



**T-6001**  
**Design and Principles**



**Process data**

| Description              | Shell Side         |        | Tube Side |        | Units             |
|--------------------------|--------------------|--------|-----------|--------|-------------------|
|                          | Inlet              | Outlet | Inlet     | Outlet |                   |
| Fluids                   | MP Saturated Steam |        | NG + PC   |        |                   |
| Quantity: total          | 255864             |        | 588608    |        | kg/h              |
| liquid                   |                    | 255864 | 435863    | 263724 | kg/h              |
| gas                      | 255864             |        | 152745    | 324884 | kg/h              |
| Operating temperature    | 240                | 240    | 168       | 226    | °C                |
| Operating pressure       | 32,7               |        | 43,3      |        | bar g             |
| Liquid: molecular weight |                    | 18,02  | 18,02     | 18,02  | kg/kmol           |
| density                  |                    | 814    | 900       | 834    | kg/m <sup>3</sup> |
| viscosity                |                    | 0,114  | 0,163     | 0,121  | cP                |
| specific heat capacity   |                    | 4,775  | 4,35      | 4,643  | kJ/kg/°C          |
| thermal conductivity     |                    | 0,6314 | 0,6842    | 0,6464 | W/m/°C            |
| boiling temperature      |                    |        |           |        | °C                |
| Gas: molecular weight    | 18,02              |        | 16,90     | 17,47  | kg/kmol           |
| density                  | 16,9               |        | 21,1      | 20     | kg/m <sup>3</sup> |
| viscosity                | 0,018              |        | 0,016     | 0,018  | cP                |
| specific heat capacity   | 3,518              |        | 2,552     | 3,066  | kJ/kg/°C          |
| thermal conductivity     | 0,0426             |        | 0,0553    | 0,0532 | W/m/°C            |
| dew point                | 240                |        | 241       |        | °C                |

**Heating and Cooling Table**

| Shell side  |              |              |                   |                  |                      |                             |                 |  |
|-------------|--------------|--------------|-------------------|------------------|----------------------|-----------------------------|-----------------|--|
| Temperature | Gas fraction | Duty profile | Liquid density    | Liquid viscosity | Liquid heat capacity | Liquid thermal conductivity | Surface tension |  |
| °C          | wt %         | MW           | kg/m <sup>3</sup> | cP               | kJ/kg/°C             | W/m/°C                      | dyn/cm          |  |
| 240         | 100,00       | 0,0          |                   |                  |                      |                             |                 |  |
| 240         | 88,89        | -6,9         | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
| 240         | 77,78        | -13,8        | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
| 240         | 66,67        | -20,7        | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
| 240         | 55,56        | -27,6        | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
| 240         | 44,44        | -34,5        | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
| 240         | 33,33        | -41,4        | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
| 240         | 22,22        | -48,3        | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
| 240         | 11,11        | -55,1        | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
| 240         | 0,00         | -62,0        | 814               | 0,114            | 4,776                | 0,6313                      | 29              |  |
|             |              |              |                   |                  |                      |                             |                 |  |
|             |              |              |                   |                  |                      |                             |                 |  |
| Temperature | Gas fraction | Duty profile | Gas density       | Gas viscosity    | Gas heat capacity    | Gas thermal conductivity    |                 |  |
| °C          | wt %         | MW           | kg/m <sup>3</sup> | cP               | kJ/kg/°C             | W/m/°C                      |                 |  |
| 240         | 100,00       | 0,0          | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 88,89        | -6,9         | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 77,78        | -13,8        | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 66,67        | -20,7        | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 55,56        | -27,6        | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 44,44        | -34,5        | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 33,33        | -41,4        | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 22,22        | -48,3        | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 11,11        | -55,1        | 16,8              | 0,018            | 3,512                | 0,0426                      |                 |  |
| 240         | 0,00         | -62,0        |                   |                  |                      |                             |                 |  |



