if using an F, G, or H shell). For phase change applications, the process is divided into a number of intervals and a MTD is determined for each interval. The overall MTD for the exchanger is then determined by weighting the interval MTDs based on heat load. If you have specified a value for the Corrected Mean Temperature Difference in the input, it is this value which the program uses in the design instead of the calculated Corrected MTD.

The **flow direction** is displayed when there is a single tube pass, in which case it is either counter-current or co-current.

The **heat flux** is the heat transferred per unit of surface area. This is of importance for boiling applications where a high flux can lead to vapor blanketing. In this condition, the rapid boiling at the tube wall covers the tube surface with a film of vapor, which causes the film coefficient to collapse. The program calculates a maximum flux for nucleate boiling on a single tube and a maximum flux for bundle boiling (nucleate and flow boiling), which can be controlled by other limits (e.g., dryout). If you specify a maximum flux in the input, this overrides the program calculated maximum flux. To analyze this data, you should check to see if the maximum flux is controlling. If it is, consider reducing the temperature of the heating medium.

Pressure Drop

The Pressure Drop section reports the following output:

- Pressure drop distribution
- User-specified bundle multiplier
- Velocity distribution
- Shell side stream analysis

- Thermal details and shell side flow
- Rho*V2 analysis
- Thermosiphon reboilers
- Used and specified values used in calculations

Pressure drop distribution

The pressure drop distribution is one of the most important parts of the output for analysis. You should observe if significant portions or the pressure drop are expended where there is little or no heat transfer (inlet nozzle, entering bundle, through baffle windows, exiting bundle, outlet nozzle).

If too much pressure drop occurs in a nozzle, consider increasing the nozzle size. If too much is consumed entering or exiting the bundle, consider using a distributor belt. If too much pressure drop is taken through the baffle windows, consider a larger baffle cut.

On the shell side, the program determines the **dirty pressure dro**p by assuming that the fouling will close the clearance between the shell I.D. and the baffle OD and the clearance between the baffle and the tube OD. The bypassing around the outside of the bundle (between the shell I.D. and the outer tube limit) is still present in the dirty pressure drop.

The program determines the dirty pressure drop in the tubes by estimating a thickness for the fouling, based on the specified tube side fouling resistance, which decreases the cross-sectional area for flow.

User specified bundle multiplier

The user specified bundle multiplier, which you can specify in the input, is included in the bundle portion of the calculated pressure drop, clean and dirty.

Velocity distribution

The velocity distribution, between the inlet and outlet nozzle, is shown for reference. In other parts of the output, the velocity, which is shown for the shell side, is the diametric crossflow velocity. For the tube side it is the velocity through the tubes. For two phase applications, the velocities for crossflow, through baffle windows, and through tubes are the highest velocities based on the maximum vapor flow.

Shell Side Stream Analysis

The shell side stream analysis displays the characteristics and potential problems of the shell side flow. The program determines the shell side film coefficient and pressure drop by using the stream analysis method. This method is based on the concepts originally developed by Townsend Tinker at the University of Delaware in the early 1950's. B-JAC has further developed and fine-tuned this method which attempts to predict how much of the fluid will flow through each of the possible flow paths.

The stream analysis method considers many variables, including shell diameter, baffle spacing, baffle cut, baffle type, tube diameter, tube hole diameter, baffle diameter, tube rows, and outer tube limits.

The flow fractions are shown for the various streams and the clearances, which the program has used. The clearances are either those based on the TEMA standards or specified in the input.

The crossflow stream is the portion of the flow, which crosses the bundle and flows through the baffle window. This is sometimes referred to as the "B" stream. Since crossflow gives the highest film coefficient, we usually want to maximize the percentage of flow in crossflow, unless the design is solely controlled by shell side pressure drop. In turbulent flow, you should expect a crossflow percentage of 40 to 70%. In laminar flow, the crossflow often drops to 25 to 40%.

Thermal Details - Shell Side Flow

The tube-baffle hole clearance is the annular opening between the tube OD and the baffle. This is the location of the primary leakage stream and is sometimes referred to as the "A" stream. Leakage through this opening can significantly decrease the pressure drop and will also reduce the film coefficient.

The opening between the shell I.D. and the baffle OD is shown as the shell-baffle clearance. This is a secondary leakage stream and is sometimes called the "E" stream.

The last stream shown is through the opening between the shell I.D. and the outermost tubes as defined by the outer tube limits (OTL). This is called a bypass stream, because it largely bypasses the heat transfer surface. This is also known as the "C" stream. When this shell-bundle OTL clearance is large as in the case of an inside floating head exchanger (TEMA rear head types S & T) the program automatically adds sealing strips to force the flow back into the bundle.

Rho*V2 Analysis

The rho*V2 Analysis is shown on the lower half of this output and is based on the analysis suggested by TEMA at the five locations listed. Rho*V2 is the product of the density and the velocity squared. Experience has shown that these limits set by TEMA are good guidelines for avoiding excessive erosion, vibration, and stress fatigue of the tubes at the inlet and outlet.

The program does not automatically change the design when the TEMA limits are exceeded, but instead gives you a warning message and suggests that you change the shell inlet or outlet construction in order to lower inlet or outlet velocities.

If the rho*V2 is too high through the shell inlet nozzle, consider a larger nozzle, reducer piece, or dome.

The shell entrance and exit velocities are based on the flow area between the tubes under the nozzle and the radial flow area into the shell between the tube bundle and the shell I.D. If the rho*V2 is excessive at shell entrance or exit, consider increasing the appropriate nozzle diameter, removing tubes under the nozzle, or using a nozzle dome.

The bundle entrance and exit velocities are based on the flow area between the tubes in the first row(s) in the inlet and outlet compartments between the tubesheet and the first baffle, excluding area blocked by any impingement plate. When the rho*V2 entering or exiting the bundle are too high, consider increasing the inlet or outlet baffle spacing or removing tubes under the nozzle

Thermosiphon Reboilers

This output only appears for thermosiphon applications.

This section shows the **equivalent length of piping** from the column to the heat exchanger inlet and the piping from the outlet back to the column. Equivalent length is a method of specifying a length of piping which accounts for the pressure drop of pipe as a ratio of length to diameter and the effect of valves, bends, tees, expansions, contractions, etc. Refer to a piping handbook for more details.

The **liquid level above the top tubesheet**, shows the relationship between the liquid level in the column and the top face of the top tubesheet. A positive value indicates the level is above the tubesheet; a negative value indicates the level is below the tubesheet.

Height of return connection above top tubesheet provides the elevation difference of the return connection to the column. It is from the top face of the top tubesheet to the centerline of the opening into the column.

Used and Specified Values

These columns indicate the values actually used in the calculations and values specified in input.

The **bubble point** in the column, which was specified in the input, is given. The bubble point in the exchanger is calculated based on the effect of the liquid head, which will elevate the bubble point.

The **sensible zone** is the tube length required to heat the liquid back up to its boiling point due to the elevation of the boiling point caused by the pressure of the fluid head. If this is a significant part of the tube length, say more than 20%, you should consider putting a valve or orifice in the inlet line to take a pressure drop, which will reduce the flow rate and area, required.

The **vaporization zone** is the tube length required for the specified or calculated amount of vaporization.

TEMA Sheet

The Aspen Hetran program generates the complete TEMA data sheet.

Mechanical Summary

The Mechanical Summary Section is subdivided into three headings:

- Exchanger Dimensions
- Vibration & Resonance Analysis
- Setting Plan & Tubesheet Layout

Exchanger Dimensions

The shell, front head, and nozzle, tube, and bundle dimensions are briefly described in this output. The following table summarizes the results:

Item	Description
cylinder diameters	The **shell and front head cylinder outside and inside diameters** are provided. The thicknesses used to derive the cylinder inside or outside diameter are based on a basic mechanical design. However, due to assumptions made by the program or unknown data (e.g., exact material specifications) this may not match the thicknesses calculated in the detailed mechanical design. For **kettle type** exchangers, the shell cylinder diameter refers to the smaller cylinder at the tubesheet, and the kettle outside diameter is the larger cylinder containing the disengagement space.
vapor belt length	The vapor belt length is the total length of the vapor belt including the transition pieces that are attached to the shell.
nozzles	The program automatically determines the diameter of a nozzle, if you do not specify it in the input. The default nozzle diameter is determined by the calculated maximum velocity, which is a function of the density of the fluid and the allowable pressure drop.
tube length, number of tubes	These are for straight tubes. In the case of U-tubes they are the straight length and the number of tube holes in the tubesheet.
area ratio Ao/Ai	This is the ratio of the outside tube surface to the inside tube surface for finned tubes.
Pass partition lane	This is the opening across a pass partition from tube edge to tube edge.
deviation in tubes/pass	This is the largest deviation from the median number of tubes per pass.
baffle cut	This is the window expressed as a percent of the shell inside diameter. For double segmental baffles, it is printed with the percent of the innermost window / percent of one of the outer windows (e.g., 28/23). For triple segmental baffles, it is printed with the percent of the innermost window / percent of one intermediate window / percent of one outermost window (e.g., 15/17/15).
open distance at top	This is the distance from the top of the inside of the shell to the top edge of the topmost tube row. Similarly, the Open Distance at Bottom is the distance from the bottom of the inside of the shell to bottom edge of the bottom-most tube row.
clearances	These are diametric clearances.

Nozzle Sizing

The program automatically determines the diameter of a nozzle, if you do not specify it in the input. The default nozzle diameter is determined by the calculated maximum velocity which is a function of the density of the fluid and the allowable pressure drop. The maximum velocity is calculated as follows:

max. velocity = k / (density)0.5

where:

velocity is in m/s or ft/s

k is a constant as shown below

density is in kg/mÛ or lb/ftÛ

For all nozzles, except condensate drains, when the allowable pressure drop is greater than or equal to 0.12 bar (1.7 psi):

for SI units:k = 47.2

for US units:k = 38.7

For all nozzles, except condensate drains and X-shell nozzles, when the allowable pressure drop is less than 0.12 bar (1.7 psi):

for SI units:k = 296 * (allowable pressure drop in bar) + 12.2

for US units:k = 16.70 * (allowable pressure drop in psi) + 10.0

For condensate drains:

for SI units:k = 30.49

for US units:k = 25.0

Nozzle sizes selected or specified in the input will then be checked for compliance with TEMA recommend mass velocity limits. If exceeded a warning will be issued. The program will increase the diameter of the nozzles larger than TEMA minimums to avoid excessive pressure drop in the nozzles, if greater than 15% of the allowable pressure drop.

Vibration & Resonance Analysis

Vibration Analysis

Flow-induced tube vibration on the shell side of a heat exchanger can cause serious damage to a tube bundle, sometimes very quickly. It is very important to try to avoid potential vibration damage by making changes at the design stage to limit the probability of vibration occurring. Although vibration analysis is not yet an exact science, TEMA has included two methods, which are fully implemented in the Aspen Hetran program.

The calculations are done at three or four points:

Inlet	This is the longest tube span at the inlet. For segmental baffles (except NTIW) this is from the inside face of the tubesheet to the second baffle. For grid baffles and NTIW this is from the inside face of the tubesheet to the first baffle.
Bundle	This is the longest tube span excluding the inlet and outlet zones. For segmental baffles (except NTIW) this is two times the baffle spacing. For grid baffles and NTIW this is the baffle spacing.

Outlet	This is the longest tube span excluding the inlet and outlet zones. For segmental baffles (except NTIW) this is two times the baffle spacing. For grid baffles and NTIW this is the baffle spacing.
Other areas	This is for other tube spans resulting from using intermediate supports with the NTIW construction.

Crossflow and Critical Velocities

The most dependable predictor of vibration is the check on critical velocity. It is based on the comparison of the crossflow velocity to the critical velocity for fluid elastic whirling, which was developed by Connors. Basically it indicates the point at which the kinetic energy can not be dampened through the structure of the heat exchanger and the tube will move.

The crossflow velocity is based on the average velocity of the fluid across a representative tube row in that region using the stream analysis method. The crossflow velocity for two phase mixtures is based on a homogeneous fluid density.

Acoustic and Natural Frequencies

When the shell side fluid is a gas, TEMA also recommends checking the relationship between the natural frequency of the tubes and the acoustic frequency of the gas. If these two frequencies are close, the tubes may vibrate in resonance. The program indicates vibration when the acoustic frequency matches the natural frequency within + or - 20%.

Design Strategies to Avoid Vibration

The best design strategies to avoid tube vibration are primarily design changes, which reduce the shell side velocity, such as: using a multi-segmental baffle (double or triple) or a grid baffle (rod or strip); using a J-shell or X-shell; increasing the tube pitch. Also, you may want to consider using a no tubes in the window (NTIW) baffle arrangement.

Acoustic Resonance Analysis

The acoustic resonance analysis is also based on the latest edition of TEMA and is done at the same points described previously for vibration analysis.

Acoustic resonance is a problem of sound, but not usually tube vibration. Therefore its avoidance may not be as critical as tube vibration, but still should be avoided if practically possible.

When a low density gas is flowing on the shell side of the heat exchanger at a relatively high velocity, there is the possibility that it will oscillate as a column somewhat like an organ pipe. This results in a noise, which can be very loud. Noise levels of more than 140 decibels have been reported, which would be very painful to the human ear.

Problems Resulting from Acoustic Resonance

If acoustic resonance occurs and its frequency approaches the tube natural frequency, vibration may also occur. Even if tube vibration does not occur, it is wise to avoid acoustic resonance for many reasons. First, the noise levels may not be allowable under company standards or government regulations (e.g., OSHA in the U.S.) or acceptable to insurance companies. Second, the noise may produce significant stresses in the shell and attached piping. Third, it may result in an increase in the shell side pressure drop, which is not considered in the Aspen Hetran program.

Determination

The primary mechanisms, which cause acoustic resonance, are vortex shedding and turbulent buffeting. If either the vortex shedding frequency or the turbulent buffeting frequency match the acoustic frequency within + or - 20%, then the program will predict acoustic resonance.

TEMA also describes two other conditions, which indicate acoustic resonance--a condition B and a condition C velocity which are compared to the crossflow velocity. Acoustic resonance is indicated when the crossflow velocity exceeds either the condition B velocity or the condition C velocity and the limit C is exceeded. These indicators seem to be less reliable than the frequency matching, and the program may not show the results in some cases.

Design Strategies to Avoid Acoustic Resonance

The best design strategies to avoid acoustic resonance are the same for avoiding tube vibration, such as: using a multi-segmental baffle (double or triple) or a grid baffle (rod or strip); using a J-shell or X-shell; increasing the tube pitch.

If such design changes are not practical, then deresonating baffles can be installed. These are designed to break the column of gas in order to minimize oscillation. These baffles are plates, which are positioned between the conventional segmental baffles, perpendicular to the segmental baffle and perpendicular to the baffle cut.

Setting Plan & Tubesheet Layout

Setting Plan drawing

The scaled outline drawing provides an accurate depiction of the exchangers under review. It shows the types of heads, types of flanges, nozzle positions and functions, and the actual position of the baffles with respect to the inlet and outlet shell side nozzles. This allows you to determine any potential conflicts between nozzles and baffles. The drawing can be zoomed in by dragging a frame around a drawing section and selecting "Zoom In" from the "View" command in menu bar.

Tubesheet Layout

The tubesheet layout drawing provides an accurate depiction of the tube arrangement selected by the program for the exchanger under review. It shows the shell side nozzles, tubes, tie rods, impingement plate, baffle cuts, pass lanes, tube pattern, tube pitch, and tubes per row. This drawing is particularly useful in understanding and resolving high velocity problems at the shell and/or bundle entrance and exit. You can zoom in by dragging a frame around a drawing section and selecting "Zoom In" from the "View" command in the menu bar.

Once you have a specified an exchanger geometry and executed the Hetran in the Rating Mode, you can interactively make modifications to the tube layout. Reference the Tube Layout description in the Rating/Simulation Data program input section.

Calculation Details

The Calculation Details Section is subdivided into six sections:

- Interval Analysis – Shell Side
- Interval Analysis – Tube Side
- VLE - Hot Side
- VLE - Cold Side
- Maximum Rating
- List of vapor and liquid Property Temperature Limits

Interval Analysis - Shell Side & Tube Side

The Interval analysis section provides you with table of values for liquid properties, vapor properties, performance, heat transfer coefficients and heat load over the shell & tube side temperature ranges.

Heat Transfer Coefficient - Single Phase

Flow regimes are mapped in this section with the corresponding overall calculated film coefficients. The overall film coefficients are base upon the following:

The **liquid coefficient** is the calculated heat transfer coefficient assuming the total flow is all liquid.

The **gas coefficient** is the calculated heat transfer coefficient assuming the total flow is all vapor.

Heat Transfer Coefficient - Condensation

Flow regimes are mapped in this section with the corresponding overall calculated film coefficients. The overall film coefficients are base upon the following:

"Desuperheating Dry Wall" is for the part of the desuperheating load, which is removed, where no condensing is occurring. This only happens when the tube wall temperature is above the dew point temperature. In such a case, the film coefficient is based on a dry gas rate and the temperature difference is based on the inlet temperature.

"Desuperheating Wet Wall" which shows the part of the desuperheating load which is removed coincident with condensation occurring at the tube wall. This case is more common. The film coefficient and temperature difference are the same as the first condensing zone.

Liquid Cooling coefficient is for the cooling of any liquid entering and the condensate after it has formed and flows further through the heat exchanger. The program assumes that all liquid will be cooled down to the same outlet temperature as the vapor.

The **dry gas coefficient** is the heat transfer coefficient when only gas is flowing with no condensation occurring. It is used as the lower limit for the condensing coefficient for pure component condensation and in the mass transfer and proration model for complex condensation applications.

The **pure condensing coefficients** (shear and gravity) are the calculated condensing coefficients for the stream for that regime. The resulting pure condensing coefficient is a pure shear coefficient, pure gravity coefficient or a proration between the two, depending on the condensing regime.

The **condensing film coefficient** is the heat transfer coefficient resulting from the combined effects of the pure condensing coefficient and the dry gas coefficient.

Heat Transfer Coefficient - Vaporization

The **two phase factor** is the correction factor applied to the liquid coefficient to calculate the two phase heat transfer coefficient.

The **two phase coefficient** is the heat transfer coefficient calculated based on the combined liquid and vapor flow.

The **nucleate coefficient** is the heat transfer coefficient due to the nucleation of bubbles on the surface of the heat transfer surface.

The **vaporization film coefficient** is the heat transfer coefficient for the specified side resulting from the vectorial addition of the two-phase and nucleate boiling coefficient. Observe the change in the film coefficient to see if it decreases severely at the end of the vaporizing range. This usually indicates that the tube wall is drying out and the film coefficient is approaching a dry gas rate. If a significant percentage of the area required is at this low coefficient, consider a higher circulation rate (less vaporized each time through) if it is a reboiler.

VLE - Hot Side, Cold Side

If the Aspen Hetran program generates the heat release curve, the following VLE information is provided.

vapor liquid equilibrium	The condensation curve is provided as a function of equal heat load increments or temperature increments. Cumulative heat load and vapor/liquid flow rates as a function of temperature are shown.
condensation details	Component flow rates as function of temperature increments are provided.
vapor properties	Vapor properties are provided as a function of temperature increments.
liquid properties	Liquid properties are provided as a function of temperature increments.

Maximum Rating

In design mode, the program searches for a heat exchanger to satisfy the performance requirements you have specified in the input. In rating mode, the program checks the specified heat exchanger against these process requirements. In both cases it is often important to know what the actual outlet temperatures and heat exchanged will be when the exchanger is clean and when it reaches the specified fouling. Since the heat exchanger is usually oversurfaced or undersurfaced, the actual outlet temperatures will differ from those in the input.

The Maximum Performance Rating output predicts these actual outlet temperatures and heat exchanged. To do this, the program uses the overall coefficient and effective surface area calculated in design or rating mode. It then varies the outlet temperatures, which will determine the heat duty and the mean temperature difference until the basic heat transfer equation is in exact balance:

$$\frac{Q}{CMTD} = U * A$$

Where there are multiple exchangers in series, the program will show each exchanger separately.

Hetran Design Methods

Optimization

Optimization Logic

In design mode, the Aspen Hetran program searches for a heat exchanger configuration that satisfies the desired process conditions. It automatically changes a number of the geometric parameters as it searches. However, the program will not automatically evaluate all possible configurations and may not find the true optimum. It is up to the user to determine what possible changes to the construction could lead to a better design, and then present these changes to the program.

Aspen Hetran searches to find a design, which satisfies the following criteria:

- Enough surface area to do the desired heat transfer
- Pressure drops within the allowable limits
- Physical size within acceptable limits
- Velocities within an acceptable range
- Mechanically sound and practical to construct

In addition to these criteria, Aspen Hetran also determines a budget cost estimate for each design, and in most cases performs a vibration analysis. However, cost and vibration have no affect on program logic for optimization.

There are over thirty mechanical parameters which directly or indirectly affect the thermal performance of a shell and tube heat exchanger. It is not practical for the program to evaluate all combinations of these parameters. In addition, the acceptable variations are often dependent on process and cost considerations (for example the cost and importance of cleaning), which are beyond the scope of the program). Therefore the program automatically varies only a number of parameters which are reasonably independent of other process, operating, maintenance, or fabrication considerations.

The parameters which are automatically optimized are:

- Shell diameter

- Tube length
- Baffle spacing
- Number of baffles
- Tube passes
- Number of tubes
- Exchangers in series
- Exchangers in parallel
- Pass layout type

The design engineer should optimize the other parameters, based on good engineering judgment. Some of the important parameters to consider are:

- Shell type
- Tube outside diameter
- Impingement protection
- Rear head type
- Tube pitch
- Nozzle sizes
- Tube pattern
- Tubesheet type
- Baffle type
- Tube type
- Materials
- Exchanger orientation
- Baffle cut
- Tube wall thickness
- Fluid allocation

Optimization of Shell Diameter

The highest priority variable in design mode is the shell diameter. The program attempts to find the smallest diameter shell that will satisfy surface area, pressure drop, and velocity requirements. The diameter is incremented based on the shell diameter increment and is limited by the minimum shell diameter, and the maximum shell diameter. Each of these can be specified in the input.

Optimization of Tube Length

Once the smallest shell diameter has been found, the program optimizes the tube length to the shortest standard length, within the allowable range, which will satisfy surface area, pressure drop, and velocity requirements. The length is incremented or decremented based on the tube length increment and is limited by the minimum tube length and maximum tube length. Each of these can be specified in the input.

Optimization of Baffle Spacing

The program seeks the minimum reasonable baffle spacing, which gives a pressure drop and velocity within the maximums allowed. The program wants to maximize the shell side velocity thereby maximizing the shell side film coefficient and minimizing any velocity dependent fouling.

The minimum baffle spacing is usually equal to 20% of the shell inside diameter or 50 mm (2 in.), whichever is larger. The maximum baffle spacing is usually equal to one half the maximum unsupported span, as suggested by TEMA, for segmental baffles, and one times the maximum unsupported span for grid baffles or no tubes in the window construction. You can override these default values by specifying the minimum and/or maximum baffle spacing in the input.

Optimization of Number of Baffles

The program attempts to find the maximum number of baffles, which will fit between the inlet and outlet nozzles. Since the exact locations of the inlet and outlet nozzles are very much dependent upon the mechanical design, the program attempts to locate the nozzles by estimating the thickness of the tubesheet, the thickness of any shell or backing ring flanges, the maximum reinforcement pad diameters, and the necessary clearances.

Optimization of Tube Passes

The program seeks the maximum reasonable number of tube passes that gives a pressure drop and velocity within the maximums allowed. The program wants to maximize the tube side velocity thereby maximizing the tube side film coefficient and minimizing any velocity dependent fouling.

The maximum reasonable number of tube passes is usually a function of the shell diameter and the tube outside diameter. It can also be a function of the tube side application (e.g., a tube side condenser is usually limited to one pass and should never be more than two passes) or a function of the rear head type (e.g., the W type head is limited to two passes).

The tube passes for tubes with an outside diameter up to 25.4 mm (1.00 in) are limited by shell diameter as follows:

Shell OD	**Maximum**	
mm-in	**Tube Passes**	
102-168	4-6	4
169-610	7-24	8
611-914	25-36	12
915-3000	37-120	16

The maximum number of tube passes is further restricted for tubes with an outside diameter larger than 25.4 mm (1.00 in).

Optimization of Tube Count

The Aspen Hetran program contains the same tube count subroutine, which is in the ENSEA tubesheet layout program. Therefore it determines an exact number of tubes and their location for each design. The program will try different tube pass layout types (quadrant, mixed, and ribbon) when appropriate and choose the layout giving the highest number of tubes.

Optimization of Exchangers in Series

The program will automatically increase the number of exchangers in series when it reaches the maximum allowable shell diameter and tube length and still is unable to find a design with enough heat transfer area. It will also go to exchangers in series when the correction factor on the MTD falls below 0.7 (or the minimum allowable correction factor specified in the input).

Optimization of Exchangers in Parallel

The program will automatically increase the number of exchangers in parallel when it reaches the maximum allowable shell diameter and minimum allowable tube length and still is unable to satisfy the allowable pressure drop.

Nozzle Sizing

The program will automatically determine the diameter of a nozzle, if you do not specify it in the input. The default nozzle diameter is determined by the calculated maximum velocity, which is a function of the density of the fluid and the allowable pressure drop. The maximum velocity is calculated as follows:

max. velocity = k / (density)0.5

where:

velocity is in m/s or ft/s

k is a constant as shown below

density is in kg/m3 or lb/ft3

For all nozzles, except condensate drains, when the allowable pressure drop is greater than or equal to 0.12 bar (1.7 psi):

for SI units: k = 47.2

for US units k = 38.7

For all nozzles, except condensate drains and X-shell nozzles, when the allowable pressure drop is less than 0.12 bar (1.7 psi):

for SI units: k = 296 * (allowable pressure drop in bar)+12.2

for US units: k = 16.70 * (allowable pressure drop in psi)+10.0

For condensate drains:

for SI units: k = 30.49

for US units: k = 25.0

Minimum Velocities

Although the program requests minimum velocities as an input option, these values do not directly affect the logic of the program. The program does compare the calculated velocity with the specified or defaulted minimum velocity and it then issues a warning if the calculated is less than the minimum velocity.

The minimum velocity is not used to change the logic, because in design mode, the program is already trying to maximize the velocity within the allowable pressure drop and the maximum allowable velocity.

Maximum Velocities

It is important to establish maximum allowable velocities for both the shell and tube sides. On the shell side, a well-chosen maximum velocity will avoid vibration, excessive erosion, and stress fatigue of the tubes. For the tube side, avoiding excessive velocities will limit erosion of the tube and wear of the tube to tubesheet joint.

On the shell side, the maximum velocity is for the crossflow stream. Where there is a change of phase, the maximum velocity applies to the vapor velocity.

If you do not specify the maximum velocity in the input, the program will calculate one. This default value is independent of tube material. Some materials can withstand higher velocities than the maximum velocity chosen by the program.

The default value calculated by the program for maximum allowable velocity is equal to the appropriate constant shown below divided by the square root of the density (kg/m3 in SI units or lb/ft3 in US units).

Vmax = k / (Density)0.5

	k in SI units	**k in US units**
Shell Side Fluid	60.9	50.0
Tube Side Fluid	93.8	77.0

No Phase Change

Film Coefficient

The shell side film coefficient is based on a Sieder-Tate correlation using the velocity which is determined using a modified Tinker stream analysis method.

The tube side film coefficient is based on a Dittus-Boelter correlation.

MTD

The program uses a corrected log mean temperature difference for all geometries.

Pressure Drop

The pressure drop is determined by using a Fanning-type equation. On the shell side a modified Tinker stream analysis method is used. Velocity heads are used to determine pressure losses through the nozzles and various types of baffle windows. The program uses end zone corrections for the pressure drop in the inlet spacing and outlet spacing on the shell side. It also considers the number of tube rows crossed and the shell and bundle inlet and outlet losses based on the actual tube layout.

Simple Condensation

The program divides the condensing range into ten equal zones based on temperature from the dew point to the bubble point or outlet temperature. For each zone it calculates the following:

- **Film coefficient**, consisting of a condensing coefficient, gas cooling coefficient, liquid cooling coefficient, and two phase coefficient.
- MTD

  The program assumes that the MTD is linear over the condensing range. Subcooling is also assumed to be linear. The MTD calculation is based on the local temperature difference of the interval. For multipass exchangers, the local temperature difference of the multipass stream is weighted based on the stream temperatures at each pass.
- Two phase **pressure drop**, based on the vapor liquid equilibrium and physical properties for each zone. The program uses a two phase Martinelli equation to calculate pressure drop.

You may also select the number of zones to be used in the analysis, as well as the division of the zones by equal temperature or heat load increments.

Desuperheating- Film Coefficient

The program determines at what temperature point the tube wall will be wet by using a dry gas coefficient on the hot side and the coolant coefficient on the cold side. If the program determines that any part of the desuperheating range will result in a dry wall, it will calculate a separate desuperheating zone using a dry gas coefficient. Once the tube is wet, any remaining superheat is removed coincident with the condensation in the first condensing zone and the first zone film coefficient is used.

Condensing - Film Coefficient - Horizontal Inside Tube

The program determines the dominant flow regime in each of the zones. The flow regimes are divided into annular, annular with stratification, wavy/stratified, intermediate wavy, high wavy/slug/plug, and bubble. For each flow regime there is a separate equation, which reflects the contribution of shear, controlled or gravity controlled flow.

The shear controlled equations are derived from a single phase Dittus-Boelter equation with a two phase multiplier as a function of the Martinelli parameter. The gravity controlled equations are modified Nusselt and Dukler equations.

Condensing - Film Coefficient - Horizontal Outside Tube, Vertical Inside or Outside Tube

The program determines if the flow is shear controlled or gravity controlled in each of the zones. If it is in transition, then the result is prorated. The shear controlled equations are derived from a single phase Dittus-Boelter equation with a two phase multiplier as a function of the Martinelli parameter. The gravity controlled equations are modified Nusselt and Dukler equations.

Liquid Cooling and Subcooling - Film Coefficient

The cooling of the condensate (and any liquid entering) down to the outlet temperature and any subcooling below the bubble point are calculated using the greater of a forced convection or free convection equation for the full temperature range.

In the case of a knockback reflux condenser the program does not consider any liquid cooling or subcooling.

Complex Condensation

The program divides the condensing range into a number of equal zones based on temperature or heat load from the dew point to the bubble point or outlet temperature. For each zone it calculates the following:

- Film coefficient, consisting up of a condensing coefficient, gas cooling coefficient, liquid cooling coefficient, and two phase coefficient
- MTD
- Two phase pressure drop, based on the vapor liquid equilibrium and physical properties for each zone.

The user may also select the number of zones to be used in the analysis as well as the division of the zones by temperature or heat load.

Desuperheating- Film Coefficient

The program determines at what temperature point the tube wall will be wet by using a dry gas coefficient on the hot side and the coolant coefficient on the cold side. If the program determines that any part of the desuperheating range will result in a dry wall, it will calculate a separate desuperheating zone using a dry gas coefficient. Once the tube is wet, any remaining superheat is removed coincident with the condensation in the first condensing zone and the first zone film coefficient is used.

Condensing - Film Coefficient

A separate condensing coefficient is determined for each zone, based on the flow regime and whether it is shear or gravity controlled.

Gas Cooling - Film Coefficient

The cooling of the vapor once condensation has begun (after any desuperheating) and the cooling of any noncondensables is based on a single phase coefficient for each zone. On the shell side it is a modified Sieder-Tate equation. On the tube side it is a modified Dittus-Boelter equation.

Liquid Cooling and Subcooling - Film Coefficient

The cooling of the condensate and any liquid entering down to the outlet temperature and any subcooling below the bubble point is calculated using a two phase coefficient based on the Martinelli equation. It is calculated for each of the ten zones, based on the liquid carried over from previous zones.

Overall Heat Transfer Coefficient

The overall heat transfer coefficient calculated for each zone is dependent on the condensing correlation chosen. The program defaults to the mass transfer method, which is a film model based on a Colburn-Hougen correlation for condensable(s) with noncondensable(s) and a Colburn-Drew correlation for multiple condensables. Our experience and research indicate that if the composition of the vapor is well known, the mass transfer method is the most accurate method.

The program also allows you to choose the Silver-Bell proration method, which is an equilibrium model.

MTD

Superheating

The program determines at what temperature point the tube wall will be wet by using a dry gas coefficient on the hot side and the coolant coefficient on the cold side. If the program determines that any part of the desuperheating range will result in a dry wall, it will use the inlet temperature and the vapor temperature point, which yields the wet tube wall to determine the MTD for the desuperheating zone.

Once the tube wall is wet, the rest of the desuperheating occurs using the dew point to calculate the MTD.

The MTD calculation is based upon the interval's local temperature difference. For multipass exchangers, the local temperature difference of the multipass stream is weighted based upon the stream temperatures at each pass.

Condensing

The program calculates an MTD for each of the zones using the starting and ending temperature for each zone. The MTD calculation is based upon the interval's local temperature difference. For multipass exchangers, the local temperature difference of the multipass stream is weighted based upon the stream temperatures at each pass.

Liquid Cooling

The liquid cooling load is divided evenly among the zones. This avoids the common mistake of assuming that the vapor and liquid are kept in equilibrium and are at the same temperature. In fact much of the liquid cooling may actually occur early in the heat exchanger. An MTD for the liquid cooling is calculated for each zone and then weighted.

Pressure Drop

Desuperheating

If the program determines that there is a dry wall zone, as described above, then the pressure drop for this zone is calculated using the stream analysis method if on the shell side or a modified Fanning equation if on the tube side.

Condensing

The pressure drop for the vapor cooling, condensing, and condensate formed is determined using a two phase Martinelli equation.

Simple Vaporization

Liquid Preheating - Film Coefficient

The film coefficient for the heating of the liquid from its inlet temperature to the bubble point is the greater of the forced convection coefficient and the free convection coefficient.

Pool Boiling - Film Coefficient

The pool boiling coefficient is derived by the vectorial addition of the nucleate boiling coefficient and the flow boiling coefficient.

The nucleate boiling coefficient is based on the Stephan-Abdelsalam equation corrected for pressure and molecular weight. If a boiling range exists and is specified in the input, the program also corrects for the depression of the coefficient resulting from the boiling of mixtures.

The flow boiling coefficient is based on a no phase change liquid coefficient with a two phase multiplier. This coefficient is corrected for the effect of recirculation of the liquid around the tube bundle. The program automatically determines the recirculation rate based on the geometry of the shell and tube bundle.

In a kettle, the program divides the boiling into a number of vertical zones, from the bottom of the bundle to the top of the bundle. The boiling temperature for each zone is calculated based on the effect of the static head of the liquid in the zones above. A separate boiling coefficient is calculated for each zone. The effect of liquid recirculation around the bundle in a kettle can be very significant and is used to modify the coefficient accordingly.

Forced Circulation - Film Coefficient

The boiling coefficient for forced circulation is also determined by using a vectorial addition of the nucleate boiling coefficient and the flow boiling coefficient and corrected as described above for pool boiling. However there is no recirculation of liquid around the bundle.

Thermosiphon - Tube Side - Film Coefficient

The vaporization side is divided into a liquid preheating zone and a number of vaporizing zones divided equally by temperature. The boiling coefficient is determined by using a vectorial addition of the nucleate boiling coefficient and the flow boiling coefficient and corrected as described above for pool boiling. The flow regime is determined using a modified Baker flow regime map.

MTD

Liquid Preheating

The liquid preheat MTD is calculated as a linear LMTD.

Pool Boiling

The MTD for the boiling zones is determined as a linear LMTD using the calculated boiling temperatures of the bottom zone and top zone and the average temperature of the heating medium on the tube side.

Forced Circulation

The MTD calculation is based upon the interval's local temperature difference. For multipass exchangers, the local temperature difference of the multipass stream is weighted based upon the stream temperatures at each pass.

Thermosiphon

The MTD is calculated as an arithmetic MTD using the average temperature in each of the eleven zones and the corresponding temperature of the heating medium on the shell side.

Pressure Drop

Pool Boiling

The pressure drop in pool boiling is the total of the liquid pressure drop, determined using a Fanning equation, times a two phase Martinelli multiplier, plus the vapor acceleration pressure drop and the static head pressure drop.

Forced Circulation

The liquid pressure drop, determined using a Fanning equation, is multiplied by a two phase Martinelli multiplier. If the exchanger is in a vertical position, a vapor acceleration pressure drop and static head pressure drop are also added.

Thermosiphon

The program considers the pressure changes due to the inlet and outlet piping. The pressure drop within the heat exchanger is calculated in the same way as described under forced circulation.

Complex Vaporization

The program divides the vaporization range up into a number of equal zones based on temperature or heat load from the bubble point to the outlet temperature. For each zone it calculates a film coefficient, MTD, and two phase pressure drop, based on the vapor liquid equilibrium and physical properties for each zone.

Liquid Preheating - Film Coefficient

The film coefficient for the heating of the liquid from its inlet temperature to the bubble point is the greater of the forced convection coefficient and the free convection coefficient.

Forced Circulation - Film Coefficient

The boiling coefficient for each zone is derived by the vectorial addition of the nucleate boiling coefficient and the flow boiling coefficient.

The nucleate boiling coefficient is based on the Stephan-Abdelsalam equation corrected for pressure and molecular weight. If a boiling range exists and is specified in the input, the program also corrects for the depression of the coefficient resulting from the boiling of mixtures.

The flow boiling coefficient is based on a no phase change liquid coefficient with a two phase multiplier.

MTD

The program calculates an MTD for each of the ten zones using the starting and ending temperature for each zone. The MTD calculation is based upon the interval's local temperature difference. For multipass exchangers, the local temperature difference of the multipass stream is weighted based upon the stream temperatures at each pass.

Pressure Drop

The liquid pressure drop, determined using a Fanning equation, is multiplied by a two phase Martinelli multiplier for each zone. If the exchanger is in a vertical position, a vapor acceleration pressure drop and static head pressure drop are also added.

Falling Film Evaporators

The program uses the design methods of Chun and Seban for determining the film coefficient and acceptable liquid loading of the tube.

In design mode the program determines the cross-sectional area for tube side flow so that the liquid loading of the tube is below the point where the liquid would begin to move down the center of the tube (rather than remain as a film). The liquid loading is kept above the point where the film would no longer be continuous. In rating mode, the program warns if the liquid loading is above or below these respective points.

The program assumes that the vapor also continues to move down the tube and is separated from the liquid in the bottom head or a receiver below the bottom tubesheet.

Aspen Teams

Teams Input

Problem Definition

Headings/Application sheet

Use this sheet to specify **Headings**, which appear at the top of the TEMA specification sheet, Input Summary results, and the Title block of the drawings. Headings are 1 to 5 lines of up to 75 characters per line. Note that only the first 40 characters of each line appear on the drawings.

To create global headings for use by any B-JAC program, click **Tools | Program Settings**, display the **Headings/Drawings** tab, and enter the heading information.

For the application, select either a complete exchanger design of a shell-and-tube **heat exchanger** or a **pressure vessel**.

Codes and Standards Sheet

Use this sheet to specify:

- Design code

  The Teams program selects applicable mechanical design methods based on the selected code: ASME (American), CODAP (French), or AD-Merkblatter (German).

- Material standard

  The selected material standard - ASTM, AFNOR, DIN, or other - determines the materials of construction to be used. The default is the material standard per applicable code specified.

- TEMA class

  Select the appropriate TEMA class for the service:

  – Class B - chemical service exchanger (default)

  – Class C - general service exchanger

  – Class R - refinery service exchanger

- Code only - Program will not use TEMA defaults for corrosion allowances, minimum thicknesses, etc.

- Dimensional standard

  The selected dimensional standards - ANSI (American), ISO (International), or DIN (German) - apply to such things as pipe cylinder dimensions, nozzle flange ratings, and bolt sizes. DIN also encompasses other construction standards such as standard tube pitches.

- Service class

  If you select **low temperature** (design temperature less than -50°F) or **lethal service** (exchanger contains a lethal substance), the program selects the corresponding Code requirements for that class, such as full radiography for butt welds and PWHT for carbon steel construction. The default is **normal** service class.

Design Specifications Sheet

Use this sheet to specify:

- Design pressure

  Design pressure should be set higher than the highest normal operating pressure. If static pressure is to be considered, add the static to the normal design pressure. For components subject to two pressures, the program follows standard methods to investigate the effect of simultaneous design pressures (for example, TEMA).

- Vacuum design pressure

  The program will design simultaneously for internal as well as external pressure. The program expects an entry of 15 psia (1 bar) for full vacuum condition.

- Test pressure

  The program will calculate the required hydrotest pressure in accordance with the specified design code.

- Design temperature

  This is the design temperature at which material properties will be obtained.

- Corrosion allowances

  Corrosion Allowance is obtained from the TEMA standards as follows: For carbon steel TEMA B and C: 0.0625" (1.6 mm). For carbon steel TEMA R: 0.125" (3.2 mm). Enter zero for no corrosion allowance. There is no default corrosion allowance for materials other than carbon steel. You can specify any reasonable value for corrosion allowance.

- Radiographing

  The program follows the applicable construction code in the calculation of weld joint efficiencies based on the degree of radiography performed on the subject welds. Typically the joint efficiencies used in the thickness formulas follow these values:

Degree of Radiography:	None	Spot	Full
Joint Efficiency:	0.7	0.85	1

  Non-destructive testing performed on welds (i.e. radiography) can directly affect the joint efficiency used in the thickness calculations. Generally, the higher the efficiency, the thinner the component.

- Post weld heat treatment

  The post weld heat treatment requirement is dependent upon the applicable Code requirements. If specified the cost estimate will be adjusted to include the cost of post weld heat treatment of the unit.

- Lethal service

  If the fluids in the exchanger are considered to be of lethal nature, specify lethal service. The default is no.

- Plate tolerance

  You can specify a tolerance to plate materials. Tolerance will be added to the required code thickness calculated. The program default is zero tolerance.

Exchanger Geometry

Front Head

Front Head Sheet

Use this sheet to specify:

- **Front head type**

  This is the TEMA type front head closure.

- **Front head cover type**

  If you selected front head type B, you must select a cover type.

- **Front head connected to a cylinder**

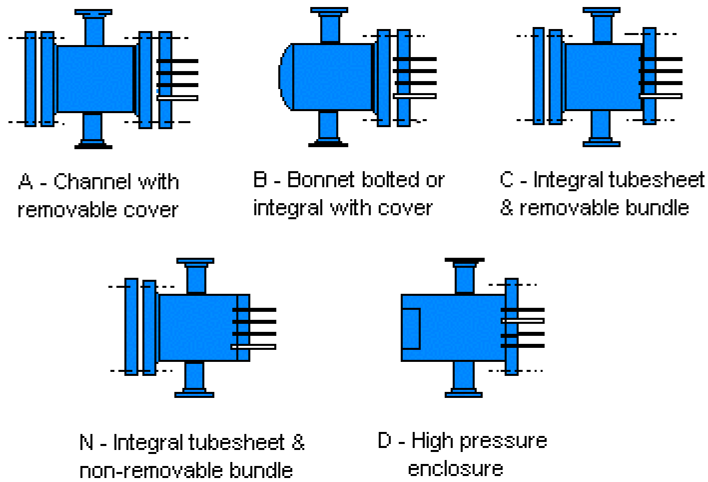
  A cylinder is required if a nozzle has been indicated at Zone 2 on the Nozzles sheet of the Nozzles - General input form. The default is the front head cylinder provided for all types.

- Front channel/cover bolted to tubesheet

  Select **Yes** to have the channel assembly bolted to the tubesheet. Select **No** to have the head welded to the tubesheet with no flanges. The default is the channel bolted to the tubesheet for A and B type front heads.

Front Head Type

Specify the TEMA type front head closure. The default is B - bonnet bolted of integral with tubesheet.

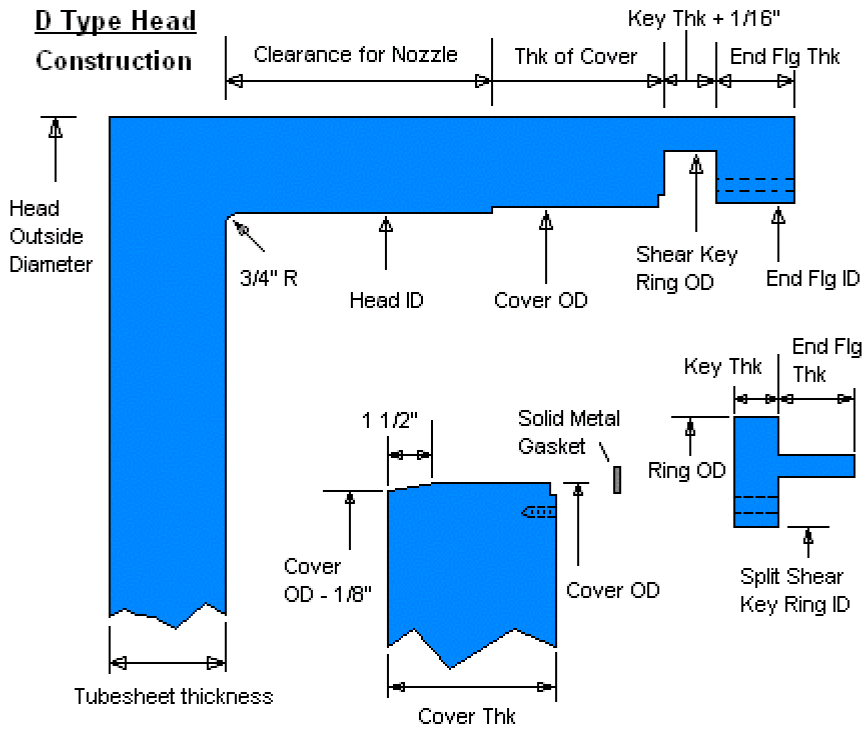


The high pressure D type is a shear key ring. The Teams program uses one specific design approach for this type.

D Type Front Head Design

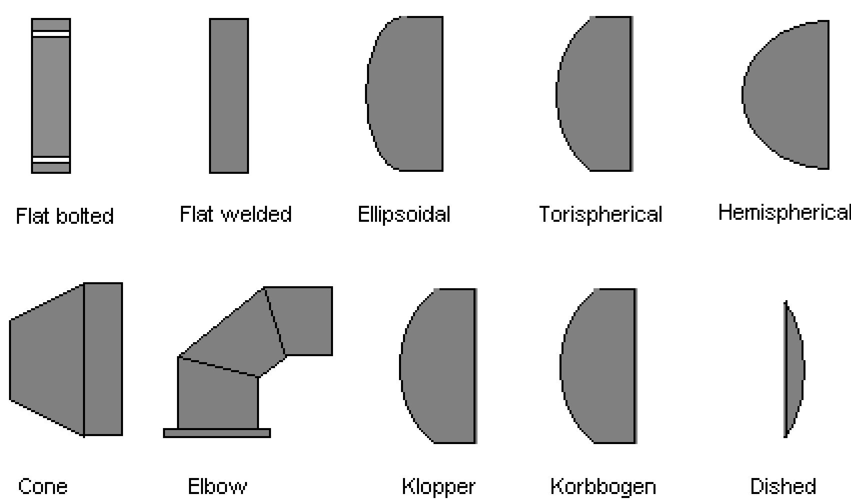
The Aspen Teams program uses one specific design approach for the D type, high pressure closure. The pressure vessel design methods used in the program are not specifically defined in the design codes, ASME or TEMA. Therefore, it is recommended that you carefully review the Teams results for the high pressure closure and modify as necessary to meet your specific design construction needs.

These are the construction details for the Teams D type head:



Front Head Cover Type

Select the cover type for the B type front head. The default is ellipsoidal cover (Korbbogen for ADM).



Front Head Cylinder Details Sheet

Use this sheet to specify these **front head cylinder** details:

- Outside and inside diameters
- Thickness
- Length
- Length for external pressure
- Joint efficiency
- Girth weld location
- Longitudinal weld location angle

If you specify an **outside diameter**, the program will hold the outside diameter and calculate and inside diameter based upon the calculated required cylinder thickness. If you specify an **inside diameter**, the program will hold the inside diameter and calculate and an outside diameter based upon the calculated required cylinder thickness.

If a pipe material is specified, cylinders 24 inches and smaller, we recommend that you specify the outside diameter so that a standard pipe wall thickness can be determined.

If check rating an existing design, specify the cylinder outside diameter or inside diameter, thickness, length, length for external pressure, and joint efficiency.

Cover Details Sheet

Use this sheet to specify these **front head cover** details:

- Outside and inside diameters
- Thickness
- Forming tolerance
- Joint efficiency
- Head ratio
- Straight flange length
- Depth

If check rating an existing design, specify the cover outside diameter, cover inside diameter, cover thickness, and cover joint efficiency.

Front Head Flat Heads Sheet

If you select a font head type that includes flat heads, use this sheet to specify the relevant details.

Front head flat bolted cover

If check rating an existing design, specify the following **flat bolted**, **front head cover** information:

- Clad thickness
- Clad OD (if cladded)
- 1st recess depth (from center)
- 1st recess diameter
- 2nd recess depth (from center)
- 2nd recess diameter

Front head flat welded cover

If check rating an existing design, specify the following **flat welded**, **front head cover** information:

- Clad thickness (if cladded)
- Flat head weld attachment type
- "C" factor in calculation of flat cover

Shell

Shell Sheet

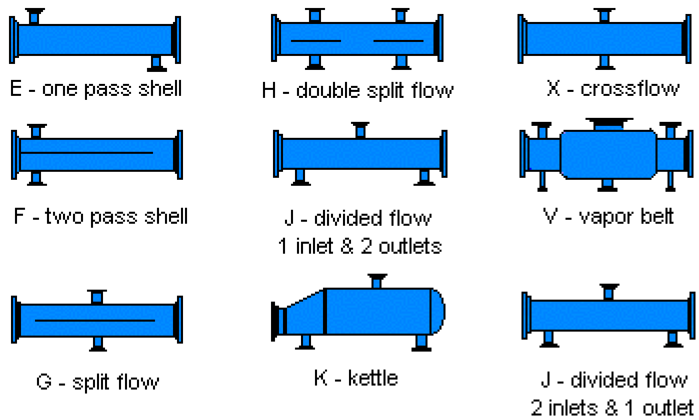
Use this sheet to specify:

- **Shell type**
  This is the shell TEMA type, except type V.
- Exchanger (vessel) position
  Specify horizontal (default) or vertical position.
- Shell outside and inside diameters
  If you specify an **outside diameter**, the program will hold the outside diameter and calculate and inside diameter based upon the calculated required cylinder thickness. If you specify and **inside diameter**, the program will hold the inside diameter and calculate and an outside diameter based upon the calculated required cylinder thickness.

  If a pipe material is specified, shells 24 inches and smaller, we recommend that you specify the outside diameter so that a standard pipe wall thickness can be determined.

Shell Type

These are the shell type choices:



The V type shell, which is not currently part of the TEMA standards, is used for very low shell side pressure drops. It is especially well suited for vacuum condensers and has an advantage over the X shell, in that it can readily have vents at the top of the bundle.

The vapor belt is an enlarged shell over part of the bundle length. It is essentially a cross flow exchanger in this section. The remaining portions of the bundle on each side are then baffled and fitted with vents and drains.

Default: E type (except pool boilers), K type for pool boilers

Shell Cylinder Sheet

If check rating an existing design, use this sheet to specify these **shell cylinder details**:

- Cylinder thickness
- Cylinder length
- Length for external pressure
- Cylinder joint efficiency
- Girth weld location
- Longitudinal weld location angle

Note: girth and longitudinal weld locations are not considered in the code calculations.

If external pressure is controlling the shell cylinder design, you can specify **shell stiffening rings** to reinforce the shell. If details are not provided, the program will select a ring size.

Kettle Cylinder Sheet

If the exchanger has a kettle type shell, use this sheet to specify the kettle cylinder outside or inside diameter.

If you are check rating an existing design, use this sheet to specify these details:

- Kettle length
- Kettle length for external pressure
- Kettle joint efficiency

Kettle Reducer/Weir Sheet

If the exchanger has a kettle type shell and you are check rating an existing design, use this sheet to specify these **kettle reducer** details:

- Reducer thickness
- Reducer cover joint efficiency
- Reducer conical angle

When liquid recirculation is required in a kettle reboiler service, a weir plate is generally specified beyond the U-bends. Use this sheet to specify the following **Weir** related details:

- Weir in kettle option
- Weir plate material
- Weir thickness
- Weir plate outer diameter
- Weir height

Teams will add additional required shell length for the weir plate and reservoir.

Vapor Belt Sheet

Use this sheet to specify the details for the vapor belt assembly.

The vapor belt acts as a distribution device for the flow into the bundle. The vapor belt may act also as a flange & flued type expansion joint devise

Rear Head

Rear Head Sheet

Use this sheet to specify:

- **Rear head type**

  The rear head type selection should be based on service requirements.
- **Rear head cover type**

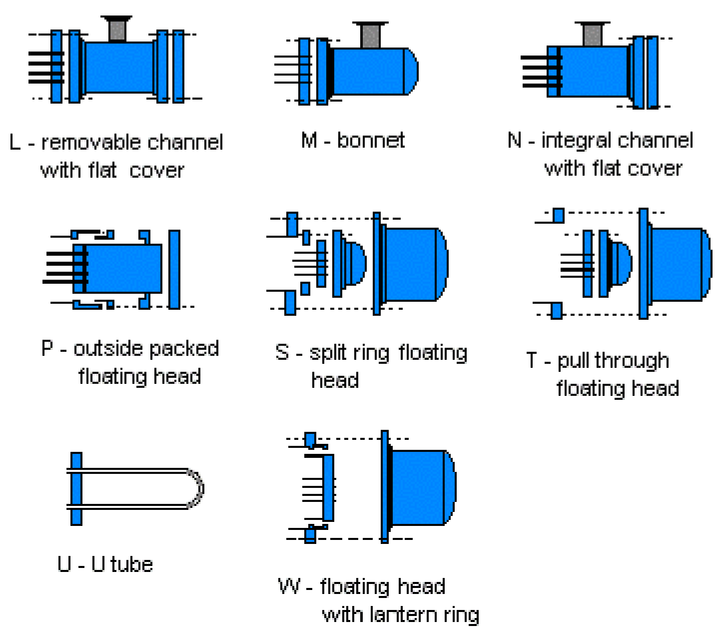
  Select the cover type for the rear head.
- **Rear head connected to a cylinder**

  A cylinder is required if a nozzle has been indicated at Zone 8 on the Nozzles sheet of the Nozzles - General input form. The default is the rear head cylinder provided for one-pass exchangers.
- Rear channel/cover bolted to tubesheet

  Select **Yes** to have the channel assembly bolted to the tubesheet. Select **No** to have the head welded to the tubesheet. The default is the channel bolted to the tubesheet for L and M type rear heads.

Rear Head Type

The rear head type selection should be based upon service requirements.



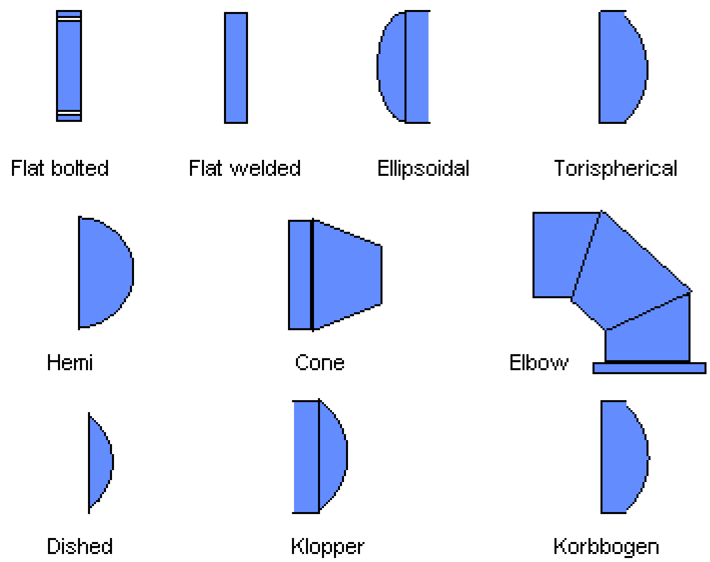
The removable tube bundle types - P, S, T, U, and W - provide access to the bundle for cleaning and do not require an expansion joint.

The fixed tubesheet types - L, M, and N - do no allow access to the bundle but have lower construction costs.

The default is U type for kettle shells; M type for all others.

Rear Head Cover Type

Select the cover type for the rear head.



The default is flat bolted for L, N, P, and W types; ellipsoidal for M type; dished for S and T types

Rear Head Cylinder Details Sheet

Use this sheet to specify these **rear head cylinder** details:

- Outside and inside diameters
- Thickness
- Length
- Length for external pressure
- Joint efficiency
- Girth weld location
- Longitudinal weld location angle

If you specify an **outside diameter**, the program will hold the outside diameter and calculate and inside diameter based upon the calculated required cylinder thickness. If you specify and **inside diameter**, the program will hold the inside diameter and calculate and an outside diameter based upon the calculated required cylinder thickness.

If a pipe material is specified, cylinder 24 inches and smaller, it is recommended to input the outside diameter so that a standard pipe wall thickness can be determined.

If check rating an existing design, specify the cylinder outside diameter or inside diameter, thickness, length, length for external pressure, and joint efficiency.

Rear Head Cover Details Sheet

Use this sheet to specify these **rear head cover** details:

- Outside and inside diameters
- Thickness
- Forming tolerance
- Joint efficiency

If check rating an existing design, specify the rear head cover outside diameter or inside diameter, thickness, and joint efficiency. Depending on the type of cover, other parameters may be required.

Rear Head Flat Heads Sheet

If you select a rear head type that includes flat heads, use this sheet to specify the relevant details.

Rear head flat bolted cover

If check rating an existing design, specify the following **flat bolted, rear head cover** information:

- Cladding thickness and clad OD (if cladded)
- 1st recess depth (from center)
- 1st recess diameter
- 2nd recess depth (from center)
- 2nd recess diameter

Rear head flat welded cover

If check rating an existing design, specify the following **flat welded**, **rear head cover** information:

- Clad thickness (if cladded)
- Flat head weld attachment type
- "C" factor in calculation of flat cover

Rear Head S Type Sheet

If you select an **S type rear head**, specify the inside floating head backing:

- Ring type
- Recess type

If the recess type is angled-ASME, or angled TEMA style A, specify the backing ring angle.

Rear Head W Type Sheet

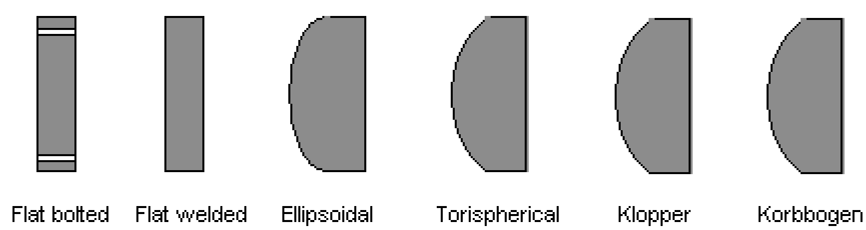
If you select a W type rear head, specify the type of lantern ring to be used.

If check rating an existing design, specify the lantern ring details, which include the outer diameter, inner diameter, thickness, width, slope and recess.

Shell Cover

Shell Cover Sheet

Use this sheet to specify a **shell cover type** for U-tube or floating head type exchangers.



The default for applicable type exchangers is an ellipsoidal welded cover.

The cover can be welded directly to the shell, or it can be welded to a separate cylinder that is welded or bolted to the shell. If the **shell cover is bolted to the shell**, select Yes.

If the **shell** assembly is to be **bolted to the tubesheet** to facilitate removable bundles, select Yes. By default the program will bolt the shell to the tubesheet, depending on the specified TEMA rear head closure type.

Shell Cover Cylinder Details Sheet

If you are check rating an existing design with a **shell cover cylinder**, specify these detail dimensions for the cylinder:

- Outside and inside diameters

- Thickness
- Length
- Length for external pressure
- Joint efficiency
- Girth weld location
- Longitudinal weld location

Shell Cover Details Sheet

Use this sheet to specify these shell cover details:

- Outside and inside diameters
- Thickness
- Forming tolerance
- Joint efficiency

If you are check rating an existing design, specify shell cover outside and inside diameters, the thickness, and joint efficiency.

For a **torispherical** type shell cover, specify:

- Knuckle radius, 5 or diameter
- Crown radius, % of diameter
- Straight flange length
- Cover depth

Shell Cover Flat Heads Sheet

If you select a shell cover that is a flat head type, use this sheet to specify the relevant details.

For a **flat bolted shell cover**, specify:

- Cladding thickness and cladding outside diameter (if cladded)
- 1st recess depth (from center)
- 1st recess diameter
- 2nd recess depth (from center)
- 2nd recess diameter

For a **flat welded shell cover**, specify:

- Cladding thickness (if cladded)
- Flat head weld attachment type
- "C" factor in the calculation of the flat cover

Body Flanges

Body Flanges Sheet

Use this sheet to specify:

- Tube side and shell side **flange type**

  Select the general form of the flange. The categories refer to the shape of the flange as found in ASME Section VIII Division 1, Appendix 2 and other applicable construction codes.

- Tube side and shell side **flange design standard**

  For exchanger applications with shell sizes greater that 24" (610mm) diameter, the body flanges are normally custom designed flanges, and the program optimizes to find the best and lowest cost solution for the flange.

  If you want a pre-designed, standard flange (quite often used for shells 24" and smaller), select the appropriate standard. Note that with a pre-designed flange, flange design calculations will not be provided because they are not required per the code.

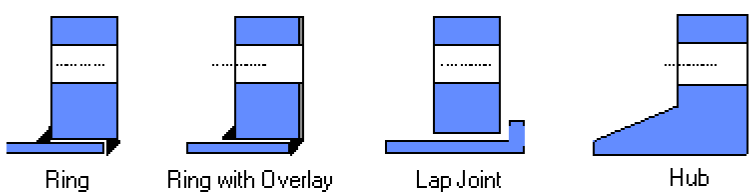
  By default the program optimizes the design based on the applicable code.

- Tube side and shell side confined joints

  A flange can have different types of faces in relation to the adjoining surface. The default is unconfined (except TEMA R).

Tube Side Flange Type

Select the general form of the flange, which may be a ring flange, lap joint flange, or hub flange.

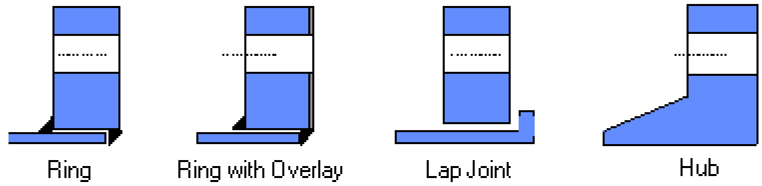


These categories refer to the shape of the flange as found in ASME Section VIII Division 1, Appendix 2 and other applicable construction codes.

Default: ring flange according to figure 2-4(8) of ASME, if attached to a carbon steel cylinder or head;
lap joint flange when attached to an alloy cylinder or head.

Shell Side Flange Type

Specify the general form of the flange, which may be a ring flange, lap joint flange, or hub flange.

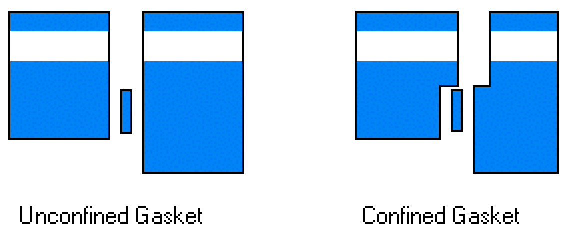


These categories refer to the shape of the flange as found in ASME Section VIII Division 1, Appendix 2 or other applicable construction codes.

Default: ring flange according to figure 2-4(8) of ASME, if attached to a carbon steel cylinder or head;
lap joint flange when attached to an alloy cylinder or head.

Tube Side/Shell Side Confined Joints

A flange can have different types of faces in relation to the adjoining surface. The simplest form is a flat face on which the gasket seats without being restricted radially. A confined joint forms a containment around the gasket.



Default: unconfined (except TEMA R)

Individual Standards Sheet

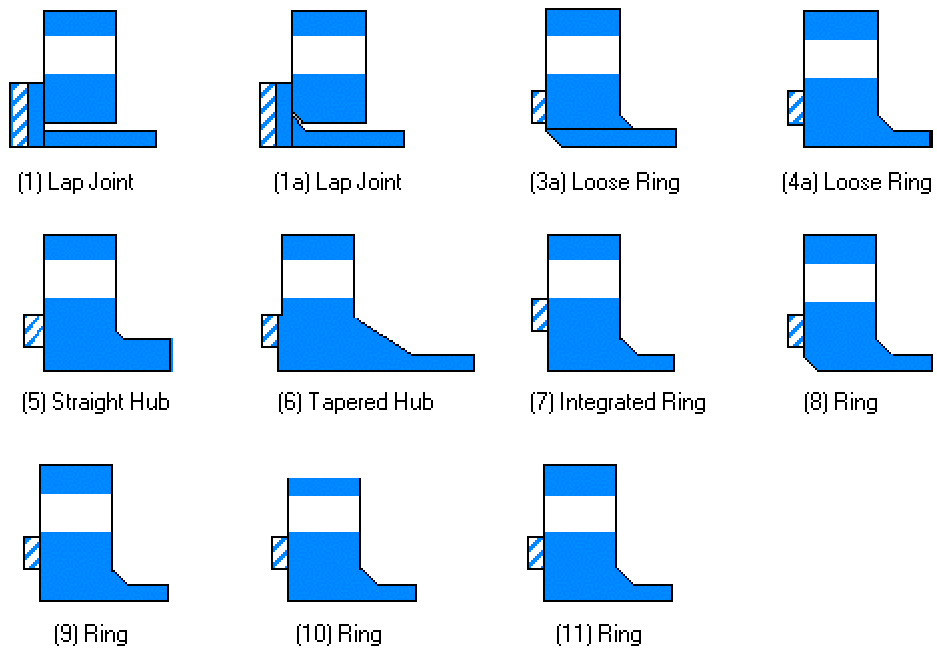
Use this sheet to modify individual standards for

- Front head flange at the cover or the tubesheet
- Front shell flange
- Rear shell flange
- Shell cover flange
- Rear head flange at the tubesheet or the cover

You can specify a design standard, code type, standard type, standard rating, code facing, standard facing, and confined joint.

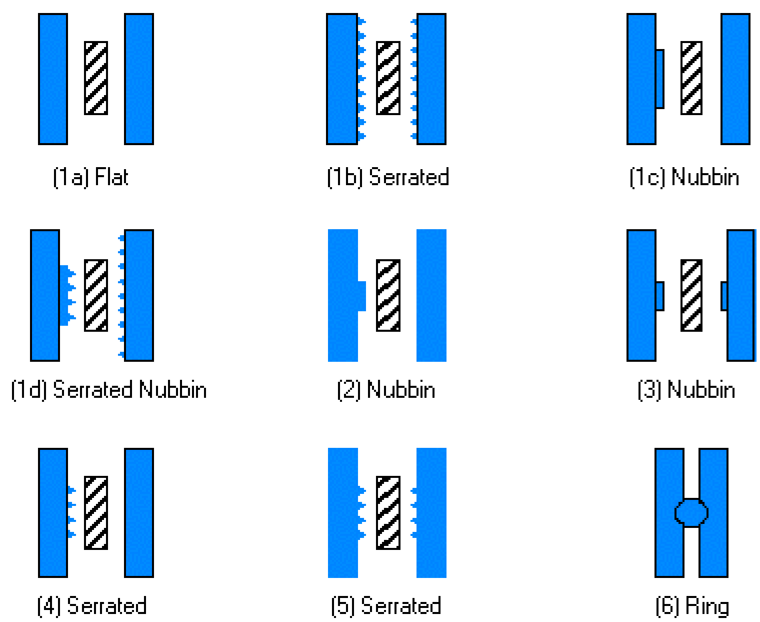
Special Flange Types per ASME Fig. 2.4

Select the code type from the list.



Special Flange Facing Types per ASME Table 2.5.2

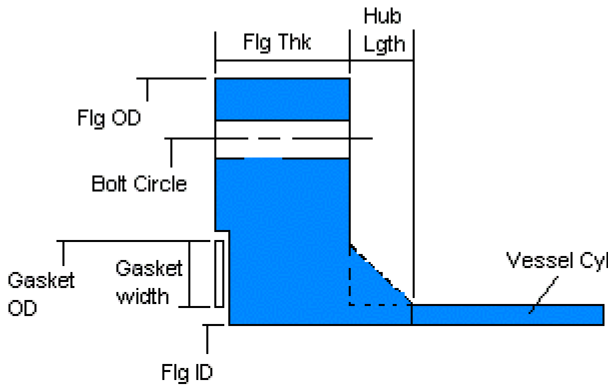
Select the code facing from the list.



Dimensions Sheet

Use this sheet to specify these major flange dimensions for all the flanges on the exchanger:

- Flange outside and inside diameter, bolt circle, and thickness
- Gasket outside diameter, width, and thickness
- Bolt diameter and number
- Hub length and slope
- Weld height



Body flanges can be designed per code rules or selected from standards. You can also enter flange dimensions when executing a rating program run. Designed flanges follow the rules dictated by the specified code. As in the case of nozzle flanges, typical flange types available are ring, lap joint and hub type. The program also automatically investigates the feasibility of optional type flanges calculated as loose or integral.

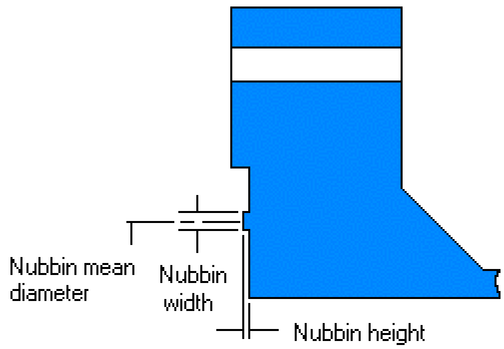
If check rating an existing flange, you may specify all of the geometry parameters listed of the existing flange or you can specify only partial geometry data. If you are providing partial information, you must, at least, specify all the information listed in one of the following data groups for the flange:

- Flange thickness only
- Bolt diameter only
- Bolt diameter and number of bolts
- Gasket diameter, gasket width, gasket thickness, bolt diameter, and number of bolts
- Flange OD, bolt circle, gasket O.D., gasket width, gasket thickness, bolt diameter, number of bolts, hub length, hub slope, and weld height (if applicable)
- All the flange geometry data listed

Nubbin/Recess/Gasket Sheet

Use this sheet to specify these flange dimensions:

- Nubbin width, height, and diameter
- Recess depth and diameter
- Overlay thickness
- Gasket factor m and factor y



If check rating an existing flange, specify the nubbin width, height, and diameter; the recess depth and diameter; the overlay thickness; the gasket m factor and gasket seating stress, when applicable.

Options Sheet

Use this sheet to specify these body flange **design options**:

- Design temperature - flanges shell side and flanges tube side

  You can set specific design temperatures for the body flanges in lieu of the global design temperatures.
- Include gasket rib area for gasket seating

  The program will adjust the flange design to include the rib seating area of the gasket (default). This assures that the flange will be able to keep the gasket sealed for operating conditions. You may omit the gasket seating area for the pass partition ribs for the flange calculations.
- Type of bolt

  You can set the bolt type to US or Metric or Din. The default is the type applicable to the specified code and standards.
- Body flange full bolt load

  Per Note 2 of ASME Section VIII, paragraph 2-5(e), if additional safety is needed against abuse or where is it is necessary to withstand the full available bolt load, AbSa, specify **Yes**, for this full bolt load to be considered. The default is standard bolt load, (Am+Ab) * Sa / 2

- Design to satisfy flange rigidity rules

  Specify **Yes** to have the program adjust the flange design as required to flange rigidity rules. The default is **No** – flange will not be adjusted for rigidity rules.
- Minimum bolt diameter

  You can specify the minimum bolt diameter to be used for the body flanges or allow the program to select from the minimum diameters recommended by TEMA standards.

  The program default for minimum bolt diameter is 5/8" (16mm) for optimized body flange designs. You can change that limit here for the optimized flange design to start at a different minimum diameter. Note that you can re-set this minimum bolt diameter limit in the Cost Database standards so that all flange designs will use your specified limit.
- Gasket unit stress

  This is a secondary method to check the bolt area to assure gasket seating. If this factor is less than the minimum Code gasket seating stress, y, the number of bolts will be increased to assure gasket will be seating at bolt up. This method is similar to the method in ASME (Appendix 2) that checks the minimum bolt area. The program default is to use the applicable code method. By selecting Y**es**, Teams determines the minimum gasket seating stress for the flange configuration.

For a **pressure vessel** tank design, indicate the locations where you want to locate body flanges. Possible flange locations are at the:

- Front head cover
- Front shell
- Rear tubesheet
- Rear head cover

Backing Sheet

If you are check rating an existing S type rear head, use this sheet to specify the dimensions for the backing ring:

- Flange outer diameter and inner diameter
- Recess
- Flange actual thickness

The default is to design a new backing ring if no dimensions are given.

You can also specify any required **corrosion allowance to the outer diameter of the floating flange and backing ring**, overriding the default, which does not apply any corrosion allowance to these surfaces.

Tubesheet

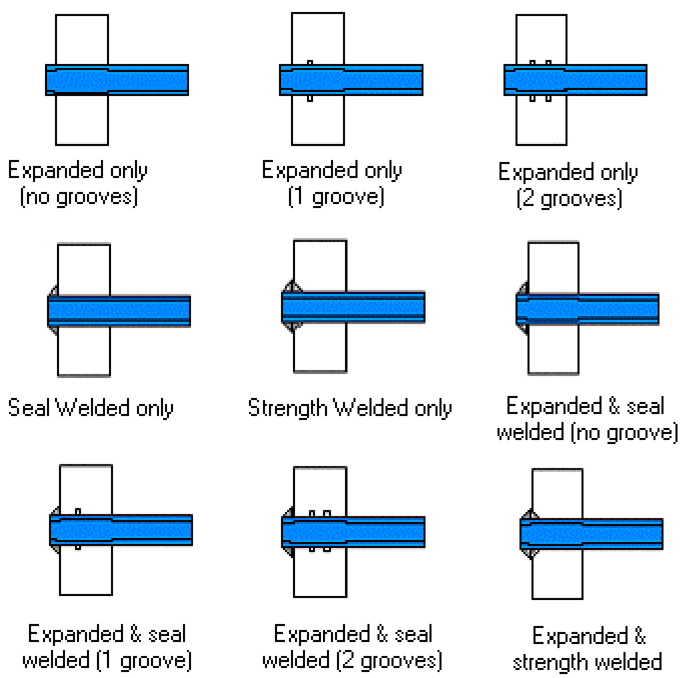
Tubesheet Sheet

Use this sheet to specify:

- Tube-to-tubesheet joint type - Appendix A
- Tube-to-tubesheet strength welded joint type and tube design strength, if applicable
- Tubesheet extension type
- Tubesheet type

Tube-to-Tubesheet Joint Type - Appendix A

This is the type of joint used to attach the tubes into the tubesheet holes. The simplest form is by expanding the tube wall into the holes with an expanding tool. One or two grooves inside the tubesheet holes are sometimes used to strengthen the attachment.