| Tube side   |              |              |                   |                  |                      |                             |                 |  |
|-------------|--------------|--------------|-------------------|------------------|----------------------|-----------------------------|-----------------|--|
| Temperature | Gas fraction | Duty profile | Liquid density    | Liquid viscosity | Liquid heat capacity | Liquid thermal conductivity | Surface tension |  |
| °C          | wt %         | MW           | kg/m <sup>3</sup> | cP               | kJ/kg/°C             | W/m/°C                      | dyn/cm          |  |
| 226         | 55,20        | 0,0          | 834               | 0,121            | 4,643                | 0,6464                      | 29              |  |
| 223         | 51,05        | 6,9          | 838               | 0,122            | 4,622                | 0,6493                      | 29              |  |
| 220         | 47,05        | 13,8         | 842               | 0,124            | 4,597                | 0,6526                      | 29              |  |
| 216         | 43,22        | 20,7         | 847               | 0,127            | 4,57                 | 0,6563                      | 29              |  |
| 211         | 39,60        | 27,6         | 853               | 0,13             | 4,54                 | 0,6604                      | 29              |  |
| 205         | 36,23        | 34,5         | 860               | 0,133            | 4,507                | 0,6650                      | 30              |  |
| 198         | 33,15        | 41,4         | 868               | 0,138            | 4,471                | 0,6699                      | 30              |  |
| 190         | 30,40        | 48,3         | 878               | 0,144            | 4,432                | 0,6750                      | 30              |  |
| 180         | 28,01        | 55,1         | 888               | 0,152            | 4,392                | 0,6799                      | 30              |  |
| 168         | 26,02        | 62,0         | 900               | 0,163            | 4,351                | 0,6842                      | 30              |  |
|             |              |              |                   |                  |                      |                             | Tubing Size     |  |
| Temperature | Gas fraction | Duty profile | Gas density       | Gas viscosity    | Gas heat capacity    | Gas thermal conductivity    |                 |  |
| °C          | wt %         | MW           | kg/m <sup>3</sup> | cP               | kJ/kg/°C             | W/m/°C                      |                 |  |
| 226         | 55,20        | 0,0          | 20                | 0,018            | 3,066                | 0,0532                      |                 |  |
| 223         | 51,05        | 6,9          | 20                | 0,018            | 3,017                | 0,0537                      |                 |  |
| 220         | 47,05        | 13,8         | 20                | 0,018            | 2,964                | 0,0541                      |                 |  |
| 216         | 43,22        | 20,7         | 20                | 0,017            | 2,908                | 0,0546                      |                 |  |
| 211         | 39,60        | 27,6         | 20                | 0,017            | 2,848                | 0,0550                      |                 |  |
| 205         | 36,23        | 34,5         | 20,1              | 0,017            | 2,787                | 0,0555                      |                 |  |
| 198         | 33,15        | 41,4         | 20,2              | 0,017            | 2,725                | 0,0558                      |                 |  |
| 190         | 30,40        | 48,3         | 20,3              | 0,017            | 2,664                | 0,0559                      |                 |  |
| 180         | 28,01        | 55,1         | 20,5              | 0,016            | 2,606                | 0,0557                      |                 |  |
| 168         | 26,02        | 62,0         | 20,9              | 0,016            | 2,552                | 0,0552                      |                 |  |



Open HTRI and Input Summary sheet and enter data in red areas

Xist - [Input] - untitled2 - Input Summary

**Input Summary**

Case Mode: **Rating** (Simulation, Design)

Exchanger Configuration: Exchanger service: **Generic Shell and Tube**

Process Conditions:

|                    |           |   |           |   |                       |
|--------------------|-----------|---|-----------|---|-----------------------|
| Flow rate          | Hot Shell |   | Cold Tube |   | kg/hr                 |
| Inlet/outlet Y     |           | / |           | / | Weight fraction vapor |
| Inlet/outlet T     |           | / |           | / | C                     |
| Inlet P/allow dP   |           | / |           | / | bar-G / bar           |
| Fouling resistance |           |   |           |   | m <sup>2</sup> -K/W   |

Shell Geometry: TEMA type: A E S; ID: mm; Orientation: Horizontal; Hot fluid: **Shellside**

Baffle Geometry: Type: Single segmental; Orientation: Program sets; Cut: % ID; Spacing: mm

Tube Geometry: Type: Plain; Wall thickness: mm; Length: 6.096 m; Layout angle: 30 degrees; Tube OD: 25.4 mm; Tubepasses: 1; Pitch: mm; Tubecount:

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Bottom Bar: Input, Reports, Graphs, Drawings, Shells-in-Series, Design, Session