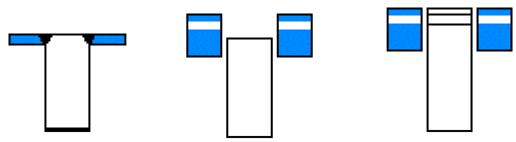
Depending on the process, users may desire to weld the tubes into the tubesheets with a seal or strength weld in addition to expanding the tube. For detail requirements for strength joints, see the applicable construction code (such as UW-20 of ASME Section Div.1).

A seal or strength weld can also be used without any expansion of the tubes. If you select partial strength, specify the tube design strength.

Default: expanded only (2 grooves)

Tubesheet Extension Type

When applicable, the program evaluates the tubesheet extension against the adjoining flange moments.

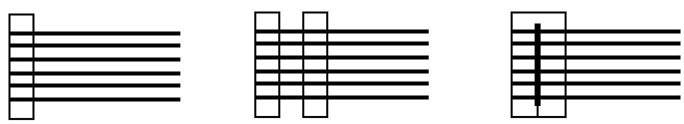


Tubesheet extended to shell OD | Tubesheet extended to gasket OD | Tubesheet extended to flange OD

Default: extended edge for bolting depending on the type of geometry

Tubesheet Type

Double tubesheets are used when it is extremely important to avoid any leakage between the shell and tube side fluids. Double tubesheets are most often used with fixed tubesheet exchangers, although they can also be used with U-tubes and outside packed floating heads.



Single tubesheet | Double tubesheet gap type | Double tubesheet integral type

The gap type double tubesheet has a space, usually about 150 mm (6 in.), between the inner (shell side) and outer (tube side) tubesheets. TEAMS will provide a recommended gap.

The integral type double tubesheet is made by machining out a honeycomb pattern inside a single thick piece of plate so that any leaking fluid can flow down through the inside of the tubesheet to a drain. This type is rare, since it requires special fabrication tools and experience.

Default: normal single tubesheet(s)

Tubesheet Types/Welds Sheet

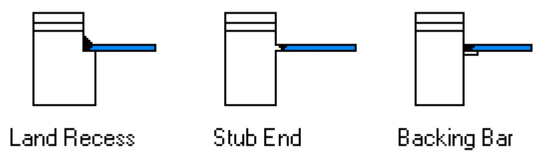
Use this sheet to specify the tubesheet attachment type and tube-to-TS weld type - UW-20.

- Tubesheet attachment type
- Tube-to-TS weld type - UW-20

  Specify if the tube to tubesheet welds are to be considered as strength welds per ASME, and specify the af and ag dimensions:
- **Fillet weld length, af** - Fillet weld leg size for the tube to tubesheet welds.
- **Grove weld length, ag** - Groove weld leg for the tube to tubesheet welds.

Tubesheet Attachment Type

Select a tubesheet attachment type:



The tubesheet attachment defaults to land. This is a recess behind the tubesheet on which the shell rests (typically 3/16" - 5 mm).

Stub end is an extension parallel to the shell axis to which the shell is attached. This method normally requires machining of the stub end with inner and outer radii. For an example, see ASME VIII-1 Fig. UW-13.3(c).

Tubesheet Method/Dimensions Sheet

Use this sheet to specify the tubesheet:

- Tubesheet design method
- Tubesheet/Cylinder optimization
- Dimensions

If you specify the **tubesheet design temperature** on this sheet, the program uses this temperature as the design temperature for the tubesheets in lieu of the general shell/tube side design temperatures specified on the Design Specifications sheet.

Tubesheet Design Method

You can select one of these tubesheet design methods:

- TEMA (Eight Edition)
- Code (Appendix AA - latest addenda)
- The thicker of the two methods
- The thinner of the two methods

Code accepts both methods for the tubesheet design. If no method is selected, the program will use the thicker tubesheet of the two methods. Depending on the design conditions and materials of construction, either method may result in a thicker tubesheet.

Generally the ASME method will result in thicker tubesheets, especially, if the tubesheet is welded to the shell or head cylinder. Most users select the thinner tubesheet of the two methods to save cost.

ASME UHX Tubesheet design

Select Yes to have Teams apply the new ASME (non-mandatory) heat exchanger standard requirements. Refer to the appendix in ASME Section VIII for additional details for these requirements.

Tubesheet/Cylinder Optimization

Select the tubesheet/Cylinder optimization method:

- Program

  Program calculates the minimum required tubesheet thickness for bending and shear. Then it checks the stresses on the tubes and cylinders (shell or channel) welded to the tubesheet(s). If the stresses on the tubes are exceeded, the program automatically inserts an expansion joint. If the welded shell (i.e., BEM) or welded channel (i.e., NEN) is overstressed at the junction with the tubesheet, the program will issue a warning.
- Increase tubesheet thickness

  The program increases the tubesheet thickness until all stresses are satisfied, including adjacent components – tubes, shell, channel. This selection results in the *thickest* tubesheet(s) and thinnest cylinder thickness at the junction.
- Increase adjacent cylinder thickness

  The program increases the shell thickness (only a small portion adjacent to the tubesheet) and/or the channel thickness (depending of which one is controlling) until the cylinder stresses at the junction with the tubesheet(s) are satisfied. This selection results in the *thinnest* tubesheet(s) and thickest cylinder thickness at the junction. As the cylinder thickness is increased, the tubesheet is reinforced by the thicker cylinder welded to it, and consequently the tubesheet thickness is automatically reduced.

If a warning message appears stating that either the shell cylinder or channel cylinder at the tubesheet junction is overstressed, select the increase adjacent cylinder thickness method and rerun the program. This may take a while in some designs. If the resulting cylinder thickness adjacent to the tubesheet is acceptable, the optimization run is finished.

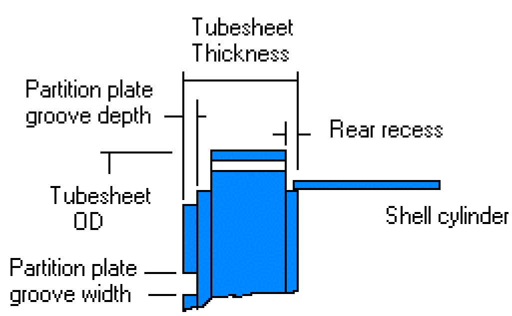
If this thickness is not acceptable (too thick), fix this thickness on the Miscellaneous sheet of the Tubesheet form. Then select increase tubesheet thickness and rerun the program. This methodology usually results in a tubesheet thickness less than TEMA with a somewhat thicker cylinder welded to the tubesheet.

Note: The program automatically adjusts all the affected components (adjacent flange geometry) during these optimizations.

Tubesheet Dimensions

Specify these front and rear tubesheet dimensions on the Method/Dimensions sheet:

- Tubesheet outer diameter and thickness
- Front tubesheet partition groove width and rear pass partition plate groove width
- Front tubesheet partition groove depth and rear pass partition plate groove depth



Tubesheet cladding is typically a layer of alloy material applied to a carbon steel base on the tube-side face of the tubesheet. If cladded, enter the front and rear:

- Clad diameter and thickness
- Tubesheet cladding material, tube side

Specify how the cladding is bonded to the tubesheet base material, explosively bonded or loose type. The type of bonding does not affect Code calculations.

If check rating an existing exchanger, enter the tubesheet outer diameter, and width and depth partition groove. If cladded, enter the clad diameter and thickness and tubesheet cladding material.

Recess/Corrosion Allowance Sheet

Use this sheet to specify **corrosion allowance** requirements for the shell side and tube side of the tubesheets. The values entered here override the global corrosion allowances entered for the shell and tube sides on the Design Specifications sheet.

You can specify any reasonable value for corrosion allowance. By default the corrosion Allowance is obtained from the TEMA standards as follows:

- For carbon steel TEMA C and , 0.0625" (1.6 mm)
- For carbon steel TEMA R, 0.125" (3.2 mm)

Enter zero for no corrosion allowance. There is no default corrosion allowance for materials other than carbon steel.

If check rating an existing exchanger, enter the these **recess dimensions** for the front/rear tubesheet shell side and tube side:

- Recess depth and diameter at ID gasket surface
- Recess depth and diameter at OD gasket surface

A **backing flange behind the tubesheet** is used to avoid transferring the flange moment caused by the adjoining flange to the tubesheet. You can specify the **front/rear backing ring flange material**. When the tubesheet is made of alloy, the backing ring flange can be made of inexpensive steel material.

Select **tubesheet tapped** option to have bolt holes tapped in the rear tubesheet instead of bolted through the tubesheet.

Miscellaneous Sheet

Use this sheet to specify:

- Adjacent tubesheet data

  if cylinders attached to the tubesheet are of different materials and design specifications from that of the general cylinders specifications, specify the applicable data here.

- Differential design pressure

  if you select **Yes**, the tubesheets will be designed to a differential design pressure condition between the tube side and shell side of the exchanger. The normal default is to design the tubesheet applying the full tube side pressure for the first case and then the full shell side pressure for the second case and use the greater tubesheet thickness for those two conditions.
- Tube expansion depth ratio

  You can specify the ratio of the tube expansion length in the tubesheet to the total length of the tubesheet. This will be used for the tube pull out load analysis. The default is TEMA requirements.
- Load transferred from flange to tubesheet

  The program will automatically transfer the calculated load from the body flange to the tubesheet for the flange extension calculations. For special design considerations, you can specify the load to be used in these calculations.
- Tubesheet allowable stress at design temperature

  If you wish to specify a special allowable design stress for the tubesheet calculations, enter that value. If not specified, the program will use an allowable design stress per the applicable code.
- Actual differential pressure

  If you have specified to design the tubesheets using a differential design criteria, the program, by default, uses the design pressures to determine the differential design pressure. You can override the default and specify the differential pressure to be used.
- ASME for thermal cases - use design temperature

  By default the program uses the mean metal (operating) temperatures for the tubesheet thermal cases. Select this option to have the program use the design temperatures for these cases instead.
- Expansion joint height, hj

  You can specify the height of the bellows for the expansion joint calculations. If not specified, the program will optimize and select a height.

Double Tubesheet Sheet

If double tubesheets have been selected, use this sheet to specify any special temperature and geometry design requirements. For any value not provided, the program will select optimum values for design.

Tube Expansion Sheet

Use this sheet to specify these tube expansion parameters:

- Tube expansion maximum length

  The length of the tube expansion into the tubesheet affects the strength of the joint.

  You can set a maximum tube expansion length limit. By default, Teams uses a tube expansion length as recommended by TEMA or as limited by the tubesheet thickness.
- Tube expansion clearance from shell/channel face

  Aspen Teams follows TEMA guidelines for the recommended clearance (non-expanded tube sections near the tubesheet faces), unless you specify the clearance needed here.
- Tube expansion depth ratio

  The ratio of the tube expansion length to the total thickness of the tubesheet. This value is used in the tube pull out load analysis.

Heat Transfer Data

Use the following to specify the heat transfer tube parameters:

- **Heat Transfer Data**

  If the mean metal temperatures are not known, you can provide shell and tube coefficients, temperatures, and conductivity. From the specified data, Teams estimates the actual mean metal temperatures to use in the tubesheet and expansion joint calculations. If the mean metal temperatures are not provided, Teams uses the specified design temperatures as the mean metal temperatures.

Expansion Joints

Expansion Joints Sheet

Use this sheet to specify if you want an **expansion joint for the fixed tubesheet design**. Choices are:

- **Program** - program checks and adds expansion joint if required. This is the default.
- **Yes** -program will add an expansion, even if one is not required.
- **No** - the unit will be designed without an expansion joint. The program will notify you if the unit is overstressed.

Select the **expansion joint type**. Aspen Teams defaults to the flanged and flued type for TEMA exchangers. If a suitable joint cannot be determined, specify the bellows type.

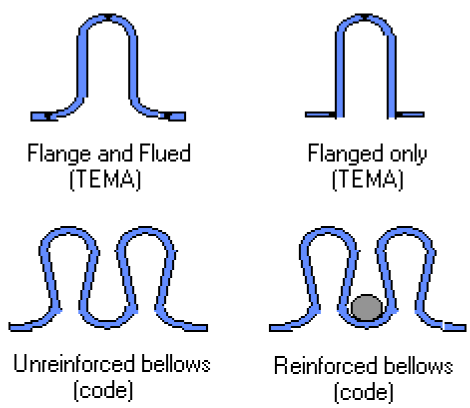
The program uses the specified **shell mean metal temperature** and the **tubes mean metal temperature** to design a fixed tubesheet and expansion joint. If not specified, the program will use the design temperatures.

The shell/tubes mean metal temperatures are very important in the correct calculation of the relative expansion of tubes and shell. It is especially important when the program defaults to the design temperatures because these may not be realistic. If the Teams input file is generated by Aspen Hetran, the mean metal temperatures is provided automatically, based upon the TEMA method.

Specify the **tubesheet mean metal temperature** to be used in the tubesheet design calculations. Normally, the tubesheet metal temperature is very close to the tube metal temperature.

Expansion Joint Type

You can select Program or one of the following:



The flange and flued type refers to an expansion joint with two radii. The flanged only type has a radius only at the outer edge. The joint with the shell is a straight angle.

The thin-wall expansion joint is also known as a bellows type and has as an "S" shape. Typical thicknesses are less than 1/8" (3.2 mm) and made of alloy materials. Reinforced bellows requires extra material to be placed on the outside of the joint to provide additional rigidity.

The flanged type is generally the lowest cost expansion joint but is not as flexible as the bellows type.

Aspen Teams defaults to the flange and flued type for TEMA exchangers. If a suitable joint cannot be determined, specify the bellows type.

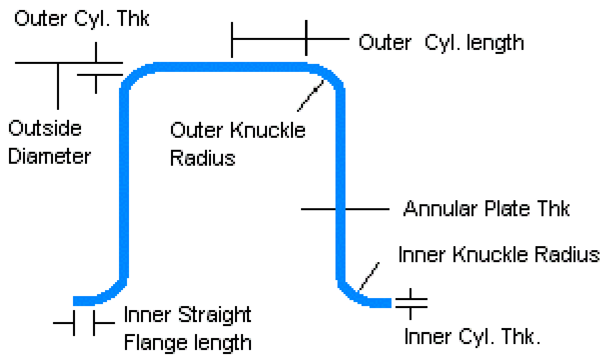
The design method for the flanged type is TEMA; for the bellows type, per the specified Code.

Aspen Teams will design thick-wall expansion joints per TEMA Section 5 and thin -wall expansion joints per ASME-VIII-1 App. 26.

Default: flanged and flued type

Geometry Sheet

If an expansion joint is required, use this sheet to specify the dimensions.



You can also specify the maximum thickness multiplier and outer diameter multiplier, and whether an outer cylinder is required.

If you are check rating an existing expansion joint, specify the outer cylinder thickness, annular plate thickness, cylinder length, straight flange length, knuckle radius

For additional information, see TEMA 1988 section 5.

Corrosion Allowance/Spring Rate Sheet

Use this sheet to specify:

- Expansion joint corrosion allowance

  The corrosion allowance specified here overrides the global corrosion allowance.
- Number of joints

  You can specify up to two expansion joints.
- Location one

  This is the Zone location for the first expansion joint.

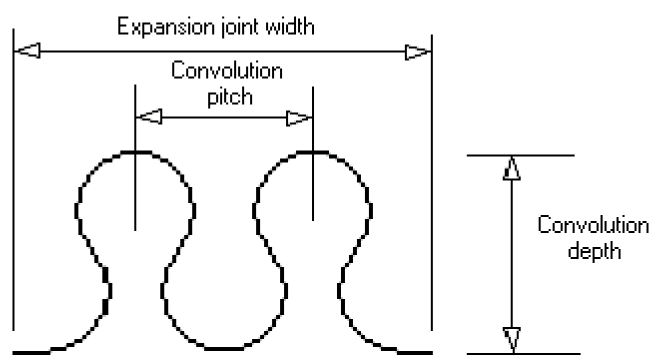
- Location two
  This is the Zone location for the second expansion joint.
- Spring rate (corroded), Spring rate (new)
  These are the bellows type expansion joint spring rates for the corroded and new conditions. If not specified, the program will calculate the spring rate.
- Expansion joint cycle life
  You can specify a required life cycle, or the program will calculate the estimated cycle life.

If you are check rating an existing joint specify the applicable corrosion allowance, number of joints, location of first joint and second joint (if required), spring rates (corroded, new), and the expansion joint life cycle.

Bellows Sheet

If check rating an existing bellows type expansion joint, use this sheet to specify the:

- Bellows reinforcing material
- Number of convolutions
- Geometry details



Stress Factors Sheet

Use this sheet to specify stress multipliers to adjust the allowable design stresses used in the TEMA expansion joint calculations. If left blank, the program uses allowable stresses recommended by TEMA.

Tubes/Baffles

Tubes Sheet

Use this sheet to specify the tube geometry:

- **Number of tubes:** If you do not specify the number of tubes, the program calculates the maximum number of tubes that will fit in a given exchanger geometry. This number varies not only with the tube diameter, pitch and layout, but also with the type of exchanger (floating head, etc.). The default is program calculated.
- **Tube length:** Specify the overall tube length for straight tubes. For U-tubes specify the tangent straight length.
- **Tube OD:** Specify the actual dimensional outside diameter.
- **Tube wall thickness:** The program will check if the tube wall thickness is adequate to withstand the design pressure, both internal and external. If you enter the average tube wall thickness, determine the minimum tube wall based upon the manufacturing tolerance (generally in the range of 10 to 12%) and verify it is not less than the calculated required thickness for the tubes. For low fin tubes, the tube wall thickness specified will be maintained below the fins.
- **Tube type:** Plain tubes do not have any enhancing type of surface on them. Fin tubes are classified as integral low-fin types with densities of 16 to 30 fins per inch (630 to 1181 fins per meter). Typical fin heights are 0.015 to 0.040 inches (0.4 to 1 mm). The program requires only the fin density.
- **Tube wall specification:** Specify the tube wall specification, which appears on the TEMA data sheet. The default is minimum wall. If you specified average wall thickness, see tube wall thickness. The program does not adjust the tube wall thickness based upon this average or minimum wall specification. This option only sets a tubing requirement specification on the data sheet.
- **Tube projection from tubesheet:** Tube projection from the tubesheet face should be based upon the type of attachment and any customer specification requirements. The default is 1.5 mm or 0.625 in.
- **Tubes design temperature:** Specify the tube design temperature, which will determine the physical properties used in the code calculations. The default is higher of shell and tube side design temperatures.
- **Tubes corrosion allowance:** For most design applications no corrosion allowance is applied to the tubes, even if you have specified a general corrosion allowance for the shell and tube sides of the exchanger. Specify the total corrosion (shell side

and tube side) allowance required. The default is zero corrosion allowance.

- **Tubes allowable design stress at design temperature:** If not provided, the program will determine the design stress based upon tube material specified at the design temperature. You may override this calculated design stress by entering it here. The default is the allowable design stress at design temperature based upon material specified.

If you specify **fin tubes** as the tube type, you must specify the desired fin density.

Fin Tubes

If you specify fin tubes as the tube type, then you must specify the desired fin density (the number of fins per inch or per meter depending on the system of measure). Since the possible fin densities are very dependent on the tube material, you should be sure that the desired fin density is commercially available.

The dimensional standards for finned tubes made by Wolverine, High Performance Tube, and Wieland are built into the program. If you choose one of these, the program will automatically supply the corresponding fin height, fin thickness, and ratio of tube outside to inside surface area. If you do not choose one of the standard fin densities, then you must also supply the other fin data which follows in the input.

The standard fin densities, fins/inch, for various materials are:

Tube Material	Fins/Inch
Carbon Steel	19
Stainless Steel	16, 28
Copper	19, 26
Copper-Nickel 90/10	16, 19, 26
Copper-Nickel 70/30	19, 26
Nickel Low Carbon Alloy 201	19
Nickel Alloy 400 (Monel)	28
Nickel Alloy 600 (Inconel)	28
Nickel Alloy 800	28
Hastelloy	30
Titanium	30
Admiralty	19, 26
Aluminum-Brass Alloy 687	19

Fin height

The fin height is the height above the root diameter of the tube.

Fin thickness

The fin thickness is the average fin thickness.

Teams Baffles Sheet

Use this sheet to specify:

- **Baffle type**, which can be divided into two general categories:

  Segmental baffles, which are pieces of plate with holes for the tubes and a segment that has been cut away for a baffle window. Single, double, triple, no tubes in window, and disk & donut are examples of segmental baffles.

  Grid baffles, which are made from rods or strips of metal that are assembled to provide a grid of openings through which the tubes can pass. The program covers two types of grid baffles - rod baffles and strip baffles.
- **Baffle orientation** - horizontal, vertical, or rotated - is with respect to a horizontal exchanger. On vertical units the baffle cut will be typically perpendicular to the shell nozzles axes.
- **Bundle removal space**, the bundle removal space required depends on the specified TEMA type of the exchanger.

  Bundle removal space is not applicable to fixed tubesheet designs but is needed for removal type bundles,
  S / T / P / W / U rear head types.

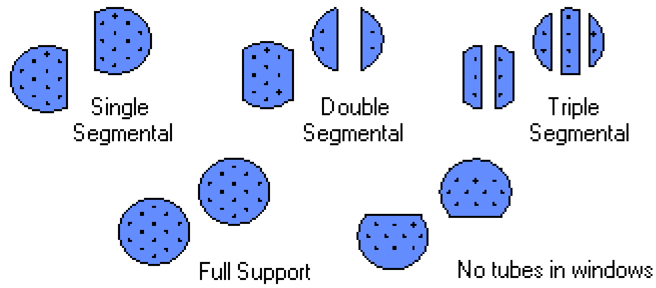
  The type of front head specified also affects the removal space needed. The A & B front type heads are generally removed before the bundles are removed and therefore, removable clearance for the front heads is not needed.

Teams Baffle Type

Baffle types can be divided up into two general categories:

- Segmental baffles
- Grid baffles

Segmental baffles, the most common type of baffle, are pieces of plate with holes for the tubes and a segment that has been cut away for a baffle window. Single, double, triple, no tubes in window, and disk & donut are examples of segmental baffles, with the single segmental baffle being the type used in a majority of shell and tube heat exchangers.



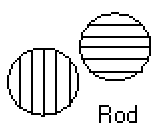
The baffles should have at least one row of overlap, and therefore become practical for a 20 mm or 0.75 in. tube in shell diameters of 305 mm (12 in.) or greater for double segmental and 610 (24 in.) or greater for triple segmental baffles.

Note: The B-JAC triple segmental baffle is different than the TEMA triple segmental baffle.

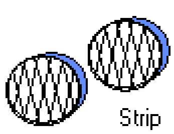
Full supports are used in K and X type shells where baffling is not necessary to direct the shell side flow.

No tubes in window is a layout using a single segmental baffle with tubes removed in the baffle windows. This type is used to avoid tube vibration and may be further enhanced with intermediate supports to shorten the unsupported tube span. The standard abbreviation for no tubes in the window is NTIW.

Grid baffles are made from rods or strips of metal that are assembled to provide a grid of openings through which the tubes can pass. The program covers two types of grid baffles - rod baffles and strip baffles.



Rod baffle design is based on the construction and correlations developed by Phillips Petroleum. Rod baffles are limited to a square tube pattern. The rods are usually about 6 mm (0.25 in.) in diameter. The rods are placed between every other tube row and welded to a circular ring. There are four repeating sets where each baffle is rotated 90 degrees from the previous baffle.



Strip baffles are normally used with a triangular tube pattern. The strips are usually about 25 mm (1 in.) wide and 3 mm (0.125 in.) thick. The strips are placed between every tube row. Intersecting strips can be notched to fit together or stacked and tack welded. The strips are welded to a circular ring. Strip baffles are also sometimes referred to as nest baffles.

Default: single segmental except X shells; full support for X shell

Baffle Details Sheet

Use this sheet to specify these baffle details:

- **Baffle cut in percent of vessel diameter:** The baffle cut is based on the percent of shell diameter. Typically 15% to 45%, depending on flow parameters and type of baffle (single vs. double vs. triple segmental or no-tubes-in-window). For double-segmental baffles, the baffle cut is the size of the inner window divided by the shell diameter X 100. For triple-segmental baffles, the baffle cut is the size of the innermost window divided by the shell diameter X 100. For nests or rod baffles, there is no baffle cut (leave blank or zero).
- **Baffle number:** Number of transverse baffles including full supports when applicable. The number of baffles applies to all transverse baffles and full supports. It should include the full support(s) under the nozzle(s) on a G, H, or J type shell. It should not include the full support at the beginning of the u-bend of a u-tube bundle.
- **Baffle spacing:** Specify the center-to-center baffle spacing. This number and the number of baffles are complementary. If not entered, the program will determine the inlet and outlet baffle spacing.
- **Baffle inlet spacing:** Specify the baffle spacing at the inlet nozzle. If not entered, the program will set based upon the center to center spacing and outlet spacing if specified. If the outlet spacing is not specified, the program will set the inlet and outlet spacing the same based upon available tube length.
- **Baffle outlet spacing:** Specify the baffle spacing at the outlet nozzle. If not entered, the program will set based upon the center to center spacing and the inlet spacing if specified. If the inlet spacing is not specified, the program will set the inlet and outlet the spacing the same based upon available remaining tube length.
- **Baffle thickness:** Specify the actual thickness of the baffles. The default is TEMA standards.
- **Baffle diameter:** Specify the actual baffle outside diameter. The default is TEMA standards.
- **Unsupported tube span:** Normally you allow the program to calculate the unsupported tube span based upon the baffles spacing. If you specify an unsupported tube span, Aspen Teams uses this value in lieu of the program value in the TEMA fixed tubesheet calculations.
- **Unsupported tube span Factor k:** Enter the unsupported tube span k factor used to determine the Cc variable in the TEMA

tube compressive stress calculations, if you want to override the program calculated k factor.

Double/Triple Cuts Sheet

Use this sheet to specify double baffle and triple segmental cuts. The baffle cut is based on the percent of shell diameter.

For more information on double and triple segmental baffle cuts, see the Appendix.

Tubesheet Layout

Tubesheet Layout Sheet

Use this sheet to specify:

- Tube pattern

  The tube pattern is the layout of the tubes in relation to the shell side crossflow direction, which is normal to the baffle cut edge. The default is 30 degrees.
- Tube pitch

  This is the center-to-center distance between adjacent tubes within the tube pattern. The default is the minimum recommended by TEMA.
- Tube passes

  Specify the number of tube passes.
- Tube pass layout type

  This is the layout of the tubes for four or more passes.
- Impingement protection type

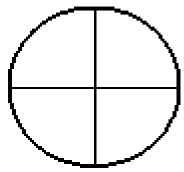
  The purpose of impingement protection is to protect the tubes directly under the inlet nozzle by deflecting the bullet shaped flow of high velocity fluids or the force of entrained droplets.
- Outer tube limit diameter

  The outer tube limit (OTL) is the diameter of the circle beyond which no portion of a tube will be placed. If you specify an OTL, the program determines the maximum number of tubes that will fit. If no OTL is specified, the program calculates the OTL based upon the specified shell diameter and TEMA standard bundle clearances. By default the program calculates the OTL.
- Layout option

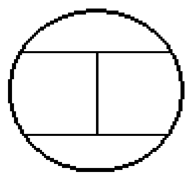
  You can select to have the program generate a new tube layout for each run (default), or you can select to use an existing layout. For the second option, you must first run Teams to establish a layout and then select the option to use the existing layout for all subsequent runs.

Tube Pass Layout Type

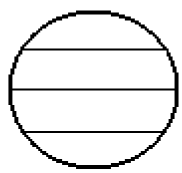
There are several possible ways to layout tubes for four or more passes.



Quadrant layout has the advantage of usually (but not always) giving the highest tube count. It is the required layout for all U-tube designs of four or more passes. The tube side nozzles must be offset from the centerline when using quadrant layout. The program automatically avoids quadrant layout for shells with longitudinal baffles and 6, 10, or 14 pass, to avoid having the longitudinal baffle bisect a pass.



Mixed layout has the advantage of keeping the tube side nozzles on the centerline. It often gives a tube count close to quadrant and sometimes exceeds it. The program automatically avoids mixed layout for shells with longitudinal baffles and 4, 8, 12, or 16 passes.



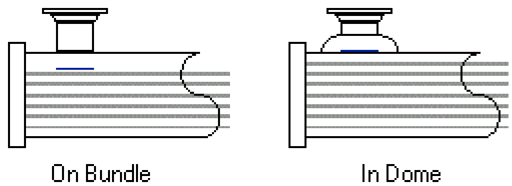
Ribbon layout nearly always gives a layout with fewer tubes than quadrant or mixed layout. It is the layout the program always uses for an odd number of tube passes. It is also the layout preferred by the program for X-type shells. The primary advantage of ribbon layout is the more gradual change in operating temperature of adjacent tubes from top to bottom of the tubesheet. This can be important when there is a large change in temperature on the tube side, which might cause significant thermal stresses in mixed and quadrant layouts.

Default: program will optimize

Impingement Protection Type

The purpose of impingement protection is to protect the tubes directly under the inlet nozzle by deflecting the bullet shaped flow of high velocity fluids or the force of entrained droplets. TEMA recommends that inlet impingement protection be installed under the following conditions:

- when the rho*V^2 through the inlet nozzle exceeds 2232 kg/(m*s^2) or 1500 lb/(ft*s^2) for non-corrosive, non-abrasive, single phase fluids
- when the rho*V^2 through the inlet nozzle exceeds 744 kg/(m*s^2) or
- 500 lb/(ft*s^2) for corrosive or abrasive liquids
- when there is a nominally saturated vapor
- when there is a corrosive gas
- when there is two phase flow at the inlet



If you choose a **plate on the bundle** the program automatically removes tubes under the inlet nozzle so that the shell entrance area equals the cross-sectional area of the nozzle. This is approximately equal to removing any tubes within a distance of 1/4 the nozzle diameter under the center of the nozzle. The program default uses a circular impingement plate equal in diameter to the inside diameter of the nozzle, and approximately 3 mm or 1/8 in. thick.

An alternative is to put a **plate in a nozzle dome**, which means suspending the impingement plate in an enlarged nozzle neck, which may be a dome or a cone.

Details/Pass Partitions Sheet

Use this sheet to specify tubesheet layout details and pass partitions details.

You can specify these **tubesheet layout details**:

- Max deviation per pass in percent

  The program defaults to 5% maximum deviation per pass when calculating how many tubes can fit in a given pass.
- Degree of symmetry

  If specified, the program will attempt to put the same number of tubes per pass. If not specified, the program will optimize as many tubes as possible in a given configuration.
- Min U-bend Diameter

  The program default is 3 times the tube OD.

You can specify the following detailed information about the **pass partitions**:

- Pass partition lane clearance
- Allowable pressure drop across the partition plate
- Pass partition corrosion allowance
- Front (top) pass partition plate thickness
- Front head pass partition rib length and width
- Pass partition dimension ‘a’ and pass partition dimension ‘b’ (TEMA standards).

Tie Rods/Spacers Sheet

Use this sheet to specify tie rod and tie rod spacer information.

You can specify the following **tie rod** information:

- Number of tie rods
- Diameter and length of the tie rod
- Tie rod material

You can specify the following for the information for the tie rod **spacers**:

Number of spacers

Diameter and thickness of the spacer

Spacer material

Drawing Sheet

Once you have run the Teams program and have mechanical design results, you can interactively make modifications to the tube layout.

Tubes: Tubes can be removed from the layout by clicking on the tube to be removed (tube will be highlighted in red) and then selecting the red X in the menu. If you want to designate a tube as a plugged tube or as a dummy tube, click on the tube (tube will be highlighted in red) and then select the plugged tube icon or dummy tube icon from the menu.

Tie Rods: To remove a tie rod, click on the tie rod (tie rod will be highlighted in red) and then select the red X in the menu. To add a tie rod, select the add a tie rod icon in the menu and then specify the location for the tie rod.

Sealing Strips: To remove a sealing strip, click on the sealing strip (sealing strip will be highlighted in red) and then select the red X in the menu. To add a sealing strip, select the add a sealing strip icon in the menu and then specify the location for the sealing strip. Once you have completed your changes to the tube layout, you may want to elect to fix the layout for subsequent Teams runs by selecting the "Use existing layout" option located on the Tubesheet Layout tab.

Nozzles General

Shell Side & Tube Side Nozzles Sheets (General)

Use the Shell Side sheet and Tube Side sheet to specify the following information:

- Nozzle flange design

  Select the design. ISO or DIN standards can be referenced. Also an optimized, program calculated flange, may be selected.
- Nozzle elevation above vessel wall

  Specify the nozzle elevation from vessel centerline to face of nozzle.
- Couplings on nozzles

  Select number of couplings to be provide in each nozzle. The default is TEMA standards.
- Nozzle flange rating

  Select the flange rating. The default is to select a flange rating in accordance with the applicable specified code.
- Nozzle flange type

  Select the nozzle flange type from the list. The default is slip on type.
- Code flange type

  For code calculated flanges, select a flange type for the optimized nozzle flange.
- Nozzle flange facing

  Select raised or flat face type. The default is flat face.
- Code flange face type

  Select facing type for a calculated nozzle flange. The default is a flat facing.

Nozzles & Couplings Sheets

Use the Nozzles sheet and Couplings sheet to specify the following information:

- Name

  Specify the identification of each nozzle for the drawings and text output. Program default starts with the letter A through J.

- Description

  You can provide a description for each nozzle that will appear in the text output.
- Function

  Select the function of nozzle, such as inlet, outlet, vent, drain. Note that by identifying the inlet nozzles, the program locates impingement plates if one has been specified.
- Type

  For couplings only, select the coupling design rating.
- Diameter

  Specify the nominal diameter of nozzle. If actual diameters are specified, the program selects the closest standard nozzle diameter per the applicable code. Program determines actual diameter from the application pipe standards.
- Location

  Specify a zone location for the nozzle or coupling. This is an approximate location from which the program will calculate the actual dimensional location. Specify a general zone location for the nozzle, zones 1 and 2 for front head nozzles, zones 3 through 7 for shell nozzles, and zones 8 and 9 for rear head nozzles. Nozzles should be located in accordance with the TEMA type of shell that you have selected. Note that the specified zone locations override standard TEMA locations.
- Angle

  Specify the angle location. For example a nozzle located at the 45 degree points (i.e. 0, 45, 90, 135 ….) will be oriented radially to the cylinder. All other angles result in the nozzle being located hill side on the cylinder.

Domes/Distributor Belts Sheet

Use this sheet to specify dome and distributor belt information. In design mode, the program will calculate (or use defaults) for the following dome/distributor information, if program is selected.

- Dome type

  Select the type of dome: ellipsoidal (default), torispherical, conical, or distributor belt.
- Dome diameter

  Specify the outside diameter of the dome cylinder.
- Dome location

  Specify the zone location for the dome at the same location as the location for the attaching nozzle.

- Dome angle

  Specify the angle for the dome as the same for the attaching nozzle.
- Dome thickness

  Specify the thickness for the dome. The default is program calculated.
- Dome cylinder thickness

  Specify the thickness for the cylinder attached to the dome. The default is program calculated.
- Dome attachment type

  Select the weld attachment type to vessel. The default is program selected.
- Reinforcing pad

  If pad is to be provided, specify the OD and thickness. The default is added by program if required.
- Weld leg

  Weld size for the dome to vessel attachment weld. The default is program calculated.
- Distributor belt type

  Select type from ASME appendix 9.
- Knuckle radius

  Specify the knuckle radius for flanged and flued type distributor belt. The default is program selected.

If you are running in the check rating mode, specify the information required, as applicable.

Nozzle Details

Nozzle Cylinders/Re-Pads Sheet

Use this sheet to specify nozzle cylinder and nozzle reinforcing pad details. In design mode, the program calculates (or uses defaults) for the following information.

- nozzle cylinder thickness
- nozzle reinforcing pad OD
- nozzle reinforcing pad thickness
- nozzle reinforcing pad parallel limit

In check rating mode, specify the nozzle-related information, as applicable.

Nozzle Projection/Elevation/Distances Sheet

Use this sheet to specify the nozzle projection, elevation, and distances details. In design mode, the program calculates (or uses defaults) for the following nozzle detail information:

- Type attachment

  Select the type of nozzle attachment to the vessel from the list
- Weld leg height, Nozzle

  Specify the weld leg height at the nozzle attachment to the cylinder at the outside surface.
- Weld leg height, Internal Projection

  Specify the weld leg height of the nozzle attachment to the vessel cylinder at the nozzle projection into the vessel.
- Weld leg height, Re Pad

  Specify the weld leg height at the reinforcement pad.
- Projection

  Specify the projection of the nozzle into the vessel from the inside surface. The program default is having the nozzles flush with the inside vessel surface.
- Elevation

  Specify the distance the nozzle extends beyond the vessel OD. The elevation above the vessel wall defaults to a minimum of 6" (152 mm). The user can enter values to clear the thickness of insulation, if present.
- Distance from nozzle centerline, Gasket

  Specify the distance from nozzle center line to from tubesheet gasket face.
- Nozzle distance from nozzle centerline head

  Specify the distance from nozzle center line to centerline of front head nozzles.
- Offset distance, Nozzle

  As an alternate to specifying the angle location for an offset nozzle (Nozzles-General form, Nozzles sheet), you can specify the offset distance from the nozzle centerline tot he vessel centerline.

In check rating mode, specify the nozzle-related information, as applicable.

Nozzle Flanges & Nozzle Clearances Sheets (Details)

Use the Nozzle Flanges sheet and the Nozzle Clearances sheet to specify the nozzle flanges details. In design mode, the program calculates (or uses defaults) for the following information:

- Nozzle flange standard

  The nozzle flanges can be designed or selected from standards.

- Nozzle flange type

  The nozzle flange types in ASME follow the ANSI B16.5 standard including long weld neck types (thicker necks).

- Nozzle flange rating

  You can select a flange rating or allow the program to determine the appropriate rating based on materials of construction and the design pressure and temperature of the flanges per applicable standards (ANSI, DIN, or AFNOR). The default is to allow the program to determine flange rating per applicable standards.

- Nozzle face

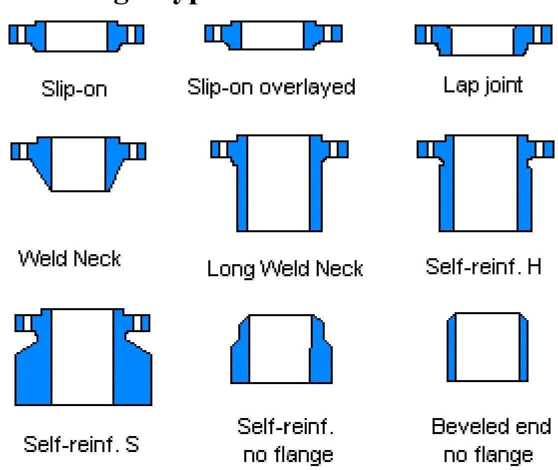
  Select the nozzle facing type. The default is flat face.

- Nozzle clearances

  Specify minimum clearances for nozzles to flanges and tubesheets. The default is one nozzle diameter.

In check rating mode, specify the nozzle-related information, as applicable.

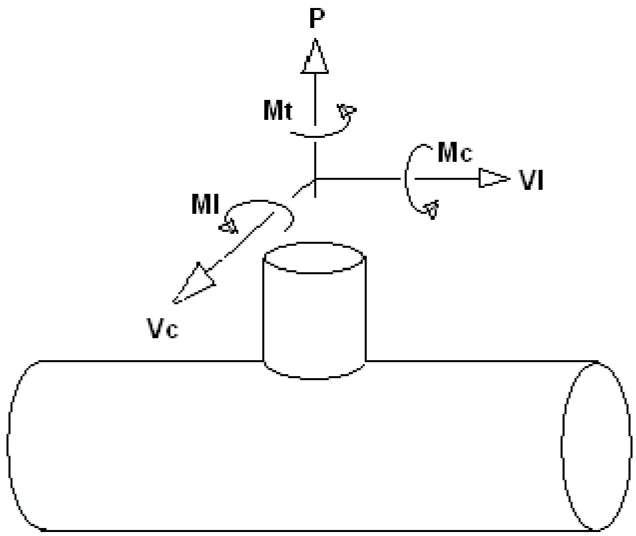
Nozzle Flange Type



The nozzle flange types in ASME follow the ANSI B16.5 standard, including long weld neck types (thicker necks). If you do not want separate reinforcing plates, self-reinforced nozzle styles 'H' and 'S' are also available. Style 'S' provides a thicker neck at the junction to the vessel than style 'H' which also provides a thicker neck than a long weld neck.

External Loads Sheet

Use this sheet to specify external loads and moments information. In design mode, the program calculates (or uses defaults) for the following nozzle detail information:



In the check rating mode, specify the nozzle-related information, as applicable.

Nozzle external loads: To evaluate external piping loads to WRC-107, enter loads and moments as indicated.

Horizontal Supports

Horizontal Sheet

Use this sheet to specify:

- Support type - horizontal

  The program analyzes the shell stresses caused by supports in both the horizontal (saddles). For saddles the program uses the method developed by L.P.Zick. When this method indicates an over-stressed condition, the program warns the user. Typical locations and angle for saddles are 4 and 6 and 180 degrees. Other angles are only used for stacked exchangers (zero degrees). Calculation methods for supports for stacked exchangers are not yet available.

  Saddles   Stacked units on saddles

- Saddle support A location

Specify general zone (zones 3 or 4) location for the front saddle support.

- Saddle support B location

  Specify general zone (zones 6 or 7) location for the rear saddle support.

- Saddle support location angle

  Specify angle location for the saddle supports (180 degrees for bottom supports or 0 degrees for top support with stacked units).

- Distance from face of front tubesheet to bolt hole in support A

  You can specify the actual dimensional location of the front support from the front tubesheet.

- Distance from face of front tubesheet to bolt hole in support B

  You can specify the actual dimensional location of the rear support from the front tubesheet

- Distance from bolt hold in support A to nearest stiffening element

  This will define the nearest shell stiffening element to be considered in the Zick support analysis.

- Distance from bolt hold in support B to nearest stiffening element

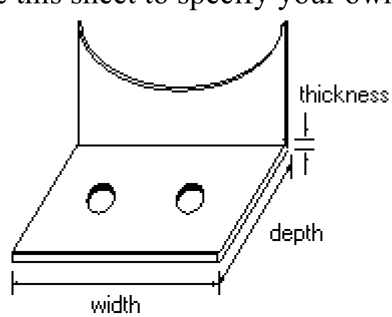
  This will define the nearest shell stiffening element to be considered in the Zick support analysis.

- Load on Saddles

  You can specify dead weight loads for the Saddle 'A' and Saddle 'B' supports. Program uses these values in lieu of the calculated loads based on the full weight of the vessel.

Details Sheet

Use this sheet to specify your own design for the saddle supports.

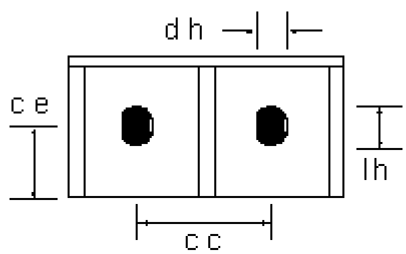


Saddle to shell angle of contact	The angle of contact is normally set at 120 degrees.

Support elevation	This is the projection of the saddle support from the vessel centerline.
Wear plate thickness	Plate thickness varies from 0.25 inches up to the thickness of the shell cylinder. Program defaults to no wear plate.
Base plate thickness	The normal thickness ranges from 0.5 inches to 2 inches.
Base plate width	Any width is accepted up to the diameter of the shell.
Base plate depth	The normal depth is from 4 inches to 12 inches.

Gussets/Bolts Sheet

Use this sheet to specify the gussets and bolt hole information for your design.



Gusset thickness	Gusset thickness ranges from 0.375 inch to 1 inch.
Gusset number per support	Ranges from one to four gussets.
Gusset direction	Supports opened towards the center of the vessel or outward towards the ends of the vessel.
Bolt holes diameter (dh)	Size ranges from 0.625 inch to 3 inch allowing for 1/8 inch clearance to bolt diameter.
Bolt distance edge to x axis (ce)	Allow a minimum of 2 times the bolt hole size.
Bolt center to center distance (cc)	Any dimension less than the diameter of the vessel.
Bolt slot length (lh)	Generally the slot is 2 times the bolt hole diameter.
Bolt quantity	Normal ranges from 2 to 8 bolts.

Stacked Units Sheet

Use this sheet to specify the number of stacked exchangers, up to four units.

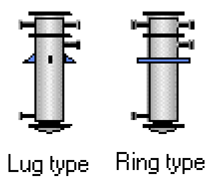
The detailed drawings include a sketch showing the stacking arrangement for the exchangers. However, you will need to evaluate the vessel support design for base and intermediate supports.

Note that it is possible to input a total weight for the stacked exchangers, and the program will design the base support using this total weight. The program also uses the base support design for the intermediate supports.

Vertical Supports

Vertical Sheet

Currently the program provides a design for vertical lug type supports. The program analyzes the shell stresses caused by vertical (lugs) positions. For vertical lug supports the program will calculate the required lug weld height to avoid over-stressing the shell. Calculations methods for (3) vertical ring supports are not yet available.



Use this sheet to specify the following vertical support information:

- Support type- vertical

  Specify type of vertical vessel support type. From two to four lug type supports can be specified. The vertical ring type is a single continuous ring around the shell. Calculations for the ring type are not yet available.

- Support location- vertical

  Specify general zone location (zones 3 through 7) for the support.

- Distance from tubesheet to support

  Specify the distanced from the tubesheet to the bolt hole in the support.

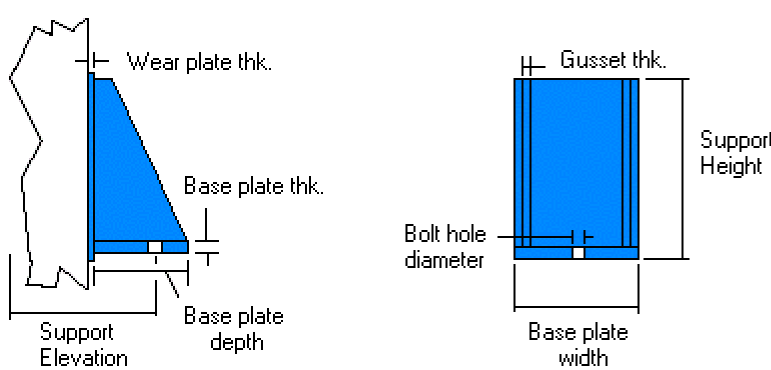
- Vertical Support angles

  Specify the angle location for the lug type supports, for example, 180 degrees apart for two lugs and every 45 degrees for 4 lugs.

Lugs Sheet

Use this sheet to specify your own design details for the saddle supports:

Wear plate thickness	Plate thickness varies from 0.25 inches up to the thickness of the shell cylinder. Program defaults to no wear plate.
Base plate thickness	Normal thickness ranges from 0.5 inches to 2 inches.
Base plate width	Any width is accepted up to the diameter of the shell.
Base plate depth	Normal depth is from 4 inches to 12 inches.
Gusset thickness	Gusset thickness ranges from 0.375 inch to 1 inch.
Gusset number per support	The number ranges from one to four gussets.
Bolt holes diameter	Diameter size ranges from 0.625 inch to 3 inch, allowing for 1/8 inch clearance to bolt diameter.
Bolt distance edge to x axis	Allow a minimum of 2 times the bolt hole size.
Bolt center to center distance	Specify any dimension less than the diameter of the vessel.
Bolt quantity	Quantity ranges from 2 to 8 bolts.



Lift Lugs

Lift Lugs Sheet

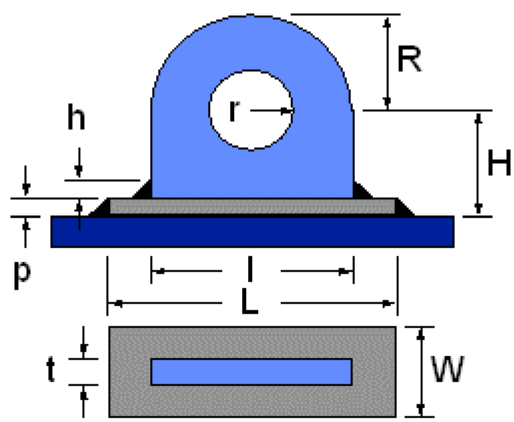
Use this sheet to specify the following information:

Lifting Lugs type	Lug type is plate type.
Number to lift the whole unit	Specify number of unit lifting lugs required.
Location and Angle of each Lug	Specify the zone location and angle for each lug.
Lifting Lugs Material	Specify material for lug.
Lifting Lugs Re-pad material	Specify the reinforcement pad material.

Lift Lugs Geometry Sheet

Use this sheet to specify the lug geometry:

h	Weld height of the attachment weld
l	Length of the attachment weld to the vessel
p	Thickness of reinforcement pad
r	Radius of lug hole
t	Thickness of the lug
H	Height from vessel wall to centerline of hole
L	Length of reinforcement pad
R	Radius of lug at top
W	Width of reinforcement pad



Materials

Material Specifications Sheet

Use this sheet to specify materials for required components. You can use the generic material types such as carbon steel (default), and the program will assign actual default material specifications depending on the product form.

For carbon steel plate, a material specification of SA-516-70 is used for an ASME design. Appropriate specifications are selected for other design construction codes.

To search for a specific material specification, click the **Search Databank** button. Type the first few characters to search for a material in the databank. Click the **Advanced** tab to view additional detailed information about the materials in the database.

The Advanced search mode is especially useful to view special ASME material notes. ASME, per the 2002 addendum, allows higher secondary stress limits if (a) the allowable stress for the material is not governed by time-dependent properties as stated in the notes, (b) the ratio of minimum yield to minimum tensile, at room temperature, is less than 0.7, (c) the yield strength at temperature is available from Table Y-1of Section II, Part D.

You can use the DefMats utility to change the default materials.

Normalized Materials Sheet

Use this sheet to specify that all carbon steel materials be normalized per Fig. UCS-66. The program default is to normalize materials when required by the applicable design code.

Nozzle Materials Sheet

Use this sheet to specify nozzle materials for required components. The materials specified here apply globally. You can use the generic material types such as "carbon steel" which the program will assign an actual default material specifications depending on the product form. For carbon steel pipe material, a material specification of SA-106-B will be used for an ASME design. Appropriate specifications will be selected for other design construction codes.

To search for a specific material specification, click the **Search Databank** button. Type the first few characters to search for a material in the databank.

You can use the **DefMats** utility to change the default materials.

Default: carbon steel

Nozzle Individual Materials Sheet

Use this sheet to specify materials for specific nozzles. Any materials specified on this sheet override global settings.

Identify each nozzle for the drawings and text output. The program default starts with the letter A through H. For each nozzle specify:

- The nominal pipe size for the diameter.

  If actual diameters are specified, the program selects the closest standard nozzle diameter per the applicable code. Program determines the actual diameter from the application pipe standards.
- Generic or actual material specification for the cylinder material, nozzle reinforcing pad material, flange, gasket, and bolting.

  If not specified, the program sets the materials to the default, carbon steel.

You can use the generic material types such as "carbon steel" and the program will assign actual default material specifications depending on the product form. For carbon steel pipe, a material specification of SA-106-B will be used for an ASME design. Appropriate specifications will be selected for other design construction codes.

To search for a specific material specification, click the **Search Databank** button. Type the first few characters to search for a material in the databank.

You can use the **DefMats** utility to change the default materials.

Dome/DB Materials Sheet

Use this sheet to specify the dome and distributor belt formed and cylinder materials and dome reinforcement material. Enter the material in the same order as the nozzles on the domes.

To search for a specific material specification, click the **Search Databank** button. Type the first few characters to search for a material in the databank.

Couplings Materials Sheet

Use this sheet to specify the shell side and tube side couplings material.

To search for a specific material specification, click the **Search Databank** button. Type the first few characters to search for a material in the databank.

Program Options

External Loads/Code Cases Sheet

Use this sheet to specify the external nozzle attachments loads, and they will be analyzed per the Welding Research Council Bulletin, WRC-107. If the nozzle loads are not known but you need the allowable loads based upon your final design, select the Heat Exchange Institute, HEI, method for external nozzle loads and the allowable loads will be calculated.

Wind Loads Sheet

Use this sheet to specify the following wind load information:

- Vessel effective length and diameter
- Velocity pressure exposure coefficient
- Topographic factor, Kzt
- Importance Factor
- Basic wind speed
- Gust response factor
- Force coefficient
- Moment arm

Wind loads are analyzed per ANSI/ASCE 7-95. The default is 160 km/hr (100 mph) wind load

To apply the wind loads to the supports, click the **Seismic Loads** tab, and select **Yes** to **Apply wind and seismic loads to supports**.

Seismic Loads Sheet

Use this sheet to specify the following seismic load information:

- Seismic effective vessel length/height
- Seismic zone coefficient, Cv
- Seismic building period coefficient, CT
- Seismic response modification factor, R
- Seismic loads are evaluated per ANSI/ASCE 7-95. The default is zone 1.

To apply wind and seismic loads to vessel supports analysis, select **Yes**. By default external loads not applied to supports.

Weights Sheet

Use this sheet to specify exchanger weights. The weights specified here:

- Override the program calculated weights
- Are used for the vessel support analysis
- Appear on the drawings

The support analysis applies one half of the full weight to each support. If support loads have been specified in the vessel support sections, those loads override what is specified here.

If weights for accessories or attachments (interconnecting shell and tube side piping) are specified, they are used in the vessel support stress analysis.

When Insulation is required, the weight of the insulation is added to the total weight of the unit. If insulation is required but you did not specify the details for the insulation, Teams sets the thickness to 2.5" with a density of 8 Lb/ft3. If insulation thickness is specified, Teams checks and adjusts the nozzle projections to clear the insulation. The default is set to "no" insulation.

Shell side and tube side fluid densities are used for the determination of the liquid weight inside the exchanger. If no densities are specified, the density of water is used for weight calculations.

Drawings

Use the **Drawings** sheet to select the drawings to be generated when the program runs. You can also specify a title for the drawing number.

CODAP and AD Codes

If the vessel is being designed to CODAP or AD code, use the sheets of the CODAP and AD Codes form to define the necessary construction categories, safety factors, and design factors.

Change Codes

Using the Change Codes Form

Use the Aspen Teams Change Codes form to specify change codes with the associated values.

The format for change code entries is: CODE=value

Change codes are processed after all of the other input and override any previously set value. For instance, if you specify the tube outside diameter as 20 mm in the regular input screens, then enter the change code TODX=25, the 25 will override the 20. If you enter the same change code more than once, the last value will prevail.

Another good use of the change code screen is to "chain" to another file containing only change codes. This is especially convenient if you have a line of standard designs, which you want to use after you have found a similar solution in design mode.

To do this, use the FILE= change code, followed by the name of the file containing the other change codes. The other file must also have a .BJI filetype. You can create this change code file with a standard edit program.

For example, the entry FILE=S-610-2 would point to a file named S-610-2.BJI, which might contain the following data:

> SODX=610,TLNG=5000,TNUM=458,TPAS=2,BSPA=690,TODX=20,TPAT=1

These are the change codes that are available in the Aspen Teams program.

General Change Codes

These are the general change codes that are available in the Teams program:

Code	Description
bttk	baffle thickness
cfac	"C" factor in calculation of flat covers
coan	conical head angle (must be less than or equal to 30 degrees)
code	code requirement: 1=ASME, 2=CODAP, 3=AD/DIN
elra	radius of turn for 90 degree elbow
fcgw	front head cylinder girth butt welds present: 0=no, 1=yes
fhct	front head flat removable cover thickness
file	specify the name of a file which contains change codes
jess	joint efficiency for shell side cylinders for nozzle repad calcs
jets	joint efficiency for tube side cylinders for nozzle repad calcs
lang	language for input and output: 1=English, 2=French, 3=Spanish, 4=German, 5=Italian
meas	system of measure: 1=U.S., 2=SI, 3=metric
nodr	no drawings in TEAMS summary output: 0, 1=yes, 2=no
otlm	outer tube limit
rblf/rblr	total length of pass partition ribs in front/rear head
srmt/stf1	stiffening ring material / number of stiffening rings
rbwf	effective width of pass partition ribs in front head
rbwr	effective width of pass partition ribs in rear head
rcgw	rear head cylinder girth butt welds present: 0=no, 1=yes
rhct	rear head flat removable cover thickness
scgw	shell cover cylinder girth butt welds present: 0=no, 1=yes
scat	CODAP construction category shell side: 1=A, 2=B, 3=C, 4=D
shgw	shell girth butt welds present: 0=no, 1=yes
shje	shell joint efficiency (ASME)
sjef	CODAP joint efficiency on shell side (0.85 or 1)
sstp	shell side test pressure
ssto	shell side tolerance for plate
suts	tubesheet considered supported: 0=program, 1=yes, 2=no
tcat	CODAP construction category tube side: 1=A, 2=B, 3=C, 4=D
tjef	CODAP joint efficiency on tube side (0.85 or 1)
tkmn	determines if input thickness of pipe is: 0=nominal, 1=minimum
tsto	tube side tolerance for plate
tstp	tube side test pressure
tupr	distance tubes project from tubesheet
weir	option to eliminate weir in kettle (-1=no weir)
heat	carbon steel material normalized/tempered: 0=no, 1=yes

Cylinders & Covers Change Codes

These are the cylinders and covers change codes that are available in the Teams program:

	Front Head		Rear Head	
	cover	**cyl**	**cover**	**cyl**
thickness	fcot=	fcyt=	rcot=	rcyt=
outside diameter	fcod=	fcyd=	rcyd=	rcod=
length (+)	fcyl=		rcyl=	
ext.press.length	eln2=		eln3=	
ellip head ratio	fcer=		rcer=	
toris head dish r.*	fcdr=		rcdr=	
toris head k. rad.*	fckr=		rckr=	
over "hub" length	fhlg=		rhlg=	

	Shell	Shell	Cover
	cyl	**cyl**	**cover**
thickness	shth=	scyt=	scot=
outside diameter	scyd=	sccd=	scod=
length (+)	scyl=	sccl=	
ext.press.length (&)	eln2=	eln4=	
ellip head ratio	scer=		
toris head dish r.*	scdr=		
toris head k. rad.*	sckr=		
cover "hub" length	sclg=		

(+)=flange/ts face-to-face or weld

*=in percent of head diameter.

(&)=eln1 and stf1 should be issued together stf1=number of stiff.rings

	Eccentric Kettle		Vapor	Distr Belt A		Distr Belt B	
	Redcr	**Cyl**	**Belt**	**Cyl**	**Ann. Ring**	**Cyl**	**Ann. Ring**
thickness	erth=	keth=	vbth=	—	—	—	—
outside dia	—	keod=	vbod=	—	—	—	—
material	ermt=	kemt=	—	—	—	—	—
id/length	—	keid/ kcyl	—	—	—	—	—

Nozzles Change Codes

These are the nozzles change codes that are available in the Teams program.

Note that nozzle NZ*A items are for the first nozzle listed in the input, NZ*B changes are for the second nozzle, etc.

	Nozzle		Nozzle Dome		
	Cyl	**Reinf Pad**	**Redcr**	**Cyl**	**Reinf Pad**
thickness	nzta-j	zrta-j	nnta-j	ncta-j	nrta-j
outside dia	—	zrda-j	—	—	nrda-j
parallel limit	—	nzpa-j	—	—	—

Code	**Description**
nzxa thru nzxj	distance nozzle extends beyond inner surface of vessel
fnfa thru fnfj	BJAC facing type for nozzle flange (ASME 2-5-2) (value=1 to 9)
wnfa thru wnfj	width of nubbin for nozzle flange (ASME table 2-5-2)
nwld	increase nozzle to vessel weld leg to eliminate pad: 0=yes, 1=no
nplm	percent parallel limit for shell nozzle adjacent to tubesheet (0=100%)
nfct	clearance between tube nozzle flange and back side of flange (0=0.5")
nrtp	provide 100% metal replacement in pad: 0=no, 1=uncorroded, 2=corroded
rpmt	minimum reinforcing pad thickness
nrcl	clearance between reinf. pad weld and back of flange/tubesheet (0=2")
nccl	clearance between nozzle cyl. weld and back of flange/tubesheet (0=2")
nfcs	clearance between shell nozzle flange & front side of tubesheet (0=0.5")

Body Flanges Change Codes

These are the body flanges change codes that are available in the Teams program:

	Front Head		Rear Head	
	Cover	**at TbSh**	**at TbSh**	**Cover**
thickness	ffct=	fftt=	rftt=	rfct=
min bolt dia	fcmb=	ftmb=	rtmb=	rcmb=
facing type	fbfa=	fbfb=	fbff=	fbfg=
nubbin width	wbfa=	wbfb=	wbff=	wbfg=
confined joint(**)	fccj=	ftcj=	rtcj=	rccj=
gasket width	gawa=	gawb=	gawf=	gawg=
weld height	fwla=	fwlb=	fwlf=	fwlg=

	Shell		
	Front	**Rear**	**Cover**
thickness	fsft=	rsft=	scft=
min bolt dia	—	—	scmb=
facing type	fbfc=	fbfd	fbfe=
nubbin width	wbfc=	wbfd=	wbfe=
confined joint(**)	fscj=	—-	sccj=
gasket width	gawc=	gawd=	gawe=
weld height	fwlc=	fwld=	fwle=

**=(0=no, 1=yes)

fbft= front backing ring flange thickness

rbft= rear backing ring flange thickness

bolt= bolt type: 1=u.s., 2=metric

shnk= DIN bolt type: 1=waisted-shank, 2=rigid

sfdt= design temperature for shell side body flanges and bolting

tfdt= design temperature for tube side body flanges and bolting

Floating Head Flange Change Codes

These are the floating head flange change codes that are available in the Teams program:

Code	Description
fhft	floating head - flange thickness (recess not included)
fhid	floating head - flange inside diameter
fhdi	floating head - dish inside crown radius
fhdt	floating head - dish (or head) thickness
fhhr	floating head - dish lever arm(+ toward tube side/- toward shell side)
fhmb	floating head - minimum bolt outside diameter
fhbf	floating head - backing ring flange thickness (recess not included)
cifh	floating head - corrosion on the shell side of floating cover
fhtd	floating head - design temperature
rtcj	confined joint for rear head gasket at tubesheet: 0=no, 1=yes
fhnu	bjac facing type for inside flt. head flange (ASME 2-5-2) (value=1 to 9)
fhwi	width of nubbin for inside float. head flange (ASME table 2-5-2)
FHFL or BFLF	floating head - flange rating (FHFL or BFLF=1 for rating)
BRRE	IFH "S" type backing ring recess: 0=program, 1=none, 2=std., 3=angled

Tubesheets & Expansion Joint Change Codes

These are the tubesheets and expansion joint change codes that are available in the Teams program:

Code	Description
conv	number of convolutions
cycl	minimum expansion joint cycle life (TEMA default=2000 cycles)
diff	differential design pressure: 0=no, 1=yes
difp	actual diff. pressure
ejbe	bellows: 1=unreinforced, 2=reinforced
ejca	expansion joint corrosion all
ejfa	expansion joint straight flange - inner cylinder (TEMA fig. rcb-8.21) **

Code	Description
ejfb	expansion joint straight flange - outer cylinder (TEMA fig. rcb-8.21) **
ejod	expansion joint outside diameter
ejra	expansion joint knuckle radius at inside junction (TEMA fig. rcb-8.21)
ejrb	expansion joint knuckle radius at outside junction (TEMA fig. rcb-8.21)
ejrm	bellows reinforcement material
ejth	expansion joint thickness (TEMA "te" fig. rcb-8.21)
ejtp	expansion joint type: 91=f*f 92=flanged only 93=bellows
ejwi	expansion joint width (TEMA 2*"lo" fig. rcb-8.21) **
ftsa	fixed tubesheet attachment: 1=backing strip, 2=land, 3=stub
ftsc	front tubesheet clad thickness
**	if -1 is entered, value will be zero in calculations
ftst	front tubesheet thickness
octh	expansion joint outer cylinder thickness (TEMA "to" fig. RCB-8.21)
rtsc	rear tubesheet clad thickness
rtst	rear tubesheet thickness
tsco	fixed tubesheet standard selection: 0=program 1=ASME 2=TEMA
xjsr	expansion joint spring rate - new
xsrc	expansion joint spring rate - corroded

** = if -1 is entered, value will be zero in calculations.

Supports Change Codes

These are the supports change codes that are available in the Teams program:

Code	Description
angc	saddle-to-shell angle of contact (100 to 170 deg)
	increasing angc will reduce all stresses except bending at midspan
satw	saddle transverse width - reciprocal of angc
stda	distance from face of front tubesheet to first saddle (a)

Code	Description
stdb	distance from face of front tubesheet to second saddle (b) placing saddle closer to respective tubesheet will decrease bending stress at saddle but increase both bending at midspan and shell tangential shear (unstiffened by head or flange/tubesheet)
salw	saddle longitudinal width
wptk	wear plate thickness (saddles and lugs) -1 = no plate increasing both salw or wptk will reduce both circumferential stress at horn of saddle and ring compression over saddle if the saddle is located further than a/r=0.5 the vessel thk. Will not include the wear plate in the calculation of the circum.stress
lugt	vertical lug thickness (base plate and gussets)
lugh	vertical lug height

Dimensions Change Codes

These are the dimensions change codes that are available in the Teams program:

Code	Description
nzel	elevation of nozzles from the centerline of the vessel
nzla thru nzlj	nozzle elevation from the centerline of the vessel
stla thru stld	support elevation from centerline of vessel
nzda thru nzdj	distance of nozzle center from front face of front tubesheet
xjda thru xjdc	distance of expansion joint from front face of front tubesheet
stda thru stdd	distance of support from front face of front tubesheet
cpda thru cpdj	distance of coupling from front face of front tubesheet
rfpt	drawing reference point. 0,1=face of front TS 2=centerline front head nozzle

Teams Results

The reported Results are divided into six sections:

- Input Summary
- Design Summary
- Vessel Dimensions
- Price
- Drawings
- Code Calculations

Input Summary

The Input Summary contains three sections:

- Basic Data/ Fittings/Flanges
- Cylinders/Covers/Tubesheets
- Materials/Lift Lugs/Partitions

Basic Data/Fittings/Flanges

This part of the input file summary includes information on:

- Description/Codes and Standards
- Design Specifications
- Geometry
- Tubesheet/Tubes
- Baffles/Tube Layout
- Supports -Horizontal/Vertical
- Nozzles
- Nozzle Cyl/Re-pads
- Flanges
- Flange Misc.

Cylinders/Covers/ Tubesheets Details

This part of the input file summary provides the detailed input information on:

- Cylinders
- Front Head Details
- Rear Head Details
- Front Head Cover
- Front Head Cover Details
- Rear Head Cover
- Rear Head Cover Details

- Shell Cylinder
- Tubesheets Details
- Expansion Joint Details
- Shell Cover

Materials/Lift Lugs/Partitions

This part of the input file summary includes information on:

- Main Materials
- Nozzle Global Materials
- Nozzle Specific Materials
- Domes/Coupling Materials
- Lift Lug Details
- Pass Partitions
- Tie Rods and Spacers
- Nozzle Clearances

Design Summary

The Design Summary contains five sections:

- Warnings & Messages
- Design Specifications/Materials
- Overall Dimensions/Fitting Locations
- MDMT/MAWP/Test Pressure

Warnings & Messages

Aspen B-JAC provides an extensive system of warnings and messages to help the designer of heat exchanger design. Messages are divided into five types. There are several hundred messages built into the program. Those messages requiring further explanation are described here.

Warning Messages: These are conditions, which may be problems, however the program will continue.

Error Messages: Conditions which do not allow the program to continue.

Limit Messages: Conditions which go beyond the scope of the program.

Notes: Special conditions which you should be aware of.

Suggestions: Recommendations on how to improve the design.

Design Specifications

This is intended to be a concise summary of the design requirements, including calculated design information such as weights and nozzle flange ratings. The codes in effect are clearly shown indicating applicable date of issue.

Materials of Construction

Provides a summary of materials used in the design for all major components. For example:

Component	Material Name
Shell Cylinder	SA-516 Gr 70 Steel Plt
Front Head Cylinder	SA-516 Gr 70 Steel Plt
Rear Head Cylinder	SA-516 Gr 70 Steel Plt
Front Head Cover	SA-516 Gr 70 Steel Plt
Rear Head Cover	SA-516 Gr 70 Steel Plt
Front Tubesheet	SA-516 Gr 70 Steel Plt
Rear Tubesheet	SA-516 Gr 70 Steel Plt
Front Head Flange At TS	SA-516 Gr 70 Steel Plt
Rear Head Flange At TS	SA-516 Gr 70 Steel Plt
Front Head Flange At Cov	SA-516 Gr 70 Steel Plt
Front Head Gasket At TS	Flt Metal Jkt Asbestos Soft Steel
Rear Head Gasket At TS	Flt Metal Jkt Asbestos Soft Steel
Front Head Gasket At Cov	Flt Metal Jkt Asbestos Soft Steel
Tubes	SA-214 Wld C Steel Tube
Baffles	SA-285 Gr C Steel Plt
Tie Rods	SA-36 Bar
Spacers	SA-214 Wld C Steel Tube
Shell Support A	SA-285 Gr C Steel Plt
Shell Support B	SA-285 Gr C Steel Plt
Nozzle A	SA-106 Gr B Sml Steel Pipe
Nozzle B	SA-106 Gr B Sml Steel Pipe
Nozzle C	SA-106 Gr B Sml Steel Pipe
Nozzle D	SA-106 Gr B Sml Steel Pipe
Nozzle Flange A	SA-105 Carbon Steel Forg
Nozzle Flange B	SA-105 Carbon Steel Forg
Nozzle Flange C	SA-105 Carbon Steel Forg
Nozzle Flange D	SA-105 Carbon Steel Forg
Nozzle Reinforcement A	SA-516 Gr 70 Steel Plt
Nozzle Reinforcement B	SA-516 Gr 70 Steel Plt
Nozzle Reinforcement C	SA-516 Gr 70 Steel Plt
Nozzle Reinforcement D	SA-516 Gr 70 Steel Plt
Front Hd Bolting At TS	SA-193 B7 Steel Blt
Rear Hd Bolting At TS	SA-193 B7 Steel Blt
Front Hd Bolting At Cov	SA-193 B7 Steel Blt
Expansion Joint	SA-516 Gr 70 Steel Plt
Nozzle Flange Bolting A	SA-193 B7 Steel Blt

Component	Material Name
Nozzle Flange Bolting B	SA-193 B7 Steel Blt
Nozzle Flange Bolting C	SA-193 B7 Steel Blt
Nozzle Flange Bolting D	SA-193 B7 Steel Blt
Nozzle Flg Gasket A	Flt Metal Jkt Asbestos Soft Steel
Nozzle Flg Gasket B	Flt Metal Jkt Asbestos Soft Steel
Nozzle Flg Gasket C	Flt Metal Jkt Asbestos Soft Steel
Nozzle Flg Gasket D	Flt Metal Jkt Asbestos Soft Steel
Shell Side Nozzle Cplgs	SA-105 C Steel Coupl
Tube Side Nozzle Cplgs	SA-105 C Steel Coupl

Overall Dimensions

Overall dimensions are calculated as well as intermediate component lengths. These dimensions will also be shown on some of the TEAMS drawings, such as the setting plan and sectional drawing.

The dimensions shown are:

- Overall front head assembly
- Front Tubesheet
- Tubesheet thickness
- Tube side recess
- Shell side recess
- Welding stub end(s)
- Cladding Thickness
- Shell
- Rear Tubesheet
- Tubesheet thickness
- Tube side recess
- Shell side recess
- Welding stub end(s)
- Cladding Thickness
- Overall rear head assembly
- Overall shell cover assembly
- Unit overall length

Fitting Locations

All fittings are located from two reference points: distance from the front tubesheet and distance from the front head nozzle. These dimensions will also appear on Aspen TEAMS setting plan drawings.

If any nozzles are offset from the vessel centerline, the amount of the offset will also be indicated.

Center of Gravity

A general center of gravity is calculated based on each component weight. This reference point can be used when preparing for vessel installation and for proper anchoring during movement.

MDMT

Minimum Design Metal Temperatures are set based upon the lowest operating temperature the pressure vessel will encounter. Material specifications, impacting testing, and PWHT should be selected that will meet the MDMT requirements per the applicable design construction code.

Controlling Component

The program will examine each component separately and calculate its minimum design metal temperature without having to impact test the material. An "*" indicates the controlling component (the one with the highest temperature).

By changing material specifications or testing the component the user can lower the minimum design metal temperature to a desired value.

The ASME Code has many rules on this subject (such as those presented in UG-20(f)) so it is recommended to use additional judgment and experience when deciding on the minimum design metal temperature for a vessel.

MAWP

The Maximum Allowable Working Pressure is the maximum pressure that the vessel may encounter and not have any component's pressure stress exceed the allowable design stress value per applicable design code.

Controlling Component

The program will calculate the maximum allowable working pressure (MAWP) for each component of the vessel. The one with the lowest pressure will be selected as the controlling component and marked with a "*" for the shell side and a "+" for the tube side.

Two sets of pressures are selected:

- One for design conditions (corroded at design temperature)
- One for "new and cold" conditions (uncorroded at ambient temperature)

If you want to redesign the equipment using the MAWP, you should change the input data to rating mode. In some cases when the tubesheet controls the MAWP, it will not be possible to design the equipment using the MAWP, because the tubesheet calculation may yield a new MAWP. This occurs because the program uses the ASME design method, which is dependent not only on the tubesheet geometry but also on the shell and channel geometries as well as different operating cases, such as thermal stresses only, pressure and thermal stresses concurrently, etc. As the design pressure changes, other parameters may control the overall MAWP resulting in a different number.

Test Pressure

The program per the applicable design construction code calculates test pressures for the unit.

PWHT

Post weld heat treatment is performed if required by the applicable design code or as specified by the user in the input.

Vessel Dimensions

The Vessel Dimensions Section is subdivided into six sections:

- Cylinders & Covers
- Nozzles/Nozzle Flanges
- Flanges
- Tubesheets/Tube Details
- Expansion Joint
- Supports/Lift Lugs/Wind & Seismic Loads

Cylinders & Covers

This section reports the following calculated design dimensions:

- Thickness

  Cylinders and covers are shown with actual thicknesses selected as well as calculated minimum required thicknesses for both internal as well as external pressure. If a TEMA standard was selected, the program also displays the minimum TEMA thickness based on materials of construction, the TEMA class and the vessel diameter.
- Radiography

  Code rules are followed for the three typical radiography options: no radiography, spot and full. The program displays the value for the joint efficiency used in the design formulas. In many cases, the program automatically increases the radiography required based on the component calculated thickness per applicable code rules.
- External Pressure

  The external pressure summary provides limits of design for pressure, thickness and length. You can clearly identify which standard controls the actual thickness selected. If reinforcement rings are required for the shell cylinder, the maximum length is shown for ring placement.

- Kettle Cylinder/Distributor Belt Thickness

  Cylinders and covers are shown with actual thicknesses selected as well as calculated minimum required thicknesses for both internal as well as external pressure. If a TEMA standard was selected, the program also displays the minimum TEMA thickness based on materials of construction, the TEMA class and the vessel diameter.
- Kettle Cylinder/Distributor Belt Radiography

  Code rules are followed for the three typical radiography options: no radiography, spot and full. The program displays the value for the joint efficiency used in the design formulas. In many cases, the program automatically increases the radiography required based on the component calculated thickness per applicable code rules.
- Kettle Cylinder/Distributor Belt External Pressure

  The external pressure summary provides limits of design for pressure, thickness and length. You can clearly identify which standard controls the actual thickness selected. If reinforcement rings are required for the shell cylinder, the maximum length is shown for ring placement.

Nozzles/Nozzle Flanges

This section reports the following calculated design dimensions:

- Nozzles

  Cylinder and nozzle reinforcement calculation results are summarized. Nozzles are shown one per column identifying the side where the opening is located (shell or tube side) as well as the outside diameter and corresponding thicknesses.
- Reinforcement

  The neck cylinder wall thickness is determined following the code rules. The reinforcement requirements follow, depending on the availability of metal around the opening including excess vessel and nozzle neck wall thickness and welds. If a reinforcing pad is necessary, the program will select one. The program optimizes the reinforcement calculation by first trying to avoid the use of a pad by increasing the nozzle weld size and then by selecting the thinnest possible pad that complies with the code. You can change all nozzle and reinforcement dimensions. For example, you can eliminate a pad by increasing the nozzle neck thickness.
- Nozzle Flanges

  Nozzle flanges can be calculated or selected from standards (for example ANSI B16.5). The program determines which flange is acceptable based on materials of construction and design pressure and temperature. Typical ANSI classes are 150, 300, 600, 900 and 1500 in a variety of shapes (slip-on, lap joint, weld necks). The program defaults to an ANSI slip-on (SO) flange type.

- Domes

  Cylinder and nozzle reinforcement calculation results are summarized. Nozzle domes are shown one per column identifying the side where the opening is located (shell or tube side) as well as the outside diameter and corresponding thicknesses.

- Reinforcement

  The dome cylinder wall thickness is determined following the code rules. The reinforcement requirements follow, depending on the availability of metal around the opening including excess vessel and dome cylinder wall thickness and welds. If a reinforcing pad is necessary, the program will select one. The program optimizes the reinforcement calculation by first trying to avoid the use of a pad by increasing the dome weld size and then by selecting the thinnest possible pad that complies with the code. You can change all nozzle and reinforcement dimensions. For example, you can eliminate a pad by increasing the dome cylinder thickness.

Flanges

This section reports these calculated design dimensions:

- Body flange design

  You can easily review all the major flange dimensions for all flanges (outside diameter, bolt circle, bolt diameter and number, etc.). The results will show optimized body flanges designs per the applicable code rules. Designed flanges follow the rules dictated by the specified code. As in the case of nozzle flanges, typical flange types available are ring, lap joint and hub type. The program results will identify which optional type flange calculation method was used, loose or integral.

- Backing flange design

  Results for any applicable backing flanges will be provided, such as for S type rear heads and for fixed tubesheets designs with removable heads were tubesheets where not extended for bolting.

Tubesheets/Tube Details

This section reports these calculated design dimensions:

- Tubesheets

  The tubesheet results always show both the TEMA method and the code results no matter which method was selected in the input (you can select TEMA, Code, or the thicker/thinner of the two methods for the tube sheet design). If no method is selected, the program uses the thicker tubesheet of the two methods.

The program then uses the thickness based upon what calculation option that you selected. Note that if the shell and/or head are welded to the tubesheet with the ASME method, the program may be able to better optimize to a thinner tubesheet thickness if you vary the attaching cylinder thicknesses.

- Tube details

  A summary of tube details is provided. The number of tubes and the outer tube limit are either those specified in the input, in which case the program checks their validity, or those calculated by the program.

- Double Tubesheets

  The standard results are based upon the TEMA methods for double tubesheet design. If you have selected to use the ASME tubesheet design methods and have also specified double tubesheets, the program uses ASME to estimate the individual tubesheet thicknesses and then apply TEMA for the gap requirements.

- Bundle Removal Space

  The amount of space required to remove the tube bundle for servicing (not applicable for fixed tubesheet type exchangers). Space excludes the front head length if head is removable, bolted to the front of the tubesheet.

Tubesheet Calculation Methods

Tubesheets are designed to the applicable design construction code requirements. For example the program uses two major methods to design tubesheets to USA standards: TEMA and ASME Section VIII Division 1 Appendix AA.

The program defaults to the thicker tubesheet result from each method. However, you can select to a specific design method. Depending on many factors, such as diameter, materials, pressures, temperatures, geometry, etc., either method could result in the thinner tubesheet.

In the case of fixed tubesheet units, the program will calculate an expansion joint if required or requested in the input.

Expansion Joint

A summary of the results of the TEMA calculations for a flanged and flued type expansion joint or the results of the ASME bellows type joint or other applicable design code will be provided.

Supports / Lift Lugs / Wind & Seismic Loads

This section reports these calculated design dimensions:

- Supports
- Lift lugs
- Wind and Seismic overturning moments

Horizontal Supports

The method used was originally developed by L.P. Zick.

The program alerts the user if any of the allowable stresses are exceeded. If that occurs several methods are available to alleviate the overstressed condition.

To alleviate an overstressed condition in horizontal units, the user can place the saddles closer to respective tubesheets/flanges (to decrease the bending at the saddle but increase both bending at midspan and shell tangential shear). Increasing the width of the saddle or adding a wear plate will reduce both circumferential stress at the horn of the saddle and ring compression over the saddle. Increasing the saddle-to-shell angle of contact will also reduce all stresses except bending at midspan.

Price

The Price Section reports the following information:

Item	Description
Cost estimate	A summary of the detailed costing showing material cost, total labor, and mark ups on material and labor are provided.
Cost summaries	Material, labor, mark up, and total selling cost are provided for the exchanger.
Material & Labor details	Material and labor will be provided for each major component of the heat exchanger.
Final assembly	Final assembly labor and material are summarized.
Bill of Materials	A complete bill of materials is provided listing all components. A rough dimensions listing for material purchase is provided as well as a finished dimensions bill of material for manufacturing.
Labor details	A complete labor per component and operation are provided for section and assemblies.

Drawings

The Drawings Section is subdivided into three sections:

- Setting Plan Drawing

  A setting plan drawing is provided showing location of nozzle, supports, and overall dimensions.
- Tubesheet Layout Drawing

A scale tube layout is provided showing tube, tie rod, and baffle cut locations.

- All Drawings: Fabrication Drawings

  Teams provides a complete set of fabrication drawings showing all components for construction. Drawings are to scale.

Code Calculations

Teams provides a complete calculation details section showing all Code methods and variables to verify the design to the applicable Code. Calculations are provided for:

- Cylinders/Cover
- Body Flanges
- Tubesheets/Expansion Joints
- Nozzles
- Supports
- Wind/Seismic Loads
- Lifting Lugs
- MAWP/MDMT/Test Pressures

Aspen Aerotran

Aerotran Input

Problem Definition

API Specification Sheet Descriptions

Use this sheet to specify the following optional descriptive information:

- **Headings**, which appear at the top of the TEMA specification sheet, Input Summary results, and the Title block of the drawings.

  Headings are 1 to 5 lines of up to 75 characters per line. Note that only the first 40 characters of each line appear on the drawings.
- **Fluid names**, which appear with other input items to help you identify to which fluid the data applies. These names also appear in the specification sheet output. Although optional, we recommend specifying meaningful fluid descriptions.

  Each fluid name can be up to 19 characters long and can contain multiple words.
- **Remarks**, which appear at the bottom of the specification sheet output.

  Each line can be up to 75 characters long.

You can also create global headings for use by any B-JAC program on the **Headings/Drawing** tab of **Program Settings** under **Tools**.

Application Options

Aerotran Application Options Sheet

Use this sheet to specify these application options:

- Equipment type
- Tube side application

- **Condensation *or* vaporization curve**, depending on the selected tube-side application

  You can input a vapor/liquid equilibrium curve or have the program calculate the curve using ideal gas laws or several other non-ideal methods.
- Draft type
- Program mode

Equipment type

You must select the type of equipment. The choices are:

- **Air-cooled heat exchangers**, which use air as the outside heat transfer medium. The fluid on the tube side will either be a no phase change fluid that is being cooled or a fluid that is condensing.
- **Hot-gas heat recuperators**, which typically use a hot gas as the outside heat transfer medium. The fluid on the tube side will either be a no phase change fluid that is being heated or a fluid that is vaporizing.
- **Fired heater convection sections**, which typically use a hot gas such as steam as the outside heat transfer medium. The fluid on the tube side will either be a no phase change fluid that is being heated or a fluid that is vaporizing. In addition to forced convection heat transfer, the program also considers heat transfer due to radiation for this application.
- **Gas-cooled heat exchangers**, which use gas as the outside heat transfer medium. The fluid on the tube side will either be a no phase change fluid that is being cooled or a fluid that is condensing.

Tube side application

You must select the tube side application. Depending on the selected type of equipment, the choices are:

- Liquid, no phase change
- Gas, no phase change
- **Narrow range condensation**, which covers cases where the condensing side film coefficient does not change significantly over the temperature range. Therefore, the calculations can be based on an assumed linear condensation profile.

  This class is recommended for cases of isothermal condensation and cases of multiple condensables without noncondensables where the condensing range is less than 6°C (10°F).

- **Multi-component condensation**, which covers the other cases of condensation where the condensing side film coefficient changes significantly over the condensing range. Therefore, the condensing range must be divided into several zones where the properties and conditions must be calculated for each zone.

  This class is recommended for all cases where noncondensables are present or where there are multiple condensables with a condensing range of more than 6°C (10°F).

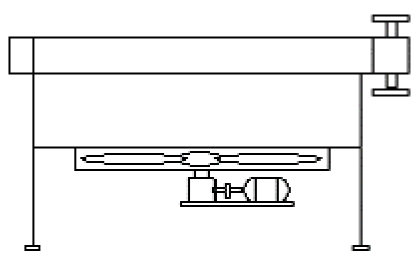
- **Narrow range vaporization**, which covers cases where the vaporizing side film coefficient does not change significantly over the temperature range. Therefore, the calculations can be based on an assumed linear vaporization profile.

  This class is recommended for cases of single components and cases of multiple components where the vaporizing range is less than 6°C (10°F).

- **Multi-component vaporization**, which covers the other cases of vaporization where the vaporizing side film coefficient changes significantly over the vaporizing range. Therefore, the vaporizing range must be divided into several zones where the properties and conditions must be calculated for each zone.

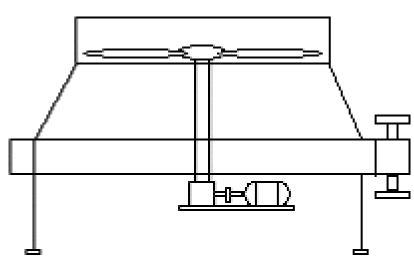
  This class is recommended for cases where there are multiple components with a vaporizing range of more than 6°C (10°F).

Draft type



Force Draft Type

Forced draft has air pushed through the bundle by a fan. This normally provides a higher fan efficiency, and the fan is not subjected to the air outlet temperature.



Induced Draft Type

Induced draft pulls the air across the bundle with the fan. This normally provides better air distribution across the bundle, but the fan is subjected to the air outlet temperature.

Program mode

Select the program mode of operation:

- Design mode

  In design mode, you specify the performance requirements. The program searches for a satisfactory heat exchanger configuration.
- Rating mode

  In rating mode, you specify the performance requirements and the heat exchanger configuration. The program checks to see if that heat exchanger is adequate.
- Simulation mode

  In simulation mode, you specify the heat exchanger configuration and the inlet process conditions. The program predicts the outlet conditions of the two streams.

Process Data

Tube Side/Hot Side Sheet

Use this sheet to specify the process data relevant to the tube side, hot side fluids. The selected application determines the required data.

- **Fluid quantity, total** - the total flow rates for the hot side streams.
- **Vapor quantity** - the flow rates for the hot side, inlet and outlet vapor streams.
- **Liquid quantity** - the flow rates for the hot side, inlet and outlet liquid streams.
- **Temperature (in/out)** -hot side inlet temperatures are required.
- **Dew / Bubble point** - the hot side inlet dew point temperature and outlet bubble point temperature, at a specified operating pressure.
- **Operating pressure (absolute)** - the absolute (not gauge) pressure. Depending on the application, the program may permit either inlet or outlet pressure to be specified. In most cases, it should be the inlet pressure.
- **Allowable pressure drop** - the maximum pressure drop permitted on the hot side.

  Where applicable, the allowable pressure drop is required. You can specify any value up to the operating pressure, although the allowable pressure drop should usually be less than 40% of the operating pressure.
- **Fouling resistance** - the hot side fouling resistance.

The fouling resistance defaults to zero if unspecified. You can specify any reasonable value. The program provides a list of typical values.

Tube Side/Cold Side Sheet

Use this sheet to specify the process data relevant to the tube side, cold side fluids. The selected application determines the required data.

- **Fluid quantity, total** - the total flow rates for the cold side streams.
- **Vapor quantity** - the flow rates for the cold side, inlet and outlet vapor streams.
- **Liquid quantity** - the flow rates for the cold side, inlet and outlet liquid streams.
- **Temperature (in/out)** -cold side inlet temperatures are required.
- **Dew / Bubble point** - the cold side inlet dew point temperature and the outlet bubble point temperature, at a specified operating pressure.
- **Operating pressure (absolute)** - the absolute (not gauge) pressure. Depending on the application, the program may permit either inlet or outlet pressure to be specified. In most cases, it should be the inlet pressure.
- **Allowable pressure drop** - the maximum pressure drop permitted on the cold side.

  Where applicable, the allowable pressure drop is required. You can specify any value up to the operating pressure, although the allowable pressure drop should usually be less than 40% of the operating pressure.
- **Fouling resistance** - the cold side fouling resistance.

  The fouling resistance defaults to zero if unspecified. You can specify any reasonable value. The program provides a list of typical values.

Outside Tube Sheet

Use this sheet to specify the process data relevant to the outside tube. The selected application determines the required data.

- **Fluid quantity, total** - the total flow rate.
- **Temperature** - enter the inlet and outlet temperatures for the fluid outside the tubes.

For no phase change applications, the program can calculate the required outlet temperature based on the specified heat load or the heat load on the opposite side. The flow rate and the inlet temperature *must* be specified.

- Altitude above sea level

  The altitude is used to determine the operating pressure outside the tube bundle in order to retrieve properties from the physical property data bank.

- Static pressure at inlet

  The gauge pressure of the flow outside the tube bundle. The gauge pressure is the pressure above or below atmospheric pressure. If below atmospheric, specify the pressure should as a negative value.

- Minimum ambient temperature

  This temperature is used to determine the possibility of the tube side fluid freeze-up when the air inlet temperature is at its minimum.

- Allowable pressure drop

  Where applicable, the allowable pressure drop across the bundle and fan, if present, is required input. You can specify any value up to the operating pressure, although the allowable pressure drop should usually be less than 40% of the operating pressure.

  Axial flow fans can develop a maximum static pressure of approximately 1.25 in H2O (32 mm H2O). The allowable pressure drop should not exceed this value when a fan is to be used.

- Fouling resistance

  The fouling resistance defaults to zero if unspecified. You can specify any reasonable value. The program provides a list of typical values.

Fluid Quantity, Total

Specify the total flow rate for no phase fluid.

For **no phase change applications**: if flow rates are not specified, the program calculates the required flow rates to meet the specified heat load or the heat load on the opposite side. All temperatures *must* be specified if the flow rates are omitted.

For **phase change applications**: the total flow rate should be approximated. The program still calculates the total required flow rate to balance the heat loads.

Temperature (in/out)

You must specify the hot and cold side inlet/outlet temperatures.

Simple condensation applications require hot side outlet and cold side outlet temperatures. For other applications the outlet temperature can be optional if sufficient data has been specified to calculate the heat load.

For **no phase change applications**: specify the inlet temperature and flowrate. The program can calculate the outlet temperature based on the specified heat load or the heat load on the opposite side.

For **narrow condensation** and **vaporization applications**: specify an outlet temperature and associated vapor and liquid flows. This represents the second point on the VLE curve, which we assume to be a straight line. With this information, the program can determine the correct vapor/liquid ratio at various temperatures and correct the outlet temperature or total flow rates to balance heat loads.

Operating Pressure (absolute)

Specify the absolute (not gauge) pressure. Depending on the application, the program may permit specifying either inlet or outlet pressure. In most cases, it should be the inlet pressure.

For a **thermosiphon** reboiler, the operating pressure should reflect the pressure at the surface of the liquid in the column.

For **condensers** and **vaporizers**: in the case where you expect the pressure drop to significantly change the condensation or vaporization curves, you should use a pressure drop adjusted vapor-liquid equilibrium data. If the program calculates the curve, you can indicate adjusting the curve for pressure drop.

Heat Load Sheet

Use this sheet to specify a value for the total **heat exchanged** when designing to a specific heat duty. If the heat exchanged is specified, the program compares the hot and cold side calculated heat loads with the specified heat load. If they do not agree within 2%, the program corrects the flow rate, or outlet temperature.

If the heat exchanged is not specified, the program compares the hot and cold side calculated heat loads. If they do not agree within 2%, the program corrects the flow rate, or outlet temperature.

The **heat load balance options** determine how the program handles heat load imbalances for the tube side and outside streams.

Use this sheet to specify whether to adjust the total **flowrate** or the **outlet temperature** to balance the heat load against the specified heat load or the heat load calculated from the opposite side. The program calculates the required adjustment.

If you select **no adjustment**, the program designs the exchanger with the specified flows and temperatures, but with the highest of the specified or calculated heat loads.

Physical Property Data

Property Options

Databanks Sheet

Use this sheet to select the source of the properties.

Properties from B-JAC Databank / User Specified properties / Interface properties from Aspen Plus

Selecting this option (default), allows you to reference the B-JAC Property Databank, specify your own properties in the Tube Side and Outside Tubes property sections, or have properties passed into the B-JAC file directly from an Aspen Plus simulation program.

Note: Any properties specified in the property sections override properties coming from a property databank.

The **B-JAC Property Databank** contains over 1500 compounds and mixtures used in the chemical process, petroleum, and other industries. You can reference the database by entering the components for the Tube Side and/or Outside Tube streams in the Composition sections. Click the **Search Database** button to locate the components in the database.

If you **specify properties** in the Tube Side and/or Outside Tube property sections, do not reference any compounds in the Tube Side and/or Outside Tube Composition sections unless you plan to use both the B-JAC Databank properties and specified properties.

Properties passed into the B-JAC file from the **Interface to an Aspen Plus simulation** run are displayed in the Tube Side and/or Outside Tube Property sections. If you pass in properties from Aspen Plus, *do not* specify a reference Aspen Plus to an Aspen Properties file, since properties are already provided by the Aspen Plus interface in the specified property sections.

Aspen Properties Databank

Aspen B-JAC provides access to the Aspen Properties physical property databank of compounds and mixtures.

If you are referencing the Aspen Properties databank, specify the **flash option** you want the Aspen Properties program to use with the VLE generation. The default is Vapor-Liquid. For more information see the *Aspen Properties Users Guide*.

To access the databank, first create an Aspen input file with stream information and physical property models. Run Aspen Plus and create the property file, xxxx.APPDF.

On the **Databanks** sheet specify the flash option and the name of the property file. If the file is not located in the same directory as your B-JAC input file, use the browse button to set the correct path to the *.APPDF file

Then specify the composition of the stream in the Property Composition section. When the B-JAC program is executed, the Aspen Properties program is accessed and the properties are passed back to the B-JAC design file.

Default: Aspen B-JAC Databank / Specified Properties

Condensation Options Sheet

Use this sheet to specify the following options:

- Condensation curve calculation method

  The calculation method determines which correlations the program uses to determine the vapor-liquid equilibrium. The choice of method is dependent on the degree of non-ideality of the vapor and liquid phases and the amount of data available.

- Condensation curve calculation type

  For a condensing stream, you should determine if your case is closer to **integral** or **differential** condensation. The program defaults to integral.

- Effect of pressure drop on condensation

  The program defaults to calculating the condensing curve in isobaric conditions (constant operating pressure). If the B-JAC Property program generates the VLE curve, you may specify non-isobaric conditions. The program allocates the specified pressure drop based on temperature increments along the condensation/vaporization curve. The vapor/liquid equilibrium at various temperature points is calculated using an adjusted operating pressure.

- Estimated pressure drop on hot side

  Specify the estimated hot side pressure drop through the exchanger. The program uses this pressure drop to adjust the VLE curve.

If actual pressure varies more than 20 percent from this estimated pressure drop, adjust this value to the actual pressure, and rerun Aspen Aerotran.

Condensation/Vaporization Curve Calculation Method

The calculation method determines which correlations the program will use to determine the vapor-liquid equilibrium. The choice of method is dependent on the degree of non-ideality of the vapor and liquid phases and the amount of data available.

The methods can be divided into three general groups:

- **Ideal** - correlations for ideal mixtures.

  The ideal method uses ideal gas laws for the vapor phase and ideal solution laws for the liquid phase. You should use this method when you do not have information on the degree of nonideality. This method allows for up to 50 components.

- **Soave-Redlich-Kwong, Peng-Robinson, and Chao-Seader** - correlations for non-ideal mixtures which do not require interaction parameters.

  The Soave-Redlich-Kwong and Peng-Robinson methods can be used on a number of systems containing hydrocarbons, nitrogen, carbon dioxide, carbon monoxide, and other weakly polar components. They can also be applied with success to systems which form an azeotrope, and which involve associating substances such as water and alcohols. They can predict vapor phase properties at any given pressure.

  The Chao-Seader method uses Redlich-Kwong equations for vapor phase non-ideality and an empirical correlation for liquid phase non-ideality. It is used with success in the petroleum industry. It is recommended for use at pressures less than 68 bar (1000 psia) and temperatures greater than -18°C (0°F). The program uses the original Chao-Seader correlation with the Grayson-Streed modification. There is no strict demarcation between these two methods since they are closely related. These methods allow for up to 50 components.

- **Uniquac, Van Laar, Wilson, and NRTL** - correlations for non-ideal mixtures which require interaction parameters.

  These methods are limited to ten components. The Uniquac, Van Laar, Wilson, and NRTL methods require binary interaction parameters for each pair of components. The Uniquac method also requires a surface parameter and volume parameter, and the NRTL method requires an additional Alpha parameter.

The Wilson method is particularly suitable for strongly non-ideal binary mixtures, for example, solutions of alcohols with hydrocarbons. The Uniquac method is applicable for both vapor-liquid equilibrium and liquid-liquid equilibrium (immiscibles). It can be used for solutions containing small or large molecules, including polymers. In addition, Uniquac interaction parameters are less temperature dependent than those for Van Laar and Wilson.

Condensation Curve Calculation Type

For a condensing stream, you should determine if your case is closer to integral or differential condensation.

Integral condensation assumes that the vapor and liquid condensate are kept close enough together to maintain equilibrium, and that the condensate formed at the beginning of the condensing range is carried through with the vapor to the outlet. Vertical tube side condensation is the best case of integral condensation. Horizontal tube side condensation is generally considered to integral.

In **differential condensation** the liquid condensate is removed from the vapor, thus changing the equilibrium and lowering the dew point of the remaining vapor. The clearest case of differential condensation is seen in the knockback reflux condenser, where the liquid condensate runs back toward the inlet while the vapor continues toward the outlet.

More condensate will be present at any given temperature with integral condensation versus differential condensation. In the heat exchanger design, this results in a higher mean temperature difference for integral condensation compared to differential condensation.

Tube Side Composition

Composition Sheet

If the stream physical properties are being accessed from the Aspen B-JAC databank or if the program is calculating a vapor/liquid equilibrium curve (B-JAC Props or Aspen Properties); use this sheet to define the stream composition.

Select the **composition specification** - weight flow rate or %, mole flow rate or %, volume flow rate or % - to determine the basis of the mixture physical properties calculations. Then use the table to define the stream composition:

- Components

List the components in the stream here if you want to access the B-JAC database for properties. Component names must match the compound name listed in the B-JAC database. Click the **Search Databank** button to scan and select compounds from the databank. If you are supplying the stream physical properties and VLE (for phase change) in the Hot Side and/or Cold Side properties section, do not list any components here.

When the program is calculating a vapor/liquid equilibrium curve, you can specify individual component physical properties by selecting **User** in the **Source** field. In this case the component field is used to identify the component in the results.

- Vapor in, Liquid in, Liquid out

  These fields identify the composition of the stream in each phase and is dependant on the Composition Specification. You must specify the inlet compositions if referencing the databank for physical properties. If outlet compositions are not specified, the program assumes the same composition as the inlet. The data for each column is normalized to calculate the individual components fraction.

- Component Type

  Use this field to specify noncondensables and immiscible components in the stream for all complex condensing applications. If a component does not condense any liquid over the temperature range in the exchanger, it is best to identify it as a noncondensable. If a component is immiscible with the other stream components, it needs to be identified so the condensation VLE can be adjusted. If the field is left blank, the program attempts to determine if a component is a noncondensable but does not try to identify any immiscibles.

- Source

  This field is currently available for components only when the program is calculating vapor/liquid equilibrium curves. **Databank** indicates that all component properties will be retrieved from one of the B-JAC databanks. **User** indicates that the physical properties for this component are specified by the user.

Component Properties Sheet

This sheet is used only for calculating condensing/vaporization curves within the program, allowing you to override databank properties or to specify properties of components that are not in the databank.

These physical properties are required for various applications:

Reference temperature	Density vapor
Viscosity vapor	Specific heat vapor
Thermal conductivity vapor	Latent heat
Vapor pressure	Density liquid
Viscosity liquid	Specific heat liquid
Thermal conductivity liquid	Surface tension liquid
Molecular volume	Molecular weight
Critical pressure	Critical temperature

Interaction Parameters Sheet

The Uniquac, Van Laar, Wilson, and NRTL methods need binary interaction parameters for each pair of components. This data is not available from the databank and must be provided by the user.

NRTL Method --Example with 3 components (Reference Dechema)

NRTL "A" Interactive Parameters –Aerotran input parameters

	1	2	3
1	--	A21	A31
2	A12	--	A32
3	A13	A23	--

NRTL "Alpha" Parameters –Aerotran input parameters

	1	2	3
1	--------	Alpha21	Alpha31
2	Alpha12	--------	Alpha32
3	Alpha13	Alpha23	--------

NRTL – Conversion from Aspen Properties parameters to Hetran parameters:

Aspen Properties NRTL Parameters – The parameters AIJ, AJI, DJI, DIJ, EIJ, EJI, FIJ, FJI, TLOWER, & TUPPER in Aspen Properties, which are not shown below, are not required for the Aerotran NRTL method.

Aspen Properties NRTL Interactive Parameters

Component I	Component 1	Component 1	Component 2
Component J	Component 2	Component 3	Component 3
BIJ	BIJ12	BIJ13	BIJ23
BJI	BJI12	BJI13	BJI23
CIJ	CIJ12	CIJ13	CIJ23

"A" Interactive Parameters – Conversion from Aspen Properties to Aerotran

	1	2	3
1	--	A21=BJI12*1.98721	A31=BJI13*1.98721
2	A12=BIJ12*1.98721	--	A32-BJI23*1.98721
3	A13=BIJ13*1.98721	A23=BIJ23*1.98721	--

"Alpha" Parameters – Conversion from Aspen Properties to Aerotran

	1	2	3
1	--	Alpha21=CIJ12	Alpha31=CIJ13
2	Alpha12= CIJ12	--	Alpha32=CIJ23
3	Alpha13=CIJ13	Alpha23=CIJ23	--

NRTL - Alpha parameters

The NRTL method requires binary interaction parameters for each pair of components and an additional Alpha parameter. This data is not available from the databank.

Uniquac - Surface & Volume parameters

The Uniquac method requires binary interaction parameters for each pair of components and also needs a surface parameter and volume parameter. This data is not available from the databank.

Tube Side Properties

Tube Side Properties Form

Use these sheets to specify the physical properties that are required for the tube side fluids:

- VLE
- Vapor

- Liquid
- Noncondensable

Properties specified here override data coming from the B-JAC Property Database or Aspen Properties programs.

VLE Properties Sheet

If you are entering a **vapor-liquid equilibrium curve**, you must specify multiple **temperature** points on the curve encompassing the expected inlet and outlet temperatures of the exchanger. The dew and bubble points of the stream are recommended.

Condensation curves require the dew point and vaporization curves require the bubble point. The first point on the curve does not have to agree with the inlet temperature, although it is recommended. For simulation runs, it is best to specify the curve down to the inlet temperature of the opposite side.

You can specify one temperature point or as many as 13 temperature points. The temperatures entered for no phase change fluids should at least include both the inlet and outlet temperatures. The inlet temperature of the opposite side fluid should also be included as a third temperature point for viscous fluids. Multiple temperature points, including the inlet and outlet, should be entered when a change of phase is present.

For each temperature point you must specify a parameter defining the **heat load**. For heat load specify **cumulative** heat load, **incremental** heat load, or **enthalpies**.

For each temperature point you must also specify a parameter defining the **vapor/liquid composition**. For the composition, you may specify **vapor flow rate**, **liquid flow rate**, **vapor mass fraction**, or **liquid mass fraction**.

The program calculates the other parameters based on the entry and the total flow specified under process data. Vapor and liquid mass fractions are recommended because they are independent of flow rates. For complex condensers, the composition should be the total vapor stream including noncondensables.

Liquid and Vapor Properties Sheets

The type of application determines the required properties. Most properties are self-explanatory.

If you are referencing the databank for a fluid, you do not need to enter any data on the corresponding physical properties input sheets. However, even if you are referencing the databank, you can also specify any property. The specified property overrides the value from the databank.

Specific Heat

Specify the specific heat for the component at the referenced temperature.

Thermal Conductivity

Specify the thermal conductivity for the component at the referenced temperature.

Viscosity

The viscosity requested is the dynamic (absolute) viscosity in centipoise or mPa*s (note that centipoise and mPa*s are equal). To convert kinematic viscosity in centistokes to dynamic viscosity in centipoise or mPa*s, multiply centistokes by the specific gravity.

The program uses a special logarithmic formula to interpolate or extrapolate the viscosity to the calculated tube wall temperature. However, when a liquid is relatively viscous, say greater than 5 mPa*s (5 cp), and especially when it is being cooled, the accuracy of the viscosity at the tube wall can be very important for calculating an accurate film coefficient. In these cases, you should specify the viscosity at a third point, which extends the viscosity points to encompass the tube wall temperature. This third temperature point may extend to as low (if being cooled) or as high (if being heated) as the inlet temperature on the other side.

Density

Be sure to specify density and not specific gravity. Convert specific gravity to density by using the appropriate formula:

density, lb/ft3 = 62.4 * specific gravity
density, kg/m3 = 1000 * specific gravity

The density can also be derived from the API gravity, using this formula:

density, lb/ft3 = 8829.6 / (API + 131.5)

Surface Tension

Surface tension is required for vaporizing fluids. If you do not have surface tension information available, the program estimates a value.

Latent Heat

Provide latent heat for change of phase applications.

Molecular Weight

Provide the molecular weight of the vapor for change of phase applications.

Diffusivity

The diffusivity of the vapor is used in the determination of the condensing coefficient for the mass transfer method. Therefore, provide this property if data is available. If not known, the program estimates a value.

Noncondensable Sheet

Noncondensables are those vapor components in a condensing stream, which do not condense in any significant proportions at the expected tube wall temperature. Examples include hydrogen, CO2, Air, CO.

Noncondensables require the following properties:

- Specific Heat
- Thermal Conductivity
- Viscosity
- Density
- Molecular Weight
- Molecular Volume

These properties can be specified or referenced from the database.

The **noncondensable flow rate** is required if it has not been defined in the databank composition input.

Outside Composition & Properties

Outside Composition Sheet

If the stream physical properties are being accessed from the Aspen B-JAC databank or if the program is calculating a vapor/liquid equilibrium curve (B-JAC Props or Aspen Properties); use this sheet to define the stream composition.

Select the **composition specification** - weight flow rate or %, mole flow rate or %, volume flow rate or % - to determine the basis of the mixture physical properties calculations. Then use the table to define the stream composition.

Components

This field identifies the components in the stream. Properties for components can be accessed from the databanks by specifying the

B-JAC Compound name. Click the **Search** button to scan and select compounds from the databank.

When the program is calculating a vapor/liquid equilibrium curve, you can specify individual component physical properties by selecting User in the Source field. In this case the component field is used to identify the component in the results.

Vapor in

This field identifies the composition of the stream in each phase and is dependant on the **Composition Specification**. You must specify the inlet compositions if referencing the databank for physical properties. If outlet compositions are not specified, the program assumes the same composition as the inlet. The data for each column is normalized to calculate the individual components fraction.

Vapor Properties (Outside)

The type of application determines the required properties. Most properties are self-explanatory.

If you are referencing the databank for a fluid, you do not need to enter any data on the corresponding physical properties input screens. However, it is also possible to specify any property, even if you are referencing the databank. Any specified property will then override the value from the databank.

Temperature

If you are entering a vapor-liquid equilibrium curve, you must specify multiple temperature points on the curve encompassing the expected inlet and outlet temperatures of the exchanger. The dew and bubble points of the stream are recommended. Condensation curves must have the dew point and vaporization curves must have the bubble point. The first point on the curve does not have to agree with the inlet temperature although it is recommended. For simulation runs, it is best to specify the curve up to the inlet temperature of the opposite side.

You can specify as few as one temperature or as many as 13 temperatures. The temperatures entered for no phase change fluids should at least include both the inlet and outlet temperatures. The inlet temperature of the opposite side fluid should also be included as a 3rd temperature point for viscous fluids. Multiple temperature points, including the inlet and outlet, should be entered when a change of phase is present. The number of temperatures specified depends on how the composition of the fluid changes, and the effect on the changing physical properties from inlet to outlet temperatures.

Specific Heat

Specify the specific heat for the component at the referenced temperature.

Thermal Conductivity

Specify the thermal conductivity for the component at the referenced temperature.

Viscosity

The viscosity requested is the dynamic (absolute) viscosity in centipoise or mPa*s (note that centipoise and mPa*s are equal). To convert kinematic viscosity in centistokes to dynamic viscosity in centipoise or mPa*s, multiply centistokes by the specific gravity.

The program uses a special logarithmic formula to interpolate or extrapolate the viscosity to the calculated tube wall temperature. However when a liquid is relatively viscous, say greater than 5 mPa*s (5 cp), and especially when it is being cooled, the accuracy of the viscosity at the tube wall can be very important to calculating an accurate film coefficient. In these cases, you should specify the viscosity at a third point, which extends the viscosity points to encompass the tube wall temperature. This third temperature point may extend to as low (if being cooled) or as high (if being heated) as the inlet temperature on the other side.

Density

Be sure to specify density and not specific gravity. Convert specific gravity to density by using the appropriate formula:

density, lb/ft3 = 62.4 * specific gravity

density, kg/m3 = 1000 * specific gravity

The density can also be derived from the API gravity, using this formula:

density, lb/ft3 = 8829.6 / (API + 131.5).

Exchanger Geometry

Tubes Sheet

Use this sheet to specify the following tube information:

- Outside diameter

  This is the outside diameter of the bare tube. The default is 20 mm or 0.75 in.

- Wall thickness

  You should choose the thickness based on considerations of corrosion, pressure, and company standards. If you work with ANSI standards, the thicknesses follow the BWG standards. The default is 1.6 mm or 0.065 in.
- Wall roughness

  The relative roughness of the inside tube surface affects the calculated tube side pressure drop. The program defaults to a relatively smooth tube surface (5.91 x 10-5 in.). A commercial grade pipe has a relative roughness of 1.97 x 10-3 in.
- Wall specification

  Specify whether tubes are to be manufactured using a **welded** process (default) or a **seamless** drawn process.
- Pattern

  This is the tube pattern in reference to the flow outside the tube bundle. The **staggered** pattern (default) is used most often and will give you the best heat transfer coefficient. The **in-line** pattern is normally used when the pressure drop outside the tubes is controlling.
- Pitch face row

  Specify the tube center to center spacing between the tubes in the first tube row. The minimum spacing depends on the outside diameter of the tube or fin. The defaults are:

  – Plain tubes: 1.25 * Tube O.D.

  – Finned tubes: Fin O.D. + 12.7 mm or 0.5 in.

  – Plate fins: 1.5 * Tube O.D.
- Pitch rows deep

  Specify the distance between the centerline of adjacent tube rows along the path of gas flow outside the tubes. The defaults are:

  – Staggard pattern: Tube pitch face row * 0.866

  – Square pattern: Tube pitch face row
- Pass arrangement

  This is the arrangement of the pass partition plates. Set the plates to be **mixed or horizontal**, or **vertical**. Note that pass arrangement may affect performance if temperature approach is limiting. The default is program optimized.
- Tube Surface

  The relative roughness of the tube surface affects the pressure drop in the exchanger. The program default is a smooth surface finish. You need to adjust the surface finish if you have selected a tube with a rougher commercial finish.

Fins Sheet

If the tube type is a fins tube, use this sheet to specify the **Fin type** and the following related information:

- Fin density

  This is the number of fins per unit length of tube. Typical fin spacings are between 2 and 12 fins/in or 78 and 473 fins/m. The default is 4 fins/in or 156 fins/m.

- Fin outside diameter

  This is the outside diameter of the fin on the finned tube. If plate fins are specified, the program calculates an equivalent fin outside diameter based on the tube pitch. The default is tube OD + 0.75 in or 19.05 mm.

- Fin thickness

  This is the average thickness of each fin. The Appendix provides a list of typical fin thicknesses. Defaults are:

  – 0.58 mm or 0.23 in (Tube O.D. < 50.8 mm (2 in.))

  – 0.91 mm or 0.36 in (Tube O.D. > 50.8 mm (2 in))

- Finned root diameter

  The root diameter is the outside diameter of the sleeve or coating.

- Fins segment width

  Segmented fin tubes are finned tubes in which pie-shaped segments have been removed from the fins. Segmented fin tubes are normally used in economizers to augment the heat transfer coefficient and reduce the tendency for fouling.

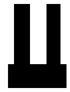
- Fin design temperature

  This is the maximum design temperature for which the fin material should be used. The program checks the fin temperature at normal operating conditions against this fin design temperature and issues a warning if it is exceeded.

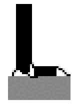
- Fins bond resistance

  This is the thermal resistance due to contact between the fin and the tube. The type of finned tubing will dictate the magnitude of the fin to tube bond resistance. The bond resistance for extruded and welded fins is normally negligible. The bond resistance for wrapped and plate fins can become significant for poorly fabricated fins. The default is no resistance.

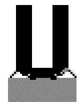
Fin type



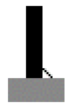
Extruded fins are an integral part of the tube. There is no fin-to-tube bond resistance.



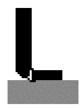
L-type welded fins are welded to the tube as shown. Fin-to-tube bond resistance is minor. L-type welded fins can be used up to the solder melting temperature.



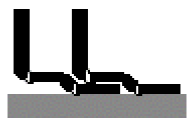
U-type welded fins have a minor fin-to-tube bond resistance. U-type welded fins can be used up to the solder melting temperature.



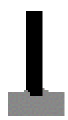
I-type welded fins have a minor fin-to-tube bond resistance. I-type welded fins can be used up to the solder melting temperature.



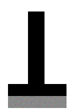
L-type tension wrapped fins have a fin-to-tube bond resistance that increases with temperature and restricts their use to lower temperatures.



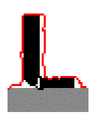
L-type tension overlapped fins have a fin-to-tube bond resistance that increases with temperature and restricts their use to lower temperatures.



Embedded fins are mounted in a groove in the tube and back filled. The fin-to-tube bond resistance is minor.



Extruded sleeve fins are extruded from a thick walled aluminum sleeve and fitted onto core tubes. The fin-to-tube bond resistance is minor so that higher operating temperatures are possible than with tension wrapped fins.



Metal coated fins are tension wrapped and then metal coated. The fin-to-tube bond resistance is minimal and operating temperatures are possible up to the melting point of the solder.

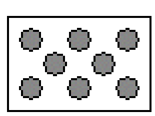


Plate fins are made from multiple tubes pushed through a series of plates. The tube-to-plate joint is pressure fitted. The fin-to-tube contact could represent a significant thermal resistance in some circumstances.

Default: None

General Sheet

Use this sheet to specify these parameters, when using twisted tapes:

- Twisted tap ratio

  Provide the ratio of the length of tape required to make a 180 degree twist to the width of the tape. The smaller the ratio, the tighter the twist.

- Twisted tape width

  Specify the width of twisted tape insert.

Geometry Sheet

If you specified the rating or simulation program mode in the **Application Options** sheet, specify the following information, as applicable:

- Number of tubes per bundle

  This is the total number of tubes per bundle. If not specified, the program selects the maximum number of tubes per bundle.

- Tube passes per bundle

  This is the number of times the tube side fluid runs the length of the bundle.

- Tube rows deep per bundle

  The number of tube rows deep in the bundle, which is the number of rows crossed by fluid flowing across the outside of the tubes.

- Tube length

  This is the straight length of the tubes from front tubesheet to rear tubesheet or tangent point of the u-bends.

- Bundles in series

  This is the number of tube bundles per bay, or per exchanger, to which the tube side flow is fed in series. The program assumes that the flow outside the tube bundle is also in series.

- Bundles in parallel

  This is the number of tube bundles per bay or per exchanger to which the tube side flow is fed in parallel. The program assumes that the flow outside the tubes is also in parallel.

- Bays in series

  This is the number of bays fed with the tube side flow in series. Note that the flow outside the tubes is considered to be in parallel to the bays.

- Bays in parallel

  This is the number of bays fed with the tube side flow in parallel. The program also sets the flow outside the tubes in parallel to the bays.
- Fans per bay

  Enter 0 if the fan calculations are not required. The program attempts to determine the power requirements for the fans based on commercial fan manufacturer standards. These standards may not be applicable to an existing fan.
- Fan diameter

  This is the fan blade diameter. Enter 0 if the fan calculations are not required.

Headers Sheet

Use this sheet to specify the following header information:

- Front header type

  The type selected affects the overall dimensions of the exchanger and the price estimate. A **Plug** type header provides limited access to the tubes for cleaning. The removable **bonnet** type (default) or **flanged covers** provide full access to the tubes.
- Rear header type

  The type selected affects the overall dimensions of the exchanger and the price estimate. A **Plug** type header provides limited access to the tubes for cleaning. The removable **bonnet** type (default) or **flanged covers** provide full access to the tubes. **U-tubes**, which eliminate the rear header, are a low cost alternate if access to the tubes is not needed.
- Dual front header

  This indicates if a split front header and a single rear header are required. Split headers are commonly used when there is a large pass-to-pass temperature difference, which could result in excessive thermal stresses on the tubesheet. The default is single header.
- Header position

  This indicates the position of the header with respect to the ground and the tube orientation: horizontal (default), vertical, or top & bottoms (vertical tubes).
- Header slop

  This is the slope of the header with respect to ground level. Headers are sometimes sloped to insure drainage of the tube side fluid during condensation and for shutdown. The default is none.

- Header box type

  Specify whether the header has the tubesheet and plug sheet of the same thickness (default) or different thicknesses. This item is primarily used for the budget cost estimate of the headers.

Headers Dimensions Sheet

Use this sheet to specify these header dimensions:

- Header width, depth, and height
- Top bottom plate thickness
- Plug sheet plate thickness
- Tubesheet plate thickness
- End plate thickness
- Weld joint efficiency

You can specify the header size and thicknesses and the program will use these dimensions for the design and costing.

Default: none

Nozzles Sheet

Use this sheet to specify the following nozzle related information:

- Nozzle nominal OD

  Specify the size of the nozzles or let the program determine them based on standard pipe sizing formulas. By default the program determines the size based on TEMA standards.

- Number of nozzles

  When in design mode, you should let the program determine the number of nozzles. For most rating cases, the program also determines the appropriate number of nozzles.

- Nozzle flange rating

  The specification of the nozzle flange rating does not affect the thermal design calculations or the cost estimate. It is included in the input to make the specification of the heat exchanger more complete.

  The pressure-temperature charts are built into the program. The program determines the rating based on the design pressure, design temperature, and material of construction.

  The values are not limited to those shown next to the input field, but you should be sure to choose a rating that is consistent with the desired standard (ANSI, ISO, or DIN).

- Nozzle flange type and facing type

  Select the type of nozzle flange and facing that you want. The nozzle flange type and facing appear on the specification sheet. By default, they are unspecified.

General Construction Options

Use the General sheet to specify the following construction options:

- Plenum type

  This is the type of ductwork used to direct air between the fan and the tube bundle. The plenum type affects the cost estimate and has a minor affect on the pressure drop outside the tubes.

- Recirculation type

  This indicates the type of air recirculation (if any) to be used for the exchanger. The type of recirculation appears on the specification sheet. However, it does not affect the actual design.

- Louvers control

  Louvers are used to provide process side temperature control and prevent damage to the bundle due to climatic conditions. Louvers affect the outside bundle pressure drop and the price estimate.

- Control action on air failure - louvers

  This indicates the desired response of the louvers upon air failure. The louver control appears on the equipment specification sheet.

- Bundle frame

  This is the material used in the fabrication of the bundle frame and is used in the cost estimate.

- Structure mounting

  This indicates where the exchanger will be mounted. **Grade** indicates the exchanger will require ground structural supports. **Piperack** indicates the exchanger will be mounted on existing piperacks. This option is used to estimate the price.

- Fan pitch control

  This is the type of control used for the fan blade pitch. The type of fan pitch appears on the equipment specification sheet.

- Fan drive type

  This is the type of driver used for the fans. The driver type appears on the equipment specification sheet.

- Control action on air failure - fan pitch

  This indicates the desired response of the fan pitch upon air failure. The air failure control appears on the equipment specification sheet.

- Steam coil

  Steam coils are sometimes used to prevent freeze-up in the tubes during severe climatic conditions. The requirement for steam coils appears on the equipment specification sheet.

- Soot blowers

  This is only available for the fired heat convection section. This equipment is used to periodically clean the heat transfer surface of fouling deposits. Use of soot blowers affect the size and price of the exchanger.

Design Data

Geometry Design Constraints Sheet

Use this sheet to specify the following **design mode** geometry constraints:

- Tube length

  The program uses the specified tube length **increment** when it increases or decreases the tube length. The default is 500 mm or 2 ft.

  The program considers the specified **minimum/maximum** length. The default minimum length considered is 1000 mm or 4 ft.; the default maximum length is 6000 mm or 20 ft. The maximum tube length must be greater or equal to the minimum length.

- Bundle width

  This is the **minimum/maximum** width of the bundle for a hot gas recuperator, fired heater convection section, or gas cooled exchanger that the program will consider. The default minimum width is 915 mm or 36 in. The default maximum bundle width, 2440 mm or 96 in., is based on normal shipping and handling limitations.

- Tube rows deep per bundle

  This sets the **minimum/maximum** number of rows deep per bundle for a hot gas recuperator, fired heater convection section, or a gas cooled type exchanger that the program will hold during design. The default minimum is 3 rows, and the default maximum is 20 rows.

- Tube passes per bundle

  This is the **minimum/maximum** number of tube passes per bundle limits. The default minimum is 1 pass.

- Minimum bundles in series

  This is the minimum number of bundles in series for a hot gas recuperator, fired heater convection section, or a gas cooled exchanger. Note that the tube side and outside fluids flow in series through the exchanger bundles.

- Minimum bundles in parallel

  This is the minimum number of bundles in parallel for a hot gas recuperator, fired heater convection section, or a gas cooled exchanger. Note that the program considers both the tube side and outside fluids flow in parallel.

- Minimum bays in series

  This is the minimum number of bays in series for air cooler applications. Note that the tube side flow is considered to be series and outside fluid flow is considered to be in parallel through the exchanger.

- Minimum bays in parallel

  This is the minimum number of bays in parallel for air cooler applications. Note that the program considers both the tube side and outside fluids flow to be in parallel.

For **air cooler applications**, you can specify the these geometry constraints:

- Bay width

  This is the **minimum/maximum** width of a bay that the program will consider. The default minimum is 915 mm or 36 in; the default maximum is 5238 mm or 192 in.

- Tube rows deep per bay

  This is the **minimum/maximum** number of tube rows per bay that the program will consider. The minimum default is 3, and less than 3 rows is not recommended. The maximum default is 20, and more than 20 rows is not recommended.

- Tube passes per bay

  This is the **minimum/maximum** number of tube passes per bay that the program will consider. The program attempts to maximize the number of tube passes within the limits of maximum velocity and tube side pressure drops. The minimum default is 1. The maximum default will restrict the maximum tube passes to 2 passes per tube rows deep.

- Minimum fans per bay

  This design restriction forces the program to design the bay with a width and length that will accommodate the specified minimum number of fans. The default is 1.

  Multiple fans per bay are sometimes desirable so that exchangers can be operated at reduced loads by turning fans off. If a fan fails, the exchanger could also operate with a reduced load.

Process Design Constraints Sheet

Use this sheet to specify the following process design constraints:

- Minimum fluid velocity

  The minimum velocities specified for **tube side/outside** are the lowest velocities the program accepts in design mode. The program may not find a design that satisfies this minimum, but it will issue a warning if the design it chooses does not satisfy the minimum.
- Maximum fluid velocity

  The maximum velocities specified for **tube side/outside** are the highest velocities the program accepts in design mode. The program tries to maximize the velocities within the allowable pressure drops and the maximum allowable velocities. Therefore, this constraint does not enter into the design mode logic. For two phase flow, it is the vapor velocity at the point where there is the most vapor.
- Minimum % excess surface are required

  This is the percent of excess surface required in the design to satisfy the heat transfer surface area requirements.

Materials Sheet

Use this sheet to select the material of construction for following items:

Tube	Select a generic material, a general material class, for the tubes. The default is carbon steel.
Fins	Select a generic material, a general material class, for the fins, if present. The default is aluminum.
Header	Select a generic material, a general material class, for the hot side components. The default is carbon steel.
Plugs	Select a generic material, a general material class, for the plugs, if present. The default is carbon steel.
Gasket	Select a generic material, a general material class, for the gaskets, if present. If not specified, the program uses compressed fiber as the material for the mechanical design and cost estimate.

To specify a specific material grade for any of these items, click the **Search Databank** button.

If you specify a material designator for the tube material, the program retrieves the thermal conductivity of the tube from its built-in databank. However, if you have a tube or fin material that is not in the databank, then you can specify the **tube or fin thermal conductivity** on this sheet.

Design Specifications Sheet

Use this sheet to specify these design specifications:

- **Design code** - ASME (American), CODAP (French), or AD-Merkblatter (German) - is used to tell the program which basic mechanical design calculations to follow and also to make the heat exchanger specification more complete.
- Code stamp

  Select **Yes** if the box headers for the unit are to be designed and stamped to the selected pressure vessel design code. The default is No – code stamp is not required
- **TEMA class**

  If you want the heat exchanger to be built according to TEMA standards, select the appropriate TEMA class - B, C, or R. If TEMA is not a design requirement, specify Code only and the program will use only the design code to determine the mechanical design. API 661 may also be specified. By default the program uses the standards defined in Program Settings under Tools.
- **Material standard** - ASTM, AFNOR, or DIN - determines the selection of materials listed in the input for materials of construction. By default the program uses the standards defined in the Program Settings under Tools.
- **Dimensional standard**- ANSI (American), ISO (International), or DIN (German) - applies to such things as pipe cylinder dimensions, nozzle flange ratings, and bolt sizes. DIN also encompasses other construction standards such as standard tube pitches.

  This selection is included primarily to make the heat exchanger specification complete, although it does have some subtle effects on the thermal design through the basic mechanical design. By default the program uses the standards defined in the Program Settings under Tools.
- Design pressure

  Used in the mechanical design calculations, the specified design pressure influences the shell, head, and tubesheet required thicknesses, and therefore affects the thermal design. If you do not specify a value, the program defaults to the operating pressure plus 10% rounded up to a logical increment. This is in gauge pressure, which is one atmosphere less than the equivalent absolute pressure.

- **Vacuum design pressure**

  By default vacuum design pressure is not calculated for vacuum service. However, if the heat exchanger is going to operate under a full or partial vacuum, you should specify a vacuum service design pressure.
- **Test pressure** is the pressure at which the manufacturer will test the heat exchanger. This has no effect on the thermal design, but is included to make the heat exchanger specification more complete. The default is Code.
- Design temperature

  Used in the mechanical design calculations, the design temperature influences the shell, head, and tubesheet required thicknesses, and therefore affects the thermal design. If not specified, the program defaults to the highest operating temperature plus 33ºC (60ºF) rounded down to a logical increment.
- **Corrosion allowance** is included in the thickness calculations for cylinders and tubesheets, and therefore has a subtle effect on thermal design. The default is 0.125 in. or 3.2 mm for carbon steel; 0 for other materials

Design Code

The **design code** is used to tell the program which basic mechanical design calculations to follow and also to make the heat exchanger specification more complete. Choices are:

- ASME (American)
- CODAP (French)
- AD-Merkblatter (German)

The program defaults to the design code specified in the Program Settings under Tools.

The design code has a subtle, but sometimes significant effect on the thermal design. This is because the design code determines the :

- Required thicknesses for the shell and heads, therefore affecting the number of tubes
- Thickness of the tubesheet, therefore affecting the effective heat transfer area
- Dimensions of the flanges and nozzle reinforcement, therefore affecting the possible nozzle and baffle placements

Due to the fact that the mechanical design calculations themselves are very complex, the Aspen Aerotran program only includes some of the basic mechanical design calculations. The full calculations are the function of the Aspen B-JAC TEAMS program.

Program Options

Thermal Analysis

Process Sheet

Use this sheet to specify:

- Heat transfer coefficient

  Normally, the film coefficients are two of the primary values you want the program to calculate. However, there may be cases where you want to force the program to use a specific coefficient, perhaps to simulate a situation that the program does not explicitly cover. You can specify neither, either, or both.

- Heat transfer coefficient multiplier

  You can specify a factor that becomes a multiplier on the film coefficient, which is calculated by the program. You may want to use a multiplier greater than 1 if you have a construction enhancement that is not covered by the program, for example tube inserts or internally finned tubes. You can use a multiplier of less than 1 to establish a safety factor on a film coefficient. This would make sense if you were unsure of the composition or properties of a fluid stream.

- Pressure drop multiplier

  Similar to the multipliers on the film coefficients, you can also specify a factor that becomes a multiplier on the bundle portion of the pressure drop, which is calculated by the program. It does not affect the pressure drop through the inlet or outlet nozzles or heads. These multipliers can be used independently or in conjunction with the multipliers on film coefficients.

- Maximum allowable heat flux

  For vaporizing applications, it is often important to limit the heat flux (heat exchanged per unit area) to avoid the generation of too much vapor so quickly as to blanket the tube surface, resulting in a rapid decline in the film coefficient. The Aspen Aerotran program has built in limits on the heat flux, but you can also establish your own limit by specifying a value for this item.

- Vaporization curve adjustment for pressure

  The program defaults to calculating the vaporization curve in isobaric conditions (constant operating pressure). You may specify non-isobaric conditions and the program will allocate the specified pressure drop based on heat load increments along the vaporization curve. The vapor/liquid equilibrium at various temperatures will be calculated using an adjusted operating pressure.

MTD Sheet

Use this sheet to specify:

- Mean temperature difference

  Usually, the program determines the MTD; however you can override the program calculated corrected (or weighted) MTD by specifying a value here.

- Minimum allowable temperature approach

  You can limit the minimum approach temperature. The program will increase the number of shells in series and/or limit the exchanger to a one pass-one pass countercurrent geometry to meet the minimum approach temperature. The default is 3 to 5°F depending on application

- Minimum allowable MTD correction factor

  Since most of the correction factor curves become very steep below 0.7, the Aerotran program defaults to 0.7 as the minimum F factor before going to multiple shells in series in design mode. The only exception is the X-type shell, where the program allows the F factor to go as low as 0.5 in design mode. In rating mode, the default is 0.5. Use this item to specify a lower or higher limit.

- Flow direction for single pass exchangers

  For special economizer applications, you can indicate counter current or co-current flow which will adjust the temperature driving force profile.

Correlations Sheet

Use this sheet to specify condensation and vaporization options.

Condensation Options

- Desuperheating heat transfer method

  The program defaults to determining the tube wall temperature at the hot side inlet. If this option is enabled, the program assumes a desuperheating zone exists from the specified inlet temperature down to the dew point.

  The program defaults to determining the tube wall temperature at the hot side inlet. If the wall temperature is below the dew point, the program assumes that the tube wall is "wet" with condensation and uses a condensing coefficient for heat transfer. If the tube wall temperature is above the dew point, the program determines at what hot side gas temperature the tube wall temperature falls below the dew point. This hot side gas temperature would represent the low temperature for the desuperheating zone.

- Condensation heat transfer model

  The **Mass transfer film model** (default) is based on a Colburn-Hougen correlation for condensable(s) with noncondensable(s) and a Colburn-Drew correlation for multiple condensables. The **Modified proration model** is an equilibrium method based on a modification of the Silver-Bell correlation.

  Researchers have developed several different methods of predicting the film coefficient for a condensing vapor. Each has its strengths and weaknesses. If the composition of the vapor is well known, the mass transfer film model is the most accurate.

- Tube side two phase heat transfer correlation

  The two major two phase condensing correlations that determine tube side film coefficients referenced in the industry are the **Taborek** (default) and the **Chen** methods.

- Liquid subcooling heat transfer method

  Select the calculation method to determine the liquid subcooling coefficient for a condensing application. For most applications, the larger of the free or forced convection should be considered.

Vaporization Options

- Indicator to suppress nucleate boiling coefficient

  If selected, the program suppresses the nucleate boiling coefficient when determining the overall film coefficient.

- Minimum temperature difference for nucleate boiling

  You can specify a minimum temperature difference requirement for nucleate boiling to be considered.

- Correlation for 2 phase tube side pressure drop

  You can select the tube side two phase pressure drop correlation to be applied: Lochart-Martinelli, Friedel, Chisholm, McKetta, or Nayyar. If not specified, the program selects the one most appropriate for the application.

- Tube side two phase heat transfer correlation

  The major two-phase vaporization correlations to determine tube side film coefficients referenced in the industry are the Steiner-Taborek (default), Collier-Polley, Chen, Dengler-Addoms, and the Guerrieri-Talty methods.

Calculation Options Sheet

Use this sheet to specify these calculation options:

- Simulation mode tolerance

  Specify the convergence tolerance for the simulation mode of the program. Note that a very low convergence tolerance may result in a longer calculation time.

- Maximum number of design mode iterations

  In the Design Mode the program will reiterate through the specified design parameters to converge on the lowest cost solution. You may set the maximum number of iterations for the optimization.

- Number of calculation intervals

  The program does an interval analysis by dividing the heat exchanger into sections. Specify how many interval sections are to be considered.

- Type of interval calculation

  The program does an interval analysis by dividing the heat exchanger into sections. Select whether the program is to use equal heat load or equal temperature increments for the sectional analysis of the exchanger.

- Heat transfer by radiation and convection

  For some waste heat recovery applications, it may be appropriate to include the radiation effects of heat transfer in addition to the normal convective heat transfer.

Change Codes

Change Codes Sheet

Use the Change Codes sheet to specify those items that can be specified only with a change code. Change codes are processed after all of the other input and override any previously set value.

One of the best uses of the Change Codes sheet is to provide a visual path of the various changes you make during program execution. For this purpose, we recommend that you place changes for a particular alternative design on a separate line.

The format for change code entries is: CODE=value

For instance, if you specify the tube outside diameter as 20 mm in the regular input screens, then enter the change code TODX=25, the 25 will override the 20. If you enter the same change code more than once, the last value will prevail.

Another good use of the Change Code sheet is to "chain" to another file containing only change codes. This is especially convenient if you have a line of standard designs, which you want to use after you have found a similar solution in design mode.

To do this, use the FILE= change code, followed by the name of the file containing the other change codes. with the file type, for example, ABC-1.BJI. The other file must also have a .BJI filetype. You can create this change code file with a standard edit program.

For example, the entry FILE=S-610-2 would point to a file named S-610-2.BJI, containing the following data:

MODE=2,TLNG=3600,TPPB=2,TRBU=6,BUSE=2

Design Mode Change Codes

These are the design mode change codes that are available for Aerotran:

MODE= program mode: 1=design 2=rating

TLMN= tube length, minimum

TLMX= tube length, maximum

BWMN= minimum bay width

BWMX= maximum bay width

MBAP= minimum bays in parallel

MBAS= minimum bays in series

MBUW= maximum bundle width

MFBA= minimum fans per bay

TRMN= minimum tube rows per bay

TRMX= maximum tube rows per bay

TPMN= minimum tube passes

TPMX= maximum tube passes

Rating Mode Change Codes

These are the rating mode change codes that are available for Aerotran:

MODE= program mode: 1=design 2=rating

BAPA= number bays in parallel

BASE= number bays in series

BUPA= number bundles in parallel

BUSE= number bundles in series

TRBU= number tube rows per bundle

TLNG= straight tube length

TNUM= number of tubes

TPPB= tube passes per bundle

FAOD= fan outside diameter

FAPB= number of fans per bay

Tube & Fin Change Codes

These are the tube and fine change codes that are available for Aerotran:

FNMT= fin material

FNOD= fin outside diameter

FNSP= number of fins per unit length

FNSW= fin segment width

FNTK= fin thickness

FNTY= type of fin:

1 = none	6 = L-tension wrapped	11= plate
2 = extruded	7 = L-tension overlapped	
3 = L-type weld	8 = embedded	
4 = U-type weld	9 = extruded sleeve	
5 = I-type weld	10= metal coated	

TODX= tube outside diameter

TWTK= tube wall thickness

Mechanical Options Change Codes

These are the mechanical options change codes that are available for Aerotran:

DTYP= type of draft: 1=forced 2=induced 3=not applicable

PARR= pass arrangement: 1=horizontal or mixed 2= vertical

RPIT= tube pitch between tube rows deep

TPAT= tube pattern: 1=staggered 2=in-line

TPIT= tube pitch in the face row

General Change Codes

This is the general change code that is available for Aerotran:

FILE= specify the name of the file that contains the change codes

Aerotran Results

The Results Section is divided into four sections:

- Design Summary
- Thermal Summary
- Mechanical Summary
- Calculation Details

Design Summary

The Design Summary Section is subdivided into four sections:

- Input Summary
- Optimization Path
- Recap of Designs
- Warnings & Messages

Input Summary

This section provides you with a summary of the information specified in the input file. It is recommended that you request the input data as part of your printed output so that it is easy to reconstruct the input, which led to the design.

Optimization Path

This part of the output is the window into the logic of the program. It shows some of the heat exchangers the program has evaluated in trying to find one that satisfies your design conditions. These intermediate designs can also point out the constraints that are controlling the design and point out what parameters you could change to further optimize the design.

To help you see which constraints are controlling the design, the conditions that do not satisfy your specifications are noted with an asterisk (*) next to the value. The asterisk will appear next to the required tube length if the exchanger is undersurfaced, or next to a pressure drop if it exceeds the maximum allowable. Column headings are described below:

In design mode, the Aerotran program will search for a heat exchanger configuration that will satisfy the desired process conditions. It will automatically change a number of the geometric parameters as it searches. However Aerotran will not automatically evaluate all possible configurations, and therefore it may not necessarily find the true optimum by itself. It is up to the user to determine what possible changes to the construction could lead to a better design and then present these changes to the program.

Aerotran searches to find a design that satisfies the following:

(1) enough surface area to do the desired heat transfer

(2) pressure drops within the allowable

(3) physical size within acceptable limits

(4) velocities within an acceptable range

(5) mechanically sound and practical to construct

In addition to these criteria, Aerotran also determines a budget cost estimate for each design. However the cost does not affect the program's logic for optimization.

There are several mechanical parameters which directly or indirectly affect the thermal performance of an air cooled type heat exchanger. It is not practical for the program to evaluate all combinations of these parameters. In addition, the acceptable variations are often dependent upon process and cost considerations that are beyond the scope of the program (for example the cost and importance of cleaning). Therefore the program automatically varies only a number of parameters that are reasonably independent of other process, operating, maintenance, or fabrication considerations. The parameters that are automatically optimized are:

tubes in face row	number rows deep	tube length
bundles in series	bundles in parallel	number of tubes
tube passes	bays in series	bays in parallel

The design engineer should optimize the other parameters, based on good engineering judgment. Some of the important parameters to consider are:

fin density	tube outside diameter	fan size
fin type	tube pitch	tube pattern
nozzle sizes	tube type	exchanger orientation
materials	fluid allocation	tube wall thickness

Optimization Path Items

Face Rows: The number of tubes in the first tube row exposed to the outside bundle flow. In the design mode, the program will minimize the number of tubes in the face row to maximize the air side and tube side velocities. For an air cooler application, face rows will be incremented based upon Bay width limits set in design constraints and pressure drop limits that have been set. For other types of equipment (economizers sections), the face rows optimization will be based upon bundle width limits set.

Rows Deep: The number of tube rows passed by the outside flow from entrance to exit. In the design mode, the program will minimize the number of rows deep to meet minimum surface area required and be within allowable pressure drop limits. For an air cooler application, face rows deep will be incremented based upon Bay rows deep limits set in design constraints and pressure drop limits that have been set. For other types of equipment (economizers sections), the rows deep optimization will be based upon the bundle rows deep limits set.

Tube Length: The straight length of one tube is from inlet header to outlet header or u-bend. Once the smallest bundle/bay size has been found, the program optimizes the tube length to the shortest standard length, within the allowable range, which will satisfy surface area, pressure drop, and velocity requirements. The length is incremented or decremented based on the tube length increment and is limited by the minimum tube length and maximum tube length. Each of these can be specified in the input. The **actual tube Length** will be shown which is the length of the straight tubes or the straight length to the tangent for U-tubes. This includes the portion of the tube, which is in the tubesheet. This length will include the portion of the tube in the tubesheet, which is ineffective for heat transfer.

Tube Pass: The number of tube side passes per bay that the tube side flow makes across the outside flow. The program seeks the maximum reasonable number of tube passes that gives a pressure drop and velocity within the maximums allowed. The program wants to maximize the tube side velocity thereby maximizing the tube side film coefficient and minimizing any velocity dependent fouling.

Bundles in Parallel: The number of tube bundles in parallel per bay or per exchanger. The program will automatically increase the number of bundles in parallel when it reaches the maximum allowable bundle width and minimum allowable tube length and still is unable to satisfy the allowable pressure drop. Note that both the outside streams and tube side streams are considered to be flowing in parallel.

Bundles in Series: The number of tube bundles in parallel per bay or per exchanger. The program will automatically increase the number of bundles in parallel when it reaches the maximum allowable bundle width and minimum allowable tube length and still is unable to satisfy the allowable pressure drop. Note that both the outside streams and tube side streams are considered to be flowing in parallel.

Bays in Parallel: The number bays with the tube side flow in parallel for air cooled applications only. The program will automatically increase the number of bays in parallel when it reaches the maximum allowable bay width and minimum allowable tube length and still is unable to satisfy the allowable pressure drop. Note that both the shell side streams and tube side streams are considered to be flowing in parallel.

Bays in Series: The number bays with the tube side flow in series for air cooled applications only. The program will automatically increase the number of bays in series when it reaches the maximum allowable bay width and tube length and still is unable to find a design with enough heat transfer area. It will also go to exchangers in series when the correction factor on the MTD falls below 0.7 (or the minimum allowable correction factor specified in the input). Note that both the outside stream is considered to be in parallel flow and the tube side stream is considered to be flowing in series.

Area Calculated: The calculated required surface area. This area is determined by the calculated heat load, corrected mean temperature difference, and the overall heat transfer coefficient. This area will be denoted with an * if the exchanger is undersurfaced.

Area Actual: The actual total outside surface area that is available for heat transfer. This is based upon the effective tube length that does not include the length of the tubes in the tubesheet(s).

Outside Pressure Drop: The total outside pressure drop calculated for flow outside the tubes. The pressure drop will be denoted with an * if it exceeds the allowable.

Tube Pressure Drop: The total tube side pressure drop calculated for flow through the tubes. The pressure drop will be denoted with an * if it exceeds the allowable.

Total Price: This is the estimated budget price for the total number of heat exchangers in series and in parallel.

Recap of Designs

The recap of design cases summarizes the basic geometry and performance of all designs reviewed up to that point. The side by side comparison allows you to determine the effects of various design changes and to select the best exchanger for the application. As a default, the recap provides you with the same summary information that is shown in the Optimization Path. You can customize what information is shown in the Recap by selecting the

Customize button. You can recall an earlier design case by selecting the design case you want from the Recap list and then select the Select Case button. The program will then regenerate the design results for the selected case.

Warnings & Messages

Aspen B-JAC provides an extensive system of warnings and messages to help the designer of heat exchanger design. Messages are divided into five types. There are several hundred messages built into the program. Those messages requiring further explanation are described here.

Warning Messages: These are conditions, which may be problems, however the program will continue.

Error Messages: Conditions which do not allow the program to continue.

Limit Messages: Conditions which go beyond the scope of the program.

Notes: Special conditions which you should be aware of.

Suggestions: Recommendations on how to improve the design.

Thermal Summary

The Thermal Summary section summarizes the heat transfer calculations, pressure drop calculations, and surface area requirements. Sufficient information is provided to allow you to make thermal design decisions. The Thermal Summary Section is subdivided into four headings:

- Performance
- Coefficients & MTD
- Pressure Drop
- API Sheet

Performance

Performance

This section provides a concise summary of the thermal process requirements, basic heat transfer values, and heat exchanger configuration on the following sheets:

- General Performance
- Thermal Resistance Analysis

General Performance

In the general performance section, flow rates, **Gases (in/out) and Liquids (in/out)**, for the outside and tube sides are shown to summarize any phase change that occurred in the exchanger.

The **Temperature (in/out)** for both side of the exchanger are given along with **Dew point and bubble poin**t temperatures for phase change applications.

Film coefficients for the shell and tube sides are the weighted coefficients for any gas cooling/heating and phase change that occurred in the heat exchanger.

Velocities for single phase applications are based on an average density. For condensers, the velocity is based on the inlet conditions. For vaporizers, it is based on the outlet conditions. Outside velocities are the crossflow velocity through the cross-section.

Overall performance parameters are given, such as **Heat exchanged**, **MTD** with any applied **correction factor** and the **effective total surface area**. For single phase applications on both sides of the shell, a MTD correction factor will be applied in accordance with TEMA standards. For multi-component phase change applications, the MTD is weighted based upon a heat release curve. The effective surface area does not include the U-bend area for U-tubes unless it was specified to do so.

The **exchanger geometry** provided in the summary includes: TEMA type, exchanger position, number of shells in parallel and in series, exchanger size, number of tubes and tube outside diameter, baffle type, baffle cut, baffle orientation, and number of tube passes.

Thermal Resistance Analysis

This portion gives information to help you evaluate the surface area requirements in the clean, specified fouled (as given in the input), and the maximum fouled conditions.

The **clean condition** assumes that there is no fouling in the exchanger, in the new condition. The overall coefficient shown for this case has no fouling resistance included. Using this clean overall coefficient, the excess surface area is then calculated.

The **specified foul condition** summarizes the performance of the exchanger with the overall coefficient based upon the specified fouling.

The **maximum fouled condition** is derived by taking the specified fouling factors and increasing them (if the exchanger is oversurfaced) or decreasing them (if undersurfaced), proportionately to each other, until there is no over or under surface.

The **distribution of overall resistance** allows you to quickly evaluate the controlling resistance(s). You should look in the "Clean" column to determine which film coefficient is controlling, then look in the "Spec. Foul" column to see the effect of the fouling resistances. The difference between the excess surface in the clean condition and the specified fouled condition is the amount of surface added for fouling.

You should evaluate the applicability of the specified fouling resistances when they dictate a large part of the area, say more than 50%. Such fouling resistances often increase the diameter of the heat exchanger and decrease the velocities to the point where the level of fouling is self-fulfilling.

Coefficients & MTD

Coefficients & MTD

This output section shows the various components of each **film coefficient.** Depending on the application, one or more of the following coefficients are shown:

- desuperheating
- condensing
- vapor sensible
- liquid sensible
- boiling
- liquid cooling

The **Reynolds number** is included so that you can readily evaluate if the flow is laminar (under 2000), transition (2000-10000), or turbulent (over 10000).

The **fin efficiency factor** is used in correcting the tube side film thermal resistance and the tube side fouling factor resistance.

The **mean metal temperature** of the shell is the average of the inlet and outlet temperatures on the shell side. The mean metal temperature of the tube wall is a function of the film coefficients on both sides as well as the temperatures on both sides. These two temperatures are intended for use in the mechanical design in order to determine the expansion joint requirements in a fixed tubesheet heat exchanger.

The calculated corrected MTD (**Mean Temperature Difference**) for no phase change applications is the product of the LMTD (Log Mean Temperature Difference), the correction factor (F), and the longitudinal baffle efficiency factor (if using an F, G, or H shell). For phase change applications, the process is divided into a number of intervals and a MTD is determined for each interval.

The overall MTD for the exchanger is then determined by weighting the interval MTDs based on heat load. If you have specified a value for the Corrected Mean Temperature Difference in the input, it is this value which the program uses in the design instead of the calculated Corrected MTD.

The **flow direction** is displayed when there is a single tube pass, in which case it is either counter-current or co-current.

The **heat flux** is the heat transferred per unit of surface area. This is of importance for boiling applications where a high flux can lead to vapor blanketing. In this condition, the rapid boiling at the tube wall covers the tube surface with a film of vapor, which causes the film coefficient to collapse. The program calculates a maximum flux for nucleate boiling on a single tube and a maximum flux for bundle boiling (nucleate and flow boiling), which can be controlled by other limits (e.g., dryout). If you specify a maximum flux in the input, this overrides the program calculated maximum flux. To analyze this data, you should check to see if the maximum flux is controlling. If it is, consider reducing the temperature of the heating medium.

Pressure Drop

Pressure Drop

The Pressure Drop section reports the following output:

- Pressure drop distribution
- User- specified bundle multiplier
- Velocity distribution
- Distribution of overall resistance

Pressure drop distribution

The pressure drop distribution is one of the most important parts of the output for analysis. You should observe if significant portions or the pressure drop are expended where there is little or no heat transfer (inlet nozzle, entering bundle, through bundle, exiting bundle, and outlet nozzle). If too much pressure drop occurs in a nozzle, consider increasing the nozzle size. If too much is consumed entering or exiting the bundle, consider increase the face area of the bundle.