Xist 6.00

Xist - [Input] - untitled3 - Input Summary-Geometry

**Input Summary**

**Geometry**

Shell Geometry: TEMA type: **B** E T; ID: 1400 mm; Orientation: **Horizontal**; Hot fluid: Shellside

Baffle Geometry: Type: Single segmental; Orientation: Program sets; Cut: 25 % ID; Spacing: 400 mm

Tube Geometry: Type: Plain; Wall thickness: 2.108 mm; Length: 6.096 m; Layout angle: 30 degrees; Tube OD: 25.4 mm; Tubepasses: 1; Pitch: 31.75 mm; Tubecount:

Navigation: << Previous, Next >>

Bottom Bar: Input, Reports, Graphs, Drawings, Shells-in-Series, Design, Session

Xist 6.00



Enter operating data in process sheet in red areas

The screenshot shows the 'Input Summary-Process' window in Xist 6.00. The window is divided into 'Hot Fluid' and 'Cold Fluid' sections. Red boxes highlight the input fields for fluid names, phases, flow rates, inlet/outlet fractions, temperatures, pressures, fouling resistance, and fouling layer thickness. The 'Duty/flow multiplier' is also highlighted with a red box.

|                         | Hot Fluid  | Cold Fluid                   |
|-------------------------|------------|------------------------------|
| Fluid name              | MPS        | NGS                          |
| Phase                   | Condensing | Boiling                      |
| Flow rate               | 255864     | 588608 kg/hr                 |
| Inlet fraction vapor    | 1          | 0.2602 weight fraction vapor |
| Outlet fraction vapor   | 0          | 0.552 weight fraction vapor  |
| Inlet temperature       | 240        | 168 C                        |
| Outlet temperature      | 240        | C                            |
| Inlet pressure          | 32.7       | 43.3 bar-G                   |
| Allowable pressure drop | 0.1        | 0.1 bar                      |
| Fouling resistance      | 0.00025    | 0.00017 m <sup>2</sup> -K/W  |
| Fouling layer thickness |            | mm                           |
| Exchanger duty          |            | MegaWatts                    |
| Duty/flow multiplier    | 1          |                              |



Enter heating and cooling table data in hot and cold fluid properties in red areas

Xist - [Input] - T-6001.Topsoe Exact.htri - Input Summary-Hot Fluid Properties

Fluid name:

Fluid compressibility:

Physical Property Input Option:

- Mixture properties via grid
- Component by component
- Component and grid properties

Heat Release Input Method:

- User specified
- Specified dew/bubble point
- Program calculated

Composition Units:

- Mass
- Moles

Flash Type:

- Differential
- Integral

Property Options:

Temperature interpolation:

Property Generator...  
Property Worksheet...

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Input Reports Graphs Drawings Shells-in-Series Design Session

Xist 6.00

Xist - [Input] - T-6001.Topsoe Exact.htri - Input Summary-Hot Fluid Properties-T & P

| Pressure       | bar-G | 32.7 | Profile 1 | Profile 2 | Profile 3 | Profile 4 | Profile 5 |
|----------------|-------|------|-----------|-----------|-----------|-----------|-----------|
| Temperature 1  | C     | 240  |           |           |           |           |           |
| Temperature 2  | C     | 240  |           |           |           |           |           |
| Temperature 3  | C     | 240  |           |           |           |           |           |
| Temperature 4  | C     | 240  |           |           |           |           |           |
| Temperature 5  | C     | 240  |           |           |           |           |           |
| Temperature 6  | C     | 240  |           |           |           |           |           |
| Temperature 7  | C     | 240  |           |           |           |           |           |
| Temperature 8  | C     | 240  |           |           |           |           |           |
| Temperature 9  | C     | 240  |           |           |           |           |           |
| Temperature 10 | C     | 240  |           |           |           |           |           |
| Temperature 11 | C     |      |           |           |           |           |           |
| Temperature 12 | C     |      |           |           |           |           |           |
| Temperature 13 | C     |      |           |           |           |           |           |
| Temperature 14 | C     |      |           |           |           |           |           |
| Temperature 15 | C     |      |           |           |           |           |           |
| Temperature 16 | C     |      |           |           |           |           |           |
| Temperature 17 | C     |      |           |           |           |           |           |
| Temperature 18 | C     |      |           |           |           |           |           |
| Temperature 19 | C     |      |           |           |           |           |           |
| Temperature 20 | C     |      |           |           |           |           |           |
| Temperature 21 | C     |      |           |           |           |           |           |
| Temperature 22 | C     |      |           |           |           |           |           |
| Temperature 23 | C     |      |           |           |           |           |           |

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Clear All Temperature Data Property Worksheet...