The program determines the dirty pressure drop in the tubes by estimating a thickness for the fouling, based on the specified tube side fouling resistance, which decreases the cross-sectional area for flow.

User specified bundle multiplier

The user specified bundle multiplier, which you can specify in the input, is included in the bundle portion of the calculated pressure drop, clean and dirty.

Velocity distribution

The velocity distribution, between the inlet and outlet nozzle, is shown for reference. In other parts of the output, the velocity, which is shown for the shell side, is the diametric crossflow velocity. For the tube side it is the velocity through the tubes. For two phase applications, the velocities for crossflow, through baffle windows, and through tubes are the highest velocities based on the maximum vapor flow.

Distribution of Overall Resistance

The distribution of overall resistance allows you to quickly evaluate the controlling resistance(s). You should look in the "Clean" column to determine which film coefficient is controlling, then look in the "Spec. Foul" column to see the effect of the fouling resistances. The difference between the excess surface in the clean condition and the specified fouled condition is the amount of surface added for fouling.

You should reevaluate the applicability of the specified fouling resistances when they dictate a large part of the area, say more than 50%. Such fouling resistances often increase the diameter of the heat exchanger and decrease the velocities to the point where the level of fouling is self-fulfilling.

API Sheet

API Sheet

The Aspen Aerotran program generates the complete API data sheet.

Mechanical Summary

Summary Section is subdivided into two sections:

- Exchanger Dimensions
- Setting Plan & Tubesheet Layout

Exchanger Dimensions

Exchanger Dimensions

These are the exchanger dimensions that are reported:

Item	Description
Unit length	The total length of the exchanger includes the tube length and the depth of the inlet and outlet headers (if any).
Unit width	The unit width is the total width of the entire unit, which includes side frames and/or ducting.
Bays in parallel	The total number of bays in parallel with the tube side flow in parallel.
Bays in series	The total number of bays in series with the tube side flow in series.
Tubes/bundle Tubes/bay	The total number of tubes per bundle or bay.
Fan specifications	Fan blade and motor information is included if the unit was specified as a forced or induced air source. Fan selection is based upon the Moore Fan correlations.
Tube summary	The tube summary includes: tube material, tube length, tube O.D., tube wall thickness, tube pitch first row, tube pitch first row, tube pattern, pass type, and area ratio. For additional information on these items, see the geometry input.
Fin specifications	The fin specification summary includes: Fin Material, Fin Type, Fin OD, Fin thickness, Fin density, Fin segment width. For additional information on these items, see the geometry input.

Setting Plan & Tubesheet Layout

Setting Plan

A scaled setting plan is provided. Setting plan shows overall dimensions, inlet / outlet nozzle arrangement and fans (if applicable).

Tubesheet Layout

The tubesheet layout drawing is displayed directly after the tube details. The complete tube layout shows all tubes and their arrangement in the tube bank. Each tube row is listed with the number of tubes per row. Three additional graphics show the number of tubes per pass and tube pass arrangement, the tube pattern with tube pitch dimensions, and the finned tube geometry with dimensions.

Calculation Details

The Calculation Details Section is subdivided into two headings:

- Interval Analysis - Tube Side
- VLE - Tube Side

Interval Analysis - Tube Side

The Interval analysis section provides you with table of values for liquid properties, vapor properties, performance, heat transfer coefficients and heat load over the tube side temperature range.

Heat Transfer Coefficient - Single Phase

Flow regimes are mapped in this section with the corresponding overall calculated film coefficients. The overall film coefficients are base upon the following:

The **liquid coefficient** is the calculated heat transfer coefficient assuming the total flow is all liquid.

The **gas coefficient** is the calculated heat transfer coefficient assuming the total flow is all vapor.

Heat Transfer Coefficient - Condensation

Flow regimes are mapped in this section with the corresponding overall calculated film coefficients. The overall film coefficients are base upon the following:

"Desuperheating Dry Wall" is for the part of the desuperheating load, which is removed, where no condensing is occurring. This only happens when the tube wall temperature is above the dew point temperature. In such a case, the film coefficient is based on a dry gas rate and the temperature difference is based on the inlet temperature.

"Desuperheating Wet Wall" which shows the part of the desuperheating load which is removed coincident with condensation occurring at the tube wall. This case is more common. The film coefficient and temperature difference are the same as the first condensing zone.

Liquid Cooling coefficient is for the cooling of any liquid entering and the condensate after it has formed and flows further through the heat exchanger. The program assumes that all liquid will be cooled down to the same outlet temperature as the vapor.

The **dry gas coefficient** is the heat transfer coefficient when only gas is flowing with no condensation occurring. It is used as the lower limit for the condensing coefficient for pure component condensation and in the mass transfer and proration model for complex condensation applications.

The **pure condensing coefficients** (shear and gravity) are the calculated condensing coefficients for the stream for that regime. The resulting pure condensing coefficient is a pure shear coefficient, pure gravity coefficient or a proration between the two, depending on the condensing regime.

The **condensing film coefficient** is the heat transfer coefficient resulting from the combined effects of the pure condensing coefficient and the dry gas coefficient.

Heat Transfer Coefficient - Vaporization

The **two phase factor** is the correction factor applied to the liquid coefficient to calculate the two phase heat transfer coefficient.

The **two phase coefficient** is the heat transfer coefficient calculated based on the combined liquid and vapor flow.

The **nucleate coefficient** is the heat transfer coefficient due to the nucleation of bubbles on the surface of the heat transfer surface.

The **vaporization film coefficient** is the heat transfer coefficient for the specified side resulting from the vectorial addition of the two-phase and nucleate boiling coefficient. Observe the change in the film coefficient to see if it decreases severely at the end of the vaporizing range. This usually indicates that the tube wall is drying out and the film coefficient is approaching a dry gas rate. If a significant percentage of the area required is at this low coefficient, consider a higher circulation rate (less vaporized each time through) if it is a reboiler.

VLE - Tube Side

If the Aspen Aerotran program generated the heat release curve, the following VLE information is provided:

- Vapor-liquid equilibrium

  The condensation or vaporization curve will be provided as a function of equal heat load increments or temperature increments. Cumulative heat load and vapor/liquid flow rates as a function of temperature will be shown.
- Condensation/vaporization details

  Component flow rates as function of temperature increments will be provided.
- Vapor properties

  Vapor properties will be provided as a function of temperature increments.
- Liquid properties

  Liquid properties will be provided as a function of temperature increments.

Aerotran Design Methods

Optimization Logic

In design mode, the Aspen Aerotran program searches for a heat exchanger configuration to satisfy the desired process conditions. It automatically change a number of the geometric parameters as it searches. However, Aspen Aerotran will not automatically evaluate all possible configurations, and therefore it may not necessarily find the true optimum by itself. It is up to the user to determine what possible changes to the construction could lead to a better design and then present these changes to the program.

Aspen Aerotran searches to find a design, which satisfies the following:

- Enough surface area to do the desired heat transfer
- Pressure drops within the allowable
- Physical size within acceptable limits
- Velocities within an acceptable range
- Mechanically sound and practical to construct

In addition to these criteria, Aspen Aerotran also determines a budget cost estimate for each design. However cost does not affect the program's logic for optimization.

There are over thirty mechanical parameters that directly or indirectly affect the thermal performance of a heat exchanger. It is not practical for the program to evaluate all combinations of these parameters. In addition, the acceptable variations are often dependent upon process and cost considerations, which are beyond the scope of the program (for example the cost and importance of cleaning). Therefore the program automatically varies only a number of parameters which are reasonably independent of other process, operating, maintenance, or fabrication considerations. The parameters which are automatically optimized are: bundle/bay width, tube rows, bundles/bays in series, tube length, tube passes, bundles/bays in parallel, number of tubes, and fan number.

The design engineer should optimize the other parameters, based on good engineering judgment. Some of the important parameters to consider are: tube outside diameter, fin type, materials, tube pitch, fin dimensions, nozzle sizes, tube type, fin density, fan requirements, tube wall thickness, exchanger orientation, materials, tube pattern, and tubesheet type.

Optimization of Heat Transfer Area

The program attempts to optimize on the most effective exchanger geometry that meets all the specified design criteria, while requiring the least amount of heat transfer area. The optimization logic changes the:

- Bundle/bay length, width, and tube rows
- Number of tubes
- Number of tube passes

Minimum and maximum limits for each of these items can be specified in the input.

Heat Transfer Coefficients

The program attempts to maximize the heat transfer coefficients by maximizing velocities within the following limitations:

- Maximum allowable velocity
- Allowable pressure drop
- Physical construction limitations

Pressure Drop, Outside Tubes

The pressure drop inside the tubes includes pressure losses:

- Through the bundle
- Accessory losses due to louvers, fan guards, and steam coils

Pressure Drop, Inside Tubes

The pressure drop inside the tubes includes pressure losses:

- Through the inlet and outlet nozzles
- Entering and exiting the tubes
- Through the tubes

Pricing

The price is based on the cost of materials and labor involved in fabricating a bay. Price includes the following components:

- Tubes
- Bundle Frame
- Header
- Tube Supports
- Fan
- Plenum
- Nozzles
- Flanges.

MTD Calculation

The calculation of the MTD is based on a rigorous iterative procedure in which each tube row is broken into intervals. MTDs are calculated for each interval, weighted and summed for an overall MTD. This allows the program to calculate an accurate MTD for virtually any number of rows deep and any pass arrangement.

Maximum Velocities

Aerotran has the following built in maximum velocity restrictions:

Tube Side: $V_{max} = 64.0 / \sqrt{density}$

Outside Tubes: $V_{max} = 50.0 / \sqrt{density}$

Fans

Fans are sized based on logic provided by the Moore Fan Company. Fan size should be used for approximation purposes only. The availability of an acceptable fan to perform the required duty does not control the design of the unit.

Nozzles Design Methods

The Aerotran program provides at least one nozzle for every five feet or 1.5 meter of header length. This insures that all tubes are supplied adequately. The nozzle size is based on a maximum velocity through the nozzle.

$V_{max} = 38.7 / \sqrt{density}$

$V_{max} = 50.0 / \sqrt{density}$ (for Phase Change)

Heat Transfer Area

The Aspen Aerotran program assumes that the total tube length is available for heat transfer.

Tube Pass Configuration

In rating mode, Aspen Aerotran accepts any tube pass configuration.

In design mode, Aspen Aerotran tries a maximum of two passes per row and maintains an equal number of tubes per pass. It generates all the valid pass arrangements for a given number of tubes and tube rows. It tries each of these arrangements to arrive at an acceptable geometry.

No Phase Change

No Phase Change Design Methods

Film Coefficient

The outside tube film coefficient is based on correlations developed from research conducted by Briggs & Young, Robinson & Briggs, and Weierman, Taborek, & Marner.

The tube side film coefficient is based on the Dittus-Boelter correlation.

MTD

The program uses a corrected log mean temperature difference for all geometries.

Pressure Drop

The pressure drop is determined by using a Fanning-type equation on the tube side. The pressure drop correlations used for finned tubes were developed from research conducted by Briggs & Young, Robinson & Briggs, and Weierman, Taborek, & Marner. The Zukauskas and Ulinskas correlations are used for bare tubes. Velocity heads are used to determine pressure losses through the nozzles.

Simple Condensation

The program divides the condensing range up into four equal zones based on temperature from the dew point to the bubble point or outlet temperature. For each zone it calculates the following:

- Film coefficient, made up of a condensing coefficient, gas cooling coefficient, liquid cooling coefficient, and two phase coefficient
- MTD
- Two phase pressure drop, based on the vapor liquid equilibrium and physical properties for each zone

Condensing - Film Coefficient - Horizontal Inside Tube

The program determines the dominant flow regime in each of the zones. The flow regimes are divided into annular, annular with stratification, wavy/stratified, intermediate wavy, high wavy/slug/plug, and bubble. For each flow regime there is a separate equation, which reflects the contribution of shear, controlled or gravity controlled flow.

The shear controlled equations are derived from a single phase Dittus-Boelter equation with a two phase multiplier as a function of the Martinelli parameter. The gravity controlled equations are modified Nusselt and Dukler equations.

Liquid Cooling and Subcooling - Film Coefficient

The cooling of the condensate (and any liquid entering) down to the outlet temperature and any subcooling below the bubble point are calculated using the greater of a forced convection or free convection equation for the full temperature range.

Complex Condensation

The program divides the condensing range up into a number of equal zones based on temperature from the dew point to the bubble point or outlet temperature. For each zone it calculates the following:

- Film coefficient made up of a condensing coefficient, gas cooling coefficient, liquid cooling coefficient, and two phase coefficient

- MTD
- two phase pressure drop, based on the vapor liquid equilibrium and physical properties for each zone.

Desuperheating - Film Coefficient

The program determines at what temperature point the tube wall will be wet by using a dry gas coefficient on the hot side and the coolant coefficient on the cold side. If the program determines that any part of the desuperheating range will result in a dry wall, it will calculate a separate desuperheating zone using a dry gas coefficient. Once the tube is wet, any remaining superheat is removed coincident with the condensation in the first condensing zone and the first zone film coefficient is used.

Condensing - Film Coefficient

A separate condensing coefficient is determined for each zone, based on the flow regime and whether it is shear or gravity controlled.

Gas Cooling - Film Coefficient

The cooling of the vapor once condensation has begun (after any desuperheating) and the cooling of any noncondensables is based on a single phase coefficient for each zone using a modified Dittus-Boelter equation.

Liquid Cooling and Subcooling - Film Coefficient

The cooling of the condensate and any liquid entering down to the outlet temperature and any subcooling below the bubble point is calculated using a two phase coefficient based on the Martinelli equation. It is calculated for each of the ten zones, based on the liquid carried over from previous zones.

Overall Heat Transfer Coefficient

The overall heat transfer coefficient calculated for each zone is dependent on the condensing correlation chosen. The program defaults to the mass transfer method which is a film model based on a Colburn-Hougen correlation for condensable(s) with noncondensable(s) and a Colburn-Drew correlation for multiple condensables. Our experience and research indicate that if the composition of the vapor is known, the mass transfer method is the most accurate method.

MTD

Desuperheating

The program determines at what temperature point the tube wall will be wet by using a dry gas coefficient on the hot side and the coolant coefficient on the cold side. If the program determines that any part of the desuperheating range will result in a dry wall, it will use the inlet temperature and the vapor temperature point which yields the wet tube wall to determine the MTD for the desuperheating zone.

Once the tube wall is wet, the rest of the desuperheating occurs using the dew point temperature to calculate the MTD.

Condensing

The program calculates an MTD for each of the zones using the starting and ending temperature for each zone.

Liquid Cooling

The liquid cooling load is divided evenly among the zones. This avoids the common mistake of assuming that the vapor and liquid are kept in equilibrium and are at the same temperature. In fact much of the liquid cooling may actually occur early in the heat exchanger. An MTD for the liquid cooling is calculated for each zone and then weighted.

Pressure Drop

Desuperheating

If the program determines that there is a dry wall zone, as described above, then the tube side pressure drop for this zone is calculated using a modified Fanning equation.

Condensing

The pressure drop for the vapor cooling, condensing, and condensate formed is determined using a two phase Martinelli equation.

Simple Vaporization

Liquid Preheating - Film Coefficient

The film coefficient for the heating of the liquid from its inlet temperature to the bubble point is the greater of the forced convection coefficient and the free convection coefficient.

Forced Circulation - Film Coefficient

The boiling coefficient for forced circulation is also determined by using a vectorial addition of the nucleate boiling coefficient and the flow boiling coefficient.

Natural Circulation Vaporizer (Thermosiphon) - Tube Side - Film Coefficient

The tube side is divided into a liquid preheating zone and a number of vaporizing zones divided equally by temperature. The boiling coefficient is determined by using a vectorial addition of the nucleate boiling coefficient and the flow boiling coefficient and corrected as described above for pool boiling. The flow regime is determined using a modified Baker flow regime map.

MTD

Liquid Preheating

The liquid preheat MTD is calculated as a linear LMTD.

Forced Circulation

The LMTD is assumed to be linear and an F factor is applied to correct for the effect of multiple tube passes.

Pressure Drop

Forced Circulation

The liquid pressure drop, determined using a Fanning equation, is multiplied by a two phase Martinelli multiplier. If the exchanger is in a vertical position, a vapor acceleration pressure drop and static head pressure drop are also added.

Ensea

Problem Definition

Headings Sheet

Use this sheet to specify **Headings**, which appear at the top of the TEMA specification sheet, Input Summary results, and the Title block of the drawings. Headings are 1 to 5 lines of up to 75 characters per line. Note that only the first 40 characters of each line appear on the drawings.

To create global headings for use by any B-JAC program, click **Tools | Program Settings**, display the **Headings/Drawings** tab, and enter the heading information.

Ensea Application Options Sheet

Use this sheet to specify:

- Application type
- TEMA class

If you want the heat exchanger to be built according to TEMA standards, select the appropriate TEMA class: B (default), C, or R. If TEMA is not a design requirement, specify Code only, and the program will use only the design code to determine the mechanical design.

For the **tube layout** you can have the program generate a **new layout** every time the program runs (default), or you can run the program to generate a layout and use this **existing layout** for all subsequent runs.

After you have run the program and generated tube layout drawing, you can modify the tube layout interactively.

Application Type

If you select **design a tube layout for specified vessel diameter**, the program holds the specified vessel diameter and determines the number of tube holes that will fit based on other tube layout information provided.

Selecting **design a tube layout for specified number of tubes** allows you specify the number of tubes and the program determines what shell size is required for that number of tubes based on tube and baffle information you have provided.

Selecting **specify the tube layout** allows you to specify the number of tube holes in each row, the location of each row, the tie rods, baffle cuts, and pass partitions. This option is primarily aimed at preparing a drawing of an existing or known tubesheet layout.

Drawing

After you specify the exchanger geometry, run the program to generate the tube layout drawing. You can modify the tube layout interactively.

Tubes

To remove a tube, click the tube to highlight it (in red) and then select the red X on the menu.

To identify a tube as a plugged tube or a dummy tube, click the tube to highlight it (in red) and then select the plugged tube icon or dummy tube icon on the menu.

Tie Rods

To remove a tie rod, click the tie rod to highlight it (in red) and then select the red X on the menu.

To add a tie rod, select the add a tie rod icon on the menu and then specify the location of the tie rod.

Sealing Strips

To remove a sealing strip, click on the sealing strip to highlight it (in red) and then select the red X on the menu.

To add a sealing strip, select the add a sealing strip icon on the menu and then specify the location of the sealing strip.

Exchanger Geometry

Exchanger

Exchanger Type Sheet

Use this sheet to specify:

- Front head type

The front head type does not affect the tubesheet layout. It is included in the input for completeness of the TEMA designation (e.g., BEM). The default is B.

- Shell type

  The shell type does not affect the tubesheet layout, except for those cases where there is a longitudinal baffle (types F, G, and H). For these cases the program avoids a solution where the longitudinal baffle would pass through the middle of a pass, for example, a 6 pass quadrant layout. The default is E.

- Rear head type

  The rear head type significantly affects the tubesheet layout, because it determines the outer tube limits (OTL) and therefore the number of tubes.

  The L, M (default), and U type (default for K type shells) rear heads have the same OTL, which the program calculates accurately.

  The P, S, T, and W (and to some extent the N) rear head types have an OTL which is very dependent on the mechanical design. The program estimates the clearance requirements for these other heads, but the OTL may not be exact. Use Aspen Teams to determine the exact outer tube limit for floating head heat exchangers.

Dimensions Sheet

Use this sheet to specify:

- Front head inside diameter

  You should specify the front head inside diameter whenever it is less than the shell inside diameter. If you leave it zero, the program uses the shell ID to determine the outer tube limit.

- Shell inside diameter

  You should always specify the shell ID except when you want the program to determine the smallest shell size that will contain the given number of tubes.

  The program uses the shell ID to calculate the outer tube limit (if not specified) and the baffle OD, to locate the tie rods and the baffle cut, as well as a reference for limiting the layout along the horizontal and vertical axis.

- Shell outside diameter

  The program determines the smallest shell outer diameter based on the specified inner diameter. For a shell ID within 24 inches, the program defaults to a 0.375 inch tube wall thickness. Otherwise, the program determines shell OD based on 0.5 inch shell wall thickness.

- Outer tube limit diameter

  This the diameter of the circle beyond which no portion of a tube will be placed. The program allows the outer edge of a tube to be on the outer tube limit (OTL).

  If you specify zero, the program calculates the OTL based on the front and rear head types and the front head ID and the shell ID.

  The program calculated OTL should be exact for fixed tubesheet exchangers with rear head types L and M and U-tube exchangers (rear head type U). It may not be exact for exchangers with N type heads, floating head exchangers (rear head types P, S, or T), or floating tubesheet exchangers (rear head type W), since the program makes assumptions on the gasket width, bolt size, and barrel thickness. For an exact OTL, you should use Aspen Teams.

Tubes & Baffles

Tubes Sheet

Use this sheet to specify:

- Number of tube holes

  If you have established an exact number of tubes, specify the number of tubes. If you want the program to maximize the number of tubes for a given shell size, you should leave this input field blank.
- Tube outside diameter

  You can specify any size for the tube outside diameter.
- Tube pitch

  This is the distance from tube center to tube center within the tube pattern. The default is per TEMA standards for specified tube diameter
- Tube pattern

  The tube pattern is the layout of the tubes in relation to the direction of the shell side crossflow, which is normal to the baffle cut edge. The one exception to this is pool boiling in a kettle type reboiler where the tube supports are sometimes baffles with a vertical cut.

Number of tube holes

If you want the program to maximize the number of tubes for a given shell size, you should leave this input field blank.

If you have already established an exact number of tubes, specify the number of tubes. The program attempts to find a reasonable layout with that tube count. If it cannot find a layout with that many tubes, it shows the layout with the maximum tubes it could find. If the specified tube count is below the program's normal solution, the program removes tubes until it reaches the desired count.

If you want to find the smallest shell ID to contain a given number of tubes, enter the desired tube count, and enter zeros for the shell ID and outer tube limits. The program will search through several shell sizes until it finds the smallest size, rounded to the nearest 0.25 inch or the nearest 5 mm, depending upon the system of measure. For U-tubes, you should specify the number of tube holes (two times the number of U's).

Default: program calculated

Ensea Baffles Sheet

Use this sheet to specify:

- Type of baffles

  The default is single segmental (full support X type shell). The program also covers full supports and the two types of grid baffles: rod baffles and strip baffles. Rod baffles are limited to a tube pattern of square or rotated square. Strip baffles are for triangular tube patterns.

  If you specify no tubes in the window (NTIW), the program will not place any tube beyond the baffle cut, minus an edge distance of 0.125 in or 3.2 mm.

- Baffle cut (% of diameter)

  For single segmental baffles, specify the percentage of the baffle window height compared to the shell ID. For double and triple segmental baffles, specify the percentage of the innermost baffle window height compared to the shell ID.

- Baffle orientation

  The baffle orientation - **horizontal** (default), **vertical**, or **rotated** 45 degrees - affects the appearance of the tube pattern and the location of the tie rods.

  Rotated orientation may be used only with a square or rotated square tube pattern.

Baffle Cut

For single segmental baffles, specify the percentage of the baffle window height compared to the shell ID.

For double and triple segmental baffles, specify the percentage of the innermost baffle window height compared to the shell ID.

Baffle Type	Baffle Cut
Single segmental	Between 15 and 45%
Double segmental	Between 30 and 40%
Triple segmental	Between 15 and 20%

Baffle Type	Baffle Cut
Full support	Zero
Grid	Zero

Note: The values are not limited to those listed, which are provided as a convenience.

For more information on double and triple segmental baffle cuts, see the Appendix.

Tie Rods/Spacers Sheet

The program optimizes the location of the tie rods to maximize the number of tube holes in the layout. Use this sheet to specify the **number of tie rods**, which can be any even number between 4 and 12. The default is per TEMA standards.

You can specify the **tie rod** and **spacer** outside **diameters** or allow the program to use default sizes.

Program Defaults

Tie Rod (mm)	Spacer (mm)	Tie Rod (in)	Space (in)
6.5	12.7	0.25	0.5
9.5	15.9	0.375	0.625
12.7	19.1	0.5	0.75
15.9	25.4	0.625	1.0

Tube Layout

Tube Layout Sheet

Use this sheet to specify:

- Pass layout type
- Number of tube passes

  You can specify any number of passes from 1 to 16.
- Maximum % deviation in tubes per pass

  For thermal performance and pressure drop reasons, it is normally desirable to reasonably balance the number of tubes per pass in multi-pass layouts. This input indicates the maximum percentage of deviation from the median number of tubes per pass (average between the lowest and highest number of tubes in a pass). The default is 5% maximum deviation. Values are not limited to those listed.

  To force the same number of tubes in each pass, specify 0.001.
- Pass partition lane width

  The clearance lane is the edge to edge distance between the tube rows on each side of a pass partition. If the tubes are welded into the tubesheet, a clearance of at least 0.75 in or 19.1 mm should be used.

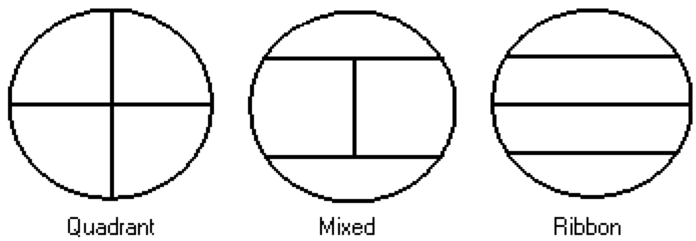
Defaults are 15.9 mm or 0.625 in for TEMA B & C exchangers; 19.1 mm or 0.75 in for TEMA R exchangers

- Design symmetrical tube layout

Pass Layout Type

For 1, 2, or 3 pass layouts, the value of this input field is not pertinent. For pass layouts of 4 or more tube passes, the value specified here determines how the tube side inlet and outlet nozzles will enter the heads and the locations of the pass partitions.

The difference between ribbon type and mixed type layouts is in how the inner passes (the passes between the first and last passes) are constructed. In the ribbon layout, each pass stretches from one side of the shell to the other, whereas the mixed layout has a vertical pass partition plate dividing the inner passes. The figure shows a 4-pass layout in each of the layout types.



Mixed and ribbon type layouts have the advantage of easier nozzle installation, especially with relatively large nozzles. Ribbon type is also preferable when there is a large pass to pass temperature change, since ribbon type minimizes the local temperature stresses in the tubesheet. Quadrant type layouts have the advantage of normally (but not always) yielding a greater number of tubes.

U-tube layouts of 4 or more passes are restricted to the quadrant type.

Default: program will optimize to the greatest number of tubes.

Design symmetrical tube layout

The program will always make the left half symmetrical to the right half of the layout, but the top half can be nonsymmetrical to the bottom half. If different values are specified on the Limits sheet for "tube limit along vertical centerline" measured in from top and from bottom, the layout will always be nonsymmetrical. In some cases of nonsymmetrical layouts, you may still want to force a pass partition to be on the horizontal centerline or a tube row to be on the centerline. To do this, select the **design symmetrical tube layout** option.

This parameter is also valuable in the case of a single pass layout where the number of tubes and the shell ID are specified as input to the program. If a greater number of tubes can fit in the shell, the program will eliminate tubes. For a non-symmetrical layout, the program will eliminate tubes only at the top of the bundle. For a symmetrical layout, the program will eliminate the appropriate tubes from both the top and the bottom of the layout.

Default: non-symmetrical

Limits Sheet

Use this sheet to specify:

- Open space between shell ID and tube bundle

  You can specify the clearance from the shell inside diameter to the tube bundle at the **top (S1)**, **bottom (S2)**, and **sides (S3)**. By default the program minimizes clearance to maximize tube count.

- Distance from tube center - to vertical (D1), horizontal (D2) centerlines

  You can use either or both of these input fields to force the program to start the layout in a specific way.

- Location of center tube in 1st row

  Use this input field to force the program to start the layout in a specific way. The location of the first tube in the first row from the bottom is pertinent for triangular, rotated triangular, and rotated square layouts, where the rows are staggered.

  If you select **off center line**, the program locates the tubes near the vertical, off of the vertical centerline in the first row from the bottom. If you select **on center line**, the program locates a tube on the vertical centerline for the first row from the bottom.

- Clearance - shell ID to baffle OD

  This determines the outer limits for spotting tie rods. The program will place the OD of the spacer within 0.125 in or 3.2 mm of the baffle edge. The default is per TEMA standards.

- Minimum u-bend diameter

  This determines the minimum tube center-to-center distance of any U-tube bundle.

- Straight length for u-tubes

  If the layout is for a U-tube bundle, the program prints out a U-bend schedule showing the quantity for each different length U-tube. The program assumes that the bends for all the tubes start at the same distance from the tubesheet and are in parallel planes.

Distance from tube center to vertical and horizontal centerlines

You can use either or both of these entries when you want to force the program to start the layout in a specific way.

To force tubes to be on either or both of the centerlines, specify a value of zero for the respective distance. If field is left blank, the program will optimize.

For nonsymmetrical layouts, the program will observe the specified distance from the vertical centerline, but it ignores a specified distance from the horizontal centerline. However, the distance from the horizontal centerline can be controlled by entering a value for the "Tube Limit from Top of Shell ID along Vertical centerline" equal to the top edge of the last tube row.

Default: program optimized

Minimum U-Bend Diameter

This determines the minimum tube center-to-center distance of any U-tube bundle.

For 2-pass. U-tube layouts, it determines the distance from the pass partition to the first row of tubes on each side of the pass partition.

For layouts of 4 or more passes, it determines the distance on each side of the vertical pass partition.

The choice of a minimum bend diameter must take into account what the tube material is, what the wall thickness is, how much thinning in the bend is permissible, and what bending dies and procedures are to be used.

Default: three times the tube OD

Nozzle/Impingement Plate Sheet

Use this sheet to specify the shell side inlet nozzle outside diameter and orientation, and impingement protection parameters.

Shell side inlet nozzle

The program uses the shell side inlet nozzle **outside diameter** to determine the position of the impingement plate. This dimension is not required if you specify the impingement plate diameter.

The program uses the shell inlet nozzle **orientation** to determine the orientation of the impingement plate. The orientation is required if you specify the impingement plate.

If you have done the thermal design for this heat exchanger, these input fields display the results determined from the thermal design program.

Impingement protection

The purpose of impingement protection is to protect the tubes directly under the inlet nozzle by deflecting the bullet shaped flow of high velocity fluids or the force of entrained droplets.

If you have done the thermal design for this heat exchanger, the impingement protection type displayed is from thermal design program.

You can also specify these impingement plate dimensions:

- Diameter

  The diameter determines the position and the dimension of the impingement plate This input is not required if you have already specified the shell inlet nozzle OD (default).
- Length (parallel to tube axis)
- Width (normal to tube axis)

  Use the length and width to specify a rectangular impingement plate size. The default length and width (square plate) is the shell inlet nozzle OD.
- Thickness

  This is required if you specify an impingement field. You can specify any thickness for the impingement plate. The default is 3 mm or 0.125 in.
- Distance in from shell ID

  You can specify the distance from the shell inside diameter to the impingement plate. The default is top row of tubes.
- Clearance to tube edge

  You can specify the distance from the impingement plate to the first row of tubes.
- Perforation area %

  If you are using a perforated type impingement plate, you can specify the percent of area that the plate is perforated.

Tube Row Details

If you are specifying the details from an existing tube layout to generate a tube layout drawing, use this sheet to provide the row number, number of holes, and location of tube row for each row in the tube layout. You can also specify the tie rod, pass partition, and baffle cut locations.

Ensea Results

The output from ENSEA is divided into six sections:

- Input Data
- Warnings and Messages
- Tubesheet Layout Summary
- Tube Row Details

- U-bend Details
- U-bend Totals

You can display and/or print any or all parts of this output. The format of the output is consistent between display and printed output, typically with two or three display screens equal to one printed page. Most printed pages will also have a heading with the program name, version, time, date, and filename.

Input Data

You can display the input data in a more condensed format than used in the input. It is recommended that you request the input data as part of your printed output so that it is easy to reconstruct the input which led to the design.

Warnings & Messages

Aspen B-JAC provides an extensive system of warnings and messages to help the designer of heat exchanger design. Messages are divided into five types. There are several hundred messages built into the program. Those messages requiring further explanation are described here.

Warning Messages: These are conditions, which may be problems, however the program will continue.

Error Messages: Conditions which do not allow the program to continue.

Limit Messages: Conditions which go beyond the scope of the program.

Notes: Special conditions which you should be aware of.

Suggestions: Recommendations on how to improve the design.

Summary

The **Summary** section provides general information about the tubes, the tube layout design parameters, and clearances.

- Outer tube circle

  The outer tube circle is often slightly different than the outer tube limit. Whereas the o.t.l. is the limit beyond which no tube can extend, the outer tube circle is the actual diameter determined by the outer edge of the outermost tube, measured radially.

- Equivalent tube perimeter

  This is the "equivalent diameter of the tube center limit perimeter" as defined in TEMA 7.133 Tubesheet Formula - Shear. It is equal to four times the area enclosed by the tube perimeter divided by the tube perimeter.

- Maximum deviation from median

  This is the maximum deviation from the median number of tubes per pass, shown "Before Balancing" and "After Balancing." "Before Balancing" is before the program removes tubes to satisfy the specified (or defaulted) input for Maximum Deviation. "After Balancing" is the recomputed deviation for the tubesheet layout shown and should always be within the specified maximum.

Tube Row Details

The **Tube Row Detail** section provides a per row tube count and row location. Most of this output is self explanatory. The items needing some additional explanation are:

- Row number and number of holes

  Row indicates the tube row number. Row number 1 is always at the bottom of the layout. The number of holes is the total number of holes in that row.

- Distance offset from centerlines

  The first column is the distance from the vertical centerline (x-axis) to the center of the first tube in that row, counting from the vertical centerline. If a tube is on the vertical centerline, the value will be 0.0. The second column is the distance from the horizontal centerline (y-axis) to the center of each tube in the row. A positive value indicates the row is above the horizontal centerline; a negative value indicates it is below. If a tube is on the horizontal centerline, the value will be 0.0.

Tube Layout Drawing

Once you have run the Ensea program and have tube layout results, you can interactively make modifications to the tube layout.

After you complete your changes to the tube layout, you may want to select the "Use existing layout" option located on the **Application Options** sheet.

Logic

Ensea Logic

The right half and left half of layout are always symmetrical for tube hole placement. Top and bottom halves can be nonsymmetrical.

The program assumes that tube side nozzles are at the top and bottom of the layout (offset from the vertical centerline for quadrant type layouts).

If the number of tubes is not given as input, the program will maximize the number of tubes by trying several solutions, varying one or more of the following:

- Location of first tube row in relation to the vertical centerline
- Location of pass partition plates
- Pass layout type

If the number of tubes is given as input, the program will choose the layout which requires the fewest tubes to be eliminated to arrive at the desired number or the layout which has the least deviation in number of tubes per pass.

If tubes are eliminated in order to balance the number of tubes per pass or to match a given number of tubes, the program follows this procedure:

For the passes on the bottom or the top:

- Tubes are eliminated starting from the end of the outermost row and moving toward the vertical centerline in that row, until the number of tubes is met.

For inner passes:

- Tubes are eliminated from each row, one tube per row, from the periphery of the bundle until the number of tubes is met.

U-tube layouts of 4 or more passes are always quadrant type.

U-tubes are always bent in parallel planes.

Cleaning lanes are always maintained for square and rotated square patterns for removable bundles in TEMA heat exchangers.

The baffle cut is cut through the center of a tube row except for baffles with no tubes in the window.

Longitudinal baffles are assumed to be of the same thickness as pass partition plates and match the location of a pass partition.

Sealing strips are assumed to not affect the placement of tubes.

Multi-segmental baffle cuts are chosen so that the total window areas per baffle are approximately equal. Whenever possible there is at least one tube row which is common to each baffle set. Reference the Appendix for more information on baffle cuts.

Tie rods are located according to the following logic:

- spacers are at least 0.125 inch or 3.2 mm from the nearest tube and from the baffle edge.
- Tie rods between the first and last tube rows are at the periphery of the bundle on or between tube rows.
- Preference is given to locations where tubes are not displaced.

- Preference is given to locations evenly distributed around the bundle or close to the baffle cut when appropriate.

The tubesheet layout is drawn to scale. The scale is chosen by the program.

The program draws all of the pitch lines within the o.t.l. It also draws the tube holes for each tube along the perimeter of each pass.

References

Ensea References

For a further understanding of subjects relating to ENSEA, see the following publications:

- Terminology, Construction Types, and Clearances

  Standards of Tubular Exchanger Manufacturers Association, TEMA, Seventh Edition, 1988

- Pass Layout Types

  Heat Exchangers: Design and Theory Sourcebook, Afgan and Schlunder, pp.33-34 (section author, K.A. Gardner), McGraw-Hill, New York, 1974

- Numerical Control

  Programming for Numerical Control Machines, A.D. Roberts and R.C. Prentice, McGraw-Hill, New York, 1968

  Modern Machine Shop NC/CAM Guidebook, Gardner Publications, Rookfield, Wisconsin

Qchex

Qchex Input

Problem Definition

Description

TEMA Specification Sheet Descriptions

Use this sheet to specify **Headings**, which appear at the top of the TEMA specification sheet, Input Summary results, and the Title block of the drawings. Headings are 1 to 5 lines of up to 75 characters per line. Note that only the first 40 characters of each line appear on the drawings.

To create global headings for use by any B-JAC program, click **Tools | Program Settings**, display the **Headings/Drawings** tab, and enter the heading information.

Exchanger Geometry

Shell/Heads Sheet

Use this sheet to specify the shell and head types and exchanger position.

- Front head type

  The front head type should be selected based on the service needs for the exchanger. A full access cover provided in the A, C, and N type heads may be needed if the tube side of the exchanger must be cleaned frequently. Type B (default) is generally the most economical type head.

- Shell type

  The shell type determines the shell side flow arrangement and the place of the shell side nozzles. The default is type E (except K type shell side pool boilers).

- Rear head type

  The rear head type affects the thermal design, because it determines the outer tube limits and therefore the number of tubes and the required number of tube passes. Type U is the default for kettle shells; for all others, M.

- Exchanger position

  Specify whether the exchanger is to be installed in the horizontal or vertical position. The default is vertical for tube side thermosiphon; for all others, horizontal.

Shell type

The shell type determines the shell side flow arrangement and the place of the shell side nozzles.

Type	Description
E	Generally provides the best heat transfer but also the highest shell side pressure drop. Used for temperature cross applications where pure counter current flow is needed.
F	This two pass shell can enhance shell side heat transfer and also maintain counter current flow if needed for temperature cross applications.
G	Will enhance the shell side film coefficient for a given exchanger size.
H	A good choice for low shell side operating pressure applications. Pressure drop can be minimized. Used for shell side thermosiphons.
J	Used often for shell side condensers. With two inlet vapor nozzles on top and the single condensate nozzle on bottom, vibration problems can be avoided.
K	Used for kettle type shell side reboilers.
X	Good for low shell side pressure applications. Units is provided with support plates which provides pure cross flow through the bundle. Multiple inlet and outlet nozzles or flow distributors are recommended to assure full distribution of the flow along the bundle.
V	This type is not currently part of the TEMA standards. It is used for very low shell side pressure drops. It is especially well suited for vacuum condensers. The vapor belt is an enlarged shell over part of the bundle length.

Default: E type (except K type shell side pool boilers)

Tubesheets/Expansion Joints Sheet

Use this sheet to specify:

- Tubesheet type

  The tubesheet type has a very significant effect on both the thermal design and the cost.

- Tube to tubesheet joint

  The tube to tubesheet joint does not affect the thermal design, but it does have a small effect on the mechanical design and sometimes a significant effect on the cost.

- Expansion joint

  The specification of an expansion joint does not affect the thermal design calculations, but does have a significant effect on the cost. This item only applies to fixed tubesheet heat exchangers; it is ignored for all other types. The default is program, based on the estimated differential expansion.

  Note that the calculations required to determine the need for an expansion joint are quite complex and are beyond the scope of the Hetran program. These calculations are part of the Teams program. However the Hetran program will estimate the differential expansion between the tubes and the shell and make a simple determination on the need for an expansion joint if you use the program default.

Tubesheet type

The tubesheet type has a very significant effect on both the thermal design and the cost. The default is normal single tubesheet(s).

Double tubesheets are used when it is extremely important to avoid any leakage between the shell and tube side fluids. Double tubesheets are most often used with fixed tubesheet exchangers, although they can also be used with U-tubes and outside packed floating heads.

Double tubesheets shorten the length of the tube which is in contact with the shell side fluid and therefore reduce the effective surface area. They also affect the location of the shell side nozzles and the possible baffle spacings.

The gap type double tubesheet has a space, usually about 150 mm (6 in.), between the inner (shell side) and outer (tube side) tubesheets. The integral type double tubesheet is made by machining out a honeycomb pattern inside a single thick piece of plate so that any leaking fluid can flow down through the inside of the tubesheet to a drain. This type is rare, since it requires special fabrication tools and experience.

Tube to tubesheet joint

The tube to tubesheet joint does not affect the thermal design, but it does have a small effect on the mechanical design and sometimes a significant effect on the cost.

The most common type of tube to tubesheet joint is expanded only with 2 grooves. Although TEMA Class C allows expanded joints without grooves, most fabricators will groove the tube holes whenever the tubes are not welded to the tubesheet.

For more rigorous service, the tube to tubesheet joint should be welded. The most common welded joints are expanded and seal welded with 2 grooves and expanded and strength welded with 2 grooves.

For normal service the default is expanded only with 2 grooves; for lethal service the default is expanded and strength welded with 2 grooves.

Exchanger Data

Shell Sheet

Use this sheet to specify these exchanger data details:

- Gross surface area

  If you do not know the exact configuration of the exchanger, you can specify the gross surface area, and the program will determine a reasonable geometry based on the program defaults. If you do not specify the gross surface area, then you must provide values for the number of tubes, tube outside diameter, and tube length.

- Shell outside, inside diameter

  If you do not specify the surface area, you must specify either the actual shell outside or inside diameter. If you specify the shell OD, we recommend leaving the ID blank.

  For pipe size exchangers, we recommend specifying the shell OD rather than ID, since the program references standard pipe schedules. For exchangers made of rolled and welded plate materials, specify either the shell OD or ID. For kettles, the shell diameter is for the small cylinder near the front tubesheet, not the large cylinder.

- Baffle spacing center-center

  Specify the center to center spacing of the baffles in the bundle.

- Baffle spacing at inlet

  Specify the inlet baffle spacing at the entrance to the bundle. For G, H, J, and X shell types, this is the spacing from the center of the nozzle to the next baffle. These types should have a full support under the nozzle. If left blank, the program calculates the space based on the center to center spacing and the outlet spacing. If the outlet spacing is not provided, the program determines the remaining tube length not used by the center to center spacing and provides equal inlet and outlet spacings.

- Number of baffles

  The number of baffles is optional input. If you do not know the number of baffles, inlet, or outlet spacing, you can approximate the number of baffles by dividing the tube length by the baffle spacing and subtracting 1. However, if you do not know the number of baffles, it is best to let the program calculate it, because it will also consider the tubesheet thickness and nozzle sizes. The number of baffles for G, H, and J type shells should include the baffle or full support under the nozzle.

- Tube length

  Specify the tube length. The length should include the length of tubes in the tubesheets. For U-tube exchangers, specify the straight length to the U-bend tangent point.

- Number of tubes

  Specify the number of tube holes in the tubesheet. This is the number of straight tubes or the number of straight lengths for a U-tube. If you specify the number, the program checks to make sure that number of tubes can fit into the shell. If you do not specify it, the program calculates number of tubes using the tubesheet layout subroutine.

- Tube passes

  Provide the number of tube passes in the exchanger.

- Kettle outside diameter

  Specify the actual kettle outside diameter. For pipe size exchangers, we recommend specifying a kettle OD rather than an ID, since the program references standard pipe schedules. For exchangers made of rolled and welded plate materials, specify either the kettle OD or ID.

Tubes Sheet

Use this sheet to specify these exchanger data details:

- Tube type

  The program covers plain tubes (default) and external integral circumferentially finned tubes.

- Fin density

  If you specify fin tubes as the tube type, then you must specify the desired fin density (i.e., the number of fins per inch/per meter). Since the possible fin densities are very dependent on the tube material, you should be sure that the desired fin density is commercially available.

- Tube outside diameter

  You can specify any size for the tube outside diameter. Correlations have been developed based on tube sizes from 10 to 50 mm (0.375 to 2.0 inch). For integral finned tubes, this is the outer diameter of the fins.

- Tube wall thickness

  The tube wall thickness should based on considerations of corrosion, pressure, and company standards. Tube wall thickness can be specified or calculated by the program.
- Tube pitch

  The tube pitch is the center-to-center distance between two adjacent tubes
- Tube pattern

  The tube pattern is the layout of the tubes in relation to the direction of the shell side crossflow, which is normal to the baffle cut edge. The one exception to this is pool boiling in a kettle type reboiler where the tube supports are sometimes baffles with a vertical cut.

Tube type

The program covers plain tubes (default) and external integral circumferentially finned tubes.

Externally finned tubes become advantageous when the shell side film coefficient is much less than the tube side film coefficient. However there are some applications where finned tubes are not recommended. They are not usually recommended for cases where there is high fouling on the shell side or for condensation where there is a high liquid surface tension.

The dimensional standards for Wolverine and High Performance finned tubes are built into the program. These standard finned tubes are available in tube diameters of 12.7, 15.9, 19.1, and 25.4 mm or 0.5, 0.625, 0.75, and 1.0 inch.

Fin density

If you specify fin tubes as the tube type, then you must specify the desired fin density (i.e., the number of fins per inch or per meter depending on the system of measure). Since the possible fin densities are very dependent on the tube material, you should be sure that the desired fin density is commercially available.

The dimensional standards for finned tubes made by Wolverine, and High Performance Tube are built into the program. If you choose one of these, the program will automatically supply the corresponding fin height, fin thickness, and ratio of tube outside to inside surface area.

The standard fin densities for various materials are:

Material	**Fin Density**
Carbon Steel	19
Stainless Steel	16, 28
Copper	19, 26

Material	**Fin Density**
Copper-Nickel 90/10	16, 19, 26
Copper-Nickel 70/30	19, 26
Nickel Carbon Alloy 201	19
Nickel Alloy 400 (Monel)	28
Nickel Alloy 600 (Inconel)	28
Nickel Alloy 800	28
Hastelloy	0
Titanium	30
Admiralty	19, 26
Aluminum-Brass Alloy 687	9

Tube outside diameter

You can specify any size for the tube outside diameter. However, the correlations have been developed based on tube sizes from 10 to 50 mm (0.375 to 2.0 inch). The most common sizes in the U.S. are 0.625, 0.75, and 1.0 inch. In many other countries, the most common sizes are 16, 20, and 25 mm.

If you do not know what tube diameter to use, start with a 20 mm diameter (ISO standards) or a 0.75 inch diameter (American standards). This size is readily available in nearly all tube materials. The primary exception is graphite, which is made in 32, 37, and 50 mm, or 1.25, 1.5, and 2 inch outside diameters.

For integral low fin tubes, the tube outside diameter is the outside diameter of the fin.

Default: 19.05 mm or 0.75 inch

Tube wall thickness

The tube wall thickness should be based on considerations of corrosion, pressure, and company standards. If you work with ANSI standards, the thicknesses follow the BWG standards.

The program defaults are a function of material per TEMA recommendations and a function of pressure. The Aspen Hetran program checks the specified tube wall thickness for internal pressure and issues a warning if it is inadequate. For low fin tubes, the tube wall thickness specified will be maintained below the fins.

Defaults:	carbon steel	0.065 in. or 1.6 mm
	titanium	0.028 in. or 0.7 mm
	graphite	0.180 in. or 5 mm
	other materials	0.049 in. or 1.2 mm

Note: The values are not limited to those listed, which are provided as a convenience.

Tube pitch

The tube pitch is the center-to-center distance between two adjacent tubes. Generally, the tube pitch should be approximately 1.25 times the tube OD. It some cases, it may be desirable to increase the tube pitch in order to better satisfy the shell side allowable pressure drop. Increasing the tube pitch beyond 1.5 times the tube OD is not recommended.

Minimum tube pitches are suggested by TEMA as a function of tube OD, tube pattern, and TEMA class. The program defaults to the TEMA minimum tube pitch, if you are designing to TEMA standards.

The DIN standards also cover tube pitch. The DIN tube pitches are a function of tube OD, tube pattern, and tube to tubesheet joint. The program defaults to the DIN standard if you are designing to DIN standards.

Tube Pattern

The tube pattern is the layout of the tubes in relation to the direction of the shell side crossflow, which is normal to the baffle cut edge. The one exception to this is pool boiling in a kettle type reboiler, where the tube supports are sometimes baffles with a vertical cut.

Use **triangular** when you want to maximize the shell side film coefficient and maximize the number of tubes, and shell side cleaning is not a major concern. If you must be able to mechanically clean the shell side of the bundle, then choose square or rotated square.

Square is recommended for pool boilers to provide escape lanes for the vapor generated.

Rotated square will give the higher film coefficient and higher pressure drop, but it will usually have fewer tubes than a square layout.

Rotated triangular is rarely the optimum, because it has a comparatively poor conversion of pressure drop to heat transfer.

Defaults: triangular for fixed tubesheet exchangers; square for pool boilers

Baffle Type

Baffle types can be divided up into two general categories:

- **Segmental baffles** are pieces of plate with holes for the tubes and a segment that has been cut away for a baffle window. Single, double, triple, and no tubes in window are examples of segmental baffles.

- **Grid baffles** are made from rods or strips of metal, which are assembled to provide a grid of openings through which the tubes can pass.

Segmental baffles are the most common type of baffle, with the single segmental baffle being the type used in a majority of shell and tube heat exchangers. The single segmental baffle gives the highest shell film coefficient but also the highest pressure drop. A double segmental baffle at the same baffle spacing will reduce the pressure drop dramatically (usually somewhere between 50% - 75%) but at the cost of a lower film coefficient. The baffles should have at least one row of overlap and therefore become practical for a 20 mm or 0.75 in. tube in shell diameters of 305 mm (12 in.) or greater for double segmental and 610 (24 in.) or greater for triple segmental baffles. (Note: the B-JAC triple segmental baffle is different than the TEMA triple segmental baffle.)

Full Supports are used in K and X type shells where baffling is not necessary to direct the shell side flow.

No Tubes In Window is a layout using a single segmental baffle with tubes removed in the baffle windows. This type is used to avoid tube vibration and may be further enhanced with intermediate supports to shorten the unsupported tube span. The standard abbreviation for no tubes in the window is NTIW.

The program covers two types of grid baffles: rod baffles and strip baffles. Both are used in cases where the allowable pressure drop is low and the tube support is important to avoid tube vibration.

Rod Baffle design is based on the construction and correlations developed by Phillips Petroleum. Rod baffles are limited to a square tube pattern. The rods are usually about 6 mm (0.25 in.) in diameter. The rods are placed between every other tube row and welded to a circular ring. There are four repeating sets where each baffle is rotated 90 degrees from the previous baffle.

Strip Baffles are normally used with a triangular tube pattern. The strips are usually about 25 mm (1 in.) wide and 3 mm (0.125 in.) thick. The strips are placed between every tube row. Intersecting strips can be notched to fit together or stacked and tack welded. The strips are welded to a circular ring. Strip baffles are also sometimes referred to as nest baffles.

Default: single segmental except X shells; full support for X shell

Baffle cut (% of diameter)

The baffle cut applies to **segmental baffles** and specifies the size of the baffle window as a percent of the shell inside diameter.

For **single segmental baffles**, the program allows a cut of 15% to 45%. Greater than 45% is not practical because it does not provide for enough overlap of the baffles. Less than 15% is not practical, because it results in a high pressure drop through the baffle window with relatively little gain in heat transfer (poor pressure drop to heat transfer conversion). Generally, where baffling the flow is necessary, the best baffle cut is around 25%.

For **double and triple segmental baffles**, the baffle cut pertains to the most central baffle window. The program automatically sizes the other windows for an equivalent flow area.

Defaults:	single segmental	45% for simple condensation and pool boiling; 25% for all others
	double segmental	28% (28/23)
	triple segmental	14% (14/15/14)

Baffle cut orientation

The baffle orientation applies to the direction of the baffle cut with segmental baffles. It is very dependent on the shell side application.

For horizontal, shell side condensation applications, the cut should be oriented vertically. This will facilitate condensate drainage. For all other applications, the cut orientation is not as critical. The program defaults to vertical cut for horizontal condensers and horizontal cut for all other applications.

For a single phase fluid in a horizontal shell, the preferable baffle orientation of single segmental baffles is horizontal, although vertical and rotated are usually also acceptable. The choice will not affect the performance, but it will affect the number of tubes in a multipass heat exchanger. The horizontal cut has the advantage of limiting stratification of multicomponent mixtures, which might separate at low velocities.

The rotated cut is rarely used. Its only advantage is for a removable bundle with multiple tube passes and rotated square layout. In this case the number of tubes can be increased by using a rotated cut, since the pass partition lane can be smaller and still maintain the cleaning paths all the way across the bundle. (From the tubesheet, the layout appears square instead of rotated square.)

For horizontal shell side condensers, the orientation should always be vertical, so that the condensate can freely flow at the bottom of the heat exchanger. These baffles are frequently notched at the bottom to improve drainage. For shell side pool boiling, the cut (if using a segmental baffle) should be vertical. For shell side forced circulation vaporization, the cut should be horizontal in order to minimize the separation of liquid and vapor.

For double and triple segmental baffles, the preferred baffle orientation is vertical. This provides better support for the tube bundle than a horizontal cut which would leave the topmost baffle unsupported by the shell. However this can be overcome by leaving a small strip connecting the topmost segment with the bottommost segment around the baffle window between the O.T.L. and the baffle OD.

Defaults: vertical for double and triple segmental baffles
vertical for shell side condensers
vertical for F, G, H, and K type shells
horizontal for all other cases

Nozzle Sheet

You should use this sheet to specify the nozzle diameters, if known. Use nominal pipe sizes. If you do not specify a value, the program assumes nozzles with a diameter equal to one-third the shell diameter.

The program determines the number of nozzles required based on the specified shell type and automatically determines the nozzle flange rating.

Design Data

Vessel Sheet

Use this sheet to select the material of construction for these items:

- Shell
- Front head
- Tubesheet
- Double tubesheet (inner)
- Baffles
- Tubes

The Qchex program uses the Metals databank to retrieve material properties and prices. You can use the generic material types such as carbon steel, and the program will assign actual default material specifications, depending on the product form. For carbon steel plate, a material specification of SA-516-70 will be used for an ASME design. Appropriate specifications will be selected for other design construction codes.

The default material is carbon steel. To select a specific material specification, click the **Databank Search** button.

If you want to exclude the pricing of a particular component, for example the tubes, specify a zero for that material.

You can use the DefMats utility to change the default materials.

Cladding/Gasket sheet

Use this sheet to specify the material of construction for these items:

- Tubesheet cladding
- Gaskets - shell side
- Gasket -- tube side

The Qchex program uses the Metals databank to retrieve material properties and prices. You may specify a generic material number or a code for a specific material specification.

To select a specific material specification, click the **Databank Search** button.

If you want to exclude the pricing of a particular component, specify a zero for that material.

You can use the DefMats utility to change the default materials.

Design Specifications Sheet

Use this sheet to specify these design specifications:

- TEMA class

  If you want the heat exchanger to be built according to TEMA standards, select the appropriate TEMA class: B (Default), C, or R. If TEMA is not a design requirement, then specify Code only, and program will use only the design code to determine the mechanical design.
- Design pressure

  Used in the mechanical design calculations, the specified design pressure influences the shell, head, and tubesheet required thicknesses, and therefore affects the thermal design. This is in gauge pressure so it is one atmosphere less than the equivalent absolute pressure.
- Design temperature

  Used in the mechanical design calculations, the design temperatures influence the shell, head, and tubesheet required thicknesses, and therefore affect the thermal design.
- Mean metal temperature

  These temperatures are used if the program needs to determine if an expansion joint should be included in the cost.

Qchex Results

The results section consists of three sections:

- **Input Summary** of the input parameters for the budget estimate.

- Warnings & Messages
- **Design Summary** of the pertinent mechanical parameters shown on the construction portion of the TEMA specification sheet.
- **Cost Summary** reports the budget pricing for the exchanger, including the cost of material, cost of labor, and mark up

Qchex Logic

Mechanical Design

The Qchex program performs an approximate mechanical design of the heat exchanger components so that the material weight can be determined. Some of the more significant assumptions used in the analysis are summarized below.

Design Pressure

Due to limitations of the analytic procedure at high design pressures, thicknesses of flanges, tubesheets and flat covers are limited to 12 in. or 300 mm.

The maximum allowable design pressure for a TEMA W-type externally sealed floating tubesheet is as detailed in TEMA.

Design Temperature and Allowable Stresses

Design temperatures are limited by the ASME maximum allowable temperature for the material specified. For design temperatures exceeding this maximum, the allowable stress is determined at the maximum allowable temperature and a warning is displayed.

Design temperature for a TEMA W-type unit is limited as detailed in TEMA.

Corrosion Allowance

Corrosion allowance for cylinders, covers, and tubesheets is determined in accordance with TEMA.

Cylinders and Covers

Calculations are to the ASME Code Section VIII Division 1.

Thickness calculations are based on internal pressure loadings and assume spot radiography.

Flat bolted covers that are not made of carbon steel or low alloy steel are assumed to be lined with an alloy liner.

Minimum TEMA thicknesses are checked.

Component weights are calculated from finished dimensions, and rough dimensions are used to determine material costs.

Tubesheets

Approximate tubesheet thicknesses are calculated in accordance with TEMA.

Tubesheets exceeding 6 in. or 152 mm in thickness and not made of carbon or low alloy steel are assumed to be clad. The number of clad surfaces is dependent upon the shell and tube side materials.

Minimum TEMA thicknesses are checked.

The tubesheet thickness is limited to a maximum of 12 in. or 300 mm.

Rough weights are calculated assuming the tubesheet is fabricated from a square plate.

If a double tubesheet is specified, the shell side tubesheet thickness is based on the shell side design pressure.

Flanges

Approximate flange thicknesses are determined using a modified bending formula.

Ring flanges are assumed for carbon and low alloy construction and for high alloy flanges less than or equal to 1 in. or 25 mm in thickness. All other flanges are assumed to be lap joint with a carbon steel ring.

The flange thickness is limited to a maximum of 12 in. or 300 mm.

Rough weights are calculated assuming the flanges are fabricated from forged rings.

Tubes

Qchex accesses the same routines which are used in TEAMS to determine tube prices for bare or finned tubes.

Nozzles and Nozzle Flanges

Inlet, outlet, and condensate nozzle sizes can be specified. The program automatically determines the number of each type of nozzle based on the shell and head types specified.

Finished and rough weights are based on correlations that consider design pressure and nozzle diameter.

Material Prices

Material Prices

The Qchex program accesses the same material price database that is used by the cost routines in the Teams program. This database contains several hundred prices and is maintained and updated by B-JAC as the market conditions change. Users can maintain their own material price database by using the COST database.

The material designators listed in this section are converted to the appropriate 4 digit material designators used by the Teams and Metals programs. You can change the correspondence between the 1 or 2 digit numbers and the 4 digit numbers by using the Defmats database.

Material unit costs are multiplied by the rough weight to determine the component material cost. The material price for the heat exchanger is determined by adding all of the component material costs.

If you do not want the price of a particular part of the exchanger to be included in the total price, you should assign a value of zero for that part material. For instance, the program would not include the cost of the tubing in the selling price if you set the tube material to zero.

Labor Hours

The labor hours required to fabricate the shell and heads of the heat exchanger are calculated from correlations that were developed by Aspen B-JAC based on several hundred labor estimates for a wide variety of exchanger types and design conditions. These correlations are a function of design pressure, shell diameter, weight, tube length, and material.

The labor hours for the bundle are determined more precisely using the same techniques used in the cost estimate portion of the Teams program. This portion of the program accesses the database of fabrication standards (machining and drilling speeds). This database is maintained by Aspen B-JAC or you can modify this database for your own use by running the Cost database.

Drilling and machining speeds for the tubesheets and baffles are based on the tubesheet material. Labor hours for loading tubes, tube-to-tubesheet joint procedures, and bending U-tubes are the same as those calculated by the Teams cost routines.

Budget Price

The budget price for the exchanger is calculated by adding the material costs, labor costs, and markups on material and labor. Labor costs are based on the total shop fabrication hours and the burdened labor rate. This rate and the markups on material and labor are the same as used in the Teams program.

The price is for one heat exchanger and does not include any shipping or escalation costs.

The Qchex program is intended to be used as a budget estimating tool. The accuracy of the estimate is dependent upon many factors, including:

- Accuracy of the Heat Exchanger Configuration

An estimate where the tube length, tube side, and shell size are known will be much more accurate than an estimate based on surface area alone.

Quantity of Materials

The material prices stored in the Aspen B-JAC standard material price file are based on average quantity brackets. Very small or very large quantities will affect the accuracy of the material prices.

Non-standard Construction

As the construction becomes more non-standard the accuracy of the estimate decreases.

Extreme Design Conditions

When the design pressure on one or both sides becomes very high the exact mechanical design becomes more important. In these cases the TEAMS program should be used.

Premium Materials

When using premium materials (for example titanium) the material price can be very volatile and highly dependent upon quantity.

Non-competitive or Rush Orders

The budget estimate is less accurate for non-competitive situations or when delivery time is a premium.

Regional Differences

The actual price is dependent upon the country of manufacture and in the case of the United States and Canada, it is dependent upon the region of manufacture. The Qchex program does not reflect these regional differences.

Qchex References

There are relatively few published sources of information on heat exchanger cost estimating. Most of the logic and much of the data in the Qchex program have come from the fabrication experience of the engineers at B-JAC who have worked with heat exchanger manufacturers.

For a further understanding of some of the underlying concepts in cost estimating, see the following publications:

- Heat Exchanger Cost Estimating

  Computerized Cost Estimation of Heat Exchangers, Bruce Noe, and Gregory Strickler, 21st National Heat Transfer Conference, ASME, 83-HT-62, 1983.
- Manufacturing Cost Estimating; Operations and Speeds

Tool & Manufacturing Engineers Handbook, Daniel Dallas, Society of Manufacturing Engineers, Dearborn, Michigan, 1976.

The Procedure Handbook of Arc Welding, The Lincoln Electric Company, Cleveland, Ohio, 1973.

Machining Data Handbook, Metcut Research Associates Inc., Cincinnati, Ohio, 1972.

Props

Application Options

Props Application Options Sheet

Use this sheet to specify whether you want to retrieve physical properties at a single temperature point, over a range of temperatures, or to produce a vapor liquid equilibrium curve with liquid and vapor properties and a heat release curve.

- At one temperature point

  If you select the mode that gives the properties at a single temperature, you need to specify only the starting temperature and the pressure.

  Optionally, you can determine the saturation temperature or saturation pressure for a single component that has properties stored for both liquid and gas phases.

  To request the saturation temperature, leave the temperature input blank and specify the desired pressure in the field for pressure. The program will return the properties at the saturation temperature for the specified pressure.

  To request the saturation pressure, specify the desired temperature, and leave the pressure input field blank. The program will return the properties at the specified temperature and the pressure that is equal to the vapor pressure at that temperature.

- Over a temperature range:

  If you select this mode, Props will give you the properties over a range of temperatures:

  You specify starting and ending temperatures, the temperature increment, and the pressure.

  The maximum number of intervals is 100. Therefore, if you specify a temperature interval that is smaller than 0.01 times the difference between the starting and ending temperatures, the program will adjust the temperature increment to accommodate the full temperature range specified.

- Over a temperature range with VLE calculation

  If you select this mode, Props will generate a vapor-liquid equilibrium curve and provide heat load, composition, and physical properties per temperature increment.

  You specify the starting and ending temperatures, the pressure, and the flowrate total.

  The program will divide the condensing range into 20 equal temperature intervals. A vapor-liquid equilibrium curve will also be provided over the specified range.

Property Options

If you select the application option to **retrieve properties over a temperature range with VLE calculations**, the Property Options form appears in the Props input tree. Use this form to specify:

- Condensation options
- Vaporization options

Condensation Options Sheet

Use this sheet to specify the following options:

- Condensation curve calculation method

  The calculation method determines which correlations the program uses to determine the vapor-liquid equilibrium. The choice of method is dependent on the degree of non-ideality of the vapor and liquid phases and the amount of data available.

- Condensation curve calculation type

  For a condensing stream, you should determine if your case is closer to **integral** or **differential** condensation. The program defaults to integral.

- Effect of pressure drop on condensation

  The program defaults to calculating the condensing curve in isobaric conditions (constant operating pressure). If the B-JAC Property program generates the VLE curve, you may specify non-isobaric conditions. The program allocates the specified pressure drop based on temperature increments along the condensation/vaporization curve. The vapor/liquid equilibrium at various temperature points is calculated using an adjusted operating pressure.

- Estimated pressure drop for hot side

Specify the estimated hot side pressure drop through the exchanger. If actual pressure varies more than 20 percent from this estimated pressure drop, adjust this value to the actual and rerun Hetran.

If the B-JAC Property program generates the VLE curve, the program uses this pressure drop to adjust the VLE curve.

The VLE calculation program does not permit the condensate to re-flash. If calculations indicate that this is happening, the program will suggest using a lower estimated pressure drop.

Condensation/ Vaporization Curve Calculation Method

The calculation method determines which correlations the program will use to determine the vapor-liquid equilibrium. The choice of method is dependent on the degree of non-ideality of the vapor and liquid phases and the amount of data available.

The methods can be divided into three general groups:

- **Ideal** - correlations for ideal mixtures.

  The ideal method uses ideal gas laws for the vapor phase and ideal solution laws for the liquid phase. You should use this method when you do not have information on the degree of nonideality. This method allows for up to 50 components.

- **Soave-Redlich-Kwong, Peng-Robinson, and Chao-Seader** - correlations for non-ideal mixtures which do not require interaction parameters.

  The Soave-Redlich-Kwong and Peng-Robinson methods can be used on a number of systems containing hydrocarbons, nitrogen, carbon dioxide, carbon monoxide, and other weakly polar components. They can also be applied with success to systems which form an azeotrope, and which involve associating substances such as water and alcohols. They can predict vapor phase properties at any given pressure.

  The Chao-Seader method uses Redlich-Kwong equations for vapor phase non-ideality and an empirical correlation for liquid phase non-ideality. It is used with success in the petroleum industry. It is recommended for use at pressures less than 68 bar (1000 psia) and temperatures greater than -18°C (0°F). The program uses the original Chao-Seader correlation with the Grayson-Streed modification. There is no strict demarcation between these two methods since they are closely related. These methods allow for up to 50 components.

- **Uniquac, Van Laar, Wilson, and NRTL** - correlations for non-ideal mixtures which require interaction parameters.

  These methods are limited to ten components. The Uniquac, Van Laar, Wilson, and NRTL methods require binary interaction parameters for each pair of components. The

Uniquac method also requires a surface parameter and volume parameter, and the NRTL method requires an additional Alpha parameter.

The Wilson method is particularly suitable for strongly non-ideal binary mixtures, for example, solutions of alcohols with hydrocarbons. The Uniquac method is applicable for both vapor-liquid equilibrium and liquid-liquid equilibrium (immiscibles). It can be used for solutions containing small or large molecules, including polymers. In addition, Uniquac interaction parameters are less temperature dependent than those for Van Laar and Wilson.

Condensation Curve Calculation Type

For a condensing stream, you should determine if your case is closer to integral or differential condensation.

Integral condensation assumes that the vapor and liquid condensate are kept close enough together to maintain equilibrium, and that the condensate formed at the beginning of the condensing range is carried through with the vapor to the outlet. Vertical tube side condensation is the best case of integral condensation. Other cases which closely approach integral condensation are: horizontal tube side condensation, vertical shell side condensation, and horizontal shell side crossflow condensation (X-shell).

In **differential condensation** the liquid condensate is removed from the vapor, thus changing the equilibrium and lowering the dew point of the remaining vapor. The clearest case of differential condensation is seen in the knockback reflux condenser, where the liquid condensate runs back toward the inlet while the vapor continues toward the outlet.

Shell side condensation in a horizontal E or J shell is somewhere between true integral condensation and differential condensation. If you want to be conservative, treat these cases as differential condensation. However, the industry has traditionally designed them as integral condensation.

More condensate will be present at any given temperature with integral condensation versus differential condensation. In the heat exchanger design, this results in a higher mean temperature difference for integral condensation compared to differential condensation.

The program defaults to integral.

Vaporization Options Sheet

Use this sheet to specify the following options:

- Vaporization curve calculation method

  The calculation method determines which correlations the program uses to determine the vapor-liquid equilibrium. The choice of method is dependent on the degree of non-ideality of the vapor and liquid phases and the amount of data available.

- Effect of pressure drop on vaporization

  The program defaults to calculating the vaporization curve in isobaric conditions (constant operating pressure). If the B-JAC Property program generates the VLE curve, you may specify non-isobaric conditions. The program allocates the specified pressure drop based on temperature increments along the condensation/vaporization curve. The vapor/liquid equilibrium at various temperature points is calculated using an adjusted operating pressure.

- Estimated pressure drop for cold side

  Specify the estimated cold side pressure drop through the exchanger. The program uses this pressure drop to adjust the VLE curve. If actual pressure varies more than 20% from this estimated pressure drop, adjust this value to the actual and rerun Hetran.

Compositions

Composition Sheet

The Aspen B-JAC Property Databank consists of over 1500 compounds and mixtures used in the chemical process, petroleum, and other industries. You can reference the database by entering the components for the stream on this sheet.

Select the **composition specification** - weight flow rate or %, mole flow rate or %, volume flow rate or % - to determine the basis of the mixture physical properties calculations. For a single component you can leave Composition blank. Then use the table to define the stream composition:

- Components

  For the databank component name, specify either the component name or its chemical formula. You can specify up to 50 components. Be careful when using the chemical formula, since several chemicals may have the same chemical formula but due to different bonding, have different properties.

  To search the databank directory, click the **Search Databank** button.

To enter your own properties for a component, **User** in the **Source** field, and then specify the properties on the **Component Properties** sheet.

- Composition

  For VLE calculations this is the composition of the stream in each phase and is dependant on the **Composition Specification**.

  You must specify the inlet compositions if referencing the databank for physical properties. If outlet compositions are not specified, the program assumes the same composition as the inlet. The data for each column is normalized to calculate the individual components fraction.

- Component Type

  This field, which is available for all VLE applications, allows you to specify whether the component is a noncondensable or an immiscible component for condensing streams, or an inert for vaporizing streams.

  If you are not sure of the component type, the program will attempt to determine the component type. However, in general, it is better to identify the type if known. If a component does not condense any liquid over the temperature range in the exchanger, it is best to identify it as a noncondensable.

- Source

  This field is currently available for components only when the program is calculating VLE curves. **Databank** indicates that all component properties will be retrieved from one of the B-JAC databanks. **User** indicates that the physical properties for this component are specified by the user.

Note: percentages do not have to add up to 100, since the program proportions each to the total.

Component Properties

Use this sheet to override databank properties or to specify properties not in the databank. This sheet is available only if a VLE curve has been requested. The physical properties required for various applications include:

- Temperature

  It is recommended that you specify property data for multiple temperature points. The dew and bubble points of the stream are recommended. The temperatures entered for no phase change fluids should at least include both the inlet and outlet temperatures. The inlet temperature of the opposite side fluid should also be included as a 3rd temperature point for viscous fluids. Multiple temperature points, including the inlet and outlet, should be entered when a change of phase is present.

- Liquid and Vapor Properties

  The necessary physical properties are dependent on the type of application. If you are referencing the databank for a fluid, you do not need to enter any data on the corresponding physical properties input screens. However, it is also possible to specify any property, even if you are referencing the databank. Any specified property will then override the value from the databank. The properties should be self-explanatory. A few clarifications follow.

- Specific Heat

  Specify the specific heat for the component at the referenced temperature.

- Thermal Conductivity

  Specify the thermal conductivity for the component at the referenced temperature.

- Viscosity

  The viscosity requested is the dynamic (absolute) viscosity in centipoise or mPa*s (note that centipoise and mPa*s are equal). To convert kinematic viscosity in centistokes to dynamic viscosity in centipoise or mPa*s, multiply centistokes by the specific gravity.

  The Aspen Hetran program uses a special logarithmic formula to interpolate or extrapolate the viscosity to the calculated tube wall temperature. However when a liquid is relatively viscous, say greater than 5 mPa*s (5 cp), and especially when it is being cooled, the accuracy of the viscosity at the tube wall can be very important to calculating an accurate film coefficient. In these cases, you should specify the viscosity at a third point, which extends the viscosity points to encompass the tube wall temperature. This third temperature point may extend to as low (if being cooled) or as high (if being heated) as the inlet temperature on the other side.

- Density

  Be sure to specify density and not specific gravity. Convert specific gravity to density by using the appropriate formula:

  – density, lb/ft3 = 62.4 * specific gravity

  – density, kg/m3 = 1000 * specific gravity

  The density can also be derived from the API gravity, using this formula:

  – density, lb/ft3 = 8829.6 / (API + 131.5)

- Latent Heat

  Specify latent heat for change of phase applications.
- Vapor Pressure

  Specify the vapor pressure for the component. If you do not enter a value for the vapor pressure, the program will estimate a value.
- Surface Tension

  Surface tension is needed for vaporizing fluids. If you do not have surface tension information available, the program will estimate a value.
- Molecular /Volume

  Specify the molecular volume of the vapor for change of phase applications. Note, the molecular volume can be approximated by molecular weight / specific gravity at the normal boiling point.
- Molecular Weight

  Specify the molecular weight of the vapor for change of phase applications.
- Critical Pressure

  The critical pressure is the pressure above which a liquid cannot be vaporized no matter how high the temperature. For mixtures, the critical pressure should be the sum of the critical pressures of each component weighted by their mole fractions. This input is required to calculate the nucleate boiling coefficient. If you do not enter a value for the critical pressure, the program will estimate a value.

Interaction Parameters Sheet

The Uniquac, Van Laar, Wilson, and NRTL methods require binary interaction parameters for each pair of components. This data is not available from the databank and must be provided by the user.

NRTL Method --Example with 3 components (Reference Dechema)

NRTL "A" Interactive Parameters -Hetran input parameters

	1	2	3
1	--	A21	A31
2	A12	--	A32
3	A13	A23	--

NRTL "Alpha" Parameters –Hetran input parameters

	1	2	3
1	--------	Alpha21	Alpha31
2	Alpha12	--------	Alpha32
3	Alpha13	Alpha23	--------

Alpha 12 = Alpha 21

Alpha 13 = Alpha 31

Alpha 23 = Alpha 32

NRTL – Conversion from Aspen Properties parameters to Hetran parameters:

Aspen Properties NRTL Parameters – The parameters AIJ, AJI, DJI, DIJ, EIJ, EJI, FIJ, FJI, TLOWER, & TUPPER in Aspen Properties (not shown in the following example) are not required for the Hetran NRTL method.

Aspen Properties NRTL Interactive Parameters

Component I	Component 1	Component 1	Component 2
Component J	Component 2	Component 3	Component 3
BIJ	BIJ12	BIJ13	BIJ23
BJI	BJI12	BJI13	BJI23
CIJ	CIJ12	CIJ13	CIJ23

"A" Interactive Parameters – Conversion from Aspen Properties to Hetran

	1	2	3
1	--	A21=BJI12*1.98721	A31=BJI13*1.98721
2	A12=BIJ12*1.98721	--	A32-BJI23*1.98721
3	A13=BIJ13*1.98721	A23=BIJ23*1.98721	--

"Alpha" Parameters – Conversion from Aspen Properties to Hetran

	1	2	3
1	--	Alpha21=CIJ12	Alpha31=CIJ13
2	Alpha12= CIJ12	--	Alpha32=CIJ23
3	Alpha13=CIJ13	Alpha23=CIJ23	--

NRTL - Alpha parameters

The NRTL method requires binary interaction parameters for each pair of components and an additional Alpha parameter. This data is not available from the databank.

Uniquac - Surface & Volume parameters

The Uniquac method requires binary interaction parameters for each pair of components and also needs a surface parameter and volume parameter. This data is not available from the databank.

Results

Properties Over a Range of Temperatures

If you select this option, PROPS will display the following properties:

Specific Heat of a Liquid & Gas	Latent Heat
Viscosity of Liquid & Gas	Vapor Pressure
Thermal Conductivity of Liquid & Gas	Surface Tension
Density of Liquid & Gas	

VLE

If the VLE calculation was selected, Props will generate a vapor-liquid equilibrium curve and provide the:

- Heat load
- Composition
- Physical properties per temperature increment

Props Logic

Databank Structure

The data in the databank is derived from a wide variety of published sources.

For constant properties, for example, molecular weight, the actual value has been stored in the databank.

For temperature dependent properties, various property specific equations are used to determine the property at the desired temperature. In these cases, the coefficients for the equation are stored in the databank.

Vapor pressures are stored using two equations - one for temperatures below the normal boiling point and one for temperatures above the normal boiling point.

Temperature Ranges

There is a separate temperature range of validity stored in the databank for each property. The temperature range shown in the

Databank Directory is the minimum range for all properties of the respective phase. Therefore, some properties may have a wider range than shown in the directory.

If you request a property at a temperature outside its valid temperature range, the program will display a warning and then determine that property at the appropriate temperature limit (i.e., it will not extrapolate), except for liquid viscosity and vapor pressure. The program extrapolates above and below the valid temperature range for vapor pressure. It extrapolates above for the liquid viscosity.

Effect of Pressure

The program attempts to correct the gaseous properties as a function of pressure (liquid properties are assumed to be independent of pressure). To do this, the program uses a generalized correlation for all components except water/steam. The generalized correlation is reasonably accurate for most cases. However, it tends to deviate from actual measured values when the temperature or pressure approach the critical region.

For water (stored under the names WATER and STEAM), the program uses a series of specialized equations which predict the corrected steam properties to within 1% of the values in the ASME Steam Tables.

Mixtures

The Props program can calculate the composite properties for multicomponent mixtures for up to 50 components.

Some care should be taken in using the databank for mixtures. Some mixtures, such as immiscibles or binary mixtures where water is one of the components, do not conform to the equations. For this reason, some of the more common water solutions have been included in the databank as single components.

Mixtures are calculated according to the following techniques:

Density of Liquid

$$\rho m = \frac{1}{\Sigma(w_i / \rho_i)}$$

Latent Heat	averaged in proportion to the weight percent
Molecular Volume	averaged in proportion to the mole percent

Specific Heat of Gas	averaged in proportion to the weight percent
Specific Heat Liquid	averaged in proportion to the weight percent
Surface Tension	averaged in proportion to the mole percent

Thermal Conductivity of Gas - Friend & Adler Equation

$$k_m = \frac{\Sigma y_i \cdot k_i \cdot (M_i)^{0.33}}{\Sigma y_i \cdot (M_i)^{0.33}}$$

Thermal Conductivity of Liquid - averaged in proportion to the weight percent

Viscosity of Gas - Herning & Zipperer Equation

$$\mu_m = \frac{\Sigma y_i \cdot \mu_i \cdot (M_i)^{0.5}}{\Sigma y_i \cdot (M_i)^{0.5}}$$

Viscosity of Liquid - Arrhenius Equation

$$\ln \mu_m = \Sigma x_i \cdot \ln \mu_i$$

Nomenclature:

µ =viscosity	*w*=weight fraction	*M*=molecular weight
k=thermal cond.	*X*=mole fraction	*I*=i-th component
ρ=density	*y*=gas phase mole fraction	*m*=mixture

Metals

Input

General Sheet

Use this sheet to specify:

- Material name for required components
- Temperature range for temperature dependent properties

For the **material name** you can use the generic material types, such as carbon steel (default), and the program will assign actual default material specifications depending on the product form. For carbon steel plate, a material specification of SA-516-70 will be used for an ASME design. Appropriate specifications will be selected for other design construction codes.

The selections to the right of the input field are provided for convenience. Values are not limited to those listed. To search for a specific material specification, click the **Search Databank** button. Type the first few characters to search for a material in the databank.

You can use the **DefMats** utility to change the default materials.

Many of the properties in the metals databank are temperature dependent. The **starting** and **ending temperatures** determine the temperature range. Either may be higher or lower. The program will retrieve properties beginning at the starting temperature, then incrementing the temperature by the **temperature increment** value until it reaches the ending temperature or a maximum of eleven points.

Results

Metals Results

The Metals program gives you the option of requesting properties at a single temperature or at up to ten temperatures. If you request properties at a single temperature you will also retrieve the properties which are not temperature dependent.

Warnings & Messages

Aspen B-JAC provides an extensive system of warnings and messages to help the designer of heat exchanger design. Messages are divided into five types. There are several hundred messages built into the program. Those messages requiring further explanation are described here.

Warning Messages: These are conditions, which may be problems, however the program will continue.

Error Messages: Conditions which do not allow the program to continue.

Limit Messages: Conditions which go beyond the scope of the program.

Notes: Special conditions which you should be aware of.

Suggestions: Recommendations on how to improve the design.

Properties Independent of Temperature

Material Properties

Property	Value
Price	31.75 USD/kg
Density	4512 kg/m3
P No.	52
Group No.	—
Specified Min. Yield	379 MPa
Specified Min. Tensile	448 MPa
Poisson Ratio	0.32
Material Class	Titanium Alloy

Properties Dependent on Temperature

This part of the output is self-explanatory. Where the property is not stored, or the temperature exceeds the acceptable range for the material, the program displays a dash.

Gasket Properties

Material Properties

Property	Value
Price	44.09 USD/kg
Density	2201 kg/m3
Gasket Factor m	2.75

Property	Value
Min. Design Seating Stress y	25511 MPa
Gasket Thickness	1.6 mm
ASME Column	2

Metals Directory - ASTM - Generic

Number	Generic Material
1	Carbon Steel
2	Low Alloy Steel C 1/2 Mo
3	Low Alloy Steel 1/2 Cr 1/2 Mo
4	Low Alloy Steel Cr 1/2 Mo
5	Low Alloy Steel 1 1/4 Cr 1/2 Mo
6	High Alloy Steel Grade 304
7	High Alloy Steel Grade 304L
8	High Alloy Steel Grade 316
9	High Alloy Steel Grade 316L
10	High Alloy Steel Grade 347
11	High Alloy Steel Grade 310S
12	High Alloy Steel Grade 310S XM-27 (E-brite)
13	High Alloy Steel Grade 410
14	Nickel Alloy 200
15	Nickel Low Carbon Alloy 201
16	Nickel Alloy 400 (Monel)
17	Nickel Alloy 600 (Inconel)
18	Nickel Alloy 800
19	Nickel Alloy 825 (Inconel 825)
20	Nickel Alloy B (Hastelloy B)
21	Nickel Alloy C (Hastelloy C)
22	Nickel Alloy G (Hastelloy G)
23	Nickel Alloy 20Cb (Carpenter 20)
24	Titanium
25	Copper-Nickel 70/30 Alloy CDA 715
26	Copper-Nickel 90/10 Alloy CDA 706
27	Copper-Nickel Alloy CDA 655
28	Naval Brass Alloy 464
29	Aluminum-Bronze Alloy 630
30	Aluminum Brass Alloy 687
31	Admiralty Alloy 443
33	Zirconium

References

Metals References

For a further understanding of subjects relating to METALS, see the following publications

Material Properties

ASME Boiler and Pressure Vessel Code, Section II, Materials, Part D Properties, annual

American National Standards Institute (ANSI)

Deutsches Institut für Normung e.V. (DIN)

AD-Merkblätter - Technical Rules for Pressure Vessels, Carl Heymanns Verlag KG, Berlin, Germany, annual

Verband der Technischen Überwachungs-Vereine e.V. (VdTÜV)

Association Française de Normalisation (AFNOR)

Standards of Tubular Exchangers Manufacturers Association, Seventh Edition, TEMA, New York, USA, 1988

Equivalent Materials

Worldwide Guide to Equivalent Irons and Steels, ASM International, Metals Park, Ohio, USA, 1987

Worldwide Guide to Equivalent Nonferrous Metals and Alloys, ASM International, Metals Park, Ohio, USA, 1987

Stahlschlüssel, C. W. Wegst, Verlag Stahlschlüssel Wegst GmBH, Marbach, Germany,1992

Material Prices

Metal Statistics - The Purchasing Guide of the Metal Industries, Fairchild Publications, New York, USA, annual

Priprops

Introduction

The Priprops program allows you to create your own chemical properties databank for those fluids not found in the B-JAC databank. By selecting the User databank when your private component is referenced in the B-JAC programs, the program will automatically access the private databank when the programs need to retrieve properties from the databank. The private databank can accommodate up to 400 different fluids.

Accessing the Priprops databank

Accessing an existing component in the databank

Access the Priprops program by selecting **Data Maintenance | Chemical Databank** under the **Tools** menu on the Menu Bar.

The user can view an existing B-JAC or Standard component in the databank by:

- selecting B-JAC or Standard from the databank option menu,
- then type in the component name, formula, B-JAC ID number, or synonym,
- if present the component will be shown with the stored properties.

Adding a new component to Priprops

Access the Priprops program by selecting **Data Maintenance | Chemical Databank** under the **Tools** menu on the Menu Bar.

To add a new private component to the databank:

- select the **User** databank

- type the reference name that you wish to call the component
- enter the required physical properties, constants, and curve fitting data for the component
- select the add button to add the new component to the database
- select the Update button to save the new component and to update the databank

Adding a new component using an existing component as a template:

- select the B-JAC or Standard databank
- search for similar component by typing in the name or reference to locate the component
- select the copy button to copy all the property information
- return to the User databank
- type in the name for the new component
- select the Add button to add the component
- select the Paste button to copy the properties from the standard databank
- modify as necessary the properties that differ from the standard component
- select the Update button to save the new component and to update the databank

Property Reference

Reference the Props section of this user guide for additional information on the components provided in the B-JAC and standard databanks.

Property Estimation

Property Curves

```
Key                        Equation
0 .... Y = C1 + C2 * T + C3 * T**2 + C4 * T**3 + C5 * T**4
1 .... Y = exp (C1 + C2 / T + C3 * ln(T) + C4 * T ** C5)
2 .... Y = C1 * T ** C2 / (1 + C2 / T + C3 / T ** 2)
3 .... Y = C1 + C2 * exp (-C3 / T ** C4)
4 .... Y = C1 + C2 / T + C3 / T ** 3 + C4 / T ** 8 + C5 / T ** 9
5 .... Y = C1 / C2 ** (1 + (1 - T / C3) ** C4)
6 .... Y = C1 * (1 - T / Tc) **
           (C2 + C3 * ( T / Tc) + C4 * (T / Tc) ** 2 + C5 * ( T / Tc) ** 3)
7 .... Y = C1 + C2 * ((C3 / T) / sinh (C3 / T)) ** 2 + C4 *
           ((C5 / T) / cosh (C5 / T)) ** 2
       C1,C2,C3,... Coefficients
       T        ... Input Temperature in K or R
       Tc       ... Critical Temperature in K or R
       Y        ... Calculated Value
       **       ... Power Function
```

Property estimation based on NBP

The physical properties program can estimate physical properties for hydrocarbon components based on their normal boiling point (NBP) and either the molecular weight or the degrees API. The estimated properties will be reasonably accurate for the hydrocarbons which meet the following criteria:

1 The normal boiling point is between 10 and 371 C (50 and 700 F).

2 The molecular weight is between 50 and 300.

3 The degrees API is between 5 and 120.

To specify the component name, use one of the following formats:

- NBC*xxx*MW*yyy* where *xxx* is NBP in C and *yyy* is the molecular weight
- NBF*xxx*MW*yyy* where *xxx* is NBP in F and *yyy* is the molecular weight
- NBC*xxx*API*yyy* where *xxx* is NBP in C and *yyy* is the degrees API
- NBF*xxx*API*yyy* where *xxx* is NBP in F and *yyy* is the degrees API

Examples: NBC113MW156 NBC98.4API40 NBF323MW70 NBF215.8API44.2

Components outside the ranges specified above will NOT be accepted.

Primetals

Introduction

Primetal is a program that allows you to build and maintain your own databank of materials which supplements the materials in the Metals databank.

The material can be in the form of plate, pipe, tube, forging, coupling, bolt, or gasket. Once you assign a material name and store the material properties, you can then use the new material name in any of the Aspen B-JAC programs which allow specific material names (Hetran, Teams, Metals).

The Primetal program provides the following functions:

- Add a material
- Modify the properties of a material
- Delete a material
- Display or print a list of materials
- Display or print the properties of a material

This program does not require an input data file, since all of the data is stored in the databank itself. You specify the input data directly into the Primetal program when you run it. The input data can be specified in either U.S., SI, or Metric units and is divided into three sections:

- Names
- Constant properties
- Temperature dependent properties

The names are:

- Full name (up to 78 characters)

- Short name (up to 39 characters) for the mechanical design output
- Very short name (up to 24 characters) for the bill of materials

The constant properties include:

- Material type and class
- Price and currency
- Equivalent material numbers for pipe, plate, forging, coupling
- Density
- Minimum thickness
- P number and group number
- External pressure chart
- Minimum tensile and yield strengths
- Maximum thickness for x-ray exemption
- Poisson ratio
- Minimum and maximum diameter for validity

The temperature dependent properties include:

- Thermal conductivity
- Allowable stress
- Yield strength
- Coefficient of thermal expansion
- Modulus of elasticity
- Stress intensity
- Tensile strength

For each of the temperature dependent properties, you can specify from 2 to 21 points, starting from a specified starting temperature, then according to a specified temperature increment. Each property should also have minimum and maximum temperatures. If a value is not available for one or more of the temperature points, you can specify a zero (or leave it blank) and the databank routine will automatically interpolate using the closest specified values.

Currency

This item refers to the currency of the values in the cost files. The original selections are:

1= $US	2= $Canadian	3= French Franc	4= British Pound
5= Belgium Franc	6= Deutch Mark	7= Italian Lire	8= Yen

The default values are already in US dollars. I recommend to always use 1 (US Dollar).

The user can enter the Korean Won in the UOM Control (Unit of Measure control - the user can enter any currency here). Go to Tools > Data Maintenance > Units of Measure > Units Maintenance. Fill out the new currency information. Save the changes. From this point forward, the user can convert to the new currency. Also, using one of three customizable unit-sets, the user can default to a currency and other special units.

Material Type

The number designators used by the program for the material type are:

1= seamless pipe	101= forging (SP = Seamless pipe, ST = Seamless tube, etc.)
2= seamless tube	102= coupling
25= welded pipe	151= gasket
26= welded tube	165= bolt
51= plate	

Material Class

The number designators used by the program for the material class are:

1= Carbon Steel	2= Low Alloy Steel
3= High Alloy Steel	4= Ni or Ni Alloy
5= Titanium Alloy	6= Cu Alloy HT (HT=High Tensile)
7= Nickel Alloy B,C, or G	8= Zirconium
9= Nickel Alloy HT	10= Cu or Cu Alloy
0=Gasket	

The material type and class is important when the user enters his/her own materials.

External Pressure Chart Reference

An external pressure chart reference, ASME Section II, Part D, must be provided for external pressure calculations. The correlation is determine the number to be entered is as follows:

Material database external pressure chart reference number = X*100 + Y

Where X represents the material type:

X=1 for CS

X=2 for HA

X=3 for NF

X=4 for HT

X=5 for CI

X=6 for CD

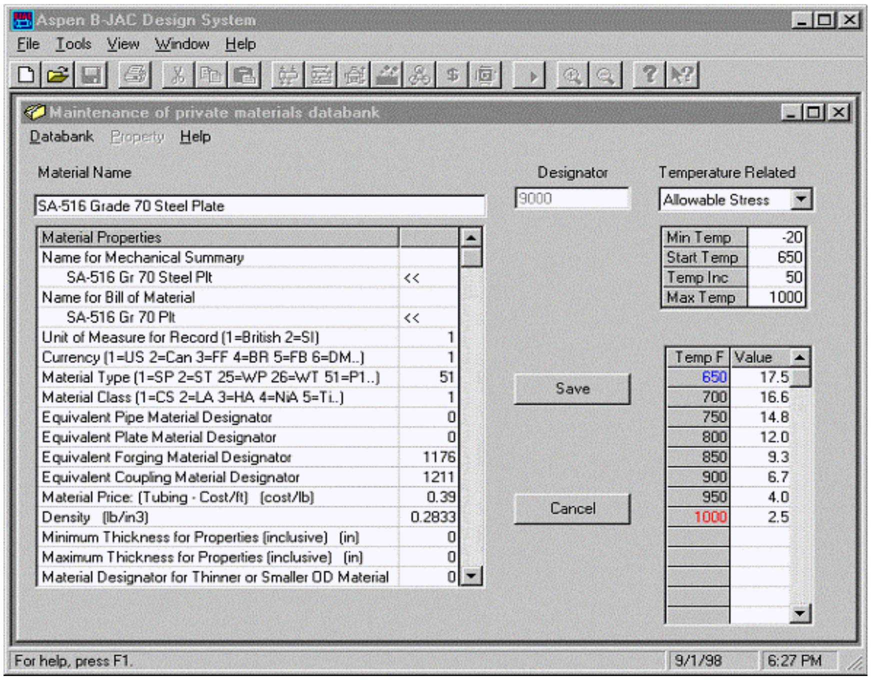
Where Y = chart number

Examples: Chart CS-3 = 103 (X=1, Y=3)

Chart NFN-16 (old reference was UNF-28.40) = 340 (X=3, Y=40)

Example Input to Primetals

Example Input to Primetals



Steps to create a private material

1 Open Materials Database by selecting Tools / Data Maintenance / Material Database form the B-JAC User Interface.

2 Open one of the existing Code material databases, such as ASME, from the Database Menu option.

3 Select a similar material in the Code database to the private material you wish to create. This will act as a template for the new material.

4 Select Property / Copy to copy the contents into the buffer.

5 Select Database / User.

6 If no user materials exist in the database, you will be asked if you wish to create a new material. Answer Yes and set the user database number for the new material. Your new material in the database will be displayed with the existing properties being used as a template. Proceed to step 8.

7 If user materials already exist, your existing database items will be displayed. To copy the template properties, select Property and Paste and then select a number new material reference number.

8 Now modify the template properties to generate your new material. If you have selected a very similar material, you may only need to modify the material names and the allowable design stresses.

9 Once all changes have been made, select Save to update the database. Now this new user material may be referenced from any of the B-JAC programs.

Newcost Database

Introduction

Newcost is a database maintenance program, designed to modify and/or print the contents of the labor and material cost files associated with the Aspen B-JAC programs which address cost estimation (Teams, Qchex, and Hetran).

B-JAC supplies a standard database with each version of the program. When you make any changes to the database, your changes will always override any values in the standard database.

To start the Newcost database, first change your working directory to where you want the modified database to reside. This can be the same directory as the Aspen B-JAC programs or other user sub-directories. When you make changes using Newcost the changes are stored in your current directory. In this way you can build separate databases on different directories, which can reflect different costing requirements for different projects or bids. Access the Newcost program by selecting Tools from the Menu Bar and then selecting Data Maintenance and then selecting Costing.

The Newcost gives you access to these databases:

1 General cost and labor adjustment

2 Fabrication and operation standards

3 Material dependent fabrication standards

4 Welding standards

5 Labor efficiency factors

6 Material prices

7 Part numbers for bill of materials and drawings

8 Horizontal support standards

Labor & Cost Standards

The Newcost database contains the following labor and cost standards.

General Cost and Labor Adjustment

This database contains the burdened labor rate (total cost per hour of labor), the markups on labor and material, and the overall efficiency factors for welding, machining, drilling, grinding, and assembly.

Fabrication and Operation Standards

This section allows you to specify over 100 specific fabrication options which affect the mechanical design and/or the cost. In many cases these options will establish the defaults for the Teams program where "0 = program." Included are such things as minimum and maximum material dimensions (e.g. minimum thickness for nozzle reinforcement pads, minimum and maximum bolt diameter, and maximum length of pipe) and cost factors (e.g., cost of x-ray, stress relieving, skidding, and sandblasting). Also included are the system of measure and the money currency, which apply to all of the Newcost databases.

Material Dependent Fabrication Standards

This file contains the fabrication variables which are dependent upon the type of material. The materials are divided into ten classes. It includes such items as machining and drilling speeds, weld deposition rates, maximum dimensions for various operations, and dimensional rounding factors.

Welding Standards

Here you can specify the type of welding to be used for each type of vessel component made from each of ten different material classes. You can choose from stick electrode, self shielded flux core, gas metal arc, submerged arc, tungsten inert gas, and plasma welding.

Labor Efficiency Factors

The cost estimate routines use the data in this file to correct the number of hours for each labor operation for each type of component. The raw hours determined by the program are divided by the appropriate efficiency factor. For example, if the program calculates 20 hours to drill a tubesheet, and the efficiency factor is 0.5, the estimated number of hours will be 40 hours. The operations covered are layout, saw, shear, burn, bevel, drill, machine, mill, form, roll, weld, grind, and assemble.

Material Prices

This is the database which contains the prices for each material. Prices for most materials are price per unit weight (e.g. $/lb), except tubing which is price per unit length for a 19.05 mm (3/4") tube with a 1.65 mm (0.065") wall thickness. The standard Aspen B-JAC price is displayed. You can specify a price for any material, which will then override the standard Aspen B-JAC price.

Part numbers for bill of materials and drawings

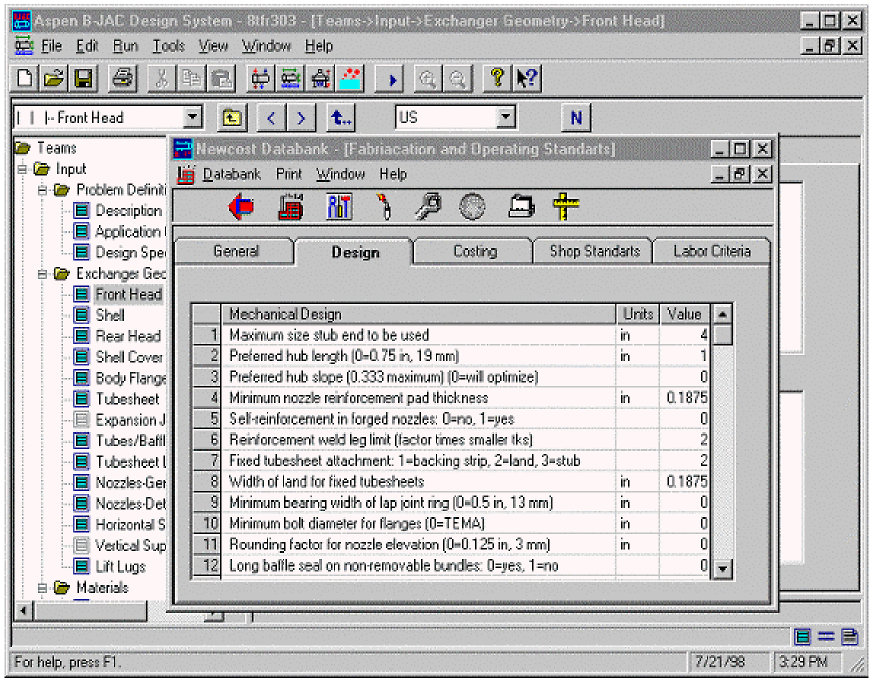
Default part numbers for every component are provided in this database. You can modify the default numbers as necessary.

Horizontal support standard dimensions

You can customize the standard support dimensions used by the programs or use the default dimensions shown in the database.

Newcost Database Example

Here is an example of the Newcost database in use:

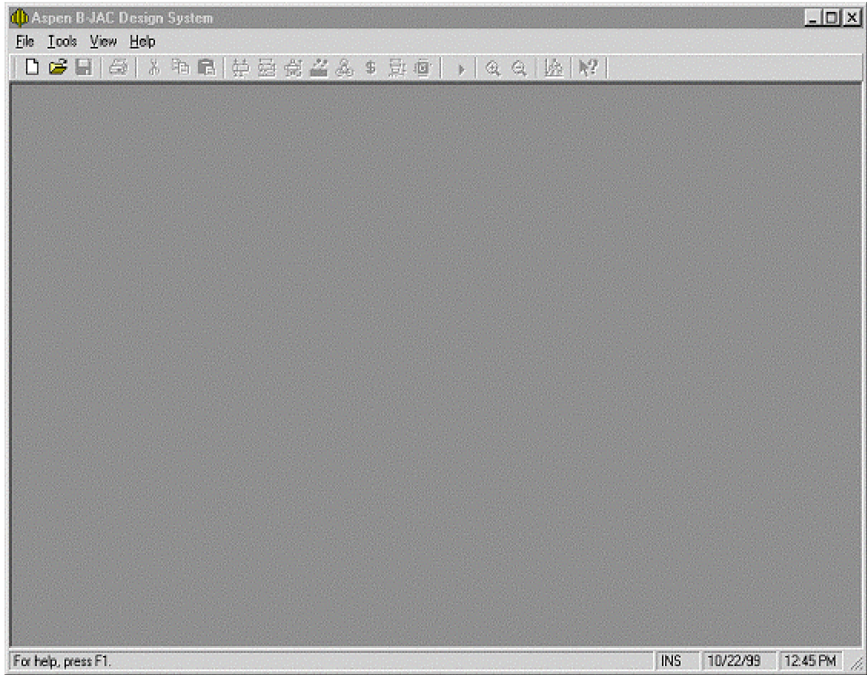


Aspen B-JAC Example

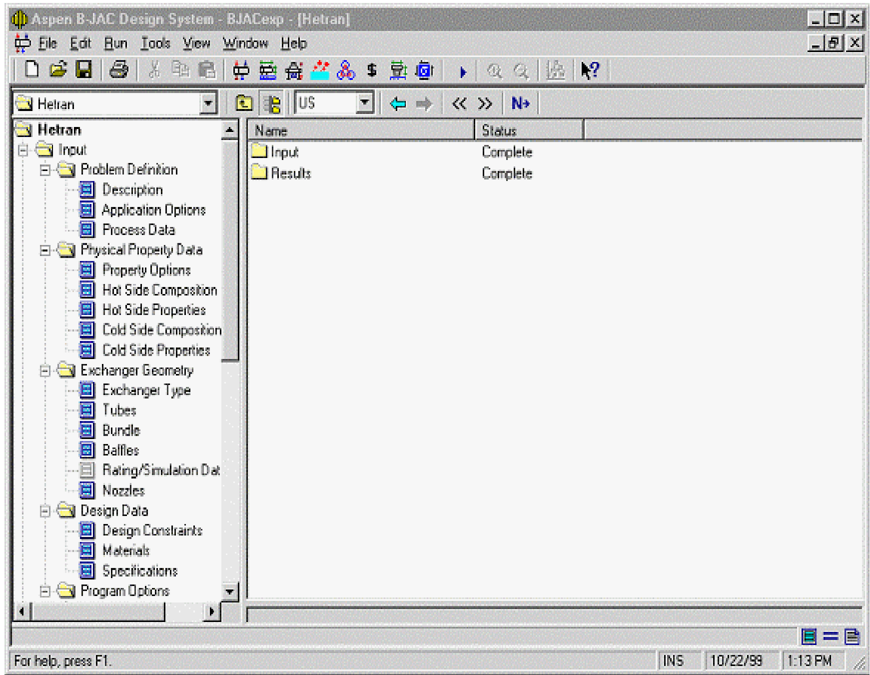
This example consists of the following sections:

- The User Interface
- General Specifications
- Specifying Components
- Completing Property Specifications
- Specifying Geometry
- Specifying Design Data
- Running the Problem
- Viewing the Results
- Tuning the Design
- Performing Mechanical Design
- Specifying Geometry in Teams
- Specifying Materials for Teams
- Running Teams
- Viewing Teams Results
- Addressing Problems Discovered by Teams

Aspen B-JAC Example: The User Interface

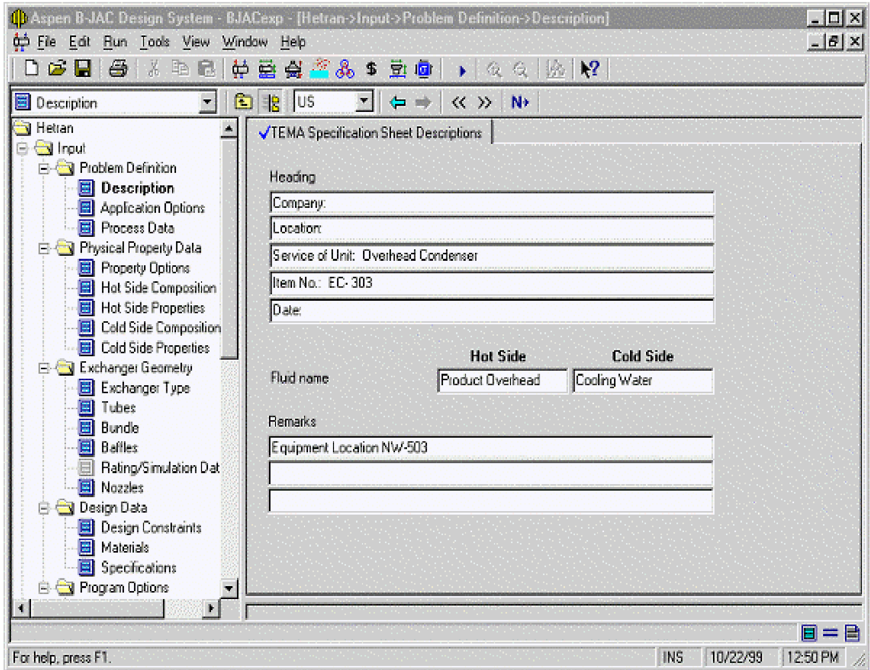


This is the Aspen B-JAC program window. Select File from the menu bar to open a new or existing file. For this example you will open an existing file to first perform a thermal design using Aspen Hetran and then transferring the information in the Aspen Teams program for a mechanical design. Operation of the Aspen Aerotran program is very similar to the Aspen Hetran program.

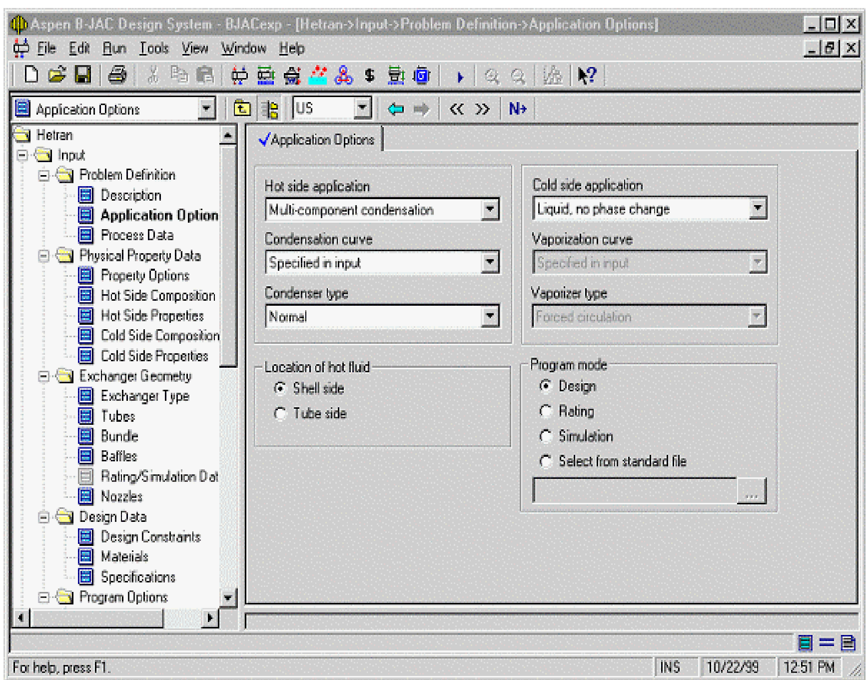


On the left hand side of the window is the data browser to help you navigate through the program. The input and results sections are organized in a series of forms or folders. Each folder may contain multiple tabs to assist you through the program. For this Aspen Hetran file, select the Description section under Problem Definition. The units of measure are set at US. You can access the specific input folders by selecting a item on the navigator. As an alternate you can select the N (Next) button to help you navigate to the next required input item. Note that with the use of the Next button, the program will use default values for some design parameters.

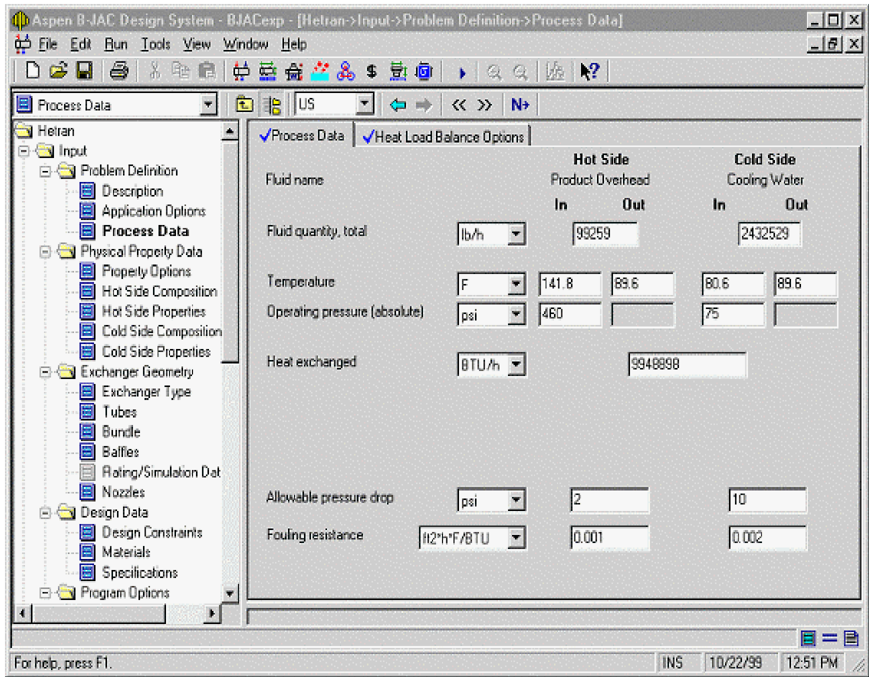
Aspen B-JAC Example: General Specifications



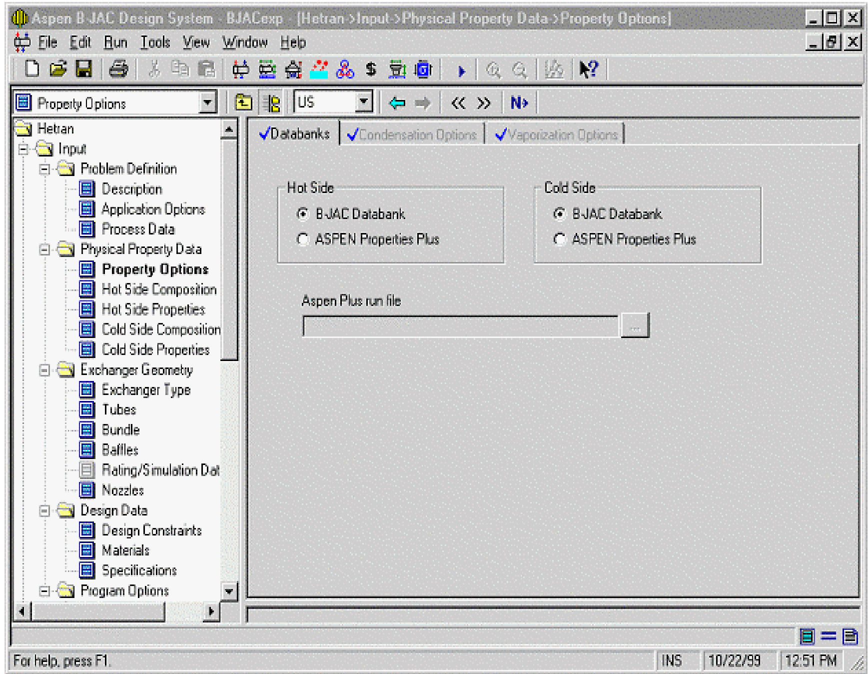
In this section provide the general equipment description and fluid titles that will appear on the heat exchanger data sheet and printed documentation.



Applications for the hot side and cold side of the exchanger are then selected. This exchanger has a multi-component mixture condensing on the shell side and coolant on the tube side. The condensation curve will be specified by you from a process simulation run. The program will run in the Design Mode to optimize a size for the exchanger.

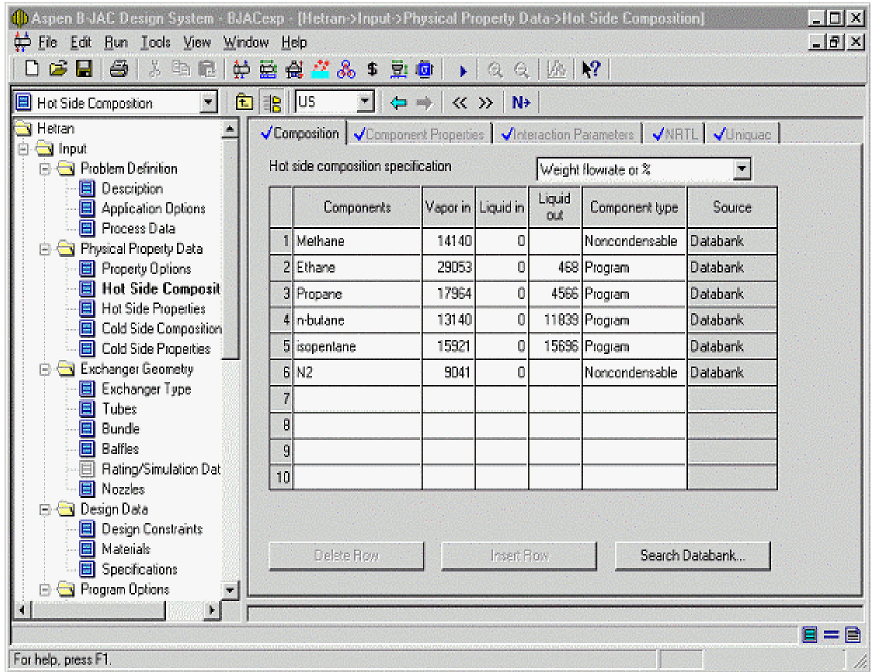


Now specify the process flow conditions for the hot and cold sides for the exchanger. At any point in the program you can obtain context sensitive Help by selecting the ? button and then selecting the input field that you need help on. You can also access the reference help for the subject by selecting the input field and then pressing F1. Input sections that are not complete will be identified by a red X on the navigator. Required input fields will be highlighted by a green background. Inputted valued which exceeds a normal range for that field will be highlighted in red. Note that if you still proceed with a value outside the normal range, the program will still use the inputted value.

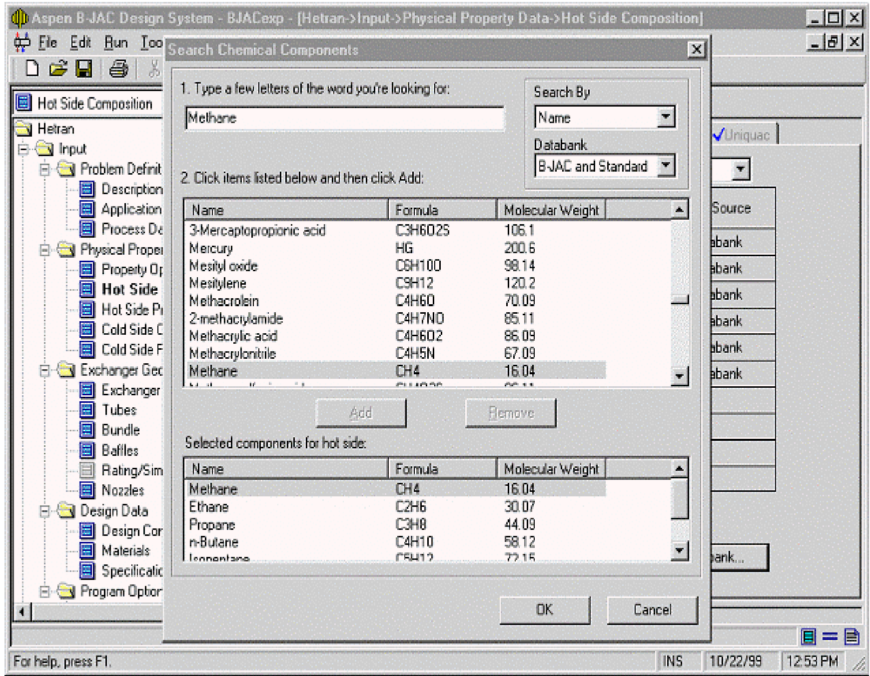


Physical property data for the streams may be supplied by the Aspen B-JAC Databank, the Aspen Properties Plus Databank, or you can input the properties. If you select the Aspen Plus Databank you must supply a APPDF interface file. For this example, you will be specifying the Aspen B-JAC Databank.

Aspen B-JAC Example: Specifying Components

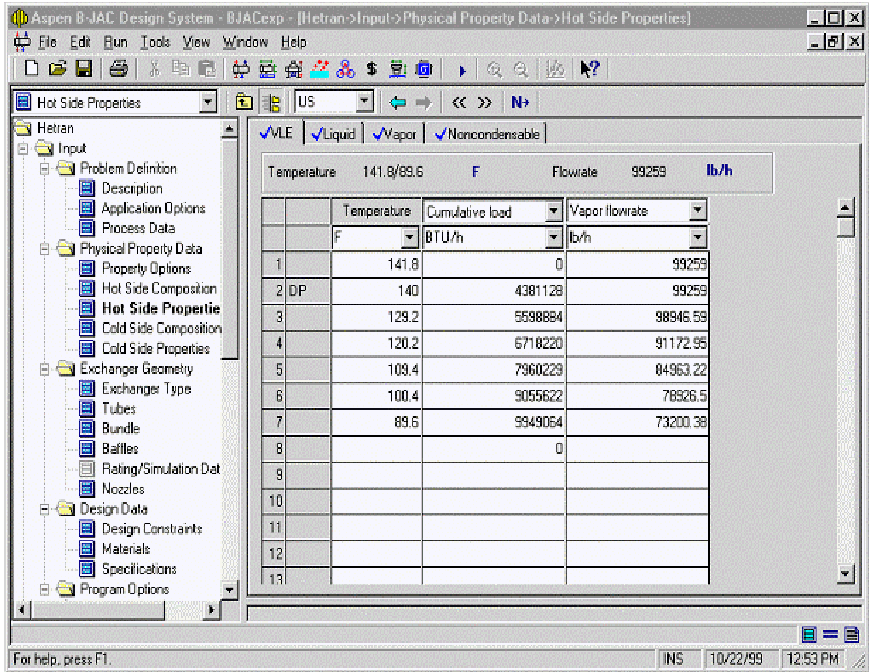


To reference the Aspen B-JAC Databank, specify each component of the stream in the Hot Side Composition section. Vapor in, liquid in, and liquid out flows are provided for each component. If a component is known to be a noncondensable or immiscible, it should be specified. You can access the Aspen B-JAC Databank listing by selecting the Search button.

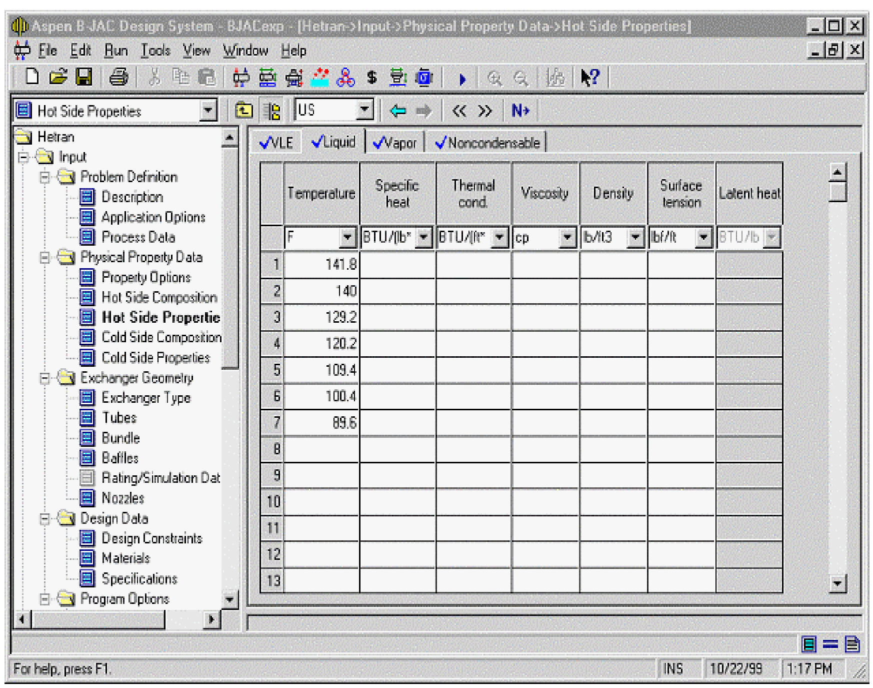


To search the Aspen B-JAC Databank for a compound, type in the component name or formula and the program will search the databank. Once located, you can select the Add key to add that component to the stream list to be referenced. Select OK to return to the composition form and the items selected will be added to the list.

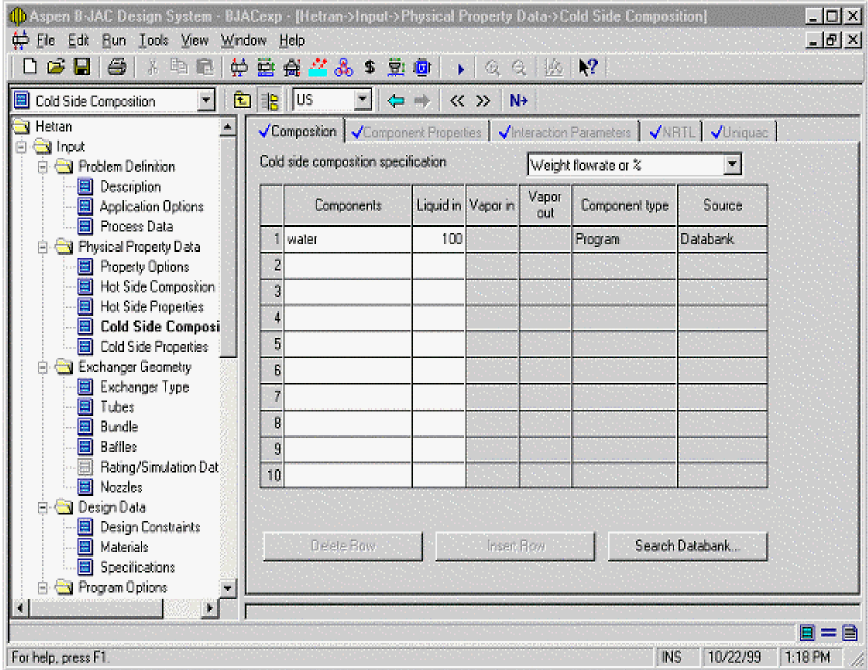
Aspen B-JAC Example: Completing Property Specifications



The VLE curve is specified in the Hot Side Properties section. Heat load may be provided as cumulative, incremental, or as enthalpy. Flowrate per increment may be specified by vapor/liquid flow rate or vapor/liquid mass fraction.

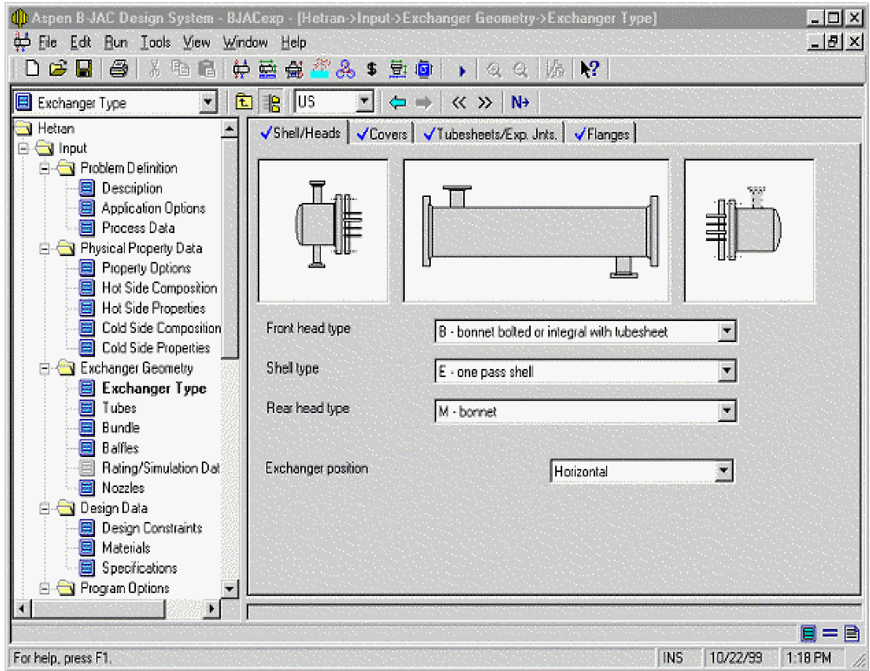


Since you are referencing the Aspen B-JAC Databank, the liquid, vapor, and noncondensable properties will be retrieved from the databank.

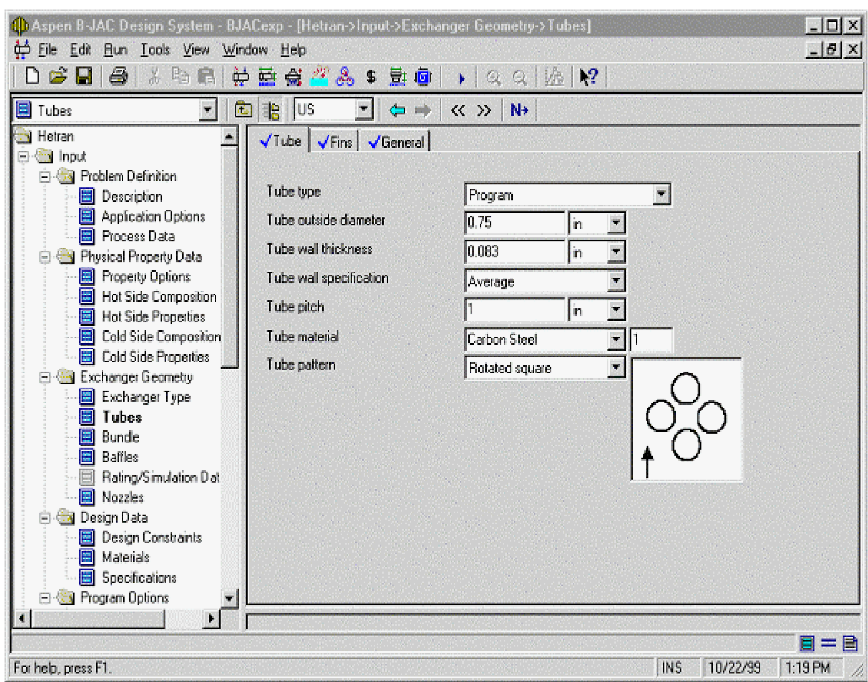


The properties for the cooling water on the cold side will be retrieved from the Aspen B-JAC Property Databank. This completes the process data section of the Aspen Hetran input file. At this point you could proceed with the calculations allowing the program to set defaults for the mechanical design constraints. We will proceed through the mechanical section to review what has been specified for this exchanger.

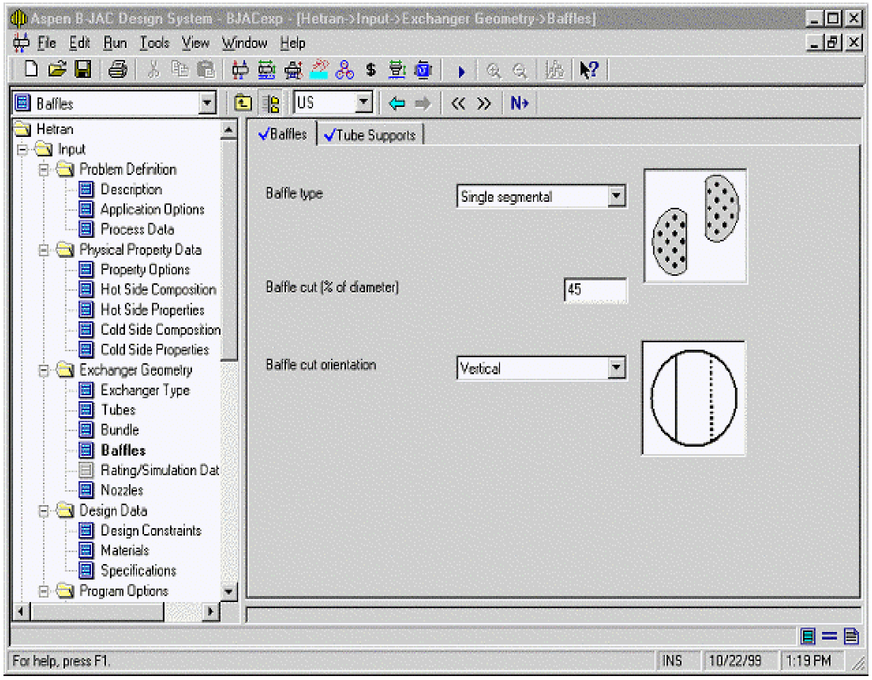
Aspen B-JAC Example: Specifying Geometry



Aspen Hetran supports all the TEMA type heads and shell configurations. For this item, a BEM type is selected. Each input field is select by clicking on the arrow in the appropriate box to see the drop down menu selections. You then select which option you want.

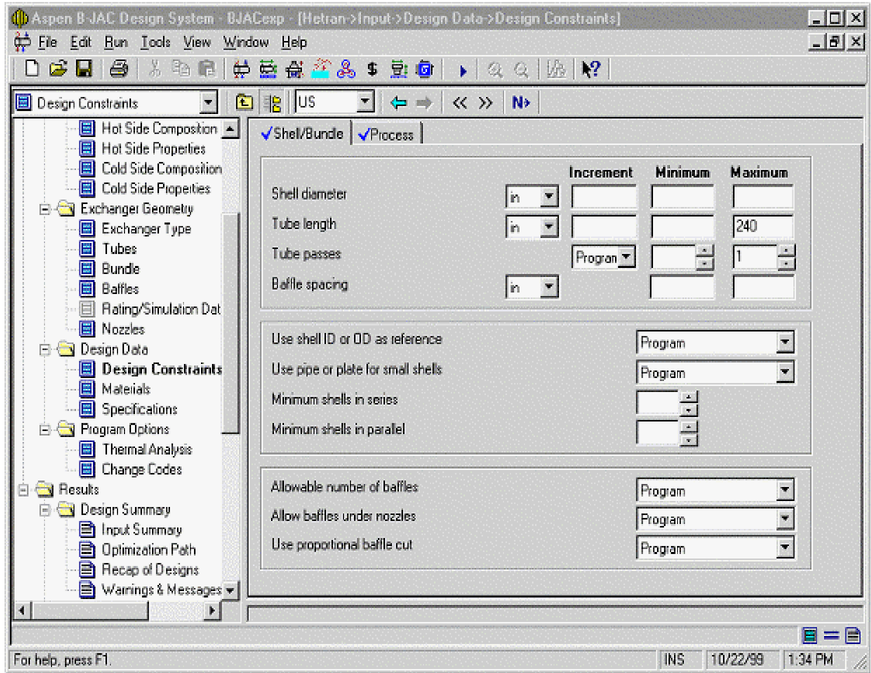


You then provide the tubing requirements: type, diameter, and thickness. Many of the drop down menus are supported with diagrams which will assist you in you selection process, such as the tube pattern shown above. Note also the Prompt Area located at the bottom of the form which will provide additional information for many of the input fields.

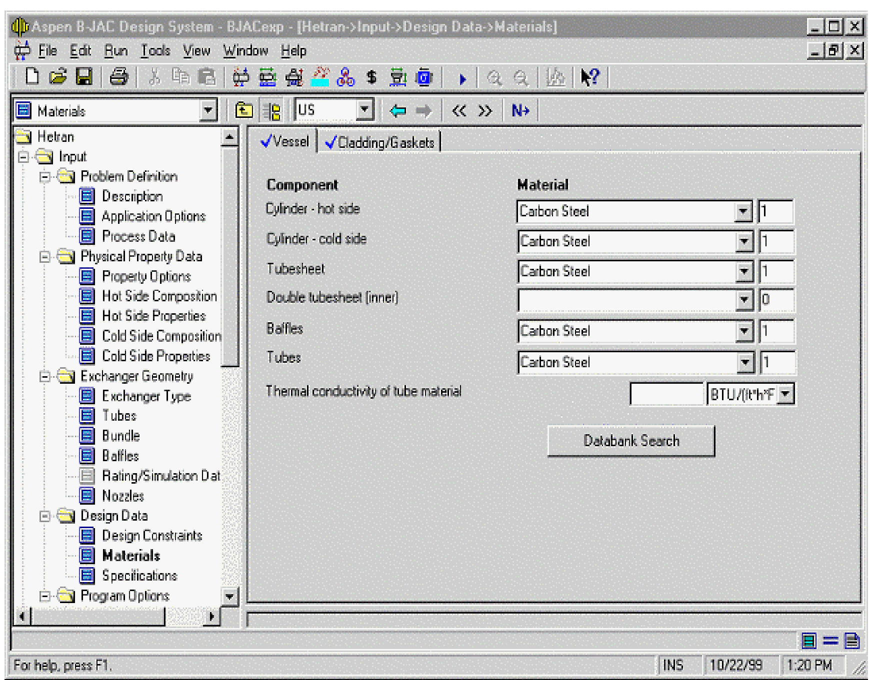


For most applications, the Aspen Hetran program will default to single segmental baffles. The program will also select a baffle cut and baffle orientation based upon the application. If the shell pressure drop is controlling the design, you may want to change to a double or triple segmental type.

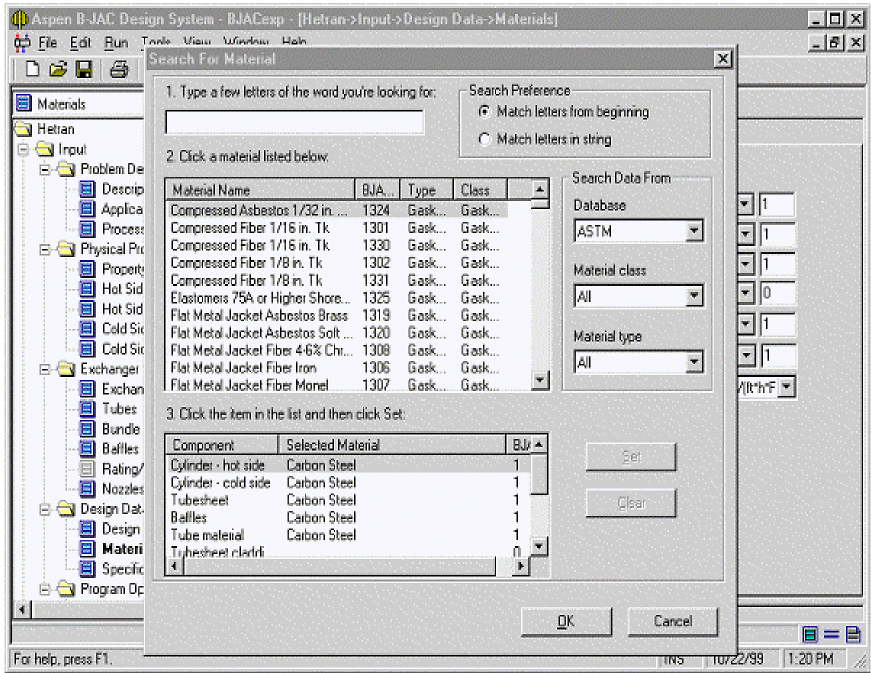
Aspen B-JAC Example: Specifying Design Data



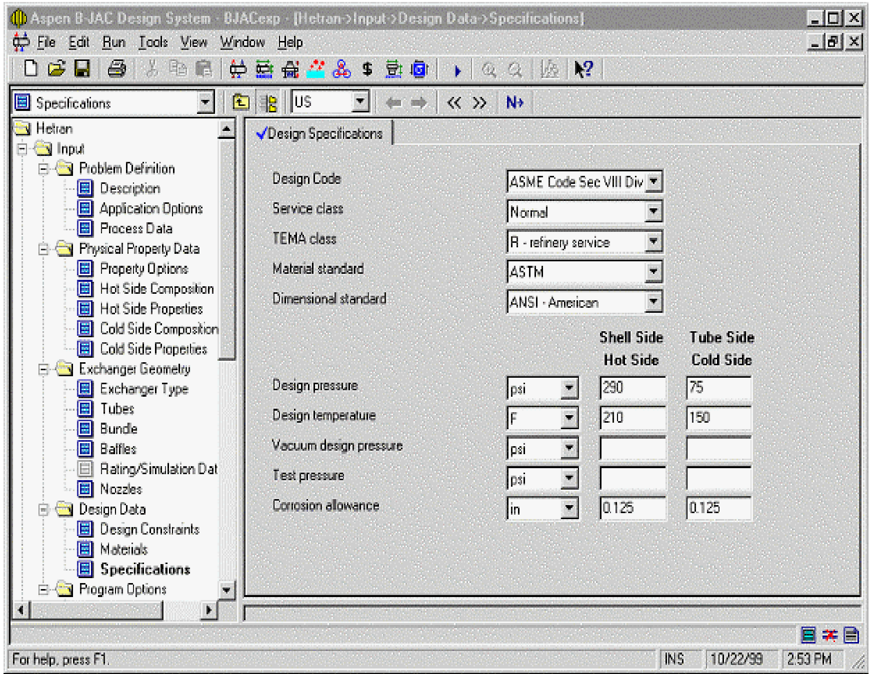
The Design Constraints section controls the optimization limits for the Design Mode of the program. Minimum and maximum limits for shell diameter and tube length should only be set as necessary to meet the exchanger size limits in the plant.



The B-JAC Metals Databank provides a generic material list which allows to specify general classes of materials, such as carbon steel or 304 stainless steel. The program will then reference an appropriate material class for a specific pressure vessel component. You can search the Metals Databank by selecting the Search button.



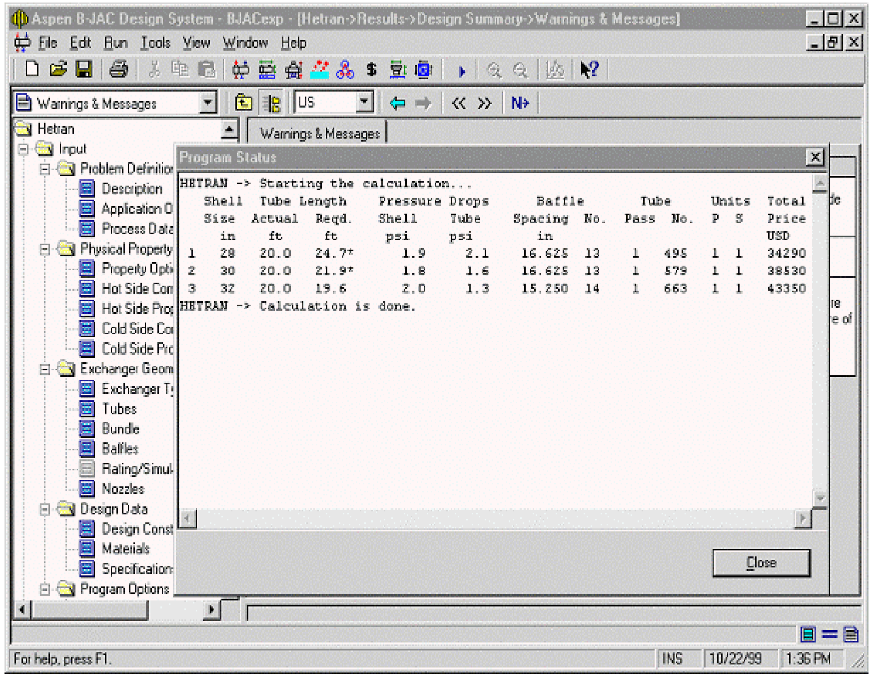
By typing the material to be referenced, the program will search to find the material in the Databank. Once located, you can select the component and then the Set Key to select that material for that component. After all materials have been selected, click OK to return to the Material form and your selections will be inserted.



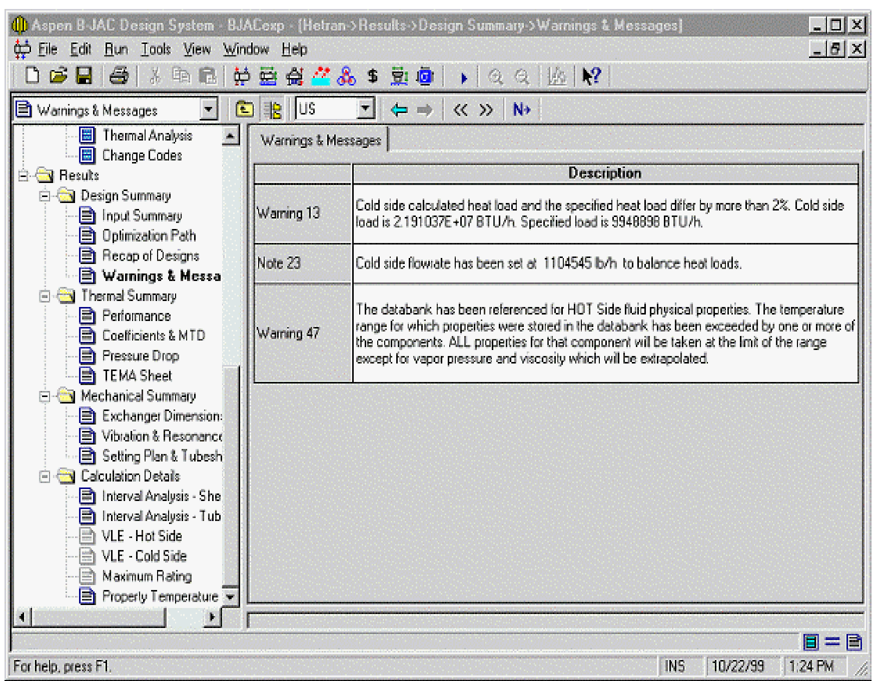
Specify the applicable design code and standards for the unit. The Aspen Hetran program will estimate the design pressure and temperature for you based upon the operating conditions but it is recommended to provide these if known.

Aspen B-JAC Example: Running the Problem

You have completed the input for the design. Select the Run command from the Menu Bar and then select to Run Hetran. As an alternate you can select the Run icon button located in the Tool Bar.

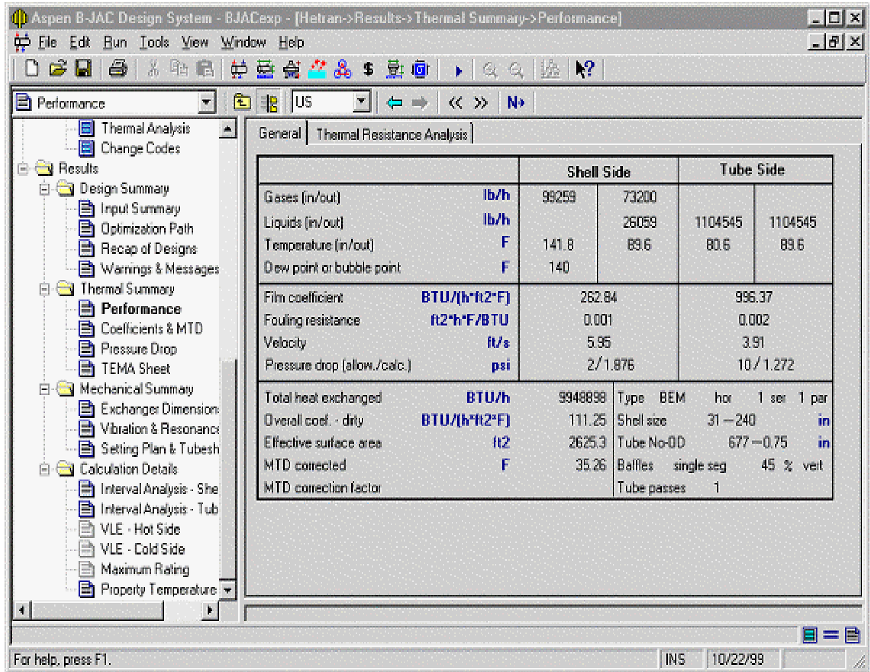


The optimization path screen will appear. Hetran will first select an exchanger size which is close to compiling to the specification requirements. The program will then provide incremental results allowing you to see

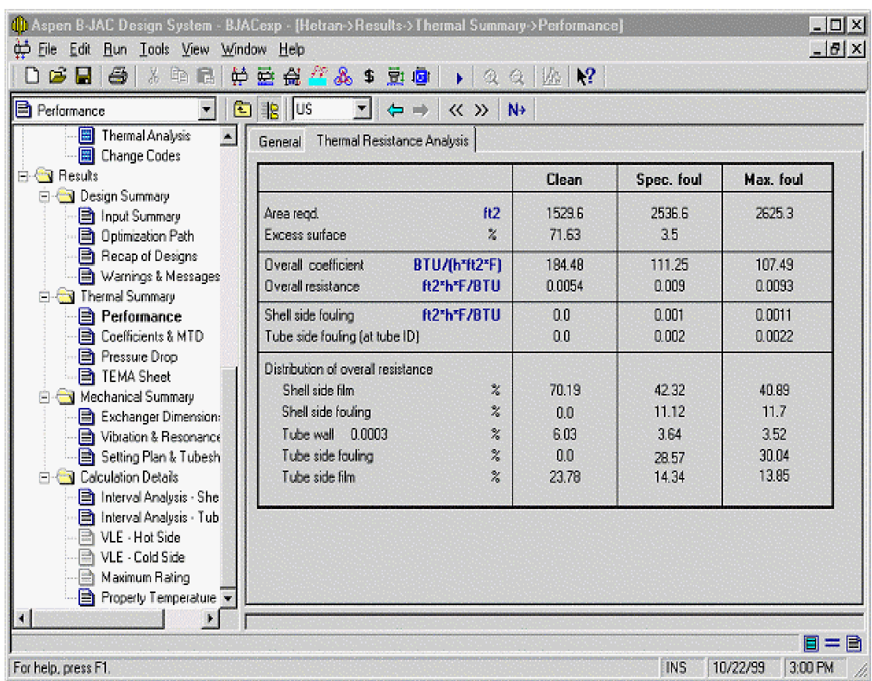


Once the optimization is complete, you can display the final resulting design. First to be displayed are any warnings or notes. Note the heat load adjustment made by the program.

Aspen B-JAC Example: Viewing Results



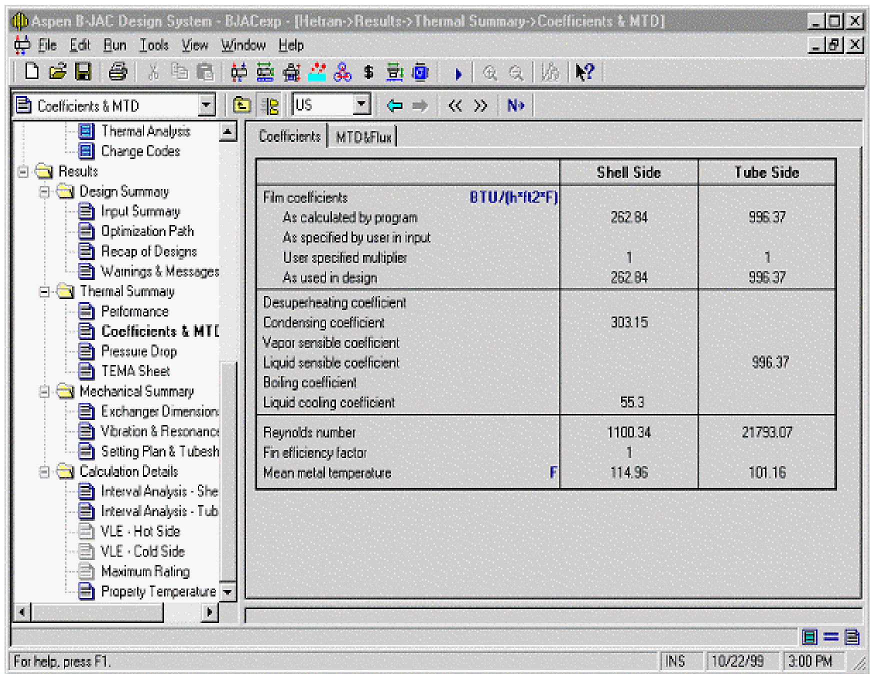
You can review the Performance Summary section. Process conditions, calculated film coefficients, pressure drops, and mechanical summary are provided.