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Xist 6.00



Xist - [Input] - T-6001.Topsoe Exact.htri - Input Summary-Hot Fluid Properties-T & P

Pressure bar-G 32.7

|                |   | Profile 1 | Profile 2 | Profile 3 | Profile 4 | Profile 5 |
|----------------|---|-----------|-----------|-----------|-----------|-----------|
| Temperature 1  | C | 240       |           |           |           |           |
| Temperature 2  | C | 240       |           |           |           |           |
| Temperature 3  | C | 240       |           |           |           |           |
| Temperature 4  | C | 240       |           |           |           |           |
| Temperature 5  | C | 240       |           |           |           |           |
| Temperature 6  | C | 240       |           |           |           |           |
| Temperature 7  | C | 240       |           |           |           |           |
| Temperature 8  | C | 240       |           |           |           |           |
| Temperature 9  | C | 240       |           |           |           |           |
| Temperature 10 | C | 240       |           |           |           |           |
| Temperature 11 | C |           |           |           |           |           |
| Temperature 12 | C |           |           |           |           |           |
| Temperature 13 | C |           |           |           |           |           |
| Temperature 14 | C |           |           |           |           |           |
| Temperature 15 | C |           |           |           |           |           |
| Temperature 16 | C |           |           |           |           |           |
| Temperature 17 | C |           |           |           |           |           |
| Temperature 18 | C |           |           |           |           |           |
| Temperature 19 | C |           |           |           |           |           |
| Temperature 20 | C |           |           |           |           |           |
| Temperature 21 | C |           |           |           |           |           |
| Temperature 22 | C |           |           |           |           |           |
| Temperature 23 | C |           |           |           |           |           |

Clear All Temperature Data Property Worksheet...

Input Reports Graphs Drawings Shells-in-Series Design Session Xist 6.00

Xist - [Input] - T-6001.Topsoe Exact.htri - Input Summary-Hot Fluid Properties-Heat Release

Heat release entered as: Total duty from inlet based on flow of 255864 kg/hr

Pressure Profile 1 - 32.700, bar-G

| Temperature C | Duty Watts | Weight Fraction Vapor |
|---------------|------------|-----------------------|
| 240.00        | 0          | 1                     |
| 240.00        | -6900000   | 0.889                 |
| 240.00        | -1.38e+7   | 0.7778                |
| 240.00        | -2.07e+7   | 0.6667                |
| 240.00        | -2.76e+7   | 0.5556                |
| 240.00        | -3.45e+7   | 0.4444                |
| 240.00        | -4.14e+7   | 0.3333                |
| 240.00        | -4.83e+7   | 0.2222                |
| 240.00        | -5.51e+7   | 0.1111                |
| 240.00        | -6.2e+7    | 0                     |

Clear All Heat Release Data Property Worksheet...