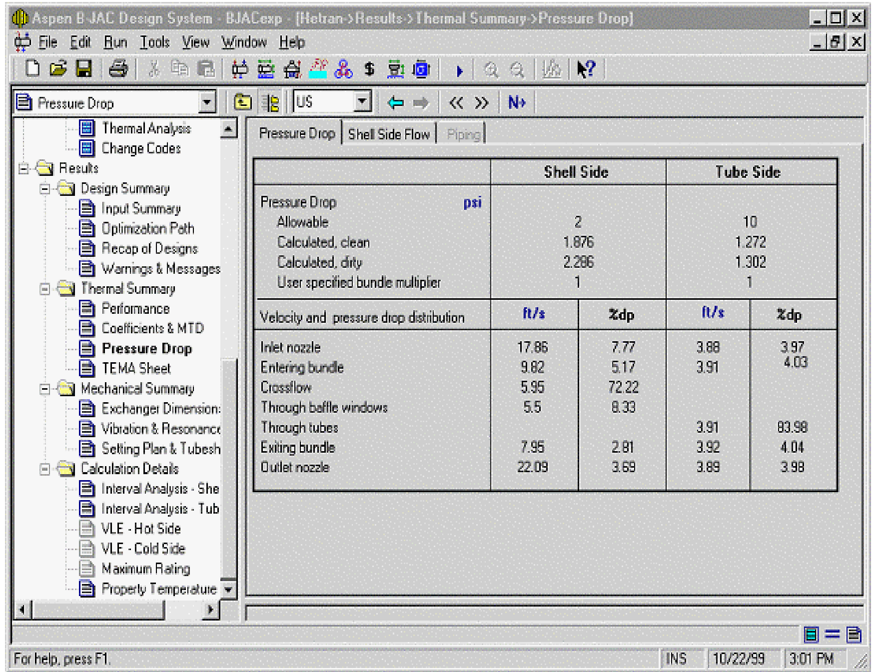
Thermal Resistance Analysis includes three cases:

- Clean
- Spec. Foul
- Max. Foul

The clean condition is expected performance assuming no fouling exists in the exchanger. For this case the exchanger is 87.7% oversurfaced in the clean condition. The Spec. Foul case shows a 7.71% excess surface area based upon the designed conditions. The last case, Max. Foul, uses all the excess surface area, the 7.71%, and translates this to additional fouling available. Fouling factors are increased to .0012 and .0024.

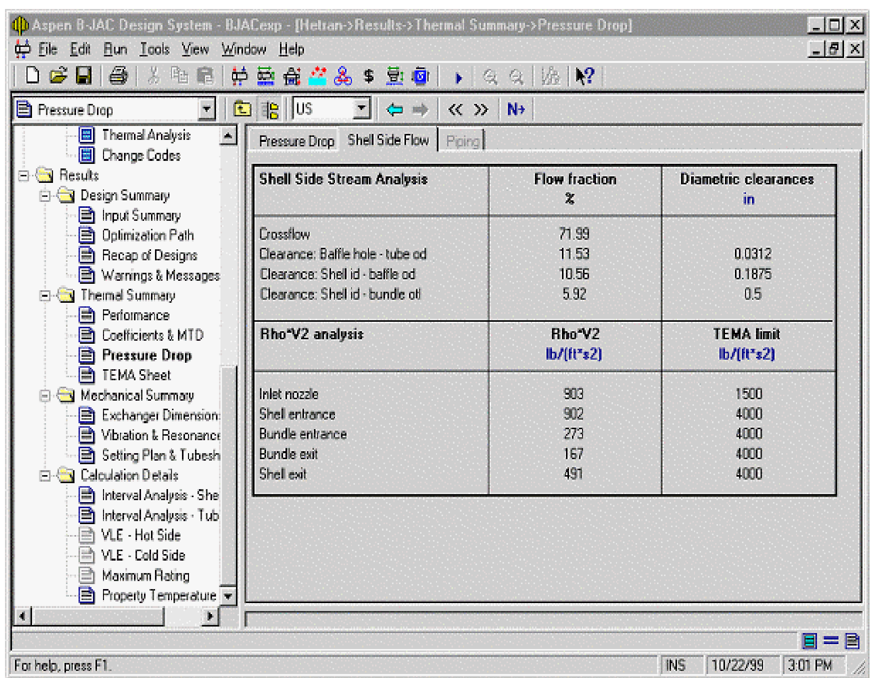


Hetran, for a multiphase application, will calculate separate film coefficients for the vapor, liquid, and condensing present. For this condenser, a condensing film of 313.25 is weighted with the liquid cooling film for an overall film coefficient of 310.38.



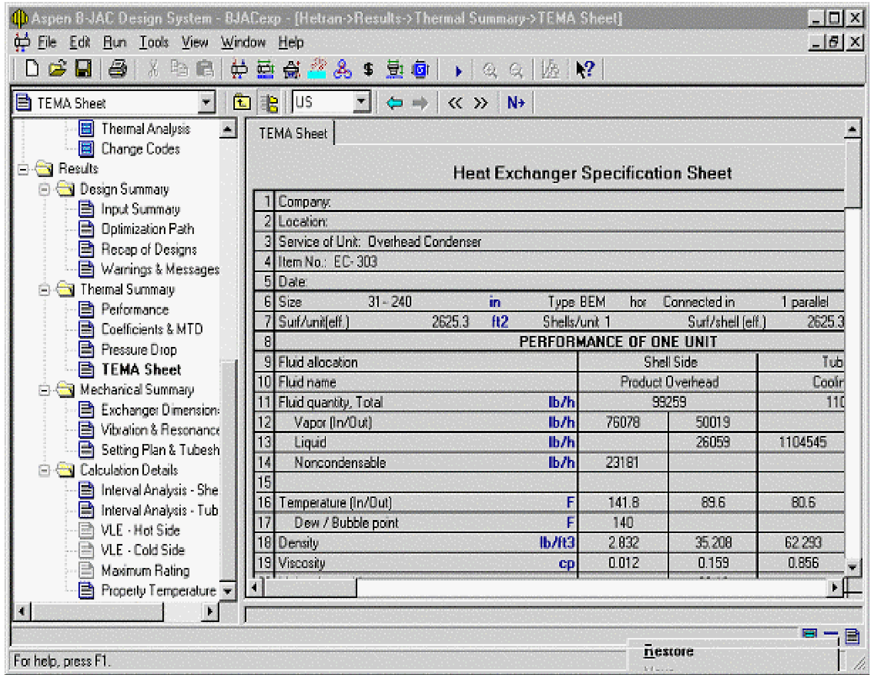
Pressure Drop psi	Shell Side		Tube Side	
Allowable	2		10	
Calculated, clean	1.876		1.272	
Calculated, dirty	2.286		1.302	
User specified bundle multiplier	1		1	
Velocity and pressure drop distribution	ft/s	%dp	ft/s	%dp
Inlet nozzle	17.86	7.77	3.88	3.97
Entering bundle	9.82	5.17	3.91	4.03
Crossflow	5.95	72.22		
Through baffle windows	5.5	8.33		
Through tubes			3.91	83.98
Exiting bundle	7.95	2.81	3.92	4.04
Outlet nozzle	22.09	3.69	3.89	3.98

The pressure drop distribution summary will help you determine if adjustments need to be made in nozzle sizes and/or baffling to re-distribute pressure loss and enhance heat transfer in the tube bundle.

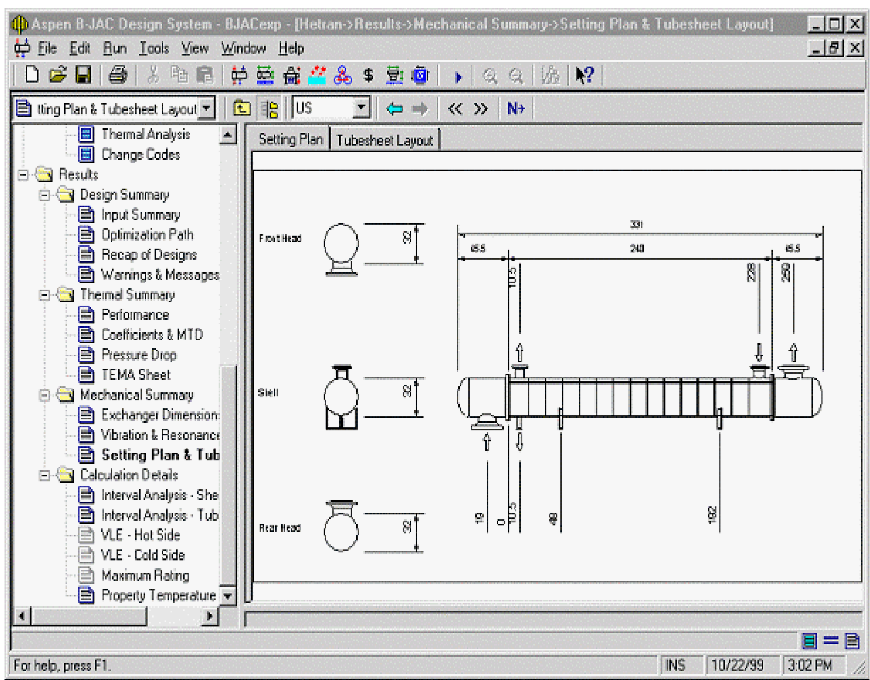


Shell Side Stream Analysis	Flow fraction %	Diametric clearances in
Crossflow	71.99	
Clearance: Baffle hole - tube od	11.53	0.0312
Clearance: Shell id - baffle od	10.56	0.1875
Clearance: Shell id - bundle otl	5.92	0.5
Rho*V2 analysis	**Rho*V2 lb/(ft*s2)**	**TEMA limit lb/(ft*s2)**
Inlet nozzle	903	1500
Shell entrance	902	4000
Bundle entrance	273	4000
Bundle exit	167	4000
Shell exit	491	4000

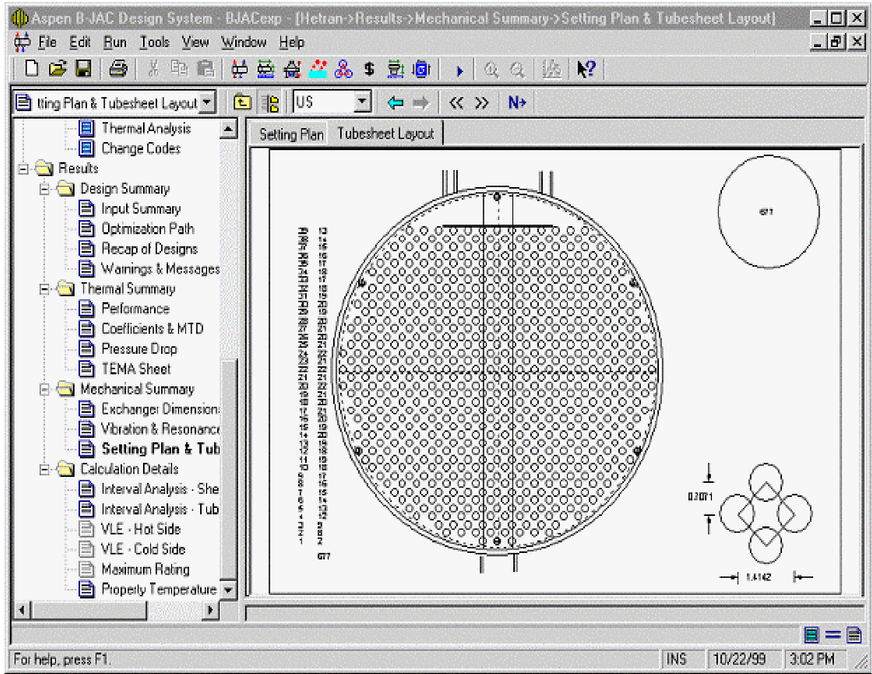
A shell side stream analysis and mass velocity summaries are provided.



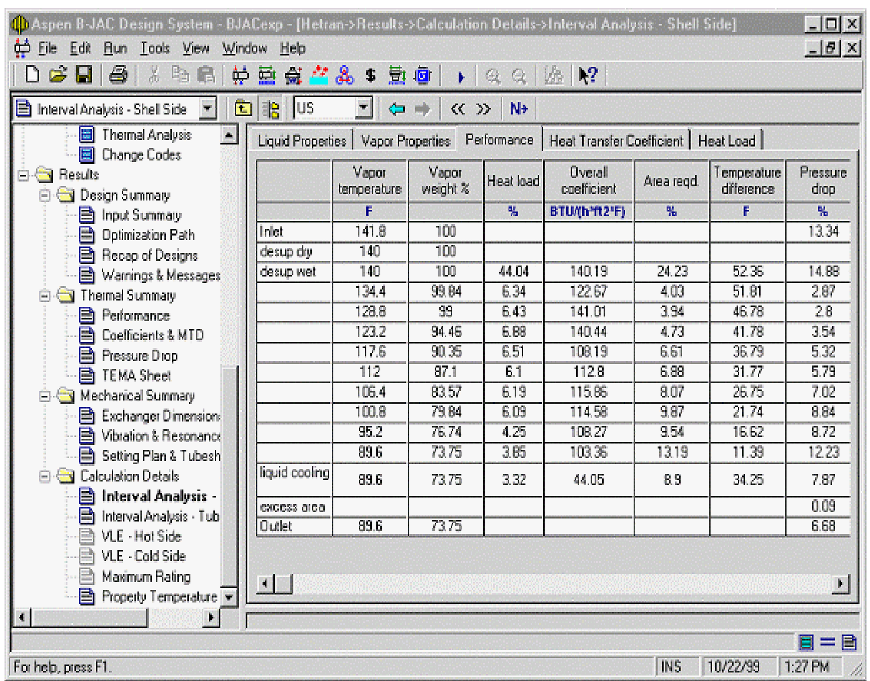
To view the exchanger data sheet, select the TEMA Sheet in the navigator. Use the slide bars to view the balance of the data sheet.



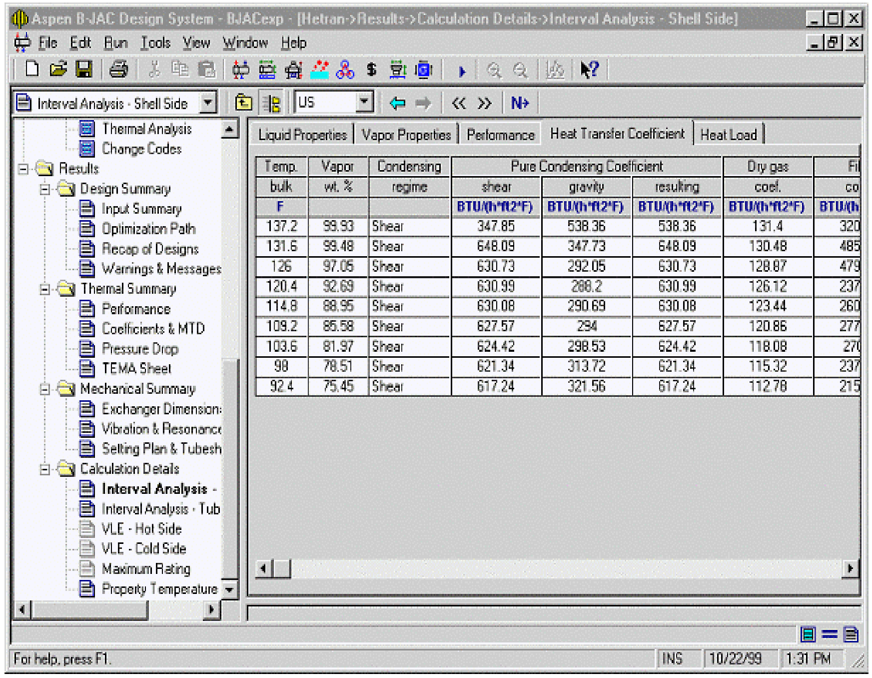
A scaled outline drawing is provided so you can view the nozzle and baffle arrangements for the exchanger design.



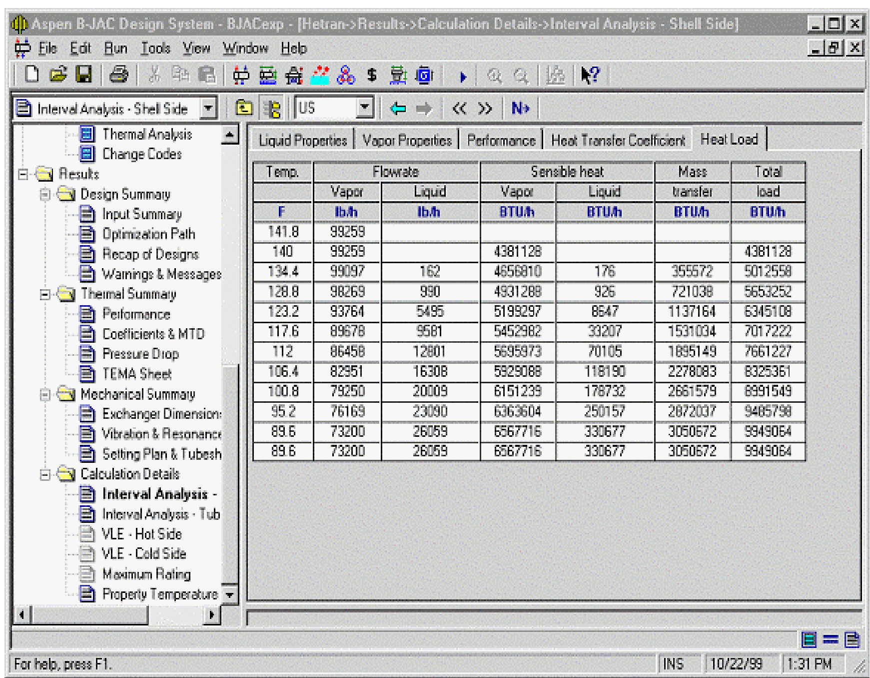
Also provided is a scaled tube layout drawing showing the location of the tubes, baffle cuts, tie rods, and nozzles.



To view the detail calculations, select the Interval Analysis sections. This section provide a results for each thermal interval analyzed by the program. Viewed above is the Performance section heat loads, overall coefficients, areas, and pressure drops for each increment.

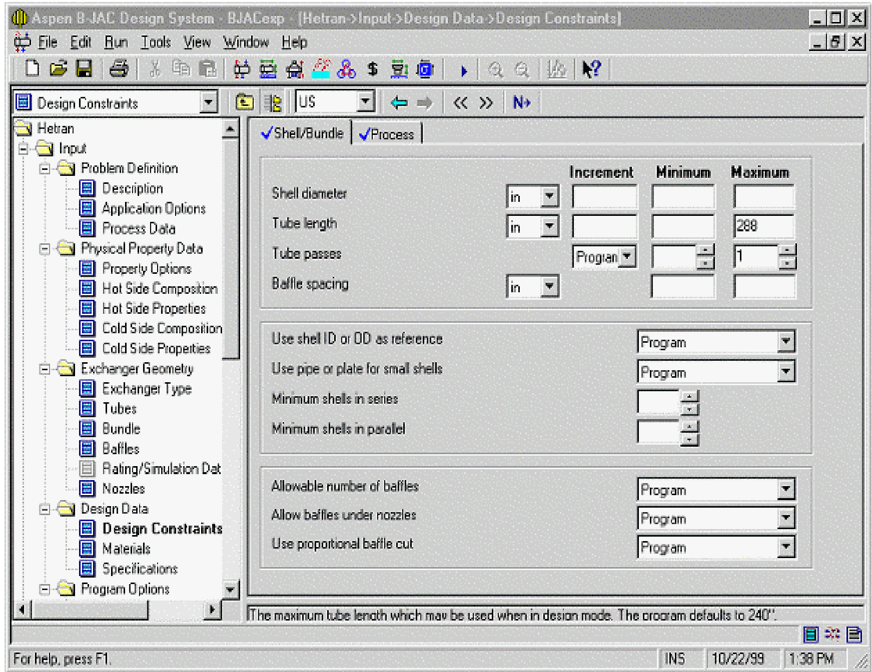


This section provides the incremental film coefficients.

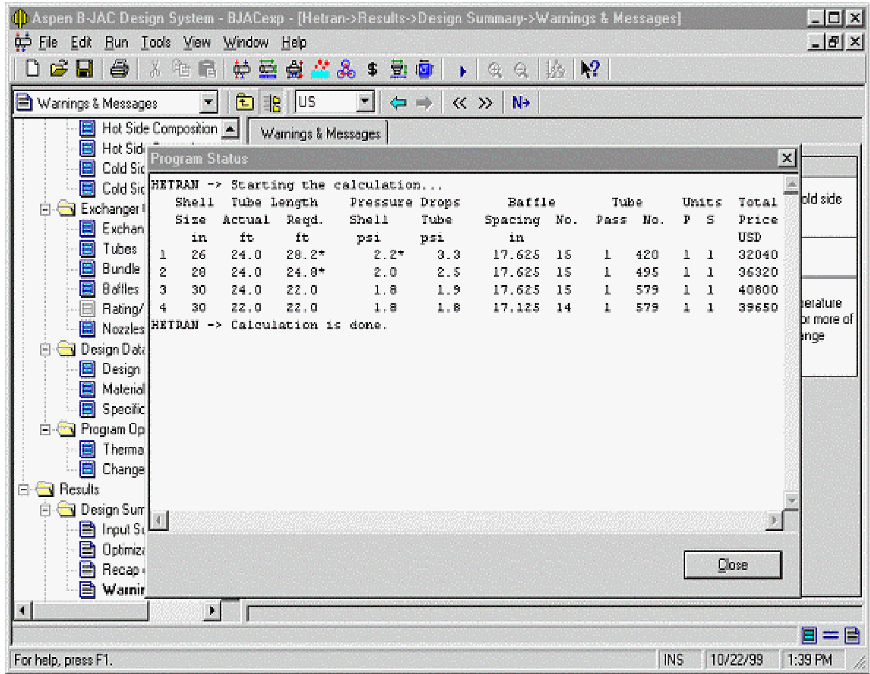


The heat load incremental analysis is also provided.

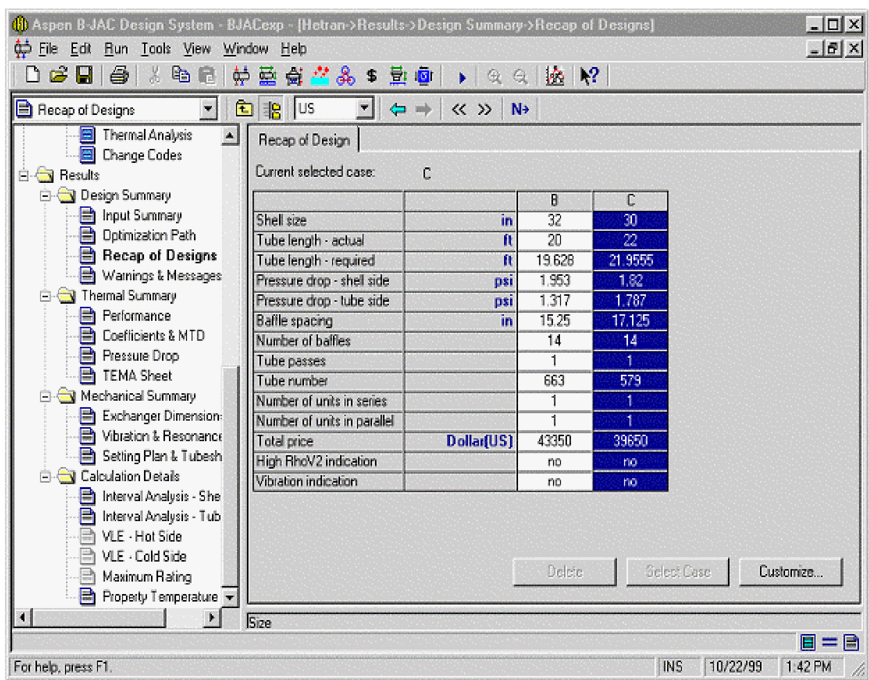
Aspen B-JAC Example: Tuning the Design



Now let us consider that the controlling design optimization parameter was the tube length. Select Design Constraints in the Navigator and change the maximum tube length to 288 inches from the original 240 inches. Select the Run button and have Aspen Hetran re-optimize the design with the longer allowable tube length.



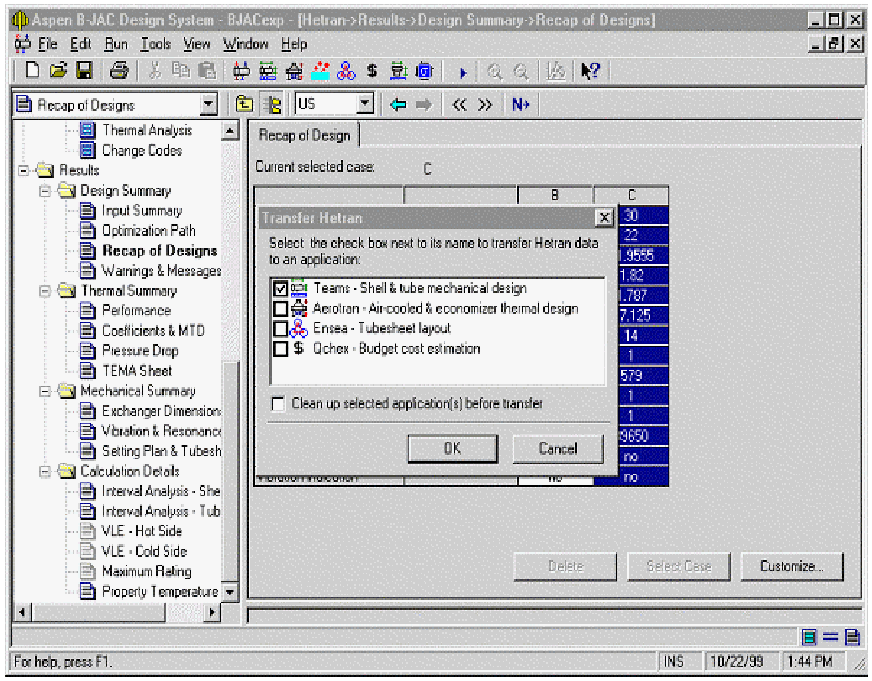
The optimization summary shows that the exchanger size and cost was reduced.



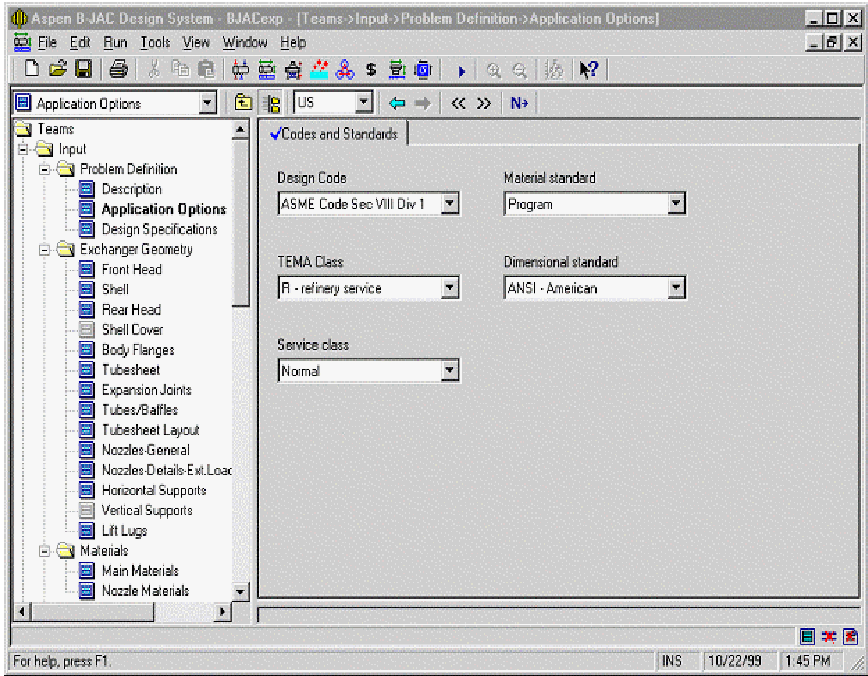
		B	C
Shell size	in	32	30
Tube length - actual	ft	20	22
Tube length - required	ft	19.628	21.9555
Pressure drop - shell side	psi	1.953	1.82
Pressure drop - tube side	psi	1.317	1.787
Baffle spacing	in	15.25	17.125
Number of baffles		14	14
Tube passes		1	1
Tube number		663	579
Number of units in series		1	1
Number of units in parallel		1	1
Total price	Dollar(US)	43350	39650
High RhoV2 indication		no	no
Vibration indication		no	no

In the results section, select the Recap of Designs in the Navigator to view the comparison summary of the original design and the new design. By following these steps, you can possibly make further improvements to the design by making adjustments and having Aspen Hetran re-optimize. We have complete the thermal design so now we will interface to the Teams program to complete the mechanical design.

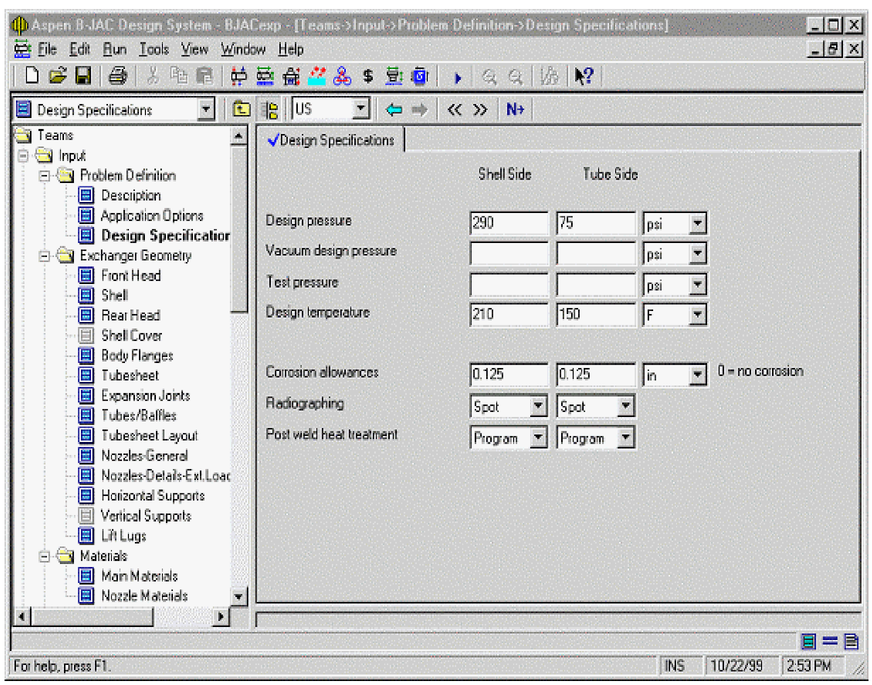
Aspen B-JAC Example: Performing Mechanical Design



First we need to transfer the necessary thermal design results from Aspen Hetran into the Teams section. Select the Run command in the Menu Bar and then select the Transfer command. Select the Teams program and select OK.

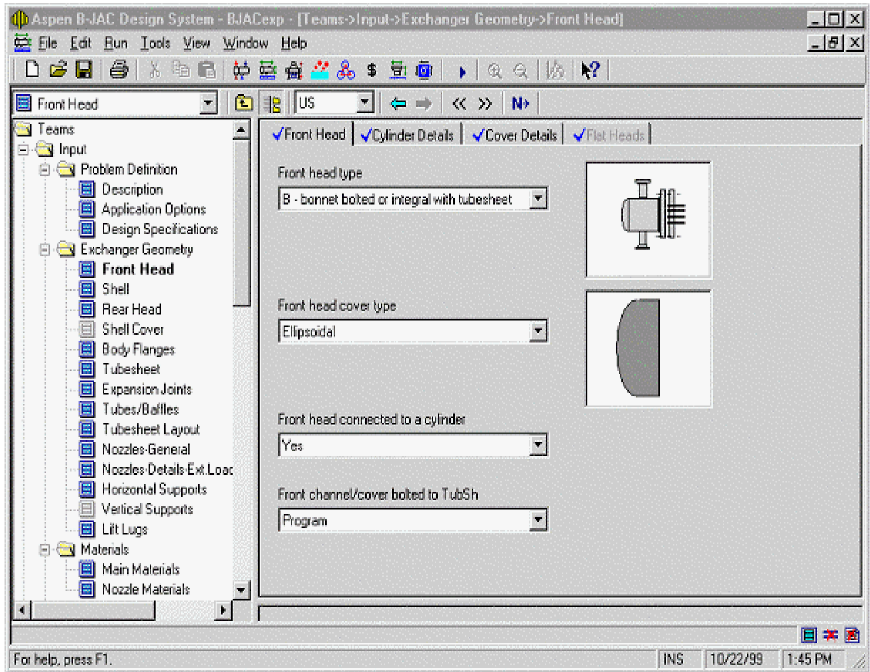


Specify the applicable code: ASME, Codap, or ADM. By selecting the TEMA class, default settings for flange design, corrosion allowance, and clearance will be set in accordance to the respective TEMA class.

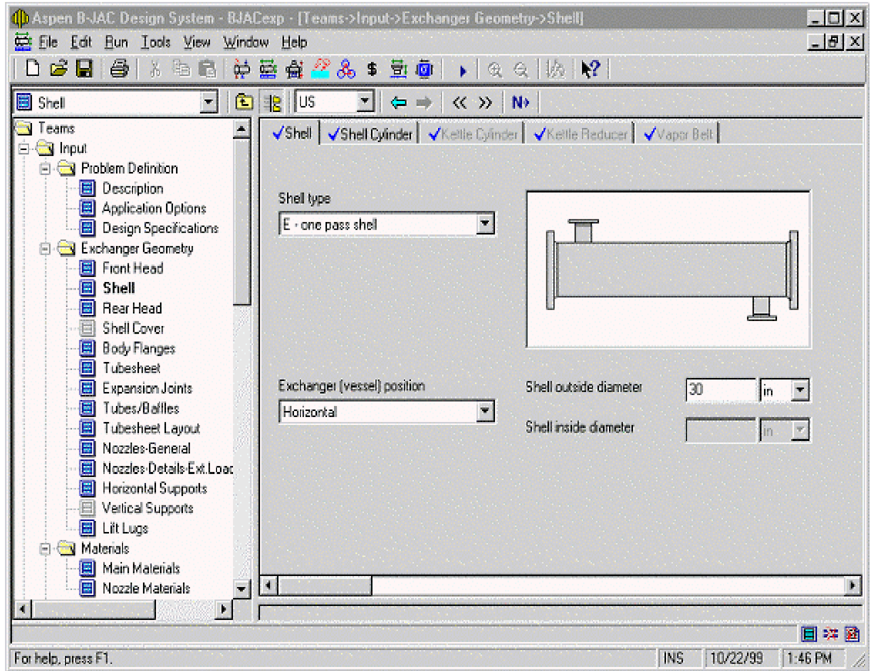


Appropriate design conditions have been entered. Note that each input field has it own unique units control. You can enter any set of units by selecting the unit set required beside the input field. If you wish to convert to a different set of units, select the desired units and the value in the field will be converted.

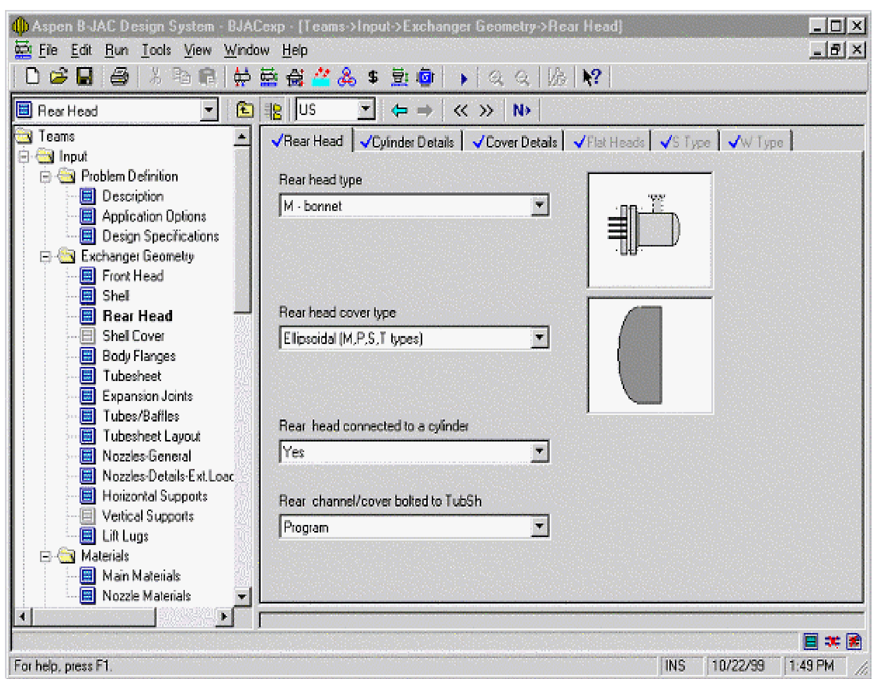
Aspen B-JAC Example: Specifying Geometry in Teams



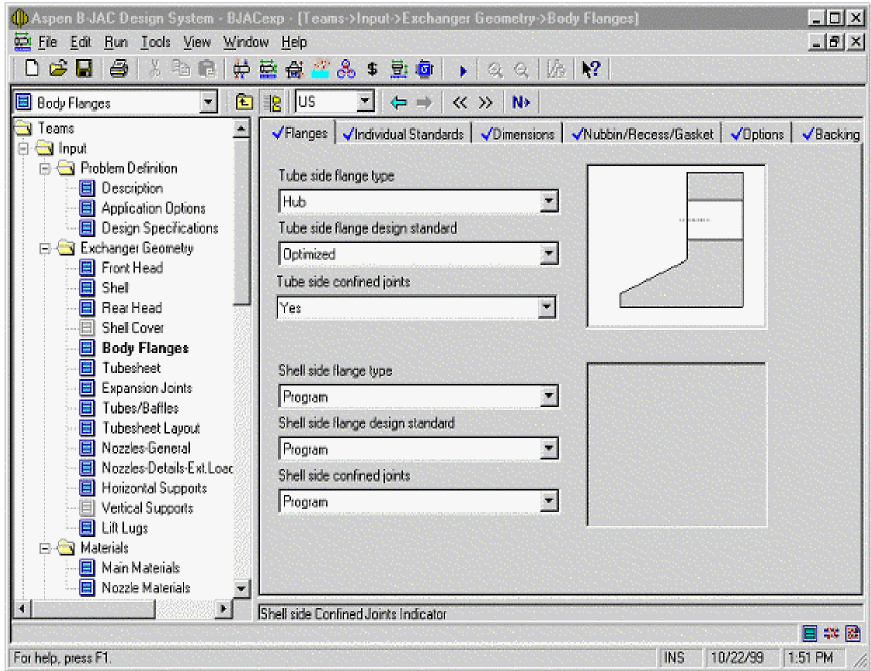
Teams has specific defaults set for each TEMA head type. For example the selected B type head will default to the ellipsoidal cover shown unless a different cover is specified. Defaults follow typical TEMA conventions. If you are rating an existing exchanger for a new set of design conditions, select the Detail Cylinder and Detail Cover tabs and enter the dimensions of the existing equipment. You can enter details for other components in a similar way.



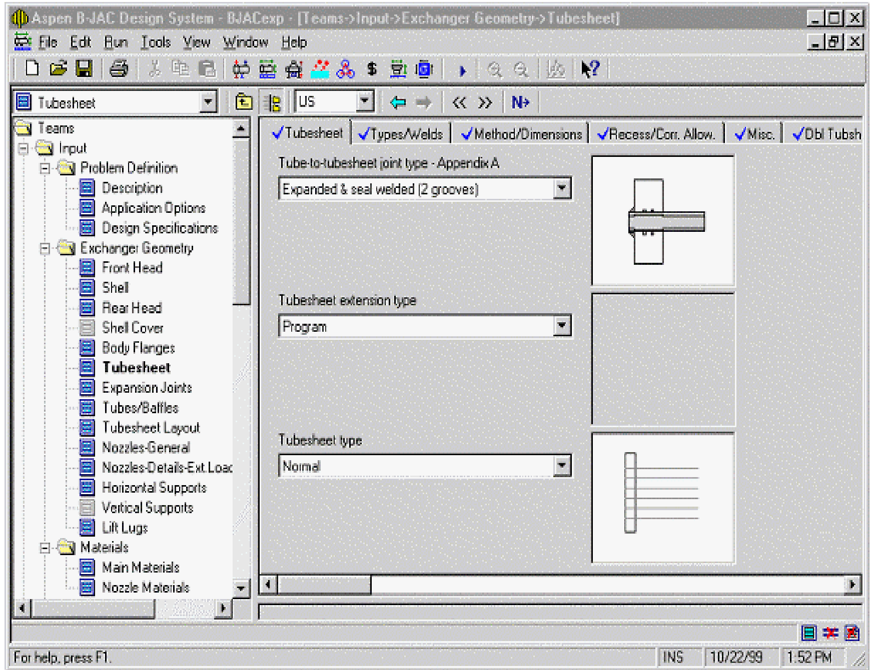
Shell type should be selected to correspond the nozzle and baffle location requirements. If pipe material is being used for the cylinders, it is best to enter an outside diameter for the vessel diameter so that standard pipe schedules may be referenced. If the cylinders are fabricated from plate material, either inside or outside diameters by being entered.



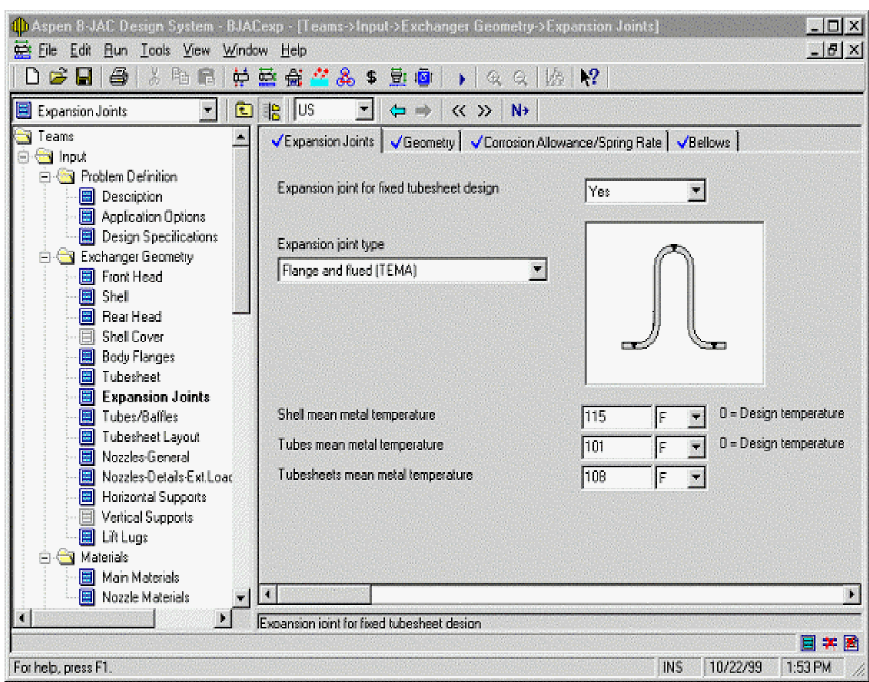
In a similar way as the front head, select the type for the head and cover for the rear head. Program will default to a ellipsoidal cover unless you specify one of the alternate types. If the exchanger is a one pass unit with a nozzle located in the rear head, specify that a rear head cylinder is to be provided.



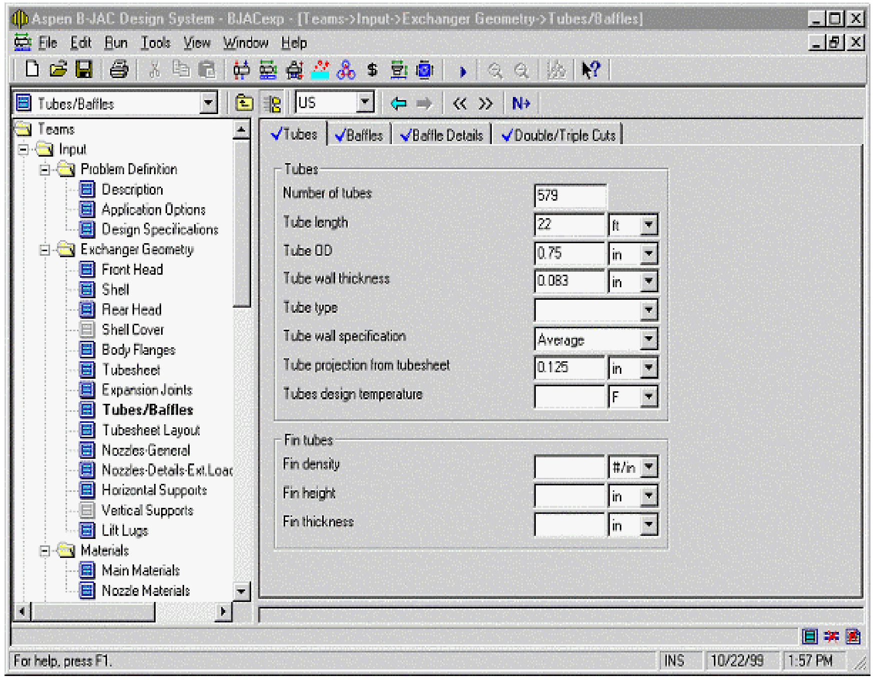
Teams will default to a hub type body flanges for a TEMA Class R exchanger. NO flanges will be specified for the shell side since this example has the tube sheet extended for bolting to the head flanges. If you need to control individual flange specifications go to the Individual Standards tab in this form. For check rating existing flange designs, enter the actual flange size by selecting the Dimensions tab.



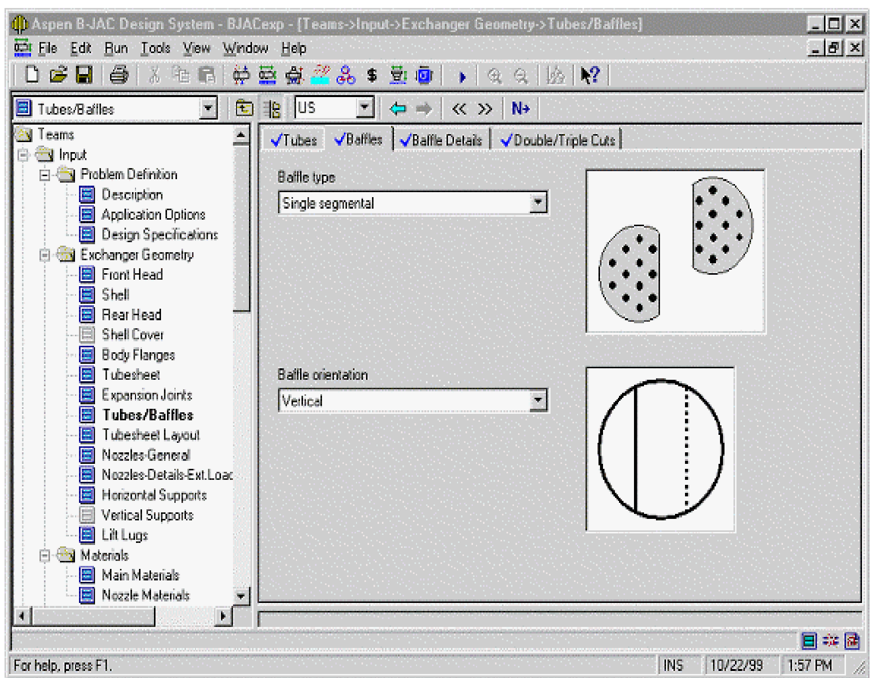
Due to the relative high design pressure on the shell side, an expanded and seal weld tube joint has been specified. The program default is to extend the tubesheet for bolting to the heads for our BEM example.



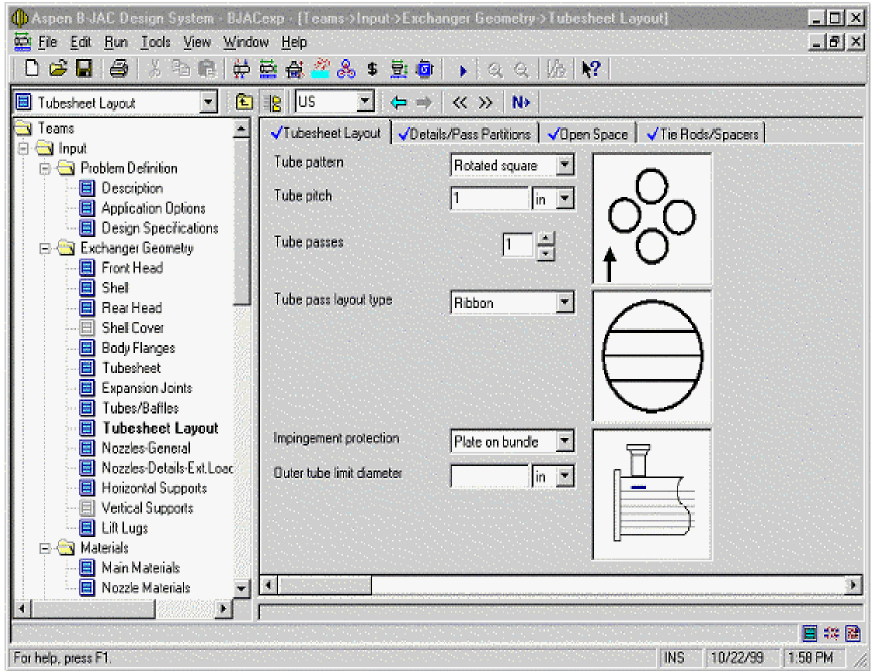
Teams will check to see if an expansion joint is required and will provide one, if necessary, if you specify by program. In this example, an expansion joint has been specified. Accurate mean metal temperatures are required to properly analyze the expansion joint/tubesheet design.



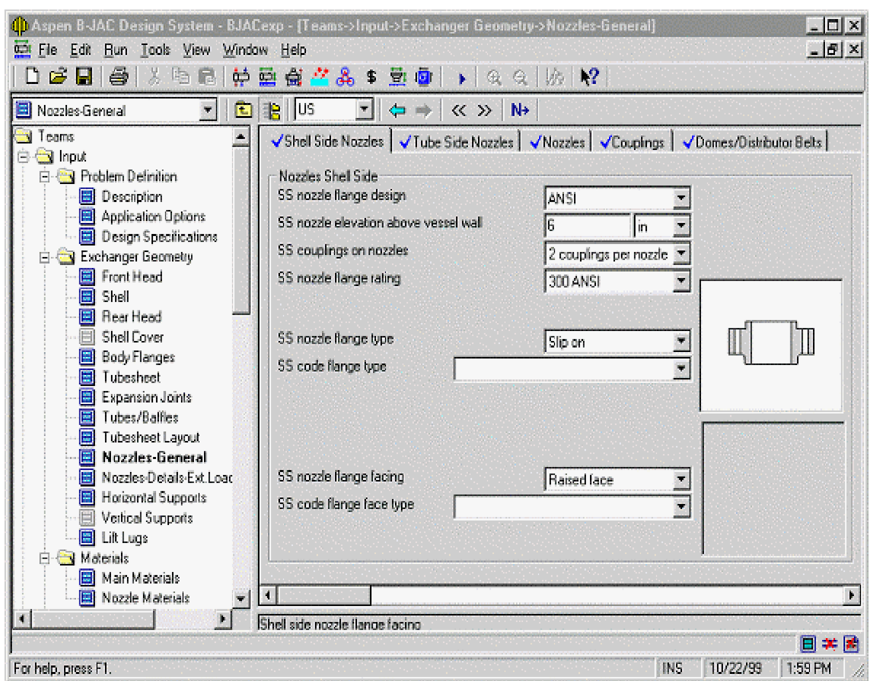
The tubing requirements are inputted. If low fin tubes are required, provide the fin density, height, and thickness.



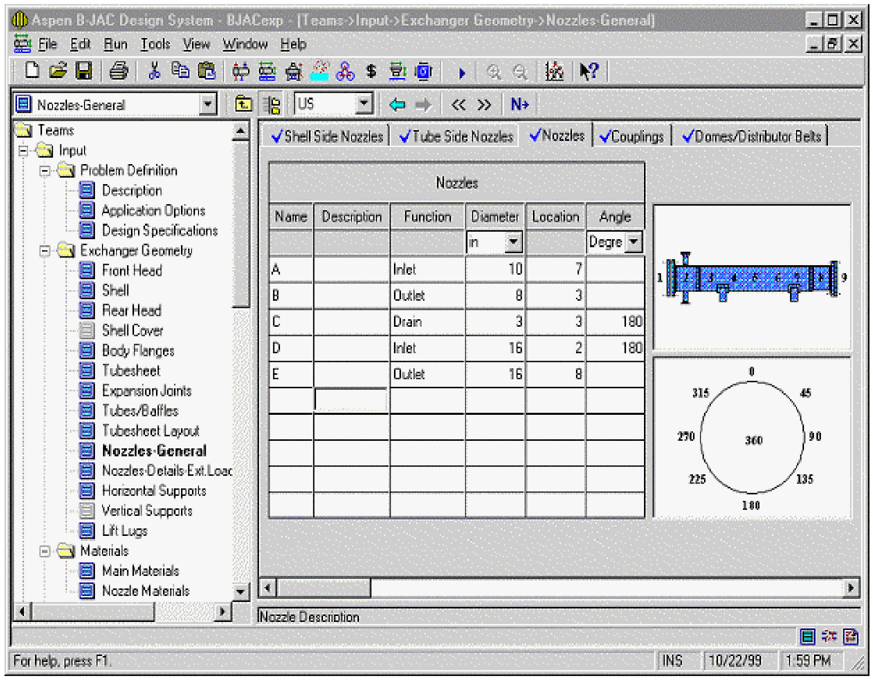
Baffle type and baffle cut orientation are specified. Enter baffle cut, number of baffles, and baffle spacings in the Baffle Details tab form.



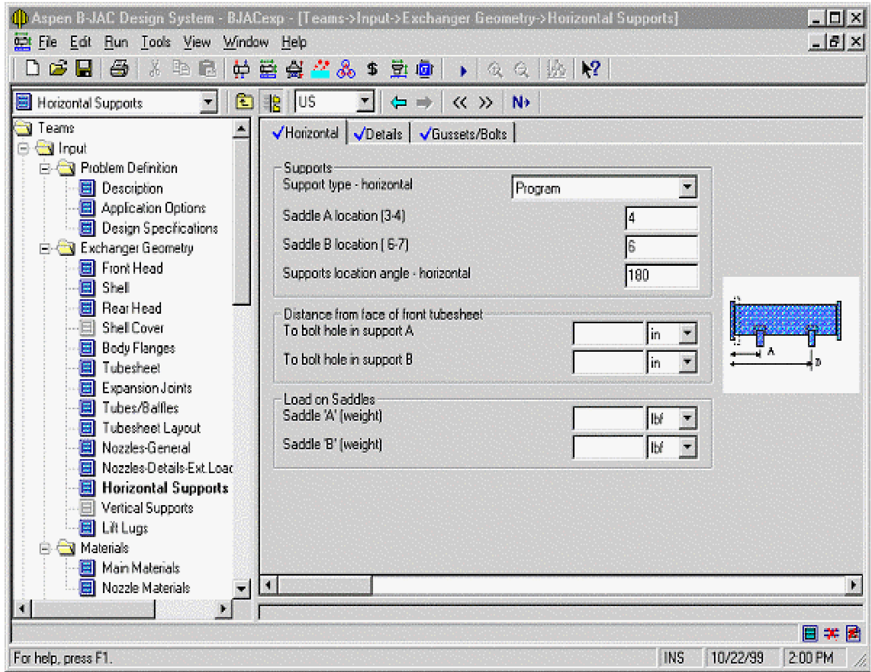
Tubesheet layout information is provided. Teams will default to TEMA requirements if you allow the program to select. Tube pass layout type was passed into TEAMS from the Aspen Hetran results. If not specified, the program will select the layout type to provide the maximum number of tubes possible.



You can set the global information for the shell side and tube side nozzles. To set specific information for each nozzle, select the Nozzles-Details section in the Navigator.

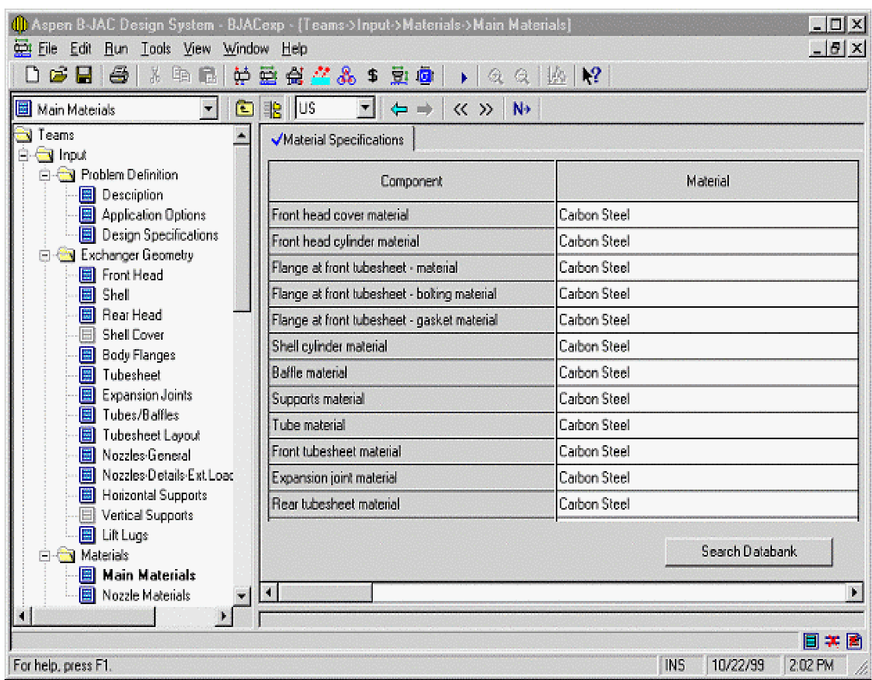


Select the Nozzles Tab to provide nominal nozzle diameters and approximate nozzle zone locations. For nozzles located in the front/rear head covers, specify zones 1 or 9 and an angle of 360 degrees. For hill side nozzles, specify any angle other than multiples of 45 degrees.

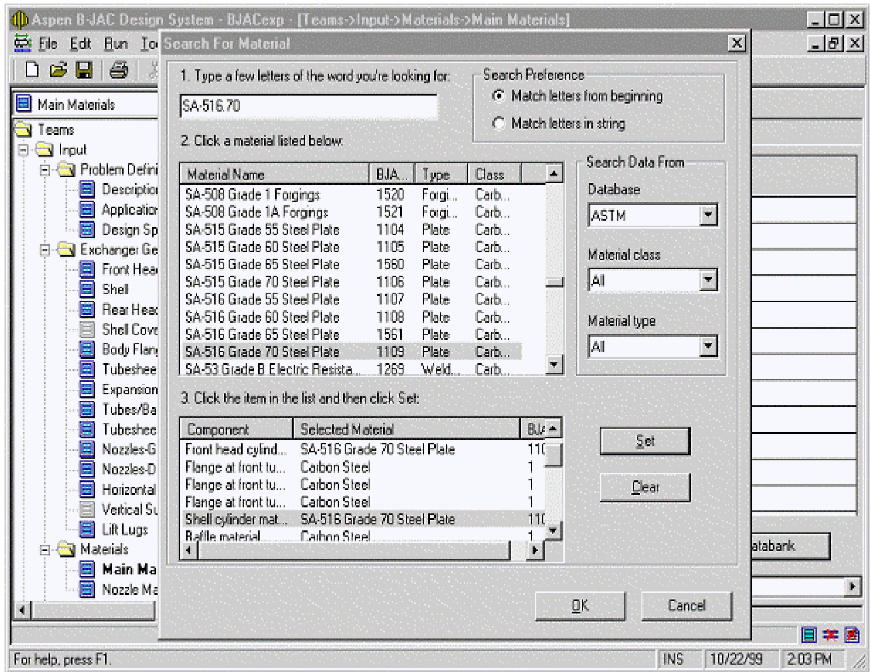


Saddle support zone locations are set.

Aspen B-JAC Example: Specifying Materials for Teams



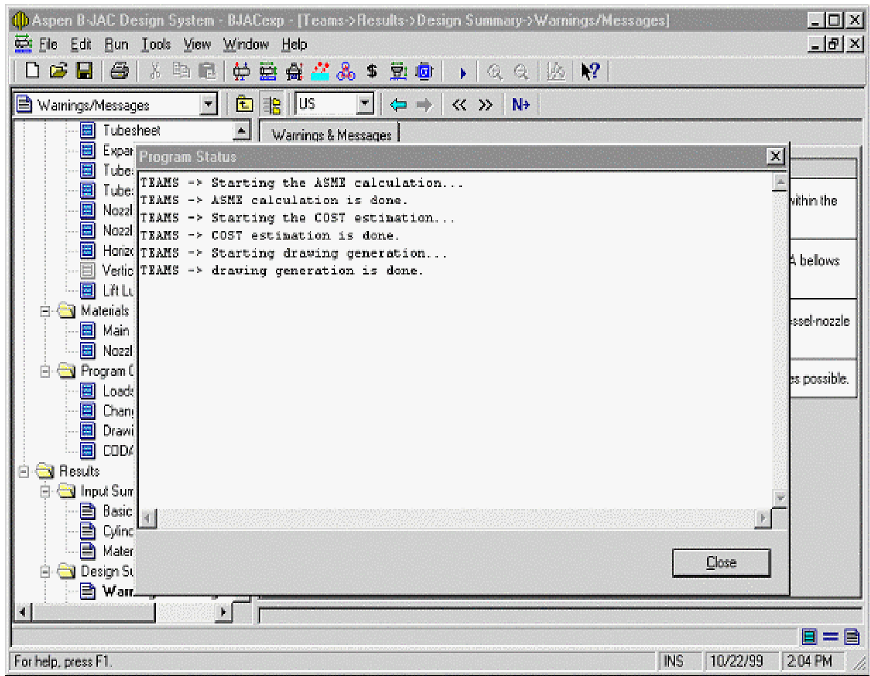
For this design, Hetran passed into Teams the generic material for all the components. Teams will then use the material properties for an appropriate material specification for each component. For example, the program will use SA-516-70 for the carbon steel tubesheet since ASTM standards were referenced. If you wish to specify actual material specifications, select the Search Databank button.



The Metals search window will then be shown. Enter the material name in the top input field and the program will search for a match. Select the desired material in the list. The next step is to select the component in the component list and then select the Set button to set the material to that component. Continue this process until the materials are selected for all the components. Nozzle materials are set in a similar method located under Nozzle Materials in the Navigator.

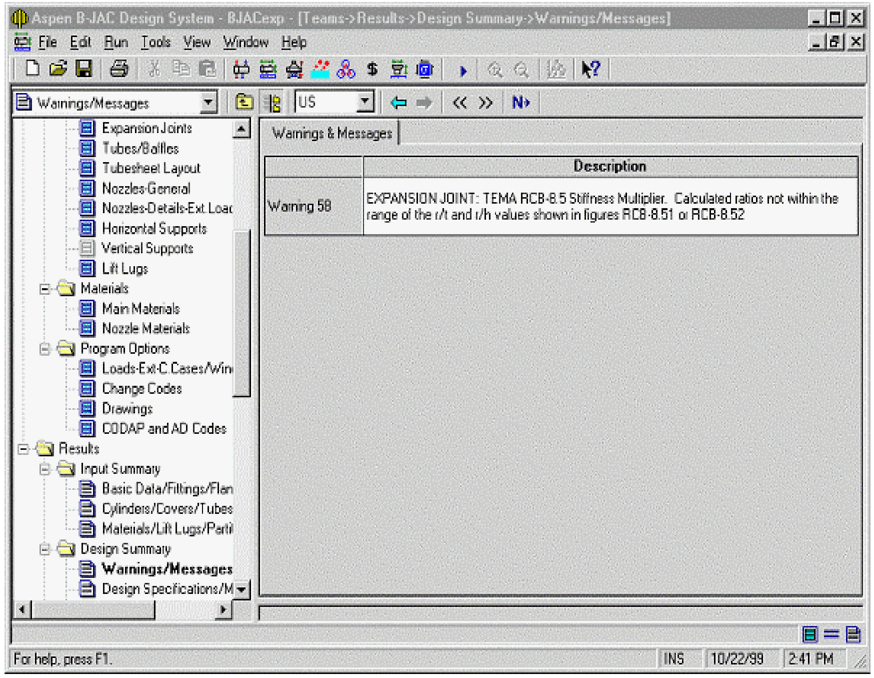
The Teams input file is now complete and the next step is to run the program.

Aspen B-JAC Example: Running Teams



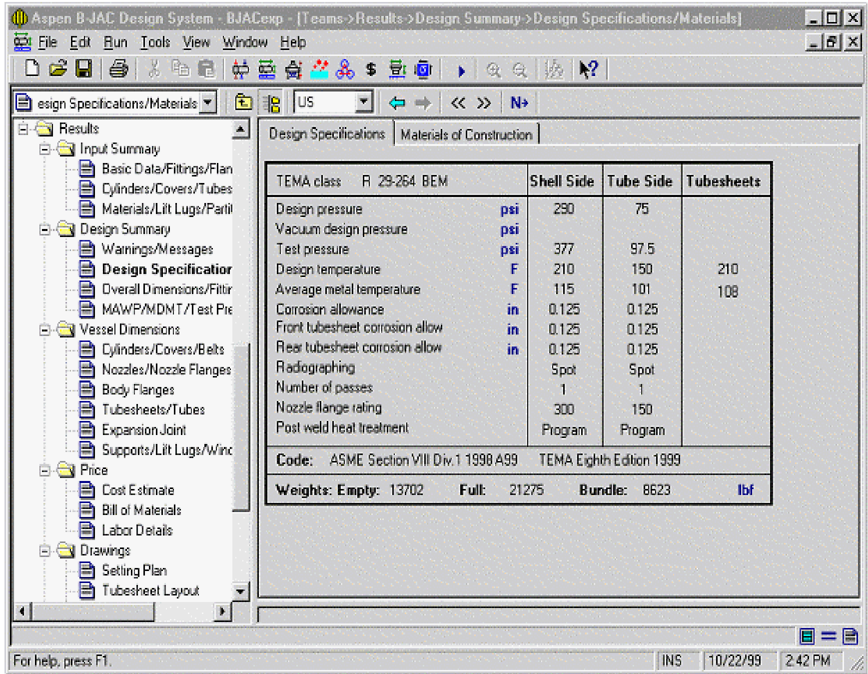
Select the Run command in the Menu Bar, then select Run Teams. The Run Teams options are: calculations only, calculations plus cost estimate, calculations plus drawings, or calculations plus cost plus drawings. As an alternative, the Run icon can be selected in the Tools Bar which will run calculations plus cost estimate and plus drawings.

The Program Status window will appear to provide you with a run status.



The warnings and notes will be displayed first. Note that the flanged and flued type expansion joint selected does not meet the design requirements. The Teams results will first be reviewed then a bellows type expansion joint will be selected as a possible solution.

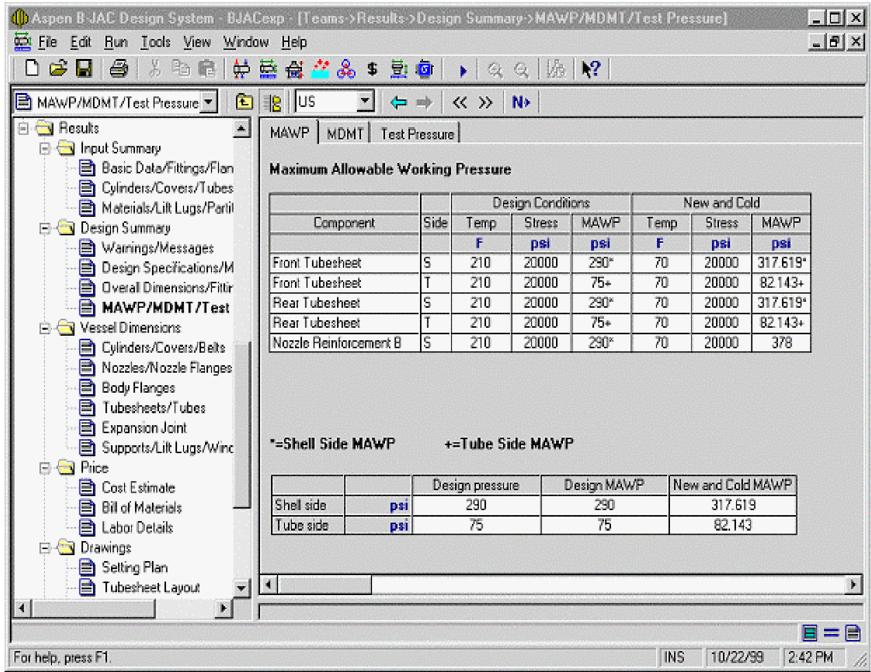
Aspen B-JAC Example: Viewing Teams Results



The Teams results are organized in two five major sections:

- Design Summary
- Vessel Dimensions
- Price
- Drawings
- Code Calculations

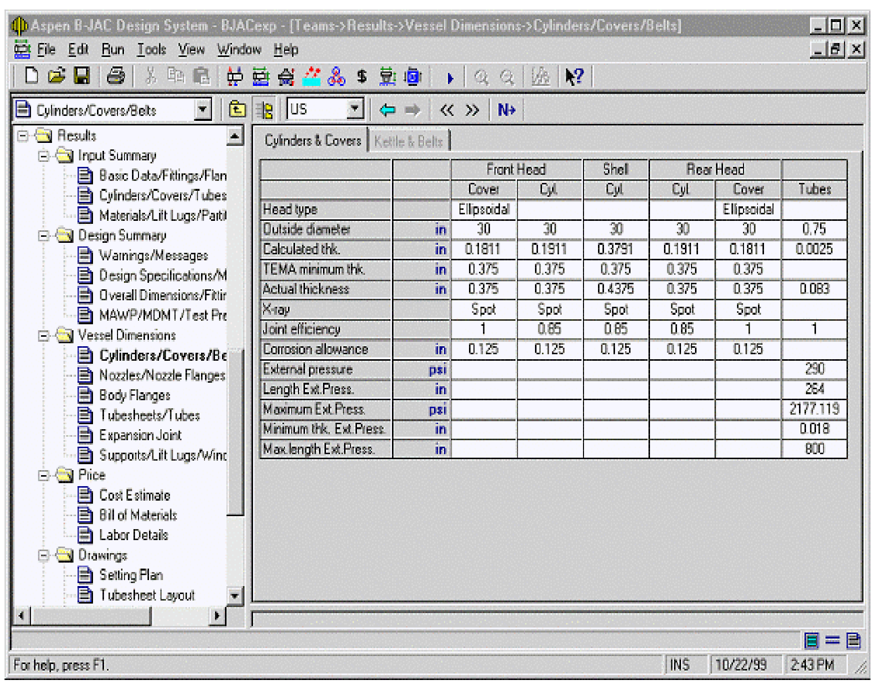
The Design Specification sections is shown here.



Component	Side	Design Conditions Temp	Stress	MAWP	New and Cold Temp	Stress	MAWP
		F	psi	psi	F	psi	psi
Front Tubesheet	S	210	20000	290*	70	20000	317.619*
Front Tubesheet	T	210	20000	75+	70	20000	82.143+
Rear Tubesheet	S	210	20000	290*	70	20000	317.619*
Rear Tubesheet	T	210	20000	75+	70	20000	82.143+
Nozzle Reinforcement B	S	210	20000	290*	70	20000	378

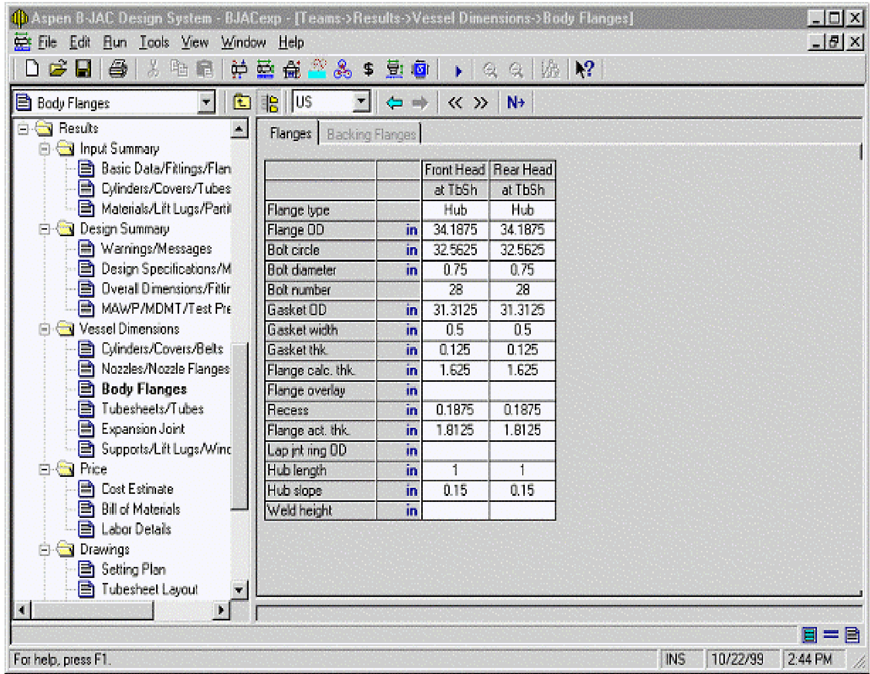
		Design pressure	Design MAWP	New and Cold MAWP
Shell side	psi	290	290	317.619
Tube side	psi	75	75	82.143

The limiting MAWP components are shown in the above summary. The MAWP for the tubesheets are limited to the specified design conditions. To review the MDMT results, select the MDMT tab.



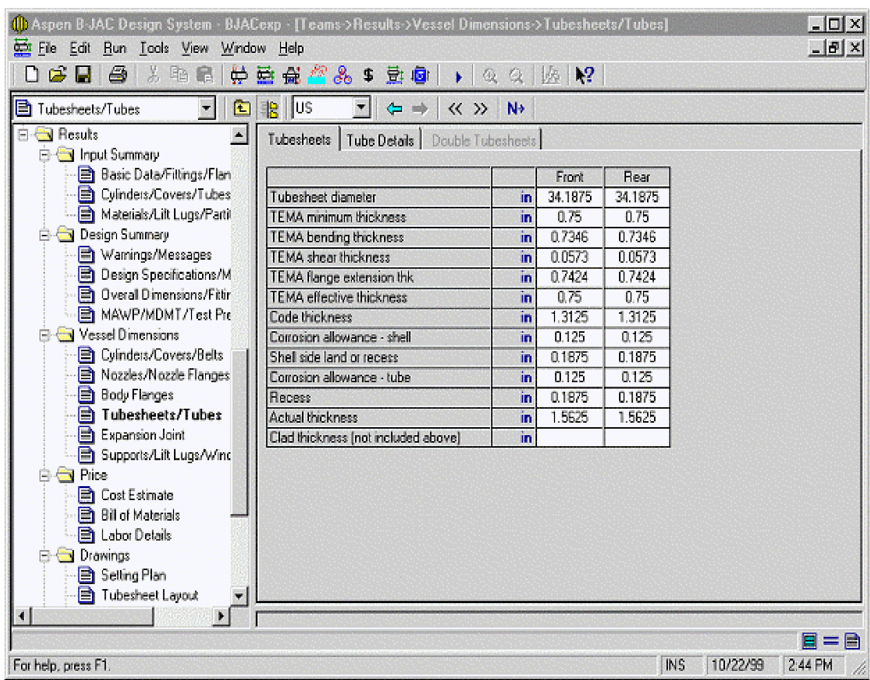
		Front Head Cover	Cyl	Shell Cyl	Rear Head Cyl	Cover	Tubes
Head type		Ellipsoidal				Ellipsoidal	
Outside diameter	in	30	30	30	30	30	0.75
Calculated thk.	in	0.1811	0.1911	0.3791	0.1911	0.1811	0.0025
TEMA minimum thk.	in	0.375	0.375	0.375	0.375	0.375	
Actual thickness	in	0.375	0.375	0.4375	0.375	0.375	0.083
X-ray		Spot	Spot	Spot	Spot	Spot	
Joint efficiency		1	0.85	0.85	0.85	1	1
Corrosion allowance	in	0.125	0.125	0.125	0.125	0.125	
External pressure	psi						290
Length Ext.Press.	in						264
Maximum Ext.Press.	psi						2177.119
Minimum thk. Ext.Press.	in						0.018
Max.length Ext.Press.	in						800

Select the Cylinders/Covers/Belts to review the cylinder results summary.



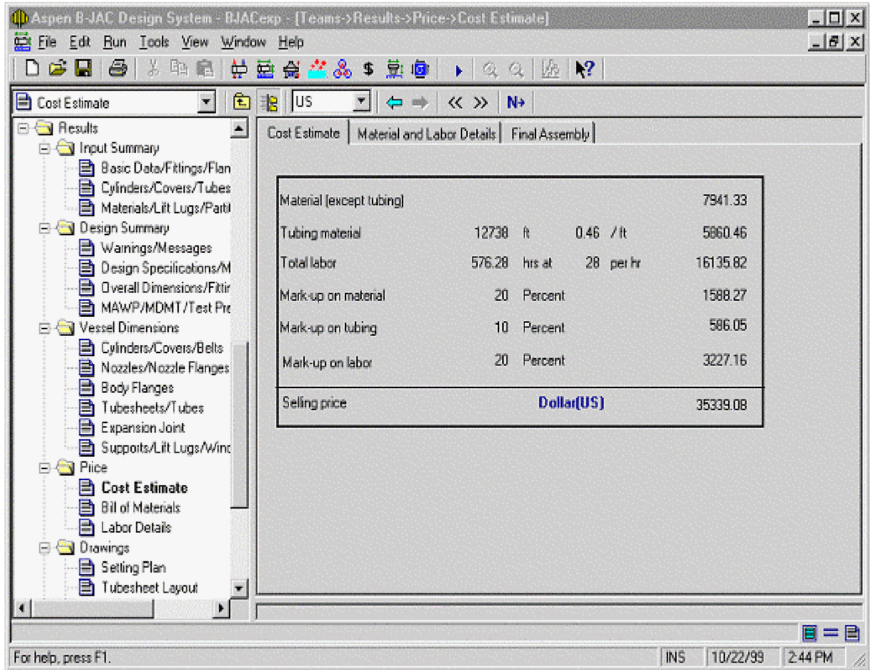
		Front Head at TbSh	Rear Head at TbSh
Flange type		Hub	Hub
Flange OD	in	34.1875	34.1875
Bolt circle	in	32.5625	32.5625
Bolt diameter	in	0.75	0.75
Bolt number		28	28
Gasket OD	in	31.3125	31.3125
Gasket width	in	0.5	0.5
Gasket thk.	in	0.125	0.125
Flange calc. thk.	in	1.625	1.625
Flange overlay	in		
Recess	in	0.1875	0.1875
Flange act. thk.	in	1.8125	1.8125
Lap jnt ring OD	in		
Hub length	in	1	1
Hub slope	in	0.15	0.15
Weld height	in		

Calculation results for the body flanges are shown above.

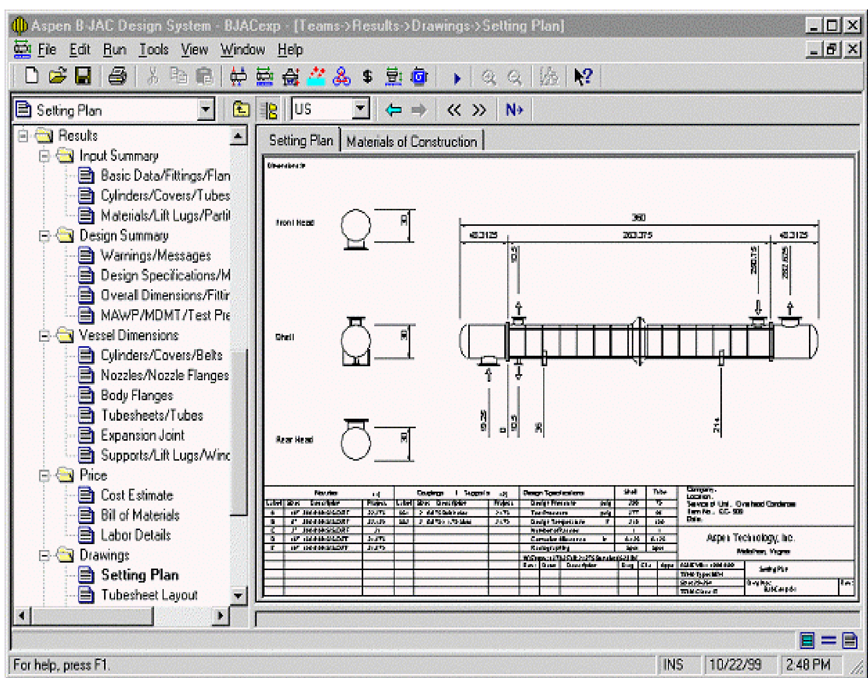


		Front	Rear
Tubesheet diameter	in	34.1875	34.1875
TEMA minimum thickness	in	0.75	0.75
TEMA bending thickness	in	0.7346	0.7346
TEMA shear thickness	in	0.0573	0.0573
TEMA flange extension thk	in	0.7424	0.7424
TEMA effective thickness	in	0.75	0.75
Code thickness	in	1.3125	1.3125
Corrosion allowance - shell	in	0.125	0.125
Shell side land or recess	in	0.1875	0.1875
Corrosion allowance - tube	in	0.125	0.125
Recess	in	0.1875	0.1875
Actual thickness	in	1.5625	1.5625
Clad thickness (not included above)	in		

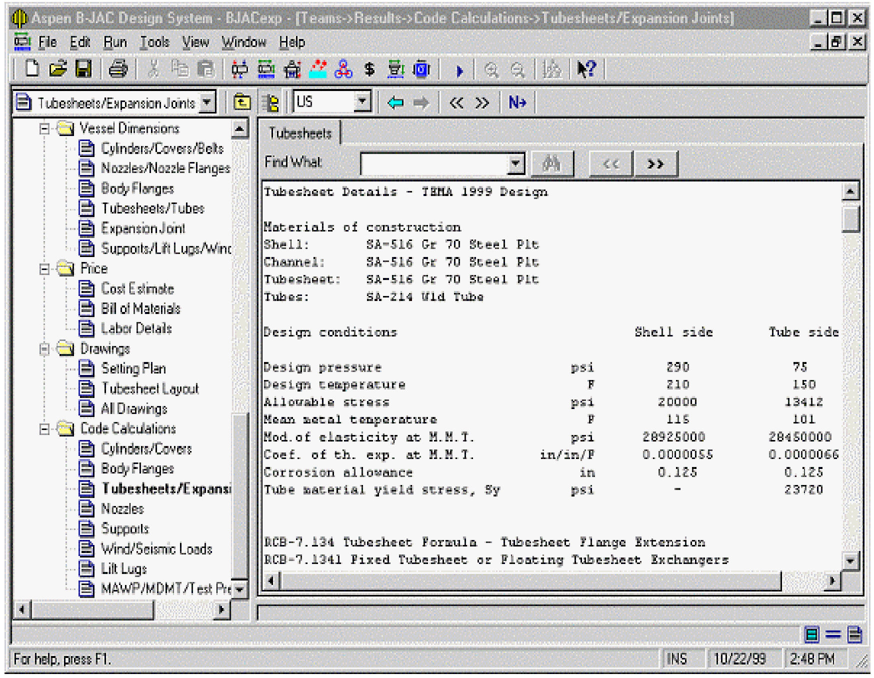
Teams provides results per the TEMA method and per the applicable selected code method. The program will use the thicker of the two methods.



The cost estimate is based upon the Teams design code calculation results and the manufacture settings. The manufacturing standards are accessed by selecting Tools from the Menu Bar, selecting Data Maintenance, and then selecting Costing.



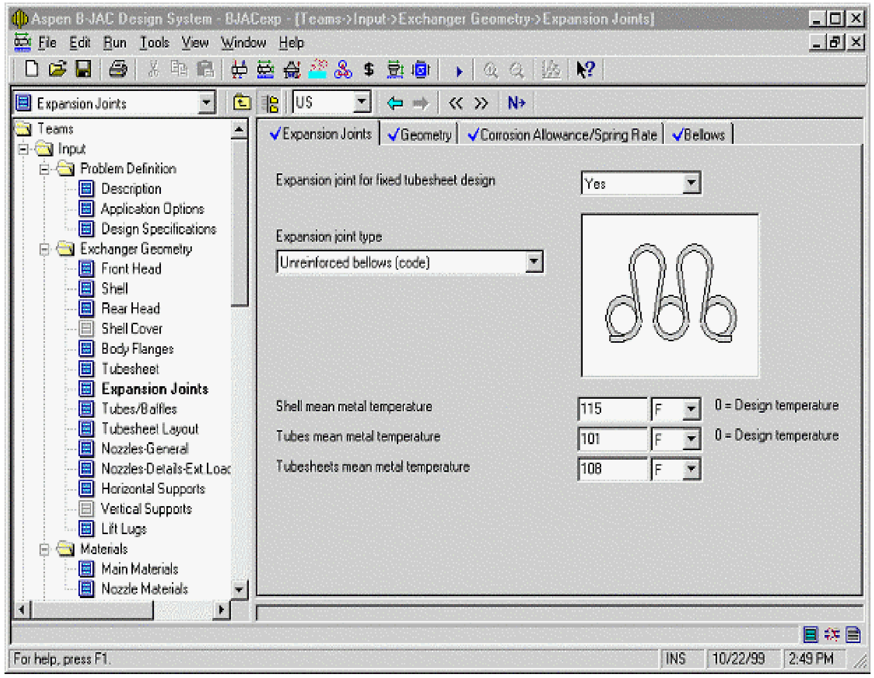
The scaled outline drawing can be viewed by selecting Setting Plan in the navigator. To view a specific area of the drawing, window the section of the drawing to be viewed. Select View command in the Menu Bar and then select Zoom In. As an alternative, use the magnifying glass icon in the Tools Bar. Use Zoom Out to restore the drawing to full view. The standard setting plan drawing can be accessed by selecting All Drawings in the navigator.



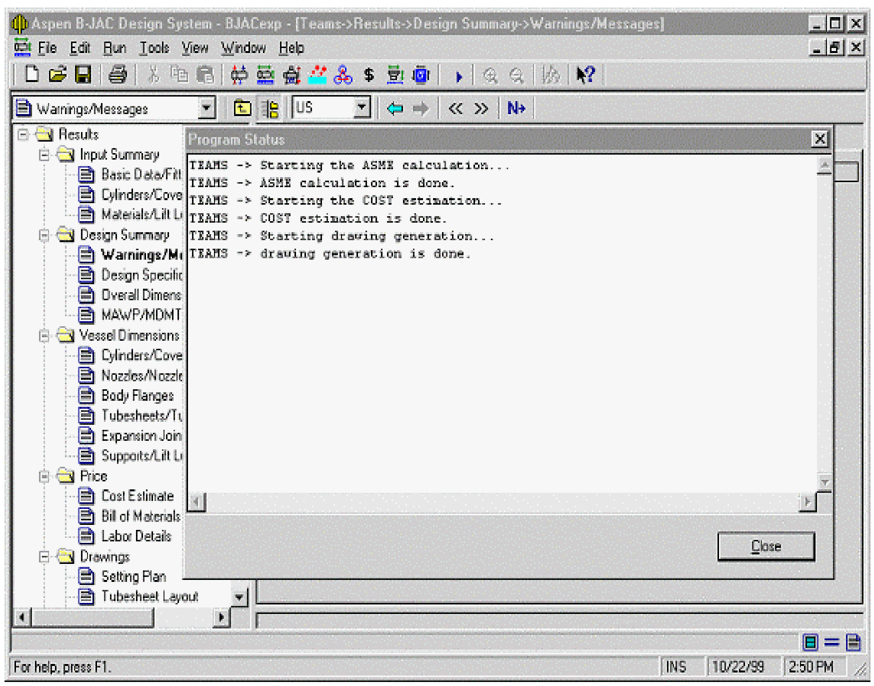
To review the detail calculation documentation, select the component from the Code Calculation area of the navigator. Shown above is the tubesheet calculations.

Aspen B-JAC Example: Addressing Problems Discovered by Teams

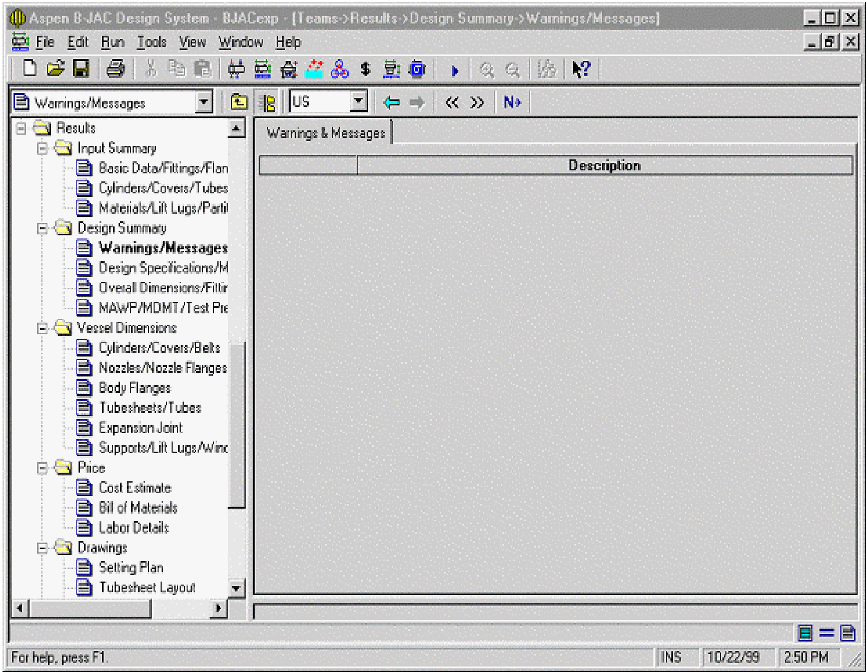
Let us now address the warning message concerning the overstress condition of the vessel supports. Generally if the supports are moved closer to the tubesheets, the shell stresses can be reduced.



Change the flanged and flued expansion joint type to bellow type.



Re-run the Teams calculations.



Review of the warnings/notes shows that the expansion joint problem has been resolved by using the bellows type. Other adjustments to the design may done in a similar sequence by making changes and re-running Teams.

This completes our mechanical design for the heat exchanger.

Exporting Results from B-JAC to Excel

Introduction

The Aspen B-JAC Windows user interface is designed to allow you to export input and results information into an Excel spread sheet.

This chapter describes how to use these export features. Topics include:

- Export features
- Exporting results to an existing spread sheet template
- Creating your own customized template
- Copying and pasting input and results from a B-JAC application to Excel
- Copying and pasting drawings to Excel
- Launching a B-JAC application from Excel

Export Features

B-JAC Templates

You can export the program results to an Excel spreadsheet. Several Excel spreadsheet templates have been provided for your use. You can select one of the pre-formatted output summaries such as TeamsSummary.xlt or you can select one of the blank templates such as HetranBlank.xlt and customize your output in Excel.

Exporting results to a B-JAC standard summary template or your customized template

File / Export function - spread sheet created without Excel being open:

First open the B-JAC program window and open an exchanger design file, *.BJT. If no results are present, run B-JAC to obtain results. Select the "File / Export to" functions from the Menu Bar. Select to open the default template or you can specify which template to open. You can set the default template from the "Tools / Program Settings / Template" window. If you are selecting which template to open, select from the template list, HetranSummary, TeamsSummary, AerotranSummary or your customized template, located in the BJAC10\DAT\Template sub-directory. Select to open the template. Then provide a file name to save the results as a spread sheet *.xls data file. Results for the B-JAC design file will be now be saved in the created Excel spreadsheet.

Spread sheet created with Excel open

First open the B-JAC program window and open an exchanger design file, *.BJT. If no results are present, run B-JAC to obtain results. Open Excel and then open the desired Excel template, HetranSummary, TeamsSummary, AerotranSummary, or your own customized template, located in the BJAC10\DAT\Template sub-directory. For information on how to create your own customized template, see the next section. Enable the macros. Results for the B-JAC design file will be shown in the Excel spreadsheet. If you wish to save these results as *.xls file, use the File / Save function in Excel.

Creating your own customized Template

To create you own customized Excel spreadsheet for the results from B-JAC, first make a copy of the *Blank.xlt template located in the BJAC10\DAT\Template sub-directory and rename it to use as your template for the customized results form. Open this new template in Excel. Enable the macros. Now by selecting various sections of the output results in B-JAC you can drag and drop into your template. You can change what information is moved from B-JAC by clicking on the right hand mouse button and selecting Drag-Drop format. You can select to drag-drop the value or units of measure only or to drag-drop the Caption, value, and units. For more information on customizing the spreadsheet in Excel, access Help provided in Excel. Once your customized template is complete and saved, every time B-JAC is run you can open your customized template to review the results from the run.

Copying Data from a B-JAC Application to Excel

Copy Format: First you need to set the format for the copy. By default, the Drag-Drop function copies only the value (or values) of information. To reset the format, select Tools/Program Settings/Advanced and set the copy format.

- Value only
- Value and units of measure
- Caption, value ands units of measure
- Units of measure only

Copying Individual fields: Select (or highlight) the information you wish to copy by clicking and holding down the left mouse button on the value and then dragging the mouse cursor to the desired location in the spread sheet. This ‘drag & drop" method will move the value as was as any caption and units you have set in the format described above.

Copying Columns of information: Select (or highlight) the column of information you wish to copy by clicking and holding down the left mouse button on any value in the column and then dragging the mouse cursor to the desired location in the spread sheet. This ‘drag & drop" method will move the entire column of information as was as any caption and units that you have set to be copied in the format settings.

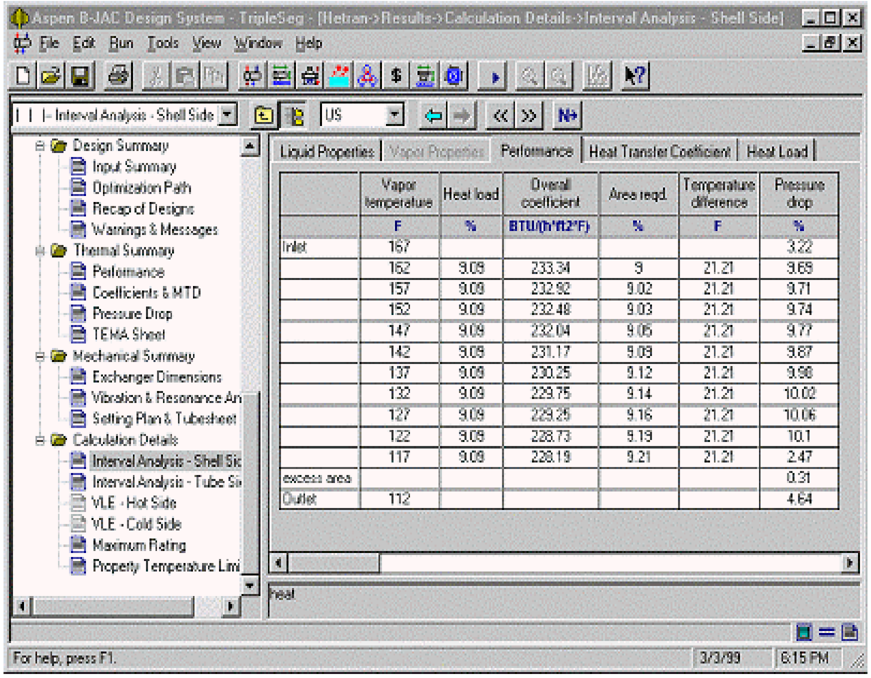
Copying Tables of information: Select (or highlight) the table you wish to copy. Select the Edit / Copy function in the Menu Bar. Select the location for the table in the spread sheet. Select the Edit / Paste function from the Menu Bar in Excel to paste the table into the spread sheet. This copy & paste method will move the entire table of information as was as any caption and units that you have set to be copied in the format settings.

Copying drawings: Select the drawing you wish to copy by clicking and holding down the left mouse button on the drawing then dragging the mouse cursor to the desired location in the spread sheet. This ‘drag & drop" method will move the drawing with border into the spread sheet.

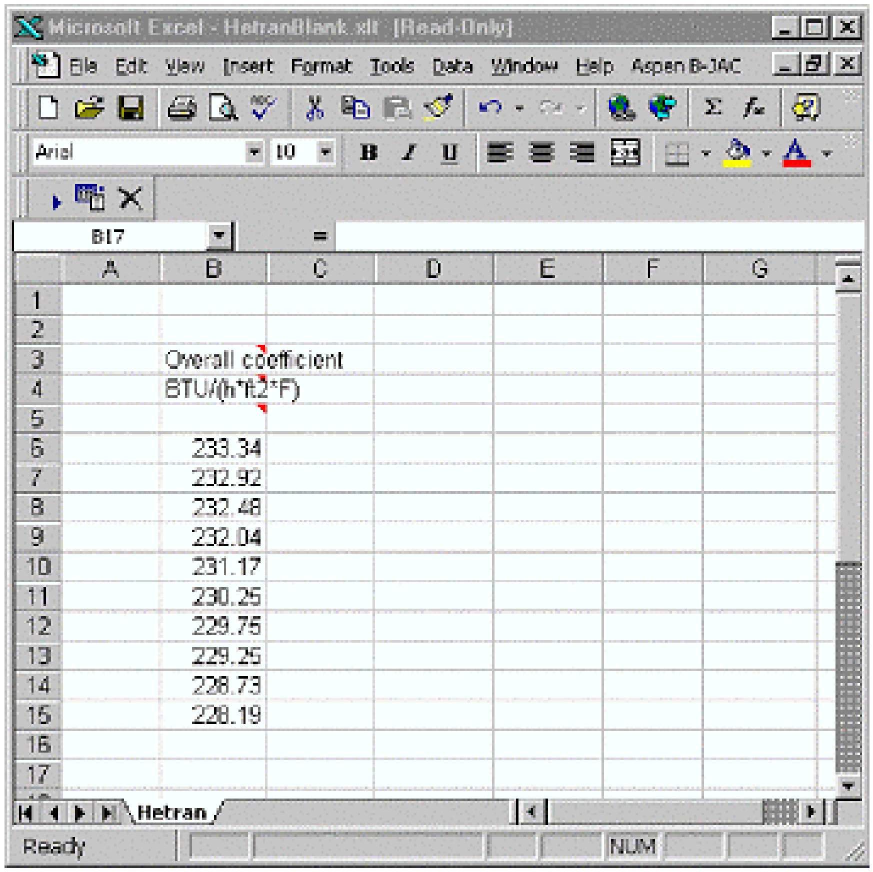
Example of Pasting Aspen B-JAC results into Excel. This example shows the steps necessary to paste a column of information from the Interval Analysis Performance in the Aspen Hetran results into an Excel spreadsheet.

- Open the B-JAC program window and select a Hetran file. If results are not present, run the file.
- Open Excel and open the HetranBlank.xlt template. Save as a different template name.

- Locate the Overall Coefficient column in the Interval Analysis / Performance section of Hetran.



- Set the format for the copy to caption, values, and units under Tools/Program settings/Advanced as described above in the Copy Format instructions.
- Using the mouse click on the Overall coefficient column with the left mouse button an hold the button down. Now drag the mouse cursor to the desired location in your Excel spread sheet and release the mouse button.



Launching B-JAC Programs from Excel

Once you have created you own Excel spread sheet, it is possible to launch the B-JAC programs from within the spread sheet. To run a B-JAC program from within Excel, select Aspen B-JAC / Run from the Excel menu bar. Input design parameters may be changed within Excel and the results in the B-JAC program and in the spread sheet will reflect these changes.

Using the Aspen B-JAC ActiveX Automation Server

Introduction

This chapter describes how to use the ASPEN B-JAC ActiveX Automation Server. The topics include:

- About the Automation Server
- Viewing the ASPEN B-JAC objects.
- Overview of the ASPEN B-JAC objects
- Programming with the ASPEN B-JAC objects
- Reference information

This chapter assumes that you are familiar with Microsoft Visual Basic and understand the concepts of object-orientated programming.

The examples in this chapter use Visual Basic 5.0 and Visual Basic for Application (VBA) as the Automation Client. Much of the code examples in this chapter are taken from the example files, which are distributed with the standard ASPEN B-JAC installation. If you installed ASPEN B-JAC in the default location, the code examples are located in the Program Files\AspenTech\BJAC101\xmp\VB.

The examples use the example problem file LiquidLiquid.BJT, which is provided with the standard ASPEN B-JAC installation. You will find this file in Program Files\AspenTech\BJAC101\xmp if you installed ASPEN B-JAC in the default location.

About the Automation Server

The ASPEN B-JAC Windows user interface is an ActiveX Automation Server. The ActiveX technology (formally called OLE Automation) enables an external Windows application to interact with ASPEN B-JAC through a programming interface using a language such Microsoft's Visual Basic. The server exposes objects through the Common Object Model (COM).

With the Automation Server, you can:

- connect both the inputs and the results of the ASPEN B-JAC program to other applications such as design programs of databases.
- write your own user interface to control the ASPEN B-JAC program from creating a new application to printing results of the calculation. With your own interfaces you can use the ASPEN B-JAC program as a model for your design plan or use the ASPEN B-JAC program as a part of your design system.

Using the Automation Server

In order to use the ASPEN B-JAC Automation Server, you must:

- Have ASPEN B-JAC installed on your PC.
- Be licensed to use ASPEN B-JAC.

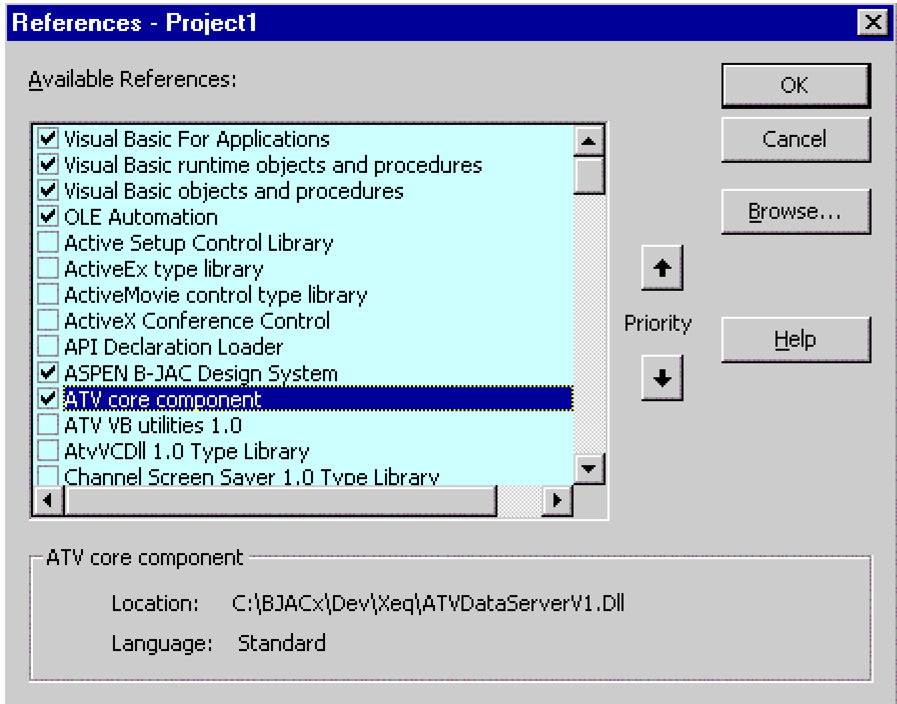
The ASPEN B-JAC Automation Server consists of its principal component BJACWIN.EXE, the core component AtvCoreComponents.DLL and other supporting components.

The principal component, BJACWIN.EXE, is an out-of-process component, or ActiveX EXE. You will use this component to deal with ASPEN B-JAC documents and applications such as Hetran. The core component, ATVDataServer.DLL, is an in-process component, or ActiveX DLL. You will use this component to access application objects and data objects. The supporting components consist of several DLLs and OCXs and are intended to be for internal use only. If you installed the program in the default location, you will find those files in the Program File\AspenTech\BJAC101\xeq.

If you access ASPEN B-JAC objects using strongly typed declaration, you must reference the ASPEN B-JAC Automation Server in your project before you access the objects in your program.

To reference the ASPEN B-JAC Automation Server from Visual Basic, or Excel, open the References dialog box, and check the

ASPEN B-JAC Design System box and ATV core component box as shown here:



If ASPEN B-JAC Design System or ATV core component does not exist in the list, click Browse and find the ASPEN B-JAC executable directory. Select BJACWIN.EXE or ATVDataServer.DLL.

If you opened a project used earlier version of the ASPEN B-JAC or the Excel example file for the ASPEN Hetran, HETRANAUTO.XLS, you might find missing components in your project. In order to use the ASPEN B-JAC objects you should open the Reference dialog box and check the ASPEN B-JAC Design System box or the ATV core component box as mentioned earlier.

Releasing Objects

One object can not be destroyed unless all of the references to the object are released. Therefore, it is a good practice that you always release the objects you have referenced when the objects are no longer needed. Releasing an object is a simple task. This can be done by setting the object to Nothing.

As a general rule, you should release the objects in the opposite sequence as the objects are referenced. For example:

```
Dim objBjac As Object
Dim objApp As Object
' References objects
Set objBjac = CreateObject("BJACWIN.BJACApp")
Set objApp = objBjac.LoadApp("Hetran")
. . .
```

```
' Release objects
Set objApp = Nothing
Set objBjac = Nothing
```

Error Handling

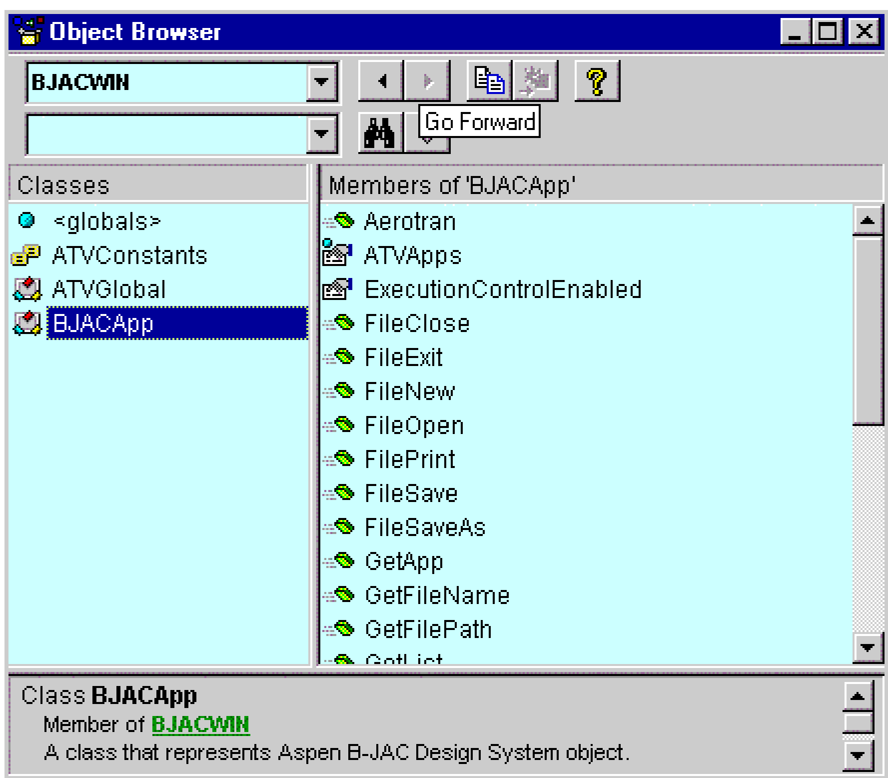
Errors may occur in calling methods or accessing properties of the ASPEN B-JAC objects. It is important to create an error handler for all code, which accesses an automation interface. An automation interface may return a dispatch error for many reasons, most of which do not indicate fatal or even serious errors.

Although any error will normally causes a dialog box to be displayed on the user's screen, it is strongly recommended that you write your own error handler to trap the error in order to exit the application cleanly or proceed with the next step.

Viewing the Aspen B-JAC Objects

The detailed description of the ASPEN B-JAC objects, including properties, methods and named constants, may be viewed in the Automation Client Object Browser.

To use the browser, in Visual Basic and Excel, from the View menu, click Object Browser, the Object Browser will be displayed as shown here:

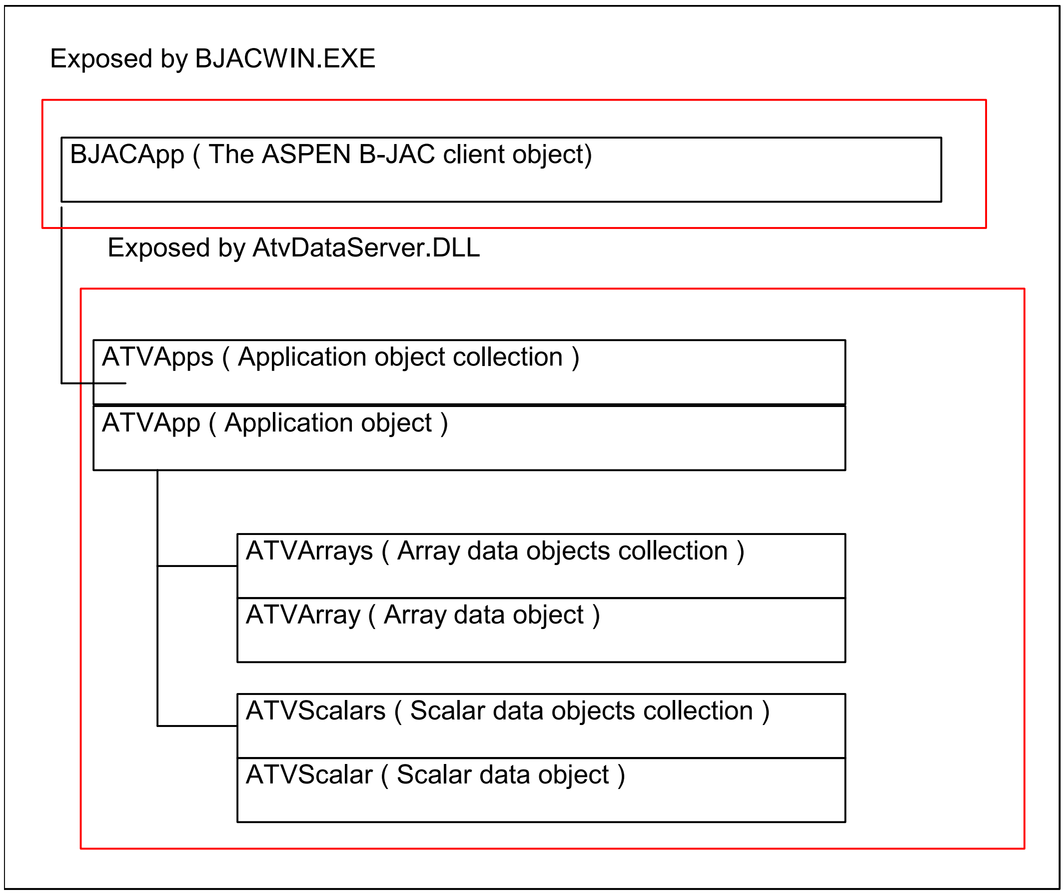


Overview of the Aspen B-JAC Objects

The object exposed by ASPEN B-JAC Automation Server is the BJACApp object. Through this object other objects and their properties and methods may be accessed.

Object Model Diagram

The following diagram provides a graphical overview of the ASPEN B-JAC object model:



The BJACApp Object

The BJACApp object is the principal object exposed by ASPEN B-JAC. This object provides methods and properties such as:

- Creating a new or opening an existing ASPEN B-JAC file
- Creating a new or getting an existing ATVApp object
- Controlling the default settings of the ASPEN B-JAC Window
- Enumerating ATVApp objects
- Printing results
- Saving a file

For more information about the BJACApp object refer to the Reference Information section.

Example of Opening an Existing File

The following Visual Basic example creates the ASPEN B-JAC object for an existing ASPEN B-JAC document, and shows the ASPEN B-JAC Window by setting the Visible property to True.

```
Function OpenFile(ByVal FileName As String) As BJACApp
       Dim objBjac As BJACApp      ' Declare the BJAC object
       Set OpenFile = Nothing
       On Error GoTo ErrorHandler  ' Error trap
       Set objBjac = New BJACApp   ' Create the BJAC object
       If Not objBjac.FileOpen(FileName) Then
       MsgBox "Can't open file " & FileName
       Exit Function
       End If
       objBjac.Visible = True      ' Show BJAC Window
       Set OpenFile = objBjac
       Set objBjac = Nothing
       Exit Function
ErrorHandler:
       MsgBox "Can't create BJAC object"
       End                         ' End the program
End Function
```

The above code uses **Set objBjac = New BJACApp** to create an ASPEN B-JAC object. You can use **Set objBjac = CreateObject("BJACWIN.BJACApp")** to get the same result.

Note If there is a running ASPEN B-JAC Automation Server on your PC, the effect of using **Set objBjac = New BJACApp** or **Set objBjac =CreateObject("BJACWIN.BJACApp")** only gets a reference to the same instance of the server.

The ATVApp object

The ATVApp object exposes the ASPEN B-JAC application, such as Hetran. Through properties and methods of the ATVApp object you can:

- Change the units of measure set
- Execute the calculation engine
- Check application status
- Enumerate inputs and results through data objects collections

Of the many properties and methods in the ATVApp object, there are four collections for representing data:

- Scalars – a collection of ATVScalar objects for representing scalar variables of input
- Arrays – a collection of ATVArray objects for representing array variables of input
- ResultScalars – a collection of ATVScalar objects for representing scalar variables of results
- ResutlArrays – a collection of ATVArray objects for representing array variables of results

Those data collections provide a bridge to allow you to manipulate data in the application including changing the units of measure, modifying the value and so on.

For more information about the ATVApp object refer to the Reference Information section.

Example of using an ATVApp object

The following Visual Basic example shows how to get the ASPEN B-JAC Hetran object from the BJACApp object by opening an existing file, checking the input status and launching the calculation engine.

```
Sub AccessHetran()
  Dim objBjac As BJACApp      ' Declare a BJAC object
  Dim objHetran As ATVApp     ' Declare a ATVApp object
  Dim nRetCode As Integer
    On Error Resume Next        ' Error trap

' We try to get a BJACApp object
  Set objBjac = New BJACApp
  If Err.Number <> 0 Then
    MsgBox "Can't create BJACApp object!"
    End
  End If

' First, we check to see if Hetran object is alreay there
' in case there is a BJACApp object running and
' Hetran object is created.
  If objBjac.Hetran Is Nothing Then

'   If no Hetran object in the current BJACApp object
'   then we open the sample file to get a Hetran object
    If Not objBjac.FileOpen( _
       "C:\Program Files\AspenTech\BJAC10\xmp\LiquidLiquid.BJT") Then
      MsgBox "Can't open the file."
      GoTo ExitThisSub
    End If
  End If

' Get the reference to Heatran
  Set objHetran = objBjac.GetApp("Hetran")
' Notice that this time we use method GetApp
' to get Hetran object. You can use
'   Set objHetran = objBjac.Hetran
' or
'   Set objHetran = objBjac.ATVApps("Hetran")

' Check to see if Hetran object is loaded
' this time.
  If objHetran Is Nothing Then
    MsgBox "Hetran is not created."
    GoTo ExitThisSub
  End If

' We change the units of measure to SI
  objHetran.UomSet = ATV_UOMSET_SI

' Check to see if you can run Hetran
  If objHetran.CanRun() Then

'   If yes, run Hetran and get the return code
    nRetCode = objHetran.Run()
```

```
'   if we got any error
    If nRetCode <> 0 Then
      MsgBox "Error in Hetran calculation. Code=" & nRetCode
    End If
  End If

' Release objects
ExitThisSub:
  Set objHetran = Nothing
  Set objBjac = Nothing
End Sub
```

ATVScalar Object and ATVArray Object

The ATVScalar object and the ATVArray object are used to represent data in the ASPEN B-JAC objects. As mentioned earlier, the ATVScalar object is used for scalar data and the ATVArray is used for array data. The ATVApp uses two pairs of collections containing ATVScalar objets and ATVArray objects to represent inputs and results, respectively. By accessing the properties and methods of the data objects, you can:

- Return or set a value
- Change the units of measure if the data is a physical quantity
- Check the status of the variable

For more information about programming with the ATVScalar object and ATVArray object is provided in the Programming with the ASPEN B-JAC Objects section. Detailed reference information about the ATVScalar object and ATVArray object is provided in the Reference Information section.

Example of accessing data objects

The following Visual Basic example shows how to access a scalar input variable, change its units of measure and value, and how to retrieve an array data from results. Note that the example code is stored in the prjAccessData.VBP VB project in the xmp\VB subdirectory.

```
Sub Main()
' Variable declarations
  Dim objBjac As BJACApp
  Dim objHetran As ATVApp
  Dim objScalar As ATVScalar
  Dim objArray As ATVArray

' We try to get a BJACApp object
  Set objBjac = New BJACApp

' We use FileClose to make sure there is no ATVApp object
' loaded since we are going to open the existing sample file
  objBjac.FileClose

' Open a BJAC document file to create a Hetran object
  objBjac.FileOpen

' Get the Hetran object reference
```

```
  Set objHetran = objBjac.Hetran
  If objHetran Is Nothing Then
    MsgBox "Cann't create Hetran object." & vbCrLf & _
           "Please try a different file."
    End
  End



' Get the data object for hot side flow rate
' Notice that "FlRaHS" is the variable name for
' hot side flow rate in Hetran object.
  Set objScalar = objHetran.Scalars("FlRaHS")

' We declare a buffer to retrieve current value
' in units "kg/s" no matter what units are actually
' used in the data
  Dim xBuf As Single
  xBuf = objScalar.Value("kg/s")  ' now xBuf is in kg/s

' Let's increase the flow rate by 0.5 kg/s
  objScalar.Value("kg/s") = xBuf + 0.5

' Let's try to access Tube OD data object
  With objHetran.Scalars("TubeOD")
    .Uom = "in"    ' Change the units string to "in"
    .Value = 0.75  ' Now the tube OD has value of 0.75 in
  End With

' Run the Hetran appliation
  If objHetran.CanRun Then objHetran.Run

' For example, let's retrieve the shell side pressure drop shown in the
' optimization path.
' Notice that because variable arPresDropShell is an array
' you will need to access the array collection.
  Set objArray = objHetran.ResultArrays("arPresDropShell")

' Loop through the array to view every element in the array
  Dim I As Integer
  For I = 1 To objArray.GetSize()
    Debug.Print objArray.Values(I)
  Next I

' release objects
  Set objScalar = Nothing
  Set objArray = Nothing
  Set objHetran = Nothing
  Set objBjac = Nothing

End Sub
```

Programming with Aspen B-JAC Objects

In this section we will discuss the programming with the APSEN B-JAC object in depth. The topics include:

- Creating application and file operations
- Enumerating objects
- Checking status
- Controlling the units of measure
- Accessing data
- Exploring variables
- Limitations and restrictions

Creating Application and File Operations

To create or get a BJACApp object, you can either use

```
Set objBJAC = new BJACApp
```

or

```
Set objBJAC = CreateObject("BJACWIN.BJACApp")
```

Once you have a connection to the BJACApp object, the next step is to create a new file or open an existing file.

The BJACApp object exposes several methods allowing you to deal with the ASPEN B-JAC document file including creating a new file, opening an existing file, printing a file or saving a file.

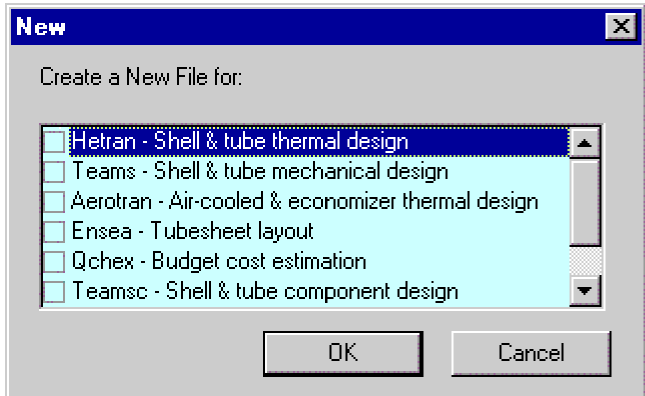
Using FileNew

One way to create an ASPEN B-JAC application is to use the FileNew method in the BJACApp object. The code segment below describes how to create a new file for the ASPEN Teams:

```
Dim objBjac As Object
Dim objTeams As Object
Set objBjac = CreateObject("BJACWIN.BJACApp")
objBjac.FileNew "Teams"
```

By executing above code a new Teams application is created. The document containing the new application is named as UNTITLE.BJT. Notice that the actual document is not created on the disk until the FileSave or FileSaveAs method is called.

The FileNew method takes the argument AppName as optional. If you just call the method using the default, in which the argument AppName is an empty string, then you will see the File New dialog box will appear:



You can check the box next the application to create one or more applications.

Note: Because the BJACApp object can only contain one document at a time, the FileNew method will unload the current document before creating a new one. In other words, you can not call the FileNew twice to create two different applications in the same BJACApp object.

Using LoadApp

The BJACApp object can contain one or more applications. If you want to add a new application to your existing document, use the LoadApp method. For example if you want to add a Hetran application in the above example code, you use

```
Dim objHetran as ATVApp
Set objHetran = objBjac.LoadApp("Hetran")
```

By executing the above code, a Hetran application object will be added to the document.

Using FileOpen

The Method FileOpen, in the BJACApp object, is the only way you can open an existing ASPEN B-JAC document file. The method uses one string argument to represent the name of the document file to be opened. The argument is optional. If the default is used or an empty string is assigned, a standard Windows File Open dialog box will appear, in which the user can browse the system to select a demand file.

Note: The FileOpen method also unloads the current document before loading the document supplied. You should save the document if you have made changes to the document before calling the FileOpen method.

Using FilePrint

Once the calculation is executed successfully, the results will be generated. And then you can use the FilePrint method to print the results in the format created by the ASPEN B-JAC program. The following code segment shows how to use the FilePrint method to print the Teams results after the calculation succeeded:

```
If objTeams.Run() = 0 Then
objBjac.FilePrint
End If
```

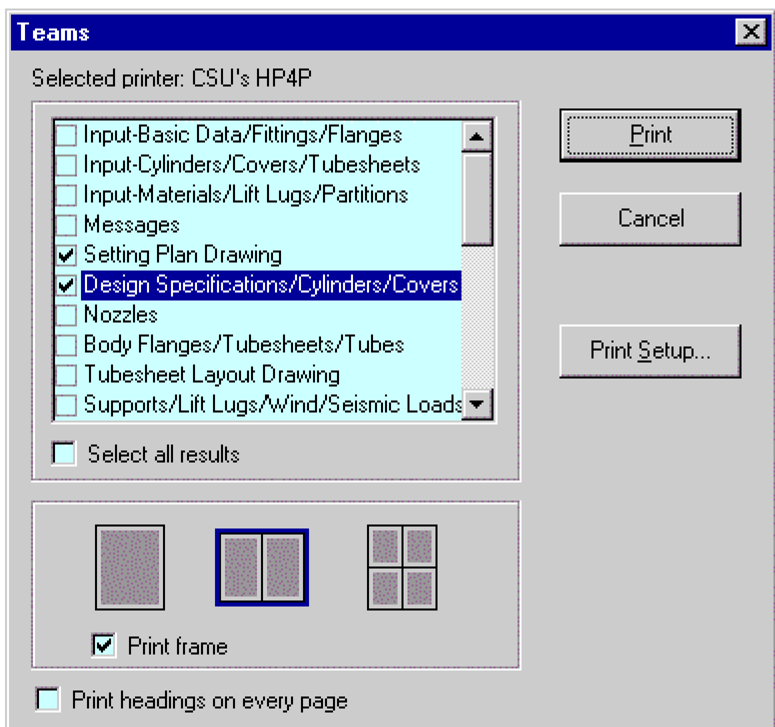
By default the FilePrint method will print every result form for every application in the object. If you want to just print one application, you can supply the application name in the first argument. For example, to print Teams only:

```
  objBjac.FilePrint "Teams"
```

Or if you only want to print a portion of the results, you can set the second argument to False. For example:

```
  objBjac.FilePrint , False
```

In this case, the ASPEN B-JAC Print Dialog box will appear as shown here:



This dialog box is the same as you select the Print menu in the ASPEN B-JAC user interface. You can select any result by checking box next the list item and change other settings as well.

Using FileSave and FileSaveAs

As mentioned earlier if you use FileNew to create a new file the actual file is not created in the disk until the file is saved. To save an ASPEN B-JAC document file to the disk you use the FileSave or FileSaveAs method.

Use the FileSaveAs method or to save a copy of an existing document under a different name or an existing document to a different drive or path. For example, supply an existing filename, path to save, and name a new document:

```
   objBjac.SaveAs "C:\Program File\MyBJACFile\Exchan
ger.BJT"
```

Use the FileSave method to save the document in the same filename, or in the default name defined by the program. For example:

```
  objBjac.Save
```

It is strongly recommended that you use the FileSaveAs method to save the document in a desire filename if the document was newly created using the FileNew method. Because the default filename defined by the program is UNTITLE.BJT.

The argument of the FileSaveAs method can be omitted. If do so, a standard "Save As" Windows dialog box will appear and you will be able to specify any filename or file path.

Enumerating Objects

The ASPEN B-JAC Automation Server provides following collections to keep track of the objects:

- Application collection: BJACApp.ATVApps
- Scalar data collection for input: ATVApp.Scalars
- Array data collection for input: ATVApp.Arrays
- Scalar data collection for results: ATVApp.ResultScalars
- Array data collection for results: ATVApp.ResultArrays

You can use For Each …Next to enumerate the objects in the collections, without losing any part of the information for the BJACApp object. This is particularly important if you want to generate your own database to store input and results information rather than using the ASPEN B-JAC document, or create your own graphic user interface to access the ASPEN B-JAC objects.

The following example code prints names and values for all scalar variables in the input:

```
Dim objApp as ATVApp
Dim objScalar as ATVScalar
      …
For Each objScalar In objApp.Scalars
  Debug.Print objScalar.Name, objScalar.Value
Next
```

Checking Status

Checking Status for an application or for a data object is important when you want to know whether you have made changes to the application, whether you can run the program, or whether the results are present.

Using IsSaved

The IsSaved property is provided in the BJACApp object and the ATVApp object. You can use this property to check to see if any change in the input of the document has been made and the changes have not been saved. This is particularly useful when changes have been made and you need to save these changes.

The following code gives an example that shows how to use the property:

```
Private Sub SaveFile(ByVal objBjac as BJACApp )
  If Not objBjac.IsSaved Then
    objBjac.FileSave
  End If
End Sub
```

If you just want to check to see if a particular application has been modified or not, you can query the ATVApp.IsSaved property. For example:

```
Dim objHetran as ATVApp
…
If Not objHetran.IsSaved Then
  objBjac.FileSave
End If
```

Notice that once the document is saved the IsSaved property will return a value of True to reflect the change of the status.

Using IsComplete

The IsComplete property is used to check the completion status for an application or check for required input data. The ASPEN B-JAC object provides a variety of comprehensive algorithms checking the completion status for applications based on various input conditions. The IsComplete property returns a value of True to indicate the status is complete.

Use the IsComplete property in an ATVApp object to check the completion status for the application. For example:

```
  Dim objHetran as ATVApp
  …
  If objHetran.IsComplete then
‘ the input is complete,
  …
  End if
```

Use the IsComplete property in a data object to check to see if the input data is complete. For an input data, if the data is not required then the property always returns True. If the data is required and the value is missing then the IsComplete property returns False.

The following example shows how to find an incomplete data in the input scalar objects:

```
Function FindIncompleteData(ByVal objApp As ATVApp)
As ATVScalar
    Dim objScalar As ATVScalar

' Loops through the scalar objects
    For Each objScalar In objApp.Scalars

' Checks to see if the data is complete
      If Not objScalar.IsComplete Then

' Found the first incomplete data, return the data
and exit
        Set FindIncompleteData = objScalar
        Exit Function
      End If
    Next
  End Function
```

Controlling the Units of Measure

The ASPEN B-JAC user interface has provided a solution to handle the complexity of different units of measure. Through the ASPEN B-JAC user interface, you can add your own units, or change any existing units in the units table, and then use these new or modified units for input field, calculation or printed results without even closing the application window.

The ASPEN B-JAC Automation Server provides you three different levels to control the units of measure in your program:

- The UomSet property in the BACApp object
- The UomSet property in the ATVApp object
- The Uom property in the data objects

UomSet in BJACApp Object

Use the UomSet property in the BJACApp object to view or change the units of measure set for the BJACApp object. For example:

```
  Dim objBjac as BJACApp
  Dim nSet as Integer
  …
‘ Gets the current units set
  nSet = objBjac.UomSet

‘ Checks to see if it’s SI, if not then change it to
SI
  if nSet <> ATV_UOMSET_SI then objBjac.UomSet =
ATV_UOMSET_SI
```

Note: The UomSet property is the default units set for application objects. Changing UomSet in the BJACApp object will not have any effect on the applications that are already created.

UomSet in ATVApp Object

Use the UomSet property in an ATVApp object to return or change the units of measure set for the application. For example:

```
  Dim objApp as ATVApp
  . . .
' Sets the units set to user defined SET1
  objApp.UomSet = ATV_UOMSET_SET1
```

Note: By changing the UomSet in the ATVApp object, the units of physical quantity data objects in the application will be changed to the units defined in the units set table. Consequently the values of these data will be converted appropriately to the new units if the current units set is different. Also, you will notice that the units controls in the ASPEN B-JAC user interface will prompt in accordance with the changes.

Uom in ATVScalar Object and ATVArray Object

Use the Uom property in the ATVScalar and ATVArray objects to view or change the units of measure for the data. For example:

```
  Dim objHetan as ATVApp
  …
' Changes the units of hot side flowrate to "lb/s"
  objHetran.Scalars("FlRaHS").Uom = "lb/s"
```

Notes:

- The Uom property only applies to the physical quantity data, for example, temperature and pressure.
- The Uom property is a string. You must assign an existing unit string to the data. The unit string remains unchanged if an invalid unit string is supplied.
- Changing the unit string will not result in the value being converted.

Accessing Data

The data in the ASPEN B-JAC applications can be accessed through the two data objects: ATVScalar and the ATVArray. You can not create a new data object, but you can access all the attributes including changing the value or unit string for all the data objects. To access a data of interest, one possible method is as follows:

- Locate the variable of interest.
- Find out the attributes for the variable. Especially, you need to know the variable is a scalar or an array, and input or result.
- Get the reference to the data object using the appropriate data object collection.
- View or change the value or unit string if necessary.

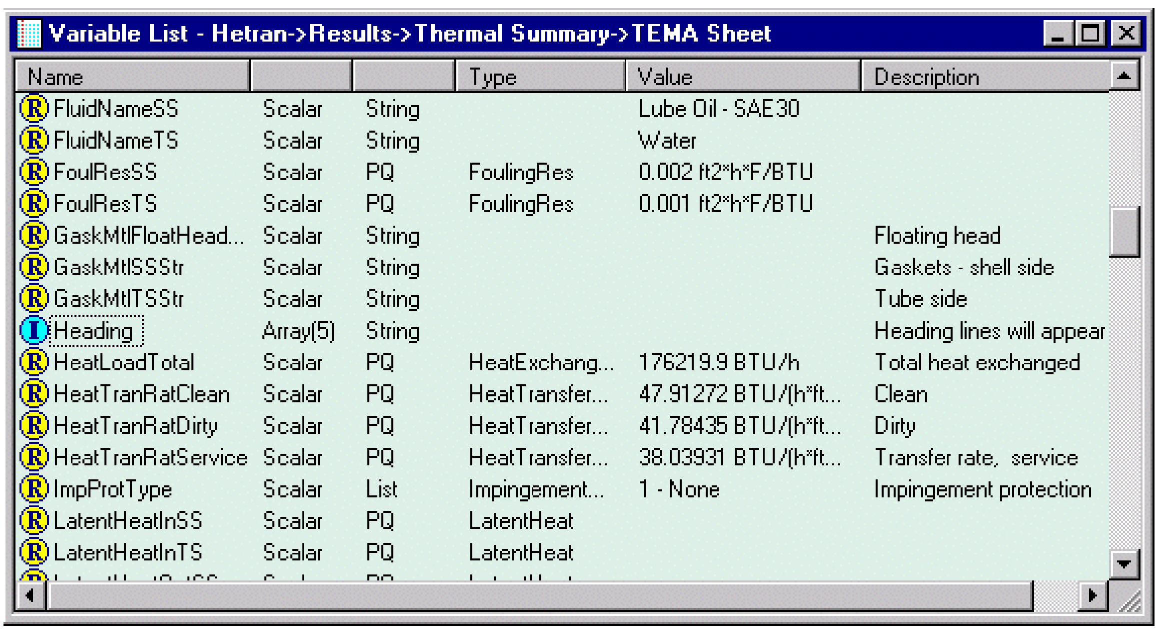
Detailed information about the data objects is given in the Reference Information section.

Exploring Variables

In order to access the data of interest in an ASPEN B-JAC design, you need to locate the variables of interest in the system. To do this, you can use the Application Browser together with the Variable List Window in the ASPEN B-JAC User Interface to navigate the data.

In the ASPEN B-JAC user interface, every application, for example, Hetran, is represented in an Application Browser. The Application Browser has a tree structure and contains the visual representation for inputs and results in a series of forms. On each form, for input and results, each data control is connected a data object, and each data has a variable associated with it. The Variable List window will list all the variables behind the form.

To open the Variable List Window, from the View menu, click Variable List.



The Variable List Window displays the attributes including names, variable type, current values, and descriptions for all the variables used on the form.

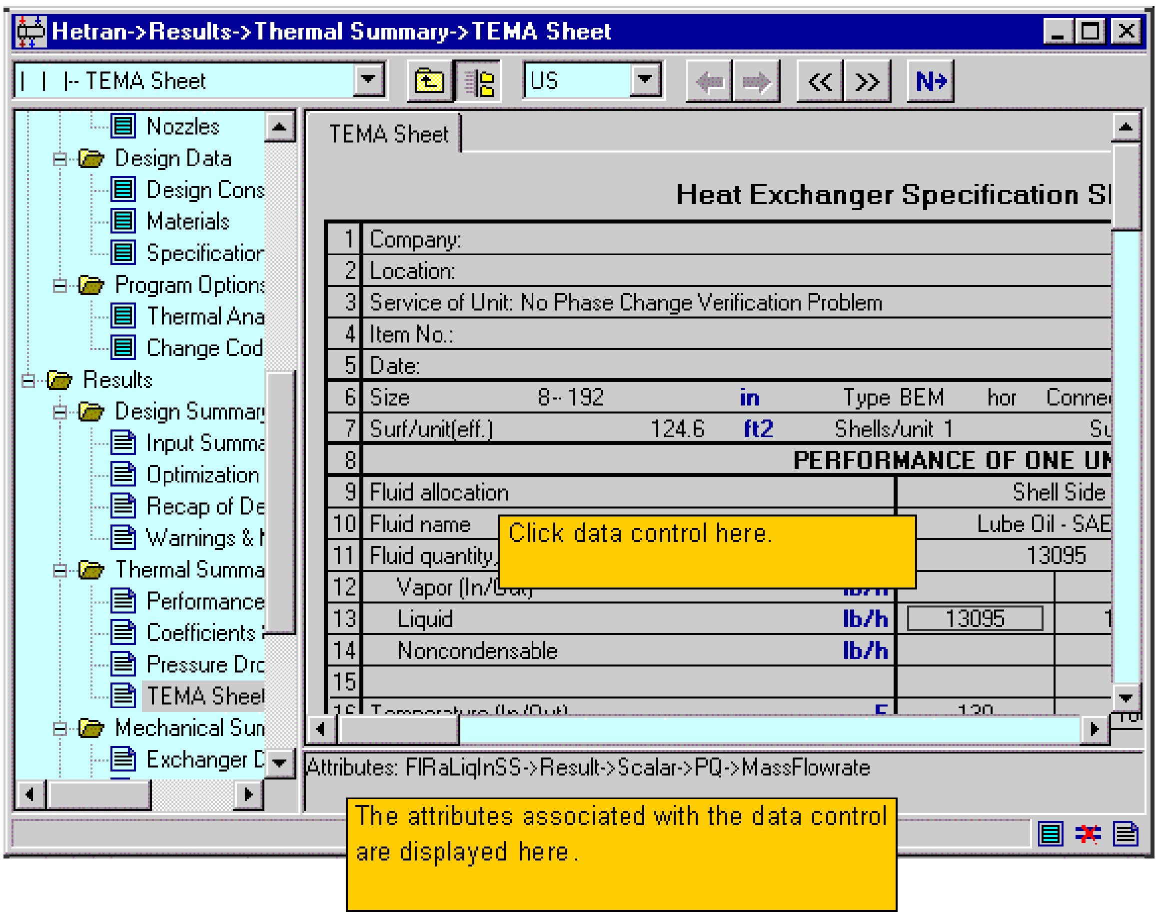
Notice that the (I) indicates an input variable, and the (R) indicate a result variable.

Another way to locate a variable is to view the variable attributes in the description pane on the Application Browser by clicking a control.

To show the variable attributes on the description pane:

- From the Tool menu, click the Program Setting to display the program setting dialog box.
- Click the Advanced tab, and check the option Show Variable Attributes on the Description Pane. Click OK to close the dialog box.
- On the Application Browser, display any input or results form.
- Click a control on the form to see the attributes of the variable associated with the control, which are displayed on the description pane.

For example:



Limitations and Restrictions

The ASPEN B-JAC Automation Server is a single threaded object and only one copy of its instance can be created at a time. In other words, if the server is running before you create a BJACApp object, using following code:

```
Set objBJAC = New BJACWIN.BJACApp
```

or

```
Set objBJAC = CreateObject("BJACWIN.BJACApp")
```

will share with the existing thread.

The BJACApp object can only deal with one document at a time. If you try to create another new document or open another existing document, the consequence is that the program will unload the current document first.

Although multiple ATVApp objects can co-exist in the BJACApp object, you can only create one kind of the application object at a time. For example, the Hetran object, is not allowed having more than one copy. In other words, you can not create two Hetran applications in the same BJACApp object.

Only the BJACApp object can be created in your code. Other objects can only be referenced. The object collections can only be referenced. You can not add any item to the collections. If you try to do so, it may cause unpredictable results.

Reference Information

The topics in this section includes:

- Lists of the members for each exposed ASPEN B-JAC classes
- Member descriptions
- Error descriptions

Members of Class BJACApp

Name	Member Type	Data Type	Description
Aerotran	Function	Object	Returns the ATVApp object for Aerotran
ATVApps	Property (Get)	Collection	Returns the ATVApp objects collection
ExecutionControlEnabled	Property (Get/Let)	Boolean	Returns/sets a value that determines execution control
FileClose	Sub		Closes the current document
FileExit	Sub		Terminates the program
FileNew	Function	Boolean	Creates a new document
FileOpen	Function	Boolean	Opens an existing document
FilePrint	Sub		Prints the results
FileSave	Function	Boolean	Saves the document
FileSaveAs	Function	Boolean	Saves the document to a different file
GetApp	Function	Object	Returns an ATVApp object
GetFileName	Function	String	Returns the current document filename
GetFilePath	Function	String	Returns path name
GetList	Function	Long	Retrieves static list information
GetListCollection	Function	Long	Retrieves static list information
GetUomString	Function	String	Returns a valid units string
GetVersion	Function	String	Returns the version information

Name	Member Type	Data Type	Description
Hetran	Function	Object	Returns the ATVApp object for Hetran
Hide	Sub		Hides the UI Windows
IsSaved	Property (Get)	Boolean	Returns a Boolean value determining whether the document is saved
Language	Property (Get/Let)	Long	Returns/sets the language for the UI Windows
LoadApp	Function	Object	Creates or gets an ATVApp object
Minimize	Sub		Minimize the UI Windows
Show	Sub		Show the UI Windows
Teams	Function	Object	Returns the ATVApp object for Teams
UomSet	Property (Get/Let)	Long	Returns/sets the default units of measure set
Visible	Property (Get/Let)	Boolean	Returns/sets a value that controls the visibilty of the UI Windows

Members of Class ATVApp

Name	Member Type	Data Type	Description
Arrays	Property (Get)	Collection	Returns the collection of array data objects for input
CanRun	Property (Get)	Boolean	Returns a value determining whether the calculation can be executed
DisplayDrawing	Sub		Displays the given drawing
ExportToDXF	Function	Boolean	Exports drawings to AutoCAD DXF format file and returns True if successful
HasResults	Property (Get)	Boolean	Returns a value indicating whether the results are present
IsComplete	Property (Get)	Boolean	Returns a value indicating whether the required data are inputted
Name	Property (Get)	String	Returns the name of the object
Parent	Property (Get)	Object	Returns the parent object
ResultArrays	Property (Get)	Collection	Returns the collection of array data objects for results
ResultScalars	Property (Get)	Collection	Returns the collection of scalar data objects for results
Run	Function	Long	Runs the calculation engine and returns the status
Run2	Function	Long	Runs the calculation engine with the given run type, and returns the status
RunFinished	Event		Gets fired when the calculation is done
Scalar	Property (Get)	Collection	Returns the collection of scalar data objects for input

Name	Member Type	Data Type	Description
UomSet	Property (Get/Let)	Collection	Returns or sets the units of measure set for the application

Members of Class ATVScalar

Name	Member Type	Data Type	Description
Category	Property (Get)	Long	Returns a value that indicates the data category
IsComplete	Property (Get)	Boolean	Returns a value that indicates whether the required data is inputted
IsEmpty	Function	Boolean	Check to see if the data is empty
Name	Property (Get)	String	Returns the name of the data object
Parent	Function (Get)	Object	Returns the parent object
PQOrListType	Property (Get)	String	Returns the physical quantity name if the data is a physical quantity, or the name of the list if the data is a static list.
Text	Property (Get)	String	Returns a supplemental information
Uom	Property (Get/Let)	String	Returns a string that represents the unit for a physical quantity data.
Value	Property (Get/Let)	Variant	Returns/sets a value for the data

Members of Class ATVArray

Name	Member Type	Data Type	Description
Category	Property (Get)	Long	Returns a value that indicates the data category
Insert	Sub		Insets an element in the array
IsComplete	Property (Get)	Boolean	Returns a value that indicates whether the required data are inputted
IsElementEmpty	Function	Boolean	Check to see if the given element is empty
IsEmpty	Function	Boolean	Check to see if the whole array is empty
Name	Property (Get)	String	Returns the name
Parent	Property (Get)	Object	Returns the parent object
PQOrListType	Property (Get)	String	Returns the physical quantity name if the data is a physical quantity, or the name of the list if the data is a static list.
Remove	Sub		Removes an element from the array
Text	Property (Get)	String	Returns a supplemental information
Uom	Property (Get/Let)	String	Returns a string that represents the unit for a physical quantity data.
Values	Property (Get/Let)	Variant	Returns/sets a value for the given element

Member Descriptions

The descriptions of the Methods, Properties, and Events in the B-JAC classes follow.

Aerotran Method

Gets a reference to an ATVApp object that represents the Aerotran application.

Applies To BJACApp Object

Syntax ***object.***Aerotran

Data Type Object

Remarks: This method is the same as the statement:
`Set objAerotran = object.GetApp("Aerotran").`

Arrays Property (Read-only)

Gets a reference to the collection containing array data objects for input in an ATVApp object.

Applies To ATVApp Object

Syntax ***object.***Arrays

Data Type Collection

ATVApps Property (Read-only)

Gets a reference to the collection containing the ATVApp objects in the BJACApp object.

Applies To BJACApp Object

Syntax ***object.***ATVApps

Data Type Collection

Remarks: In the ASPEN B-JAC object, an application object named "UTILITIES" is always loaded for the internal service purpose. This internal application object has no visual representation and will stay the BJACApp object as long as a document is loaded.

CanRun Property (Read-only)

Returns a Boolean value that determines whether or not the calculation engine can be executed.

Applies To ATVApp Object

Syntax ***object***.CanRun

Data Type Boolean

Remarks If the property ExecutionControlEnabled in the BJACApp object is True, the CanRun method will be controlled by the completion of the input. In this case, if the IsComplete method in the application object returns True, then the CanRun also is True. However, if the BJACApp.ExecutionControlEnabled is False, the CanRum always returns True.

Category Property (Read-only)

Returns a long integer that determines the category for the data object.

Applies To ATVScalar Object, ATVArray Object

Syntax *object*.Category

Data Type Long

Remarks The ASPEN B-JAC object has defined following seven constants for the data category:

Constant	Value	VB Data Type	Description
ATV_DATACATEGORY_PQ	0	Single	Physical quantities, such as temperature and pressure.
ATV_DATACATEGORY_LIST	1	Long	StaticList, such as TEAM Class. A StaticList data has a list of items from which the use can select one and the index of the item selected will be returned as the value of the data.
ATV_DATACATEGORY_NUM	2	Single	Numeric number
ATV_DATACATEGORY_STR	3	String	Character string
ATV_DATACATEGORY_BOOL	4	Boolean	Boolean data
ATV_DATACATEGORY_VOC	5	String	Vocabulary (internal use only)
ATV_DATACATEGORY_MSG	6	String	Message (internal use only)

DisplayDrawing Method

Displays the given drawing.

Applies To ATVApp Object

Syntax object.DisplayDrawing (hWndClient, DrawingID)

Parameters

hWndClient	Long	Required. A long value representing the handle of client window, on which the drawing will be displayed.
DrawingID	Long	Required. A long value representing the drawing to be displayed. See Drawing ID Definitions below for details.

Drawing ID Definitions

ID	Description	Hetran	Teams	Aerotran	Ensea
10	Outline	x	x	x	
11	Setting plan	x	x		
20	Material specifications		x		
30	Sectional		x		
40	Bundle layout		x		
50	Tubesheet layout	x	x	x	x
60	Shell		x		
61	Shell A		x		
62	Shell B		x		

ID	Description	Hetran	Teams	Aerotran	Ensea
70	Shell cover		x		
80	Front head		x		
90	Rear head		x		
100	Floating head		x		
110	Bundle		x		
120	Baffles		x		
130	Flat covers		x		
140	Front tubesheet		x		
150	Rear tubesheet		x		
160	Expansion joint		x		
171	Gaskets A		x		
172	Gaskets B		x		
173	Gaskets C		x		
181	Body flanges A		x		
182	Body flanges B		x		
183	Body flanges C		x		
184	Body flanges D		x		
185	Body flanges E		x		
186	Body flanges F		x		
190	Vertical supports		x		
191	Bottom front supports		x		
192	Top front Supports		x		
193	Bottom rear Supports		x		
194	Top rear supports		x		
200	Weld details		x		

Example

The following code shows how to display the Setting Plan drawing on a VB PictureBox control. To try this example, paste the code into the Declarations section of a form with a PictureBox control, Picture1, and two command bottoms, Command1 and Command2:

```
Dim objBjac As Object
Dim objApp As Object

Private Sub Command1_Click()
' Displays a FileOpen dialog box and let
' user to select a BJAC document file
' Note: the BJAC document must contain Teams
'       in order to test the drawing
  objBjac.FileOpen
```

```
' Releases the object first
  Set objApp = Nothing

' Gets a Teams reference
  If objApp Is Nothing Then Set objApp = Nothing
  Set objApp = objBjac.GetApp("Teams")

  If objApp is Nothing Then
   Beep
    MsgBox "The document doesn't contain Teams." & vbCrLf & _
           "Please try a differnet file."
  Else
' Displays the setting plan
' Note:  11 is the drawing ID for setting plan
    objApp.DisplayDrawing Picture1.hWnd, 11
  End If

' Displays the setting plan
' Note:  11 is the drawing ID for setting plan
  If Not objApp Is Nothing Then
    objApp.DisplayDrawing Picture1.hWnd, 11
  End If
End Sub

Private Sub Command2_Click()
  Unload Me
End Sub

Private Sub Form_Load()

' Creates a BJAC object
  Set objBjac = CreateObject("BJACWIN.BJACApp")

' Checks the error
  If objBjac Is Nothing Then
    Beep
    MsgBox "Can't create BJAC object"
    Unload Me
  End If
End Sub

Private Sub Form_Unload(Cancel As Integer)
  Set objApp = Nothing
  Set objBjac = Nothing
End Sub

Private Sub Picture1_Paint()
' Since the drawing doesn't get repainted automatically,
' we need to repaint.
  If Not objApp Is Nothing Then objApp.DisplayDrawing
Picture1.hWnd, 11
End Sub
```

ExecutionControlEnabled Property

Returns or sets a Boolean value that determines whether or not the program can take control of the calculation execution. When set to True, the input must be complete in order to execute the calculation engine. When set to False, the calculation engine can be launched at any time.

Applies To BJACApp Object

Syntax ***object***.ExecutionControlEnabled ***[= Boolean]***

Data Type Boolean

ExportToDXF Method

Exports the drawings to AutoCAD DXF format file and returns True if the function succeeds.

Applies To ATVApp Object

Syntax ***object***.ExportToDXF***([DrawingID][,DXFFileName])***

Data Type Boolean

Parameters

DrawingID	Long	Optional. A long value representing the drawing to be exported. If omitted, all the drawings in the object will be exported. For detailed definitions for DrawingID, see the DisplayDrawing method.
DXFFileName	String	Optional. A string value representing the filename drawing to be exported. If omitted, the current document file will be used. **Note**: If DrawingID is omitted, each drawing will be saved to a file with corresponding DrawingID appended to the DXFFileName.

FileClose Method

Closes the current open document.

Applies To BJACApp Object

Syntax ***object***.FileClose

Remarks The FileClose method will close all of the application user interface windows associated with the open document and destroy all the objects associated with the document as well.

Note: Prior to calling this method, you should release all the objects you have referenced in the code except the BJACApp object.

Example

```
Dim objBjac As Object
Dim obhApp As Object
Dim objDat As Object
. . .
' Gets a reference to the App object
Set objApp = objBjac.ATVApps("Aerotran")

' Gets a reference to a data
Set objDat = objApp.Arrays("BJACDBSymbHS")
. . .
```

```
‘ Release the references prior to calling FileClose
Set objApp = Nothing
Set objDat = Nothing

‘ Call  FileClose to destroy the document
objBjac.Close
. . .
```

FileExit Method

Destroys all the objects in the BJACApp object.