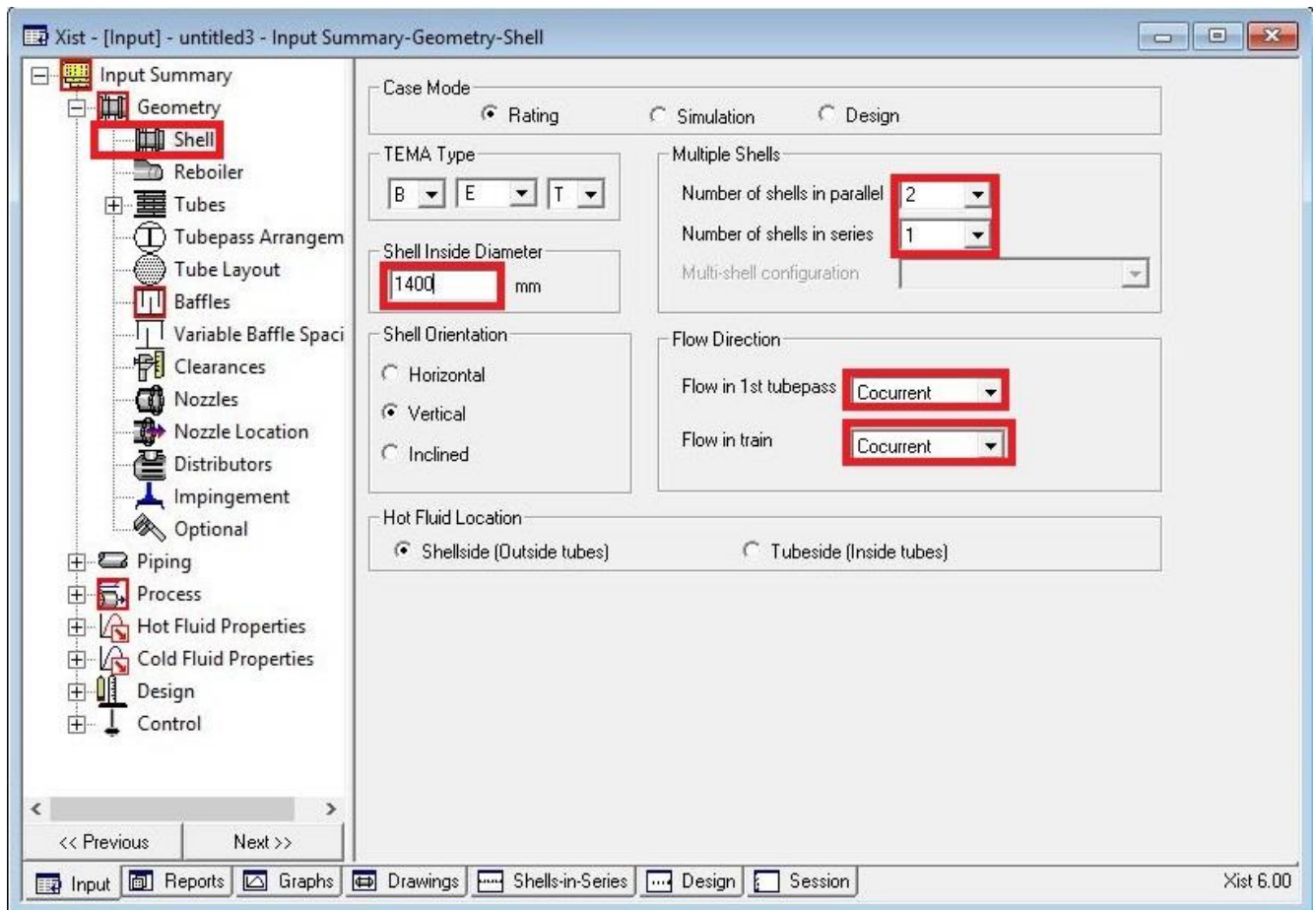
Input Reports Graphs Drawings Shells-in-Series Design Session Xist 6.00



Put shell info in shell sheet in red areas

Note:

- 1. Initially estimate shell ID between 1.5-3 times tube-side pipeline ID, here it is 18 inch so first estimation would be 55 inch.
- 2. Because of its capacity two heat exchangers in parallel are selected.
- 3. Cocurrent direction is considered as flow direction since the orientation is vertical it is solely viable for MPS to enter from top to be condensed at bottom and the same happens to water in tube to be flowed because of gravity.







In Reboiler Sheet do not enter an input

Xist - [Input] - E-5010.htri - Input Summary-Geometry-Reboiler

Input Summary

- Geometry
  - Shell
  - Reboiler**
  - Tubes
  - Tube Pass Arrang
  - Tube Layout
  - Baffles
  - Variable Baffle Sp
  - Clearances
  - Nozzles
  - Nozzle Location
  - Distributors
  - Impingement
  - Optional
- Piping
- Process
- Hot Fluid Properties
  - T & P
  - Heat Release
  - Property Grid
  - Components
  - Dew/Bubble
- Cold Fluid Properties

Reboiler Data

Reboiler type: **No piping specified**

Bundle diameter: [ ] mm

Kettle diameter: [ ] mm

Liquid level height/bundle diameter: [ ]

Entrainment ratio: [ ] kg liquid/kg vapor

Number of boiling components: [ ]