Applies To BJACApp Object

Syntax *object*.**FileExit**

Remarks The FileExit method will perform following steps:

- Close all of the application user interface windows associated with the open document if the necessary.
- If there is no running BJACWIN.EXE prior to the BJAC object is created in your code, the FileExit method will also destroy the ASPEN B-JAC user interface main window.

Note 1) Prior to calling this method, you should release all the objects referenced in your code in the opposite sequence of referencing. 2) Instead of calling this method, you could simple use **Set objBjac = Nothing** in your code.

FileNew Method

Creates a document and returns a Boolean value indicating whether or not the process succeeded.

Applies To BJACApp Object

Syntax ***object***.FileNew***([AppName])***

Data Type Boolean

Parameters

AppName	String	Optional. A string value representing the name of an application to be created. If omitted, the File New Dialog box appears and user can select one or more applications to create.

FileOpen Method

Opens an existing document from the disk and returns a Boolean value indicating whether or not the process succeeded.

Applies To BJACApp Object

Syntax ***object***.FileOpen***([Filename])***

Data Type Boolean

Parameters

Filename	String	Optional. A string value representing the name of an existing document file to be opened. If omitted, the standard Windows FileOpen Dialog box will be displayed to allow user to open any existing document.

FilePrint Method

Prints the results for the document if results are present.

Applies To BJACApp Object

Syntax ***object***.FilePrint***([AppName], [PrintAll])***

Parameters

AppName	String	Optional. A string value representing the name of an application to be printed. If omitted, every application will be printed.
PrintAll	Boolean	Optional. A Boolean value that determines whether or not to print all of the results. If False, then the Print Selection Dialog box appears and user can select the results to print.

FileSave Method

Saves the current document file to a disk without changing the name and returns a Boolean value indicating whether or not the process succeeded.

Applies To BJACApp Object

Syntax ***object***.FileSave

Data Type Boolean

FileSaveAs Method

Saves a copy of the document to the disk using a different name or path and returns a Boolean value indicating whether or not the process succeeded.

Applies To BJACApp Object

Syntax ***object***.FileSaveAs***([Filename])***

Data Type Boolean

Parameters

Filename	String	Optional. A string value representing the full path name of the document to be saved. If omitted, the standard Windows FileSaveAs Dialog box appears and user will be able to specify the name through the dialog.

GetApp Method

Returns a reference to the specified ATVApp object if succeeded or Nothing if failed.

Applies To BJACApp Object

Syntax *object*.GetApp***(Appname)***

Data Type Object

Parameters

Appname	String	Required. A string value representing the name of the application.

GetFileName Method

Returns a string value representing the full path name of the open document.

Applies To BJACApp Object

Syntax *object*.GetFileName

Data Type String

GetFilePath Method

Returns a string value representing the file path information.

Applies To BJACApp Object

Syntax *object*.GetFilePath***(Type)***

Data Type String

Parameters

Type	Long	Required. A Long value indicating the type of information to be retrieved. Accepted values are: 0 - The program installation folder name. 1 - Executable files folder name 2 - Help files folder name 5 - Current open document name 10 - Full path name for the static list database 11 - Full path name for the units of measurement database

GetListCollection Method

Retrieves information from a static list and returns the number of items in the list if succeeded or 0 if failed.

Applies To BJACApp Object

Syntax *object*.GetListCollection***(ListName, ListItems, ListIndices)***

Data Type Long

Parameters

ListName	String	Required. A string value representing the name of the static list to be retrieved
ListItems	Collection	Required. A collection to be used to store the items in the list.

ListIndices	Collection	Required. A collection to be used to store the corresponding indices for the list

Example

The following code shows how to retrieve the shell type list in the ASPEN B-JAC static list database:

```
Dim objBjac As Object
Dim ListItems As Collection
Dim ListInices As Collection
Dim nItems As Long
Dim I as Long
. . .

nItems = objBjac.GetListCollection("ShellType",ListItems,ListIndices)

For I = 1 to nItmes
  Debug.Print ListIndices(I),"," ListItems(I)
Next I
. . .
```

The code will print following results on the debug window:

```
0, Program
1, E – one pass shell
2, F - two pass shell with long. baffle
3, G - split flow
4, H - double split flow
5, J - divided flow (nozzles: 1 in, 2 out)
6, K – kettle
7, X – crossflow
8, V - vapor belt
9, J - divided flow (nozzles: 2 in, 1 out)
```

GetSize Method

Returns the number of elements in the array data object.

Applies To ATVArray Object

Syntax ***object***.GetSize

Data Type Long

GetVersion Method

Returns a string value representing the current version information of the program.

Applies To BJACApp Object

Syntax ***object***.GetVersion

Data Type String

HasResults Property (Read-only)

Returns a Boolean value that indicates whether or not the results are present.

Applies To ATVApp Object

Syntax ***object***.HasResults

Data Type Boolean

Hetran Method

Gets a reference to an ATVApp object that represents the Hetran application.

Applies To BJACApp Object

Syntax ***object.***Hetran

Data Type Object

Remarks The following statements will have the same results:

```
Set objApp = objBjac.Hetran
Set objApp = objBjac.GetApp("Hetran")
Set objApp = objBjac.ATVApps("Hetran")
```

Hide Method

Hides the ASPEN B-JAC user interface.

Applies To BJACApp Object

Syntax ***object***.Hide

Remarks This is the same as if you use the statement: object.Visible = False

Insert Method

Inserts an element into the array data object.

Applies To ATVArray Object

Syntax ***object***.Insert***(Data [,Index])***

Parameters

Data	Variant	Required. A variant value to be assigned
Index	Long	Optional. A Long value indicating where the new element should be inserted after. If omitted, the new element will be added to the last.

IsComplete Property (Read-only)

Returns a Boolean value that indicates whether or not the required data are inputted.

Applies To ATVApp Object, ATVArray Object, ATVScalar Object

Syntax ***object***.IsComplete

Data Type Boolean

IsElementEmpty Method

Returns a Boolean value that indicates whether or not an element in the array data is empty.

Applies To ATVArray Object

Syntax ***object***.IsElementEmpty***(Index)***

Data Type Boolean

Parameters

Index	Long	Required. A Long value indicating the element to be checked.

Remarks Use this method to check an individual element in the array. Use the IsEmpty method to check the entire array.

IsEmpty Method

Returns a Boolean value that indicates whether or not the data is empty.

Applies To ATVArray, ATVSalar Object

Syntax ***object***.IsEmpty

Data Type Boolean

Remarks Use this method to check to see if the data is empty or not. For ATVArray objects, the return is True only if all of the elements in the array are empty.

IsSaved Property (Read-only)

Returns a Boolean value that indicates whether or not the new changes made to the input of the open document have been saved.

Applies To BJACApp, ATVApp Object

Syntax *object*.**IsSaved**

Data Type Boolean

Language Property

Returns or sets a Long value that determines the language used in the program.

Applies To BJACApp Object

Syntax ***object***.Language ***[= Setting%]***

Data Type Long

Remarks Currently, the ASPEN B-JAC program has assigned following constants for language:

Constant	Value	Description
ATV_LANGUAGE_ENGLISH		English
ATV_LANGUAGE_GERMAN		German
ATV_LANGUAGE_SPANISH		Spanish
ATV_LANGUAGE_FRENCH		French
ATV_LANGUAGE_ITALIAN		Italian
ATV_LANGUAGE_CHINESE		Chinese
ATV_LANGUAGE_JAPANESE		Japanese

LoadApp Method

Gets or creates an ATVApp object the specified application. It returns the reference to the object if the method succeeded or Nothing if failed.

Applies To BJACApp Object

Syntax ***object*****.LoadApp*****(Appname)***

Data Type Object

Parameters

Appname	String	Required. A string value representing the name of the application.

Remarks The LoadApp method will create the object if the specified ATVApp object is available in the BJACApp object. If the object already exists, the method will act like the GetApp method.

Minimize Method

Minimize the ASPEN B-JAC user interface Windows

Applies To BJACApp Object

Syntax ***object*****.Minimize**

Name Property (Read-only)

Returns a string value representing the name of the object.

Applies To ATVApp Object, ATVArray Object, ATVScalar Object

Syntax ***object*****.Name**

Data Type String

Remarks When used for an ATVApp object, it returns the name for the application, for example, Hetran. When used for an ATVArray object or ATVScalar object it returns the variable name associated with data.

Parent Property (Read-only)

Returns a reference to the parent object.

Applies To ATVApp Object, ATVArray Object, ATVScalar Object

Syntax ***object*****.Parent**

Data Type Object

Remarks It returns a BJACApp object the ATVApp object, and returns an ATVApp object for the data objects.

PQOrListType Property (Read-only)

Returns a string value that represents the name of the physical quantity or static list assigned to the data.

Applies To ATVScalar Object, ATVArray Object

Syntax *object*.PQOrListType

Data Type String

Remarks The PQOrListType property is used only for data that are physical quantities or lists. The property returns the name of the physical quantity or the list.

Example

The following example shows how to access the PQOrListType property:

```
Dim objHetran As ATVApp
. . .
' For a PQ data
Debug.Print objHetran.Scalars("FlRaHS").PQOrListType
' For a List data
Debug.Print objHetran.Scalars("ApplTypeHS").PQOrListType
. . .
The result of these statements prints following
string on the Debug Window:

MassFlowrate
ApplicationTypeHS
```

Remove Method

Removes an element from an array data object.

Applies To ATVArray Object

Syntax ***object***.Remove***([Index])***

Parameters

Index	Long	Optional. A Long value indicating the element to be removed in the array. If omitted, the last element will be removed.

ResultArrays Property (Read-only)

Gets a reference to the collection containing array data objects for results in an ATVApp object.

Applies To ATVApp Object

Syntax *object*.ResultArrays

Data Type Collection

ResultScalars Property (Read-only)

Gets a reference to the collection containing scalar data objects for results in an ATVApp object.

Applies To ATVApp Object

Syntax *object*.ResultScalars

Data Type Collection

Run Method

Launches the calculation engine to perform the calculation and returns a status. It returns 0 if the calculation succeeded and a non-zero error code to indicate an error if the calculation failed.

Applies To ATVApp Object

Syntax *object*.Run

Data Type Long

Remarks See the error descriptions for error code.

Run2 Method

Launches the calculation engine to perform the calculation and returns a status. It returns 0 if the calculation succeeded and a none-zero error code to indicate an error if the calculation failed.

Applies To ATVApp Object

Syntax *object*.Run2*([RunType])*

Data Type Long

Parameters

RunType	Long	Optional. A Long value indicating the type of calculation to be performed. If omitted, the method will act as same as the Run method. **Note:** Currently only the Teams application has different run types as shown below: Calculations + Cost + Drawings Calculations only Calculations + Cost Calculations + Drawings

RunFinished Event

Gets fired when the calculation finished successfully.

Applies To ATVApp Object

Syntax Private Sub *object*_RunFinished

Example

The following example shows how to implement the RunFinished method to catch the event when the calculation is done.

```
' Declarations
Private objBjac as BJACApp
Private WithEvents objAerotran as ATVApp ' you must use WithEvents
 . . .
Private Sub MyMain( )
' Create a BJACApp object, and open an Aerotran problem file
  . . .
' Get the Aerotran object, and run Aerotran
  Set objAerotran = objBjac.Aerotran
  objAerotran.Run
End Sub
Private Sub objAerotran_RunFinished()
' Add your code below. For example, retrieve some results
  . . .
End Sub
```

Scalars Property (Read-only)

Gets a reference to the collection containing scalar data objects for input in an ATVApp object.

Applies To ATVApp Object

Syntax *object*.Scalars

Data Type Collection

Show Method

Shows the ASPEN B-JAC user interface.

Applies To BJACApp Object

Syntax *object*.Show

Remarks This statement is equivalent to object.Visible = False

Text Property (Read-only)

Returns supplemental information to the Value property of the data object.

Applies To ATVArray Object, ATVScalar Object

Syntax *object*.Text*([Index])* for ATVArray object

object.Text for ATVScalar object

Parameters

Index	Long	Optional. A Long value representing the element number in the array. If omitted, the first element is assigned.

Data Type String

Remarks The Text property has no effect on the calculation, and is only used to store extra information to help understanding of the Value property. For example, for a data object representing a material, the Value property of the data object will be the material number assigned by the ASPEN B-JAC, and the Text property will contains the description for the material.

Example

The example below prints the value and its text of an ATVScalar object on the Debug Window:

```
Private Sub ShowApplicationType( Byval objHetran As
ATVApp )
  Dim objAppType As ATVScalar

‘ Get a reference to application type in hot side
  Set objAppType = objHetran.Scalar("ApplTypeHS")

‘ Display the Value and Text in the Debug Window
  Debug.Print objAppType.Value, objAppType.Text
End Sub
```

On the Debug Window, the results are:

```
 1 Liquid, no phase change
```

Uom Property

Returns or sets a String that represents the unit for a physical quantity data object.

Applies To ATVArrayApp Object, ATVScalar Object

Syntax ***object***.Uom ***[=NewUnitString])***

Data Type String

Remarks If an invalid unit string is supplied, the unit string remains unchanged. Changing the unit string will not cause the value conversion.

UomSet Property

Returns or sets a units of measure used in the object.

Applies To BJACApp Object, ATVApp Object

Syntax ***object***.UomSet ***[=NewSetting%])***

Data Type Long

Remarks The UomSet property accepts the following constants:

Constant	Value	Description
ATV_UOMSET_US	1	US units set. Predefined in the program.
ATV_UOMSET_SI	2	SI units set. Predefined in the program
ATV_UOMSET_METRIC	3	METRIC units set. Predefined in the program.
ATV_UOMSET_SET1	4	User units set. Customizable through the UI
ATV_UOMSET_SET2	5	User units set. Customizable through the UI
ATV_UOMSET_SET3	6	User units set. Customizable through the UI

When a new setting is assigned to a BJACApp object, the new setting makes no effect on the ATVApp objects that are created already. However, if a new setting is assigned to an ATVApp object, the entire object, including the contained data objects, or even the user interface window that represents the object, will be changed accordingly.

Value Property, Values Property

Returns or sets a value to the data object.

Applies To ATVArray Object, ATVScalar Object

Syntax ***object***.Values***([Index],[Uom])*** for ATVArray object

object.Value***([Uom])*** for ATVScalar object

Parameters

Index	Long	Optional. A Long value representing the element number in the array. If omitted, the first element is assigned.

Uom	String	Optional. A String value representing the units of measure to be based or assigned if the data is a physical quantity. If omitted the current units of measure will be used. **Note** When the Uom parameter is used to returns a value, the data will be converted according to the Uom. However, if the Uom parameter is assigned the data object, the value of the data object will not be converted.

Data Type Variant

Remarks The Value or Values property is a variant type variable. Depending on the Category property, it uses different VB data types to represent the data, and assigns different undefined constants when the data is Empty, as shown in the following table:

Data Category	VB Data Type	Undefined Value	Note
ATV_DATACATEGORY_PQ	Single	0	Used for physical quantities. It returns 0 if the data is empty. You should use the IsEmpty method to check to see if the data is empty.
ATV_DATACATEGORY_LIST	Long	-30000	Used for StaticList. The Value property represents the index of an item in the list. The Text property stores the item. You must use a valid index number when you assign a value to the property.
ATV_DATACATEGORY_NUM	Single	0	User for numeric data except physical quantities. You should use the IsEmpty method to check the empty status.
ATV_DATACATEGORY_STR	String	""	
ATV_DATACATEGORY_BOOL	Boolean	False	

The optional parameter Index is used only for an ATVArray object. It represents the element number in the array object.

The optional parameter Uom is a string description for the units of measure, for example, kg/s for mass flow rate. You can use the Uom parameter to assign a new units of measure to the data, or returns a value based the specified Uom parameter.

Example

```
Dim objHetran As ATVApp
Dim objArray As ATVArray
Dim objScalar As ATVScalar
Dim Buf As Single
. . .
' Get the reference to the hot side flow rate
```

```
Set objScalar = objHetran.Scalars("FlRaHS")

' Get the current value in kg/h no matter what units the data is
' actually using
Buf = objScalar.Value("kg/h")

' Assign the 10000 lb/h to the data
objScalar.Value("lb/h") = 10000.0  ' Now the data's units is lb/h

' Get the reference to the specific heat for liquid cold side
Set objArray = objHetran.Arrays("SpHtLiqCS")

' Gets the value of the element #1 in the current units
Buf = objArray.Values(1)

' Assign a value to the element and change the units
objArray.Values(1,"kJ/(kg*K)") = 0.2
. . .
```

Visible Property

Returns or set a Boolean value that determines the ASPEN B-JAC user interface is visible or hidden.

Applies To BJACApp Object

Syntax ***object***.Visible ***[=NewSetting]***

Data Type Boolean

Error Descriptions

Number	Descriptions
-1	Input is incomplete
1000	An unknown error has occurred.
1001	Unknown security error occurred.
1002	Couldn't detect security key on your system.
1003	Couldn't detect HASP single-user security key on your system.
1004	Couldn't detect NetHASP key on your system or no active NetHASP server was found.
1005	License to run the program has expired.
1006	The program doesn't have enough BRUs to run.
1007	Couldn't read security key.
1008	Couldn't write to security key.
1009	The security key date or time has been changed.
1010	Failed to access NetHASP key.
1011	General security key error.
1012	Failed to access Aspen License Manager(ASPLM) or no active ASPLM was found.
1013	Number of stations that may run the application at the same time has been exceeded.
1014	No license was found to run the program.
1101	EXCEPTION_ACCESS_VIOLATION has occurred.
1102	EXCEPTION_BREAKPOINT has occurred.

Number	Descriptions
1103	EXCEPTION_DATATYPE_MISALIGNMENT has occurred.
1104	EXCEPTION_SINGLE_STEP has occurred.
1105	EXCEPTION_ARRAY_BOUNDS_EXCEEDED has occurred.
1106	EXCEPTION_FLT_DENORMAL_OPERAND has occurred.
1107	EXCEPTION_FLT_DIVIDE_BY_ZERO has occurred.
1108	EXCEPTION_FLT_INEXACT_RESULT has occurred.
1109	EXCEPTION_FLT_INVALID_OPERATION has occurred.
1110	EXCEPTION_FLT_OVERFLOW has occurred.
1111	EXCEPTION_FLT_STACK_CHECK has occurred.
1112	EXCEPTION_FLT_UNDERFLOW has occurred.
1113	EXCEPTION_INT_DIVIDE_BY_ZERO has occurred.
1114	EXCEPTION_INT_OVERFLOW has occurred.
1115	EXCEPTION_PRIV_INSTRUCTION has occurred.
1116	EXCEPTION_NONCONTINUABLE_EXCEPTION has occurred.
1200	The file <$> contains an unrecognized format.
1201	Error occurred while accessing a file.
1300	Failed to load Aspen Properties Plus DLL.
1301	Error occurred while executing Aspen Properties Plus.
1400	Fatal error in Aspen Plus / BJAC interface

Appendix

Tubing

Tube Wall Thickness

B.W.G. Gauge	in	mm
28	0.014	0.36
27	0.016	0.41
26	0.018	0.46
25	0.20	0.51
24	0.22	0.56
23	0.25	0.64
22	0.028	0.71
21	0.032	0.81
20	0.035	0.89
19	0.042	1.07
18	0.049	1.24
17	0.058	1.47
16	0.065	1.65
15	0.072	1.83
14	0.083	2.11
13	j0.095	2.41
12	0.109	2.77
11	0.120	3.05
10	0.134	3.40
9	0.148	3.76
8	0.165	4.19
7	0.180	4.57
6	0.203	5.16
5	0.220	5.59

B.W.G. Gauge	in	mm
4	0.238	6.05
3	0.259	6.58
2	0.284	7.21
1	0.300	7.62

Tube Low Fin Information

Standard fin outside diameters

in:	1.5	2.0	2.5	3.0	3.5
mm:	38	50	63	76	89

Program Default: Tube Outside Diameter + 0.75 in or 19.05 mm

Standard fin thickness

integral or extruded: 0.012-0.025 in or 0.3-0.7 mm

welded or wrapped: 0.025-0.165 in or 0.6-4 mm

in:	0.031	0.036	0.049	0.059
mm:	0.8	0.9	1.2	1.5

Program Defaults:

0.23 in or 0.58 mm for tube O.D. less than 2 in or 50.8

0.36 in or 0.91 mm for tube O.D. greater than 2 in or 50.8 mm

Enhanced Surfaces Standard Sizes

The following list contains the standard available tube sizes that are available for the indicated enhance surfaces.

Manufacture Type	Tube OD, in	Wall Thk, in
Wolverine TURBO B MHT		
1	3/4" OD	.051" WALL
2	3/4" OD	.054" WALL
3	3/4" OD	.059" WALL
4	3/4" OD	.065" WALL
7	1" OD	.053" WALL
Wolverine TURBO B LPD		
5	3/4" OD	.051" WALL
6	3/4" OD	.057" WALL
Wolverine TURBO C MHT		
1	1" OD	.052" WALL
2	3/4" OD	.051" WALL
3	3/4" OD	.054" WALL
4	3/4" OD	.058" WALL

Manufacture Type	Tube OD, in	Wall Thk, in
Wolverine TURBO C LPD		
5	3/4" OD	.051" WALL
Wolverine TURBO BII		
1	3/4" OD	.049" WALL
2	3/4" OD	.051" WALL
3	3/4" OD	.058" WALL
Wolverine TURBO CII		
1	3/4" OD	.047" WALL
2	3/4" OD	.050" WALL
3	3/4" OD	.056" WALL
Wolverine KORODENSE MHT		
Wolverine KORODENSE LPD		
1	5/8" OD	.020" WALL
2	5/8" OD	.025" WALL
3	5/8" OD	.032" WALL
4	5/8" OD	.035" WALL
5	5/8" OD	.042" WALL
6	5/8" OD	.049" WALL
7	5/8" OD	.065" WALL
8	3/4" OD	.020" WALL
9	3/4" OD	.025" WALL
10	3/4" OD	.032" WALL
11	3/4" OD	.035" WALL
12	3/4" OD	.042" WALL
13	3/4" OD	.049" WALL
14	3/4" OD	.065" WALL
15	7/8" OD	.020" WALL
16	7/8" OD	.025" WALL
17	7/8" OD	.032" WALL
18	7/8" OD	.035" WALL
19	7/8" OD	.042" WALL
20	7/8" OD	.049" WALL
21	7/8" OD	.065" WALL
22	1" OD	.020" WALL
23	1" OD	.025" WALL
24	1" OD	.032" WALL
25	1" OD	.035" WALL
26	1" OD	.042" WALL
27	1" OD	.049" WALL
28	1" OD	.065" WALL

Manufacture Type	Tube OD, in	Wall Thk, in
29	1-1/8" OD	.025" WALL
30	1-1/8" OD	.032" WALL
31	1-1/8" OD	.035" WALL
32	1-1/8" OD	.042" WALL
33	1-1/8" OD	.049" WALL
34	1-1/8" OD	.065" WALL
35	1-1/4" OD	.025" WALL
36	1-1/4" OD	.032" WALL
37	1-1/4" OD	.035" WALL
38	1-1/4" OD	.042" WALL
39	1-1/4" OD	.049" WALL
40	1-1/4" OD	.065" WALL

Material Selection

Generic Materials

Abbrev	Material
CS	Carbon Steel
C½Mo	Low Alloy Steel C½Mo
½Cr½Mo	Low Alloy Steel ½Cr½Mo
Cr½Mo	Low Alloy Steel Cr½Mo
1¼Cr½Mo	Low Alloy Steel 1¼Cr½Mo
SS 304	High Alloy Steel Grade 304
SS 304L	High Alloy Steel Grade 304L
SS 316L	High Alloy Steel Grade 316L
SS 310S	High Alloy Steel Grade 310S
SS 347	High Alloy Steel Grade 347
SS 310S	High Alloy Steel Grade 310S
SS XM-27	High Alloy Steel Grade XM-27
SS 410	High Alloy Steel Grade 410

Abbrev	Material
NI 200	Nickel Alloy 200
NI 201	Nickel Low Carbon Alloy 201
Monel	Nickel Alloy 400 (Monel)
Inconel	Nickel Alloy 600 (Inconel)
NI 800	Nickel Alloy 800
NI 825	Nickel Alloy 825 (Incoloy 825)
Hast. B	Nickel Alloy B (Hastelloy B)

Abbrev	Material
Hast. C	Nickel Alloy C (Hastelloy C)
Hast. G	Nickel Alloy G (Hastelloy G)
NI 20	Nickel Alloy 20 Cb (Carpenter 20)
Titanium	Titanium
Cu-Ni 70/30	Copper-Nickel 70/30 Alloy CDA 715
Cu-Ni 90/10	Copper-Nickel 90/10 Alloy CDA 706
Cu-Si	Copper-Silicon Alloy CDA 655
NavBrass	Naval Brass Alloy 464
AlBronze	Aluminum-Bronze Alloy 630
AlBrass	Aluminum-Brass Alloy 687
Admiralty	Admiralty Alloy 443
Tantalum	Tantalum
Zirconium	Zirconium

Gaskets - hot side

Specify one of the following generic materials for the gaskets:

- compressed fiber
- flat metal jacketed fiber
- solid flat metal
- solid teflon
- graphite
- spiral wound
- ring joint
- self-energized
- elastomers

Gaskets - cold side

Specify one on the following generic gasket materials:

- compressed fiber
- flat metal jacketed fiber
- solid flat metal
- solid teflon
- graphite
- spiral wound
- ring joint
- self-energized elastomers

Corrosion Table

The following table is provided as a quick reference for acceptable materials of construction. The corrosion ratings are at a single temperature (usually 20 C) and a single concentration. A final decision on material selection should be based on operating temperature, actual concentration and galvanic action.

A = Excellent	B = Good	C = Fair
D = Not suitable	E = Explosive	I = Ignites
- = Information not available		

These are the material abbreviations used in the table:

CS	Carbon steel
Cu	Copper
Admi	Admiralty
CuSi	Copper silicon
CN90	Cupro-nickel 90-10
CN70	Cupro-nickel 70-30
SS304	Stainless steel 304
SS316	Stainless steel 316
Ni	Nickel
Monel	Monel
Inco	Inconel
Hast	Hastelloy
Ti	Titanium
Zr	Zirconium
Ta	Tantalum

Corrosion Table	**CS**	**Cu**	**Admi**	**CuSi**	**CN 90**	**CN 70**	**SS 304**	**SS 316**	**Ni**	**Mo**	**In**	**Hast**	**Ti**	**Zr**	**Ta**
Acetaldehyde	A	E	E	E	E	E	A	A	A	A	A	A	B	-	A
Acetic acid	D	D	D	D	C	C	A	A	D	A	B	A	A	A	A
Acetic anhydride	D	B	C	B	B	B	B	B	B	B	B	A	A	A	B
Acetone	A	A	A	A	A	A	A	A	B	A	A	B	A	-	A
Acetylene	A	E	E	E	E	E	A	A	A	A	A	A	A	-	A
Aluminum chloride	D	D	D	D	D	D	D	D	C	B	D	A	A	A	A
Aluminum hydroxide	B	B	B	B	B	B	B	B	B	B	B	B	-	-	B

Corrosion Table	CS	Cu	Admi	CuSi	CN 90	CN 70	SS 304	SS 316	Ni	Mo	In	Hast	Ti	Zr	Ta
Ammonia (anhydrous)	A	A	A	A	A	A	A	A	B	A	B	B	A	-	A
Ammonium chloride	D	D	D	D	D	D	B	B	B	B	B	B	A	A	A
Ammonium sulfate	C	C	C	C	C	C	C	C	B	A	B	B	A	A	A
Ammonium sulfite	D	B	B	B	B	B	C	C	D	D	D	-	A	-	A
Amyl acetate	B	A	A	B	A	A	A	A	A	A	A	B	A	-	A
Aniline	A	D	D	D	D	D	A	A	B	B	B	B	A	-	A
Aroclor	B	A	A	A	A	A	B	B	A	A	A	A	A	-	A
Barium chloride	B	B	C	B	B	B	B	B	B	B	B	B	A	A	A
Benzaldehyde	B	B	B	B	B	B	B	B	B	B	B	A	A	-	A
Benzene	A	A	A	A	A	A	B	B	B	B	B	B	A	-	A
Benzoic acid	D	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Boric acid	D	B	B	B	B	B	A	A	B	B	B	A	A	-	A
Butadiene	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Butane	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Butanol	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Butyl acetate	A	B	B	B	B	B	B	B	A	B	A	B	A	-	A
Butyl chloride	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Calcium chloride	B	B	C	B	B	B	C	B	A	A	A	B	A	A	A
Calcium hydroxide	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Carbon dioxide(wet)	C	C	C	C	C	C	A	A	A	A	A	A	A	-	A
Carbon tetrachloride	B	B	B	B	B	B	B	B	A	A	A	B	A	A	A
Carbonic acid	C	C	C	C	C	C	B	B	B	C	A	A	A	-	A
Chlorine gas (dry)	B	B	B	B	B	B	B	B	B	B	A	B	I	A	A
Chloroform (dry)	B	B	B	B	B	B	B	B	A	A	B	B	A	A	A
Chromic acid	D	D	D	D	D	D	C	B	D	D	B	B	B	A	A
Citric acid	D	C	C	C	C	C	C	B	B	B	A	C	A	A	A
Creosote	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Dibutylphthalate	A	A	A	A	A	A	B	B	B	B	B	B	A	-	A
Dichlorobenzene	B	B	B	B	B	B	B	B	B	B	B	B	B	-	A
Dichlorofluorometh	A	A	A	A	A	A	A	B	B	B	B	A	A	-	A
Diethanolamine	A	B	B	B	B	B	A	A	A	A	A	A	A	-	A
Diethyl etheride	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Diethylene glycol	A	B	B	B	B	B	A	A	B	B	B	B	A	-	A
Diphenyl	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Diphenyl oxide	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Ethane	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Ethanolamine	B	B	B	B	B	B	A	B	B	B	B	B	B	-	A

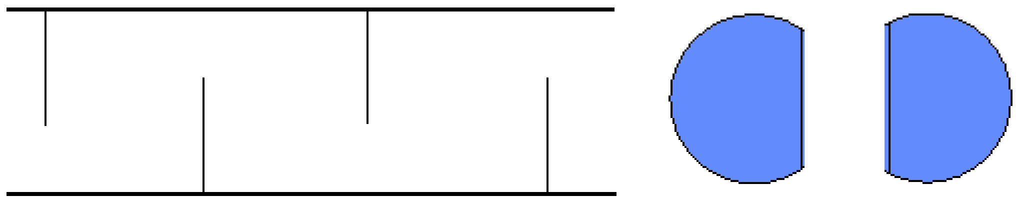
Corrosion Table	CS	Cu	Admi	CuSi	CN 90	CN 70	SS 304	SS 316	Ni	Mo	In	Hast	Ti	Zr	Ta
Ether	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Ethyl acetate (dry)	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Ethyl alcohol	B	B	B	B	B	B	B	B	B	B	B	A	A	A	A
Ethyl ether	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Ethylene	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Ethylene glycol	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Fatty acids	D	D	D	D	D	D	D	A	B	C	B	A	B	-	A
Ferric chloride	D	D	D	D	D	D	D	D	D	D	D	B	A	D	A
Ferric sulfate	D	D	D	D	D	D	B	B	D	D	D	A	A	-	A
Ferrous sulfate	D	B	B	B	B	B	B	B	D	D	D	B	A	-	A
Formaldehyde	D	B	B	B	B	B	B	B	B	B	B	B	B	-	A
Furfural	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Glycerine	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Hexane	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Hydrochloric acid	D	D	D	D	D	D	D	D	D	D	D	B	D	D	A
Hydrofluoric acid	D	C	D	D	D	C	D	D	D	C	D	A	D	D	D
Iodine	D	D	D	D	D	D	D	D	D	D	D	B	D	-	A
Isopropanol	A	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Lactic acid	D	B	C	B	B	B	B	A	B	C	A	A	A	A	A
Linseed oil	A	B	B	B	B	B	A	A	B	B	B	B	A	-	A
Lithium chloride	B	B	B	B	B	B	B	A	A	A	A	A	-	-	A
Lithium hydroxide	B	B	B	B	B	B	B	B	B	B	B	B	-	-	A
Magnesium chloride	B	B	C	B	B	B	B	B	A	B	A	A	A	A	A
Magnesium hydroxide	B	B	B	B	B	B	B	B	B	B	B	B	A	-	B
Magnesium sulfate	B	B	B	B	B	B	A	A	B	B	B	A	A	A	A
Methane	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Methallyamine	C	B	B	B	B	B	B	B	B	C	B	B	B	-	A
Methyl alcohol	B	B	B	B	B	B	B	B	B	A	B	A	A	A	A
Methyl chloride (dry)	A	A	A	A	A	A	A	A	B	B	B	B	A	-	A
Methylene chloride	B	B	B	B	B	B	B	B	B	B	B	B	B	-	A
Monochlorobenzene	B	B	B	B	B	B	B	B	A	A	A	B	B	-	A
M.dichl.difl.mehane	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Monoethanolamine	B	B	B	B	B	B	B	B	B	B	B	-	-	-	A
Naptha	A	B	B	B	B	B	B	B	B	B	B	B	B	-	A
Napthalene	A	B	B	B	B	B	A	A	A	A	A	B	B	-	A
Nickel chloride	D	B	B	B	B	B	B	B	D	B	D	A	A	A	A
Nickel sulfate	D	B	B	B	B	B	B	B	B	B	B	B	B	A	A

Corrosion Table	CS	Cu	Admi	CuSi	CN 90	CN 70	SS 304	SS 316	Ni	Mo	In	Hast	Ti	Zr	Ta
Nitric acid	D	D	D	D	D	D	B	B	D	D	D	D	A	B	A
Nitrous acid	D	D	D	D	D	D	B	B	D	D	D	-	-	-	A
Oleic acid	B	B	B	B	B	B	B	B	A	A	A	B	B	B	B
Oxalic acid	D	B	B	B	B	B	B	B	C	B	B	B	D	B	A
Perchloric acid (dry)	D	D	D	D	D	D	B	B	D	D	D	-	-	-	A
Perchloroethylene	A	B	B	B	B	B	B	B	A	A	A	-	A	-	A
Phenoldehyde	B	B	B	B	B	B	B	B	B	A	B	A	A	-	A
Phosphoric acid	D	D	D	D	D	D	B	B	D	D	B	A	C	D	B
Phthalic anhydride	B	B	B	B	B	B	B	B	B	B	B	B	-	-	A
Potassium bicarbonate	B	B	B	B	B	A	B	B	B	B	B	B	A	-	A
Potassium carbonate	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Propylene glycol	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Pyridine	A	B	B	B	B	B	B	B	B	B	B	B	B	-	A
Refrigerant 12	A	A	A	A	A	A	A	B	B	B	B	A	A	-	A
Refrigerant 22	A	A	A	A	A	A	A	A	A	A	A	A	A	-	A
Seawater	C	B	A	B	A	A	A	A	B	A	B	B	A	A	A
Silver chloride	D	D	D	D	D	D	D	D	D	D	C	B	B	-	A
Silver nitrate	D	D	D	D	D	D	B	B	D	D	B	B	A	A	A
Sodium acetate	D	B	B	B	B	B	B	B	B	B	B	B	B	-	A
Sodium hydroxide	D	D	D	D	D	D	D	D	A	B	B	B	B	B	D
Sodium nitrate	B	B	B	B	B	B	A	A	B	B	A	B	A	-	A
Sodium sulfate	B	B	B	B	B	B	B	A	B	B	B	B	A	-	A
Sulfur dioxide(dry)	B	B	B	B	B	B	B	B	B	B	B	B	A	-	A
Sulfuric acid	D	D	D	D	D	D	D	D	D	D	D	B	D	A	A
Toluene	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Trichlorethylene	B	B	B	B	B	B	B	B	A	A	B	A	A	A	A
Turpentine	B	B	B	B	B	B	B	B	B	B	B	B	B	-	A
Vinyl chloride (dry)	A	B	C	B	B	B	B	A	A	A	A	A	A	-	A
Water (fresh)	C	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Water (sea)	C	B	A	B	A	A	A	A	B	A	B	B	A	A	A
Xylene	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Zinc chloride	D	D	D	D	D	D	B	B	B	A	D	B	A	A	A
Zinc sulfate	D	B	B	B	B	B	B	A	B	B	A	B	A	-	A

Baffle Cuts

Single Segmental

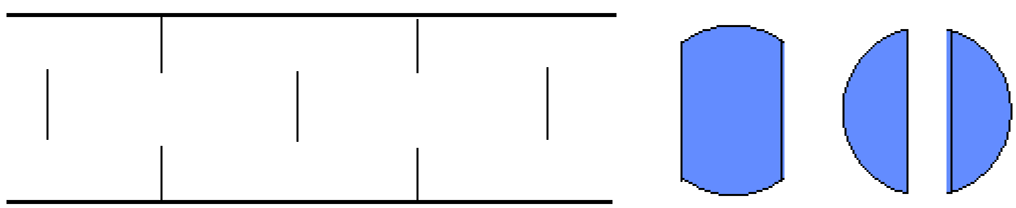
In all Aspen B-JAC programs, the single segmental baffle cut is always defined as the segment opening height expressed as a percentage of the shell inside diameter.



Typical baffle cut: 15% to 45%

Double Segmental

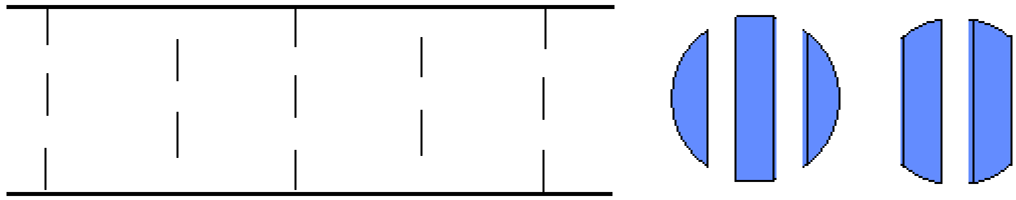
In all Aspen B-JAC programs, the double segmental cut is always defined as the segment height of the innermost baffle window expressed as a percentage of the shell inside diameter. In the output, the baffle cut will be printed with the percent of the inner window / percent of one of the outer windows. The area cut away is approximately equal for each baffle.



Typical baffle cut: 20% to 42%

Triple Segmental

In all Aspen B-JAC programs, the triple segmental cut is always defined as the segment height of the innermost baffle window expressed as a percentage of the shell tube inside diameter. In the output, the baffle cut will be printed with the percent of the innermost window / percent of one intermediate window / percent of one outermost window. The area cut away is approximately equal for each baffle.



Typical baffle cut: 22% to 32%

Asme Code Cases

ASME Code Case 2278

Alternative Method for Calculating Maximum Allowable Stresses Based on a Factor of 3.5 on Tensile Strength Section II and Section VIII Div. 1.

Important items are:

- These materials are the same as previously used. No chemical specifications have been changed.
- Materials are limited to those listed in the tables in ASME-VIII Div.1 (for example, UCS-23).
- The maximum permitted temperature for these materials are less than the original listings.
- Only materials with both tensile strength and yield strength tables can be used (ASME Section II, Part D - if the materials are not listed on tables U and Y-1, they can not be used per code case 2278).
- New figure provided for the calculation of the reduction in minimum design metal temperature without impact testing.
- The allowable stress values are calculated from the tensile strength and the yield strength.
- The application of this case is not recommended for gasketed joints or other applications where slight distortion can cause leakage or malfunction.
- The hydrostatic test factor is reduced from 1.5 to 1.3.
- All other code requirements apply (external pressure charts, etc.).

When using code case 2278, no reference is made to this case when the program lists materials. It is recommended that you note the use of code case in you file headings description. You select the usage of code case 2278 as an input in the program options section.

ASME Code Case 2290

Alternative Maximum Allowable Stresses Based on a Factor of 3.5 on Tensile Strength Section I. Part D and Section VIII Division 1.

Important items are:

- These materials are the same as previously used. No chemical specifications have been changed.
- The alternative maximum allowable stresses are listed in Table 1 of code case 2290 (same format as Section II, Part D materials).
- New figure provided for the calculation of the reduction in minimum design metal temperature without impact testing.
- The application of this case is not recommended for gasketed joints or other applications where slight distortion can cause leakage or malfunction.
- The hydrostatic test factor is reduced from 1.5 to 1.3.
- All other code requirements apply (external pressure charts, etc.).

When using code case 2290, the program will access a new database in which all materials end with the characters '2290'. Therefore, the user and inspector will know what materials fall within this code case. This new database will be listed in the user's interface as 'ASME-2290'. All materials in the new database start from the B-JAC number 5000 (5000-5999). The new database filenames for the engine are AS2290P.PDA and NAS2290I.PDA. The user selects the usage of code case 2290 by selecting any available material in the 5000 series.

Pipe Properties

ANSI Pipe Dimensions

			ANSI Pipe Dimensions				Dimensions: in			
Nom OD	0.75	1.0	1.25	1.5	2.0	2.5	3.0	3.5	4.0	5.0
Actual OD	1.050	1.315	1.660	1.900	2.375	2.875	3.500	4.000	4.500	5.563
Sch 5S	0.065	0.065	0.065	0.065	0.065	0.083	0.083	0.083	0.083	0.109
Sch 10S	0.083	0.109	0.109	0.109	0.109	0.120	0.120	0.120	0.120	0.134
Sch 10	---	---	---	---	---	---	---	---	---	---
Sch 20	---	---	---	---	---	---	---	---	---	---
Sch 30	---	---	---	---	---	---	---	---	---	---
Std	0.113	0.133	0.140	0.145	0.154	0.203	0.216	0.226	0.237	0.258
Sch 40	0.11	0.133	0.140	0.145	0.154	0.203	0.216	0.226	0.237	0.258
Sch 60	---	---	---	---	---	---	---	---	---	---
Ext Str	0.154	0.179	0.191	0.200	0.218	0.276	0.300	0.318	0.337	0.375
Sch 80	0.154	0.179	0.191	0.200	0.218	0.276	0.300	0.318	0.337	0.375
Sch 100	---	---	---	---	---	---	---	---	---	---
Sch 120	---	---	---	---	---	---	---	---	0.438	0.500
Sch 140	---	---	---	---	---	---	---	---	---	---
Sch 160	0.219	0.250	0.250	0.281	0.344	0.375	0.438	---	0.531	0.625
XX Str	0.308	0.358	0.382	0.400	0.436	0.552	0.600	---	0.750	0.864

ANSI Pipe Dimensions — Dimensions: in

Nom OD	6	8	10	12	14	16	18	20	22	24
Actual OD	6.625	8.625	10.75	12.75	14.0	16.0	18.0	20.0	22.0	24.0
Sch 5S	0.109	0.109	0.134	0.156	0.156	0.165	0.165	0.188	0.188	0.218
Sch 10S	0.134	0.148	0.165	0.180	0.188	0.188	0.188	0.218	0.218	0.250
Sch 10	---	---	---	---	0.250	0.250	0.250	0.250	0.250	0.250
Sch 20	---	0.250	0.250	0.250	0.312	0.312	0.312	0.375	0.375	0.375
Sch 30	---	0.277	0.307	0.330	0.375	0.375	0.438	0.500	0.500	0.562
Std	0.280	0.322	0.365	0.375	0.375	0.375	0.375	0.375	0.375	0.375
Sch 40	0.280	0.322	0.365	0.406	0.438	0.500	0.562	0.594	---	0.688
Sch 60	---	0.406	0.500	0.562	0.594	0.656	0.750	0.812	0.875	0.969
Ext Str	0.432	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Sch 80	0.432	0.500	0.594	0.688	0.750	0.844	0.938	1.031	1.125	1.218
Sch 100	---	0.594	0.719	0.844	0.938	1.031	1.156	1.281	1.375	1.531
Sch 120	0.562	0.719	0.844	1.000	1.094	1.219	1.375	1.500	1.625	1.812
Sch 140	---	0.812	1.000	1.125	1.250	1.438	1.562	1.750	1.875	2.062
Sch 160	0.719	0.906	1.125	1.312	1.406	1.594	1.781	1.969	2.125	2.344
XX Str	0.864	0.875	1.000	1.000	---	---	---	---	---	---

ANSI Pipe Dimensions — Dimensions: mm

Nom OD	19	25	32	38	51	64	76	89	102	127
Actual OD	26.6	33.4	42.2	48.3	60.3	73.0	88.9	101.6	114.3	141.3
Sch 5S	1.6	1.6	1.6	1.6	1.6	2.1	2.1	2.1	2.1	2.7
Sch 10S	2.1	2.7	2.7	2.7	2.7	3.0	3.0	3.0	3.0	3.4
Sch 10	---	---	---	---	---	---	---	---	---	---
Sch 20	---	---	---	---	---	---	---	---	---	---
Sch 30	---	---	---	---	---	---	---	---	---	---
St	---	3.4	3.6	3.7	3.9	5.2	5.5	5.7	6.0	6.6
Sch 40	2.8	3.4	3.6	3.7	3.9	5.2	5.5	5.7	6.0	6.6
Sch 60	---	---	---	---	---	---	---	---	---	---
Ext Str	3.9	4.5	4.9	5.1	5.5	7.0	7.6	8.1	8.6	9.5
Sch 80	3.9	4.5	4.9	5.1	5.5	7.0	7.6	8.1	8.6	9.5
Sch 100	---	---	---	---	---	---	---	---	---	---
Sch 120	---	---	---	---	---	---	---	---	11.1	12.7
Sch 140	---	---	---	---	---	---	---	---	---	---
Sch 160	5.5	6.4	6.4	7.1	8.7	9.5	11.1	---	13.5	15.9
XX Str	7.8	9.1	9.7	10.2	11.1	14.0	15.2	16.2	17.1	19.1

ANSI Pipe Dimensions — Dimensions: mm

Nom OD	152	203	254	305	356	406	457	508	559	610
Actual OD	168.3	219.1	273.1	323.9	355.6	406.4	457.2	508.0	558.8	609.6
Sch 5S	2.7	2.7	3.4	4.0	4.0	4.0	4.0	4.8	4.8	5.5
Sch 10S	3.4	3.7	4.1	4.5	4.8	4.8	4.8	5.5	5.5	6.3
Sch 10	---	---	---	---	6.3	6.3	6.3	6.3	6.3	6.3
Sch 20	---	---	---	---	7.9	7.9	7.9	9.5	9.5	9.5
Sch 30	---	7.0	7.8	8.4	9.5	9.5	11.1	12.7	12.7	14.3
Std	7.1	8.2	9.3	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Sch 40	7.1	8.2	9.3	10.3	11.1	12.7	14.3	15.1	---	17.5
Sch 60	---	10.3	12.7	14.3	15.1	16.7	19.1	20.6	22.2	24.6
Ext Str	11.0	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
Sch 80	11.0	12.7	15.1	17.5	19.1	21.4	23.8	26.2	28.6	30.9
Sch 100	---	15.1	18.3	21.4	23.8	26.2	29.4	32.5	34.9	38.9
Sch 120	13.5	18.3	21.4	25.4	27.8	31.0	34.9	38.1	---	46.0
Sch 140	---	20.6	25.4	28.6	31.8	36.5	39.7	44.5	---	52.4
Sch 160	18.3	23.0	28.6	33.3	35.7	40.5	45.2	50.0	---	59.5
XX Str	21.9	22.2	25.4	25.4	---	---	---	---	---	---

DIN / ISO 4200 Pipe Dimensions

DIN / ISO 4200 Pipe Dimensions **Dimensions: mm**

Nom OD	20	25	32	40	50	65	80	100	125	150
Actual OD	26.9	33.7	42.4	48.3	60.3	76.1	88.9	114.3	139.7	168.3
Row A	1.6	1.6	1.6	1.6	1.6	1.6	2.0	2.0	2.0	2.0
Row B	---	2.0	2.0	2.0	2.0	2.3	2.3	2.3	2.3	2.3
Row C	---	---	---	---	2.3	2.6	2.9	2.9	3.2	3.2
Row D	1.8	2.0	2.3	2.3	2.3	2.6	2.9	3.2	3.6	4.0
Row E	2.0	2.3	2.6	2.9	2.9	2.9	3.2	3.6	4.0	4.5
Row F	3.2	3.2	3.6	3.6	4.0	5.0	5.6	6.3	6.3	7.1
Row G	4.0	4.5	5.0	5.0	5.6	7.1	8.0	8.8	10	11

DIN / ISO 4200 Pipe Dimensions **Dimensions: mm**

Nom OD	200	250	300	350	400	450	500	600	700	800
Actual OD	219.1	273	323.9	355.6	406.4	457	508	610	711	813
Row A	2.0	2.0	2.6	2.6	2.6	3.2	3.2	3.2	4.0	4.0
Row B	2.6	3.6	4.0	4.0	4.0	4.0	5.0	5.6	6.3	7.1
Row C	3.6	4.0	4.5	5.0	5.0	5.0	5.6	6.3	7.1	8.0
Row D	4.5	5.0	5.6	5.6	6.3	6.3	6.3	6.3	7.1	8.0
Row E	6.3	6.3	7.1	8.0	8.8	10	11	12.5	14.2	16
Row F	8.0	10	10	11	12.5	14.2	16	17.5	20	22.2
Row G	12.5	14.2	16	17.5	20	22.2	25	30	32	36

Standard Nozzle Flange Ratings

ANSI	50	300	400	600	900		1500		2500				
ISO		10	16	20	25	40			50	100			
DIN		10	16	25	40	63	100	160			250	320	400

Technical References

Introduction

Aspen B-JAC updates its programs with the best of the most recent correlations for heat transfer and pressure drop available from research and published literature sources. The references have been categorized into their applicable areas as follows:

General Shell Side Heat Transfer & Pressure Drop

- No Phase Change
- Vaporization
- Condensation

Tube Side Heat Transfer & Pressure Drop

- No Phase Change
- Vaporization

- Condensation

Although AspenTech does not publish the exact formulas used in the program, we will gladly direct you to the correct source in the published literature pertaining to your question.

AspenTech continually examines new correlations as they become available and incorporates them into the Aspen B-JAC program only after extensive evaluation. This evaluation includes comparisons of results between new and old correlations, field data from a multitude of units currently in service, and many years of design experience.

Please do not request copies of references from AspenTech. Requests for copies of articles should be made to :

Engineering Societies Library
345 East 47th Street
New York, NY 10017
U. S. A.

General

Perry's Chemical Engineers' Handbook, Sixth Edition, McGraw-Hill, 1984

General Discussion on Heat Transfer, Institution of Mechanical Engineers London, 1951

Practical Aspects of Heat Transfer, AIChE Technical Manual, 1976

Gas Engineers Handbook, C. George Segeler, Industrial Press, 1974

Heat Transfer and Fluid Flow Data Books, General Electric, 1984

Engineering Data Book, Gas Processors Suppliers Association, 1979

Standard Handbook of Engineering Calculations, Second Edition, Tyler G. Hicks, McGraw-Hill, 1985

Heat Exchanger Design Handbooks, Volumes 1-5, Hemisphere Publishing Corporation, 1984

International Heat Transfer Conference Proceedings, Hemisphere Publishing Corporation,
Heat Transfer 1978, Toronto
Heat Transfer 1982, Munich
Heat Transfer 1986, San Francisco
Heat Transfer 1990, Jerusalem

AIChE Symposium Heat Transfer Series
Seattle 82 Volume 64, 1968
Philadelphia 92 Volume 65, 1969

Minneapolis 102 Volume 66, 1970
Tulsa 118 Volume 68, 1972
Fundamentals 131 Volume 69, 1973
Research & Design 138 Volume 70, 1974
St. Louis 164 Volume 73, 1977
Research & Application 174 Volume 74, 1978
Seattle 225 Volume 79, 1983
Niagara Falls 236 Volume 80, 1984
Denver 245 Volume 81, 1985

Process Heat Transfer, Donald Q. Kern, McGraw-Hill, 1950

Compact Heat Exchangers, Third Edition, Kays & London, McGraw-Hill, 1984

Process Design for Reliable Operations, Norman P. Lieberman, Gulf Publishing Company, 1983

Heat Exchangers: Design and Theory Sourcebook, Afgan & Schlunder, McGraw Hill, 1974

Heat Exchangers Thermal-Hydraulic Fundamentals and Design, Kakac, Bergles & Mayinger, McGraw-Hill, 1981

Convective Boiling and Condensation, John G. Collier, McGraw-Hill, 1972

Industrial Heat Exchangers, A Basic Guide, G. Walker, McGraw-Hill, 1982

Heat Transfer, J.P. Holman, McGraw-Hill, 1981

Heat Transfer in Counterflow, Parallel Flow and Cross Flow, Helmuth Hausen, McGraw-Hill, 1983

Extended Surface Heat Transfer, D.O. Kern & A.D. Kraus, McGraw-Hill, 1972

Heat Exchangers, Theory and Practice, Taborek, Hewitt & Afgan, McGraw-Hill, 1983

Two-Phase Flow and Heat Transfer in the Power and Process Industries, Bergles, Collier, Delhaye, Hewitt & Mayinger, McGraw-Hill, 1981

Standards of Tubular Exchangers Manufacturers Association, Seventh Edition, TEMA, 1988

Wolverine Trufin Engineering Data Book, Wolverine Tube Division, 1967

Heat Transfer Pocket Handbook, Nicholas P. Cheremisinoff, Gulf Publishing Company, 1984

Fluid Flow Pocket Handbook, Nicholas P. Cheremisinoff, Gulf Publishing Company, 1984

Handbook of Chemical Engineering Calculations, Chopey & Hicks, McGraw-Hill, 1984

Heat Exchangers for Two-Phase Applications, ASME, HTD-Vol. 27, 1983

Reprints of AIChE Papers, 17th National Heat Transfer Conference, Salt Lake City, 1977

Standards for Power Plant Heat Exchangers, Heat Exchange Institute Inc., 1980

A Reappraisal of Shellside Flow in Heat Exchangers, ASME HTD-36, 1984

Shellside Waterflow Pressure Drop and Distribution in Industrial Size Test Heat Exchanger, Halle & Wambsganss, Argonne National Laboratory, 1983

Basic Aspects of Two Phase Flow and Heat Transfer, ASME, HTD-Vol. 34, 1984

ASME Heat Transfer Publications, 1979, 18th National Heat Transfer Conference, Condensation Heat Transfer, & Advances in Enhanced Heat Transfer

Shell and Tube Heat Exchangers, Second Symposium, American Society for Metals, Houston, Texas, September, 1981

Two-Phase Heat Exchanger Symposium 23rd National Heat Transfer Conference, Denver, Colorado, HTD-Vol.44 August, 1985

Advances in Enhanced Heat Transfer 23rd National Heat Transfer Conference, Denver, Colorado, HTD-Vol.43 August, 1985

Heat Tranfer Equipment Design, R.K. Shah, Subbarao, and R.A. Mashelkar, Hemisphere Publishing Corporation, 1988

Heat Transfer Design Methods, Edited by John J. McKetta, Marcel Dekker Inc., 1992

Boilers Evaporators & Condesers, Sadik Kakac, John Wiley & Sons Inc., 1991

Enhanced Boiling Heat Transfer, John R. Thome, Hemisphere Publishing Corporation, 1990

Handbook of Heat Transfer Applications Second Edition Editors W.M. Rohsenow, J.P. Hartnett and Ejup N. Ganic, McGraw-Hill Book Co., 1985

Piping Handbook, Sixth Edition, Mobinder L. Nayyar, McGraw-Hill Inc., 1992

Practical Aspects of Heat Transfer, Proceedings of 1976 Fall Lecture Series of New Jersey-- North Jersey Sections of AICHE, 1976.

Air Cooled Heat Exchangers For General Refinery Services, API Standard 661 Second Edition, January 1978.

ESCOA Fintube Manual, Chris W. Weierman, ESCOA Fintube Corporation

Moore Fan Company Manual, Moore Fan Company, 1982.

Heat Transfer: Research and Application, ed. John Chen, AIChE Symposium Series, No. 174, Vol. 74, 1978

Heat Transfer—Seattle 1983, Nayeem M. Farukhi, AIChE Symposium Series, No. 225, Vol. 79, 1983.

Principles of Heat Transfer, Frank Kreith, International Textbook Company, 1958.

Fundamentals of Heat Transfer, S. S. Kutateladze, Academic Press, 1963.

NGPSA Engineering Data Book, Natural Gas Processors Suppliers Association, 1979.

"Design of Air-Cooled Exchangers," Robert Brown, *Chemical Engineering*, March 27, 1978.

"Process Design Criteria," V. Ganapathy, *Chemical Engineering*, March 27, 1978.

Shell Side Heat Transfer and Pressure Drop

Stream Analysis Type Correlations

Shell Side Characteristics of Shell and Tube Heat Exchangers, Townsend Tinker, ASME Paper No. 56-A-123.

Exchanger Design Based on the Delaware Research Program, Kenneth J. Bell, *PETRO/CHEM*, October, 1960

Heat Exchanger Vibration Analysis, A. Devore, A. Brothman, and A. Horowitz, *Practical Aspects of Heat Transfer*, (Proceedings of 1976 Fall Lecture Series of New Jersey), AIChE

The Effect of Leakage Through the Longitudinal Baffle on the Performance of Two-Pass Shell Exchangers, T. Rozenman and J. Taborek AIChE Symposium Series Heat Transfer Tulsa 118, Volume 68, 1972

Patterns of Fluid Flow in a Shell-and-Tube Heat Exchanger, J.A. Perez and E.M. Sparrow, *Heat Transfer Engineering*, Volume 5 Numbers 3-4, 1984, Hemisphere Publishing Corporation

Solution of Shell Side Flow Pressure Drop and Heat Transfer, Stream Analysis Method, J.W. Palen and Jerry Taborek, *AIChE*

Symposium Series Heat Transfer-Philadelphia 92, Volume 65, 1969

Shellside Waterflow Pressure Drop and Distribution in Industrial Size Test Heat Exchanger, H. Halle and M.W. Wambsganss, ANL-83-9 Argonne National Laboratory, 1983

A Reappraisal of Shellside Flow in Heat Exchangers, HTD-Vol. 36, ASME, 1984

Delaware Method for Shell Side Design, Kenneth J. Bell, *Heat Exchangers Thermal-Hydraulic Fundamentals and Design*, McGraw-Hill Book Co., 1981

Low Fin Tube Correlations

Handbook of Chemical Engineering Calculations, Nicholas P. Chopey and Tyler G. Hicks, McGraw-Hill Book Co., 1984

Wolverine Trufin Engineering Data Book, Wolverine Division, UOP Inc.

Fine-Fin Tubing Specifications, High Performance Tube Inc., 2MI/78

Transfer Rates at the Caloric Temperature

Improved Exchanger Design, Riad G. Malek, Hydrocarbon Processing, May 1973

Process Heat Transfer, Donald Q. Kern, McGraw Hill Book Co., 1950

The Caloric Temperature Factor for a 1-2 Heat Exchanger with An Overall Heat Transfer Coefficient Varying Linearly with Tube Side Temperature, R.B. Bannerot and K.K. Mahajan, *AIChE Symposium Series 174, Volume 74, Heat Transfer - Research and Applications, 1978*

Grid Baffle Correlations

The Energy-Saving NESTS Concept, Robert C. Boyer and Glennwood K. Pase, *Heat Transfer Engineering, Vol. 2, Number 1*, Hemisphere Publishing Corporation, July-Sept. 1980

Thermal Design Method for Single-Phase RODBaffle Heat Exchangers, C.C. Gentry and W.M. Small, Phillips Petroleum Company, 1981

RODbaffle Exchanger Thermal-Hydraulic Predictive Models Over Expanded Baffle-Spacing and Reynolds Number Ranges, C. C. Gentry and W. M. Small, *AIChE Symposium Series 245, Vol 81 Heat Transfer-Denver, 1985*

RODbaffle Heat Exchanger Thermal-Hydraulic Predictive Methods for Bare and Low-Finned Tubes, C. C. Gentry, R. K.

Young, W. M. Small, *AIChE Symposium Series Heat Transfer - Niagara Falls 236, Volume 80, 1984*

Phase Change - Natural and Forced Circulation Boiling

Thermal Design of Horizontal Reboilers, James R. Fair and Abraham Klip, *Chemical Engineering Progress*, March 1983

Two-Phase Flow and Heat Transfer in the Power and Process Industries, A. E. Bergles, J. G. Collier, J. M. Delhaye, G. F. Hewitt, and F. Mayinger, McGraw-Hill, 1981

Circulation Boiling, Model for Analysis of Kettle and Internal Reboiler Performance, J. W. Palen and C. C. Yang, *Heat Exchangers for Two-Phase Applications, ASME HTD-Vol 27, July 1983*.

A Prediction Method for Kettle Reboilers Performance, T. Brisbane, I. Grant and P. Whalley, *ASME 80-HT-42*

Nucleate Boiling: A Maximum Heat Flow Correlation for Corresponding States Liquids, C. B. Cobb and E. L. Par, Jr., *AIChE Symposium Series Heat Transfer Philadelphia 92, Volume 65, 1969*

Boiling Coefficients Outside Horizontal Plain and Finned Tubes, John E. Myers and Donald L. Katz, *Refrigerating Engineering*, January, 1952

Forced Crossflow Boiling in an Ideal In-Line Tube Bundle, G. T. Pooley, T. Ralston, and I. D. R. Grant, *ASME 80-HT-40*

Characteristics of Boiling Outside Large-Scale Horizontal Multitube Bundles, J. W. Palen, A. Yarden, and J. Taborek, *AIChE Symposium Series Heat Transfer - Tulsa 118, Volume 68, 1972*

A Simple Method for Calculating the Recirculating Flow in Vertical Thermosyphon and Kettle Reboilers", P.B. Whalley and D. Butterworth, *Heat Exchangers for Two-Phase Applications, ASME HTD-Vol.27*, July 1983

Analysis of Performance of Full Bundle Submerged Boilers, By P. Payvar, *Two-Phase Heat Exchanger Symposium, ASME HTD-Vol.44*, August 1985

Enhanced Boiling Heat Transfer, Hemisphere Publishing Corporation, 1990

Phase Change Condensation

Handbook of Chemical Engineering Calculations, Nicholas P. Chopey and Tyler G. Hicks, McGraw-Hill Book Company, 1984

Heat Transfer and Two-Phase Flow During Shell-Side Condensation, P. J. Marto, *Heat Transfer Engineering*, Vol. 5, Number 1-2, 1984

Process Heat Transfer, Donald Q. Kern, McGraw-Hill Book Company, 1950

Design Parameters for Condensers and Reboilers, P. C. Lord, R. E. Minton and R. P. Slusser, *Chemical Engineering*, March 23, 1970

Condensation of Immiscible Mixtures, S. H. Bernhardt, J.J. Sheridan, and J. W. Westwater, *AIChE Symposium Heat Transfer-Tulsa No. 118, Vol. 68*, 1972

Design of Cooler Condensers for Mixtures of Vapor with Noncondensing Gases, A. P. Colburn and O. A. Hougen, *Industrial and Engineering Chemistry*, November 1939

Simplify Design of Partial Condensers, J. Starzewski, *Hydrocarbon Processing*, March 1981

Calculate Condenser Pressure Drop, John E. Diehl, *Petroleum Refiner*, October 1957

Two-Phase Pressure Drop for Horizontal Crossflow Through Tube Banks, J. E. Diehl and C. H. Unruh, *Petroleum Refiner*, October 1958

Mean Temperature Difference for Shell-And-Tube Heat Exchangers with Condensing on the Shell Side, Robert S. Burligame, *Heat Transfer Engineering*, Volume 5, Numbers 3-4, 1984

An Assessment of Design Methods for Condensation of Vapors from a Noncondensing Gas, J. M. McNaught, *Heat Exchanger Theory and Practice*, McGraw-Hill Book Co., 1983

A Multicomponent Film Model Incorporating a General Matrix Method of Solution to the Maxwell-Stefan Equations, *AIChE Journal, Vol 22*, March 1976

Modified Resistance Proration Method for Condensation of Vapor Mixtures, R. G. Sardesai, J. W. Palen, and J. Taborek, *AIChE Symposium Series Heat Transfer - Seattle 225, Volume 79*, 1983

An Approximate Generalized Design Method for Multicomponent Partial Condensers, K. J. Bell and M. A. Ghaly, *AIChE Symposium Series Heat Transfer No. 131, Vol 69*, 1973

Rating Shell-and-Tube Condensers by Stepwise Calculations, R. S. Kistler, A. E. Kassem, and J. M. Chenoweth, *ASME 76-WA/HT-5*, 1976

Two-Phase Flow on the Shell-Side of a Segmentally Baffled Shell-and-Tube Heat Exchanger, I. D. R. Grant and D. Chismolm, *ASME 77-WA/HT-22*, 1977

Shellside Flow in Horizontal Condensers, I. D. R. Grant, D. Chisholm, and C. D. Cotchin, *ASME 80-HT-56*, 1980

Critical Review of Correlations for Predicting Two-Phase Flow Pressure Drop Across Tube Banks, K. Ishihara, J. W. Palen, and J. Taborek, *ASME 77-WA/HT-23*

Design of Binary Vapor Condensers Using the Colburn-Drew Equations, B C. Price and K. J. Bell, *AIChE Symposium Series No. 138, Volume 74*, 1974

Theoretical Model for Condensation on Horizontal Integral-Fin Tubes, T.M. Rudy and R. L. Webb, *AIChE Symposium Series Heat Transfer Seattle 225, Volume 79*, 1983

Condensers: Basic Heat Transfer and Fluid Flow, D. Butterworth, *Heat Exchangers Thermal-Hydraulic Fundamentals and Design*, McGraw-Hill Book Company, 1981

Condensers: Thermohydraulic Design, D. Butterworth, *Heat Exchangers Thermal-Hydraulic Fundamentals and Design*, McGraw-Hill Book Company, 1981

High Fin Heat Transfer & Pressure Drop

"Fired Heaters," Herbert L. Berman, *Chemical Engineering*, June 19, 1978.

"Bond Resistance of Bimetalic Finned Tubes," E.H. Young and D. E. Briggs, *Chemical Engineering Progress*, Vol. 61, No. 7, July 1965.

"Efficiency of Extended Surface," Karl A. Gardner, *Transactions of the ASME*, November, 1945.

Heat Transfer 1978: Sixth International Heat Transfer Conference, Vol. 1-6 Washington, D. C., Hemisphere Publishing Corporation, 1978

"Pressure Drop of Air Flowing Across Triangular Pitch Banks of Finned Tubes," K. Robinson and D. E. Briggs, *Eighth National Heat Transfer Conference*, Los Angeles, California, August, 1965.

"Convective Heat Transfer and Pressure Drop of Air Flowing Across Triangular Pitch Banks of Finned Tubes," D. E. Briggs and E. Young, *Chemical Engineering Progress* Symposium Series, No. 64, Vol. 62, 1966.

"Tube Spacing in Finned-Tube Banks," S. L. Jameson, *Transactions of the ASME*, Vol. 67, November 1945.

"Pressure Drop of Air Flowing Across Triangular Pitch Banks of Finned Tubes," K. Robinson and D. E. Briggs, *Chemical Engineering Progress* Symposium Series, No. 64, Vol. 62, 1966.

"Comparison of Performance of Inline and Staggered Banks of Tubes with Segmented Fins," *AIChE-ASME 15th National Heat Transfer Conference*, San Francisco, 1975.

"Efficiency of Extended Surfaces," Karl Gardner, *Transactions of ASME*, November 1945.

"Thermal Contact Resistance in Finned Tubing," Karl Gardner and T. C. Carnavos, *Journal of Heat Transfer*, November 1960.

ESCOA Fintube Manual, Chris W. Weierman ESCOA Fintube Corporation.

Tube Side Heat Transfer and Pressure Drop

No Phase Change

Process Heat Transfer, Donald Q. Kern, McGraw-Hill Book Co. 1950

Improved Exchanger Design, Transfer Rates at the Caloric Temperature, Riad G. Malek, *Hydrocarbon Processing*, May 1973

Heat Transfer Colburn-Factor Equation Spans All Fluid Flow Regimes, Bill L. Pierce, *Chemical Engineering*, December 17, 1979

An Improved Heat Transfer Correlation for Laminar Flow of High Prandtl Number Liquids in Horizontal Tubes, By J. W. Palen, and J. Taborek, *AIChE Symposium Series Heat Transfer-Denver 245, Volume 81*, 1985

The Caloric Temperature Factor for a 1-2 Heat Exchanger with an Overall Heat Transfer Coefficient Varying Linearly with Tube Side Temperature, P. B. Bannerot and K. K. Mahajan, *AIChE Symposium Series 174, Volume 74*, 1978

Turbulent Heat Transfer and Pressure Drop in Internally Finned Tubes, A. P. Watkinson, D. L. Miletti and P. Tarassoff, *AIChE Symposium Series 131, Volume 69*, 1973

The Computation of Flow in a Spirally Fluted Tube, A. Barba, G. Bergles, I. Demirdzic, A. D. Godman, and B. E. Lauder, *AIChE Symposium Series Heat Transfer-Seattle 225, Volume 79*, 1983

Investigation of Heat Transer Inside Horizontal Tubes in the Laminar Flow Region, P. Buthod, *University of Tulsa Report*, 1959

Design Method for Tube-Side Laminar and Transition Flow Regime Heat Transfer With Effects of Natural Convection, *9th International Heat Transfer Conference, Open Forum Session, Jerusalem, Israel*, 1990

Phase Change - Natural and Forced Circulation Boiling

Simulated Performance of Refrigerant-22 Boiling Inside Tubes in a Four Tube Pass Shell and Tube Heat Exchanger, By John F. Pearson and Edwin H. Young, *AIChE Symposium Series Heat Transfer-Minneapolis 102, Volume 66*, 1970

Heat Transfer to Boiling Refrigerants Flowing Inside a Plain Copper Tube, B. W. Rhee and E. H. Young, *AIChE Symposium Series 138, Volume 70*, 1974

An Improved Correlation for Predicting Two-Phase Flow Boiling Heat Transfer Coefficient in Horizontal and Vertical Tubes, S. G. Kandliker, Heat Exchanger for Two-Phase Applications, *ASME HTD-Vol. 27*, July 1983

A Simple Method for Calculating the Recirculating Flow in Vertical Thermosyphon and Kettle Reboilers, P. B. Whalley and D. Butterworth, Heat Exchangers for Two-Phase Applications, *ASME HTD-Vol. 27*, July 1983

Performance Prediction of Falling Film Evaporators, K.R. Chun and R. A. Seban, *ASME 72 HT-48*

Thermal Design of Horizontal Reboilers, James R. Fair and Abraham Klip, *Chemical Engineering Progress*, March 1983

What You Need To Design Thermosiphon Reboilers, J. R. Fair, *Petroleum Refiner*, February 1960

Vaporizer and Reboiler Design Part 1, James R. Fair, *Chemical Engineering*, July 8, 1963

Vaporizer and Reboiler Design Part 2, James R. Fair, *Chemical Engineering*, August 5, 1963

Mist Flow in Thermosiphon Reboilers, J. W. Palen, C.C. Shih and J. Taborek, *Chemical Engineering Progress*, July 1982

A Computer Design Method for Vertical Thermosyphon, N. V. L. S. Sarma, P. J. Reddy, and P.S. Murti, *Industrial Engineering Chemistry Process Design Development*, Vol. 12, No. 3, 1973

Designing Thermosiphon Reboilers, G. A. Hughmark, *Chemical Engineering Progress*, Vol. 65, No. 7, July 1969

Design of Falling Film Absorbers, G. Guerrell and C. J. King, *Hydrocarbon Processing*, January 1974

Heat Transfer to Evaporating Liquid Films, K. R. Chun and R. A. Seban *ASME 71-HT-H*

Performance of Falling Film Evaporators, F. R. Whitt, *British Chemical Engineering*, December 1966, Vol. 11, No. 12

Selecting Evaporators, D. K. Mehra, *Chemical Engineering*, February 1986

Heat Transfer in Condensation Boiling, Karl Stephan, *Springer-Verlag*, 1988

Flow Boiling Heat Transfer in Vertical Tubes Correlated by Asympotic Model, Dieter Steiner and Jerry Taborek, *Heat Transfer Engineering Vol. No. 2*, 1992

Phase Change Condensation

Flooding Velocity Correlation for Gas-Liquid Counterflow in Vertical Tubes, J. E. Diehl and C. R. Koppany, *AIChE Symposium Series Heat Transfer-Philadelphia 92, Volume 65*, 1969

Interpretation of Horizontal In-Tube Condensation Heat Transfer Correlations with a Two-Phase Flow Regime Map, K. J. Bell, J. Taborek, and F. Fenoglio, *AIChE Symposium Series Heat Transfer-Minneapolis 102, Volume 66*, 1970

Filmwise Condensation of Light Hydrocarbons and Their Mixtures in a Vertical Reflux Condenser, L. D. Clements and C. P. Colver, *AIChE Symposium Series 131, Volume 69*, 1973

Prediction of Horizontal Tubeside Condensation of Pure Components Using Flow Regime Criteria, G. Breber, J. Palen & J. Taborek, *ASME Condensation Heat Transfer*, August 1979

Prediction of Flow Regimes in Horizontal Tubeside Condensation, J. Palen, G. Breber, and J. Taborek, *AIChE 17th National Heat Transfer Conference Salt Lake City, Utah*, August 1977

Condensers: Basic Heat Transfer and Fluid Flow, D. Butterworth, *Heat Exchangers Thermal-Hydraulic Fundamentals and Design*, McGraw-Hill Book Company, 1981

Prediction of Horizontal Tubeside Condensation Using Flow Regime Criteria, *Condensation Heat Transfer, National Heat Transfer Conference, San Diego, 1979*, ASME 1979

Vibration Analysis

Natural Frequencies and Damping of Tubes on Multiple Supports, R. L. Lowery and P.M. Moretti, *AIChE Symposium Series 174, Volume 74*, 1978

Tube Vibrations in Shell-And-Tube Heat Exchangers, J. M. Chenoweth and R. S. Kistler, *AIChE Symposium Series 174, Volume 74*, 1978

Critical Review of the Literature and Research on Flow-Induced Vibrations in Heat Exchangers, P.M. Moretti, *AIChE Symposium Series 138, Volume 70*, 1974

Vibration in Heat Exchangers, Franz Mayinger and H. G. Gross, *Heat Exchangers Thermal-Hydraulic Fundamentals and Design*, McGraw Hill Book Company, 1981

Predict Exchanger Tube Damage, J. T. Thorngren, *Hydrocarbon Processing*, April 1970

Flow-Induced Tube Vibration Tests of Typical Industrial Heat Exchanger Configurations, H. Halle, J. M. Chenoweth and M. W. Wambsganss, *ASME 81-DET-37*

Fans

Moore Fan Company Manual, Moore Fan Company, 1982.

"Specifying and Rating Fans," John Glass, *Chemical Engineering*, March 27, 1978.

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