Required liquid static head: [ ] m

Inlet Pressure Location

- At inlet nozzle
- At column bottom
- At top of bundle

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Xist 6.00

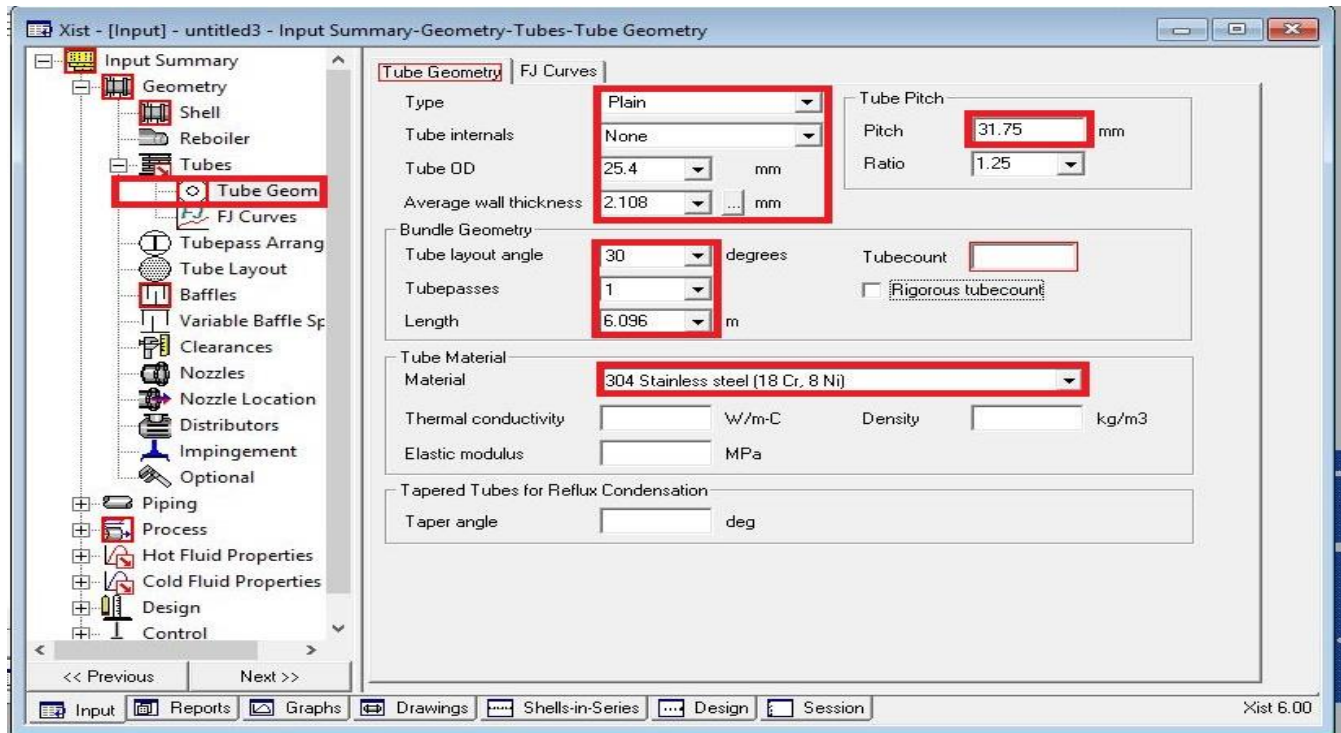


Put Tube mechanical data

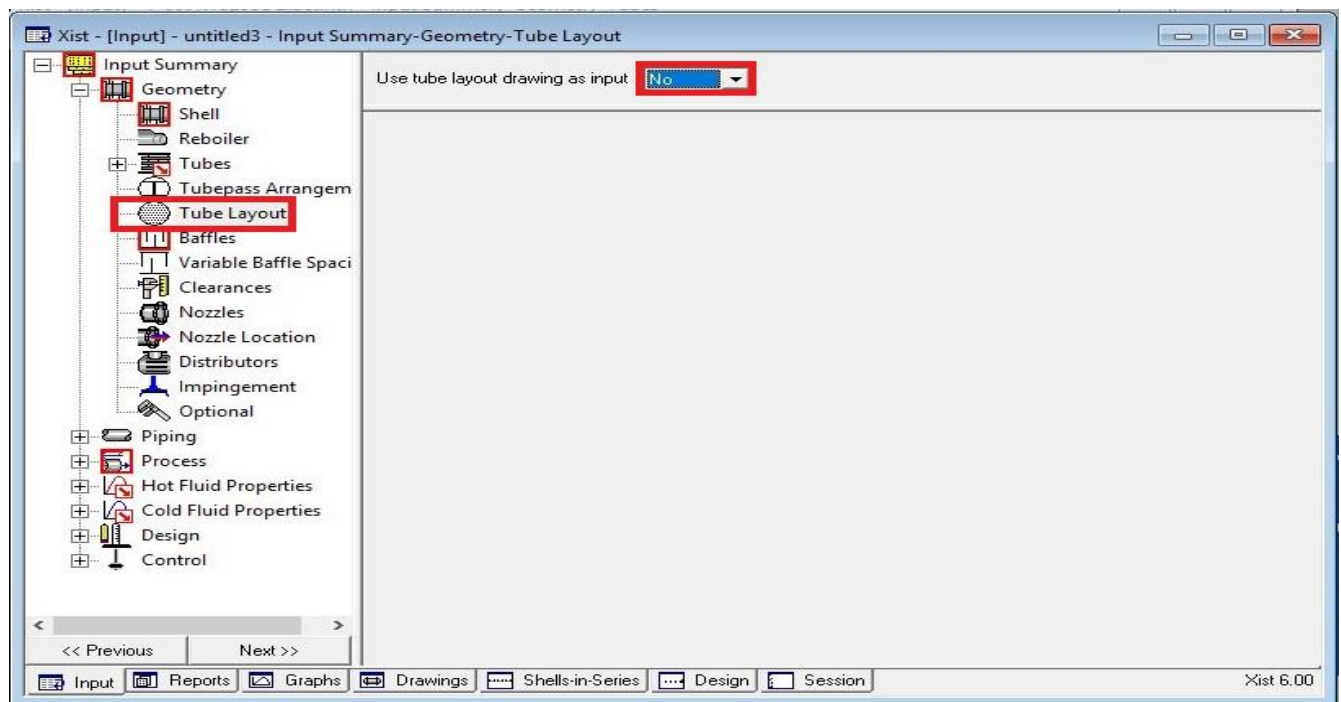
- Note that since mixing between water and natural gas is going to happen, tube with 25.4 OD is selected
- Since Tube material is SS due to presence of CO<sub>2</sub>, Tube thickness 2.11 is selected according to table below
- Select Pitch 31.7 to pass TEMA R.2.5

**Table 1.3** Typical diameters, thicknesses and pitch arrangement of tubes

| Tube outside diameter |   | mm     | 15.88           | 19.05           | 25.40          | 31.75           |
|-----------------------|---|--------|-----------------|-----------------|----------------|-----------------|
|                       |   | in     | $\frac{5}{8}$   | $\frac{3}{4}$   | 1              | $1\frac{1}{4}$  |
| Tube thickness        | Carbon and low-alloy steels                           | mm     | 1.65            | 2.11            | 2.77           | 3.40            |
|                       |   | in     | 0.065           | 0.083           | 0.109          | 0.134           |
|                       |   | b.w.g. | 16              | 14              | 12             | 10              |
|                       | Stainless steels, aluminium, copper and nickel alloys | mm     | 1.24            | 1.65            | 2.11           | 2.77            |
|                       |   | in     | 0.049           | 0.065           | 0.083          | 0.109           |
|                       |   | b.w.g. | 18              | 16              | 14             | 12              |
| Minimum tube pitch    | Clean service (30° or 60°)                            | mm     | 19.84           | 23.81           | 31.75          | 39.69           |
|                       |   | in     | $\frac{25}{32}$ | $\frac{15}{16}$ | $1\frac{1}{4}$ | $1\frac{5}{16}$ |
|                       | Fouling service (45° or 90°)                          | mm     | 22.22           | 25.40           | 31.75          | 39.69           |
|                       |   | in     | $\frac{7}{8}$   | 1               | $1\frac{1}{4}$ | $1\frac{5}{16}$ |



Act like below





Put baffle info in baffle sheet in red areas like below

The screenshot shows the 'Baffles' configuration window in Xist 6.00. The window title is 'Xist - [Input] - untitled3 - Input Summary-Geometry-Baffles'. The left sidebar shows a tree view with 'Baffles' selected. The main panel is divided into three sections:

- Baffle Geometry:**
  - Type: Single segmental (dropdown)
  - Cut orientation: Program sets (dropdown)
  - Crosspasses: [ ]
  - Radio buttons:  Cut,  Window area
  - Input: 25 % of shell ID
- Baffle Spacing:**
  - Central: 400 mm
  - Variable:
  - Inlet spacing: [ ] mm
  - Outlet spacing: [ ] mm
- Miscellaneous:**
  - Double-seg. overlap: [ ] Tuberows
  - Thickness: [ ] mm
  - Thickness at tube hole: [ ] mm
  - Support plates / baffle space: [ ] [ ]
  - Windows cut from baffles: No (dropdown)
  - Distance from tangent to last baffle: [ ] mm
  - Rho-V2 for NTIW cut design: [ ] kg/m-s2
  - Central pipe OD: [ ] mm
  - Helical baffle crossing fraction: [ ]

At the bottom, there are navigation buttons: << Previous, Next >>, and a taskbar with: Input, Reports, Graphs, Drawings, Shells-in-Series, Design, Session. The version number 'Xist 6.00' is in the bottom right corner.



Act exactly like below for impingement sheet and Clearance

Xist - [Input] - untitled3 - Input Summary-Geometry-Impingement

**Input Summary**

- Geometry
  - Shell
  - Reboiler
  - Tubes
  - Tube Pass Arrangement
  - Tube Layout
  - Baffles
  - Variable Baffle Spacing
  - Clearances
  - Nozzles
  - Nozzle Location
  - Distributors
  - Impingement**
  - Optional
- Piping
- Process
- Hot Fluid Properties
- Cold Fluid Properties
- Design
- Control

**Impingement Device**

Impingement device present: **If required by TEMA**

Impingement type: Circular plate

Rho-V<sup>2</sup> for impingement: \_\_\_\_\_ kg/m-s<sup>2</sup>

Plate/nozzle diameter: \_\_\_\_\_ plate diameter/nozzle diameter ratio

Plate thickness: \_\_\_\_\_ mm

Plate height above tubes: \_\_\_\_\_ mm

Plate length: \_\_\_\_\_ mm

Plate width: \_\_\_\_\_ mm

Rows of rods: \_\_\_\_\_

Rod diameter: \_\_\_\_\_ mm

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Xist 6.00

Xist - [Input] - E-5010.htri - Input Summary-Geometry-Clearances

**Input Summary**

- Geometry
  - Shell
  - Reboiler
  - Tubes
  - Tube Pass Arrangement
  - Tube Layout
  - Baffles
  - Variable Baffle Spacing
  - Clearances**
  - Nozzles
  - Nozzle Location
  - Distributors
  - Impingement
  - Optional
- Piping
- Process
- Hot Fluid Properties
  - T & P
  - Heat Release
  - Property Grid
  - Components
  - Dew/Bubble
- Cold Fluid Properties

**Clearances**

Pairs of sealing strips: Program Set

Seal strip width: \_\_\_\_\_ mm

Seal strip clearance: \_\_\_\_\_ mm

Baffle clearance type: TEMA

**Block Bypass Streams**

A stream     F stream

E stream

**Passlane Seal Device**

Seal device type: Rods

Number of rods: Program Set

Rod diameter: \_\_\_\_\_ mm

**Diametral Clearances**

Tube-to-baffle: \_\_\_\_\_ mm

Baffle-to-shell: \_\_\_\_\_ mm

Bundle-to-shell: \_\_\_\_\_ mm

**Height under Nozzles**

Inlet: \_\_\_\_\_ mm

Outlet: \_\_\_\_\_ mm

Liquid outlet: \_\_\_\_\_ mm

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Xist 6.00



Enter nozzle info from piping info

Xist - [Input] - T-6001.Topsoe Exact.htri - Input Summary-Geometry-Nozzles

**Input Summary**

- Geometry
  - Shell
  - Reboiler
  - Tubes
  - Tube Pass Arrang
  - Tube Layout
  - Baffles
  - Variable Baffle Sp
  - Clearances
  - Nozzles**
  - Nozzle Location
  - Distributors
  - Impingement
  - Optional
- Piping
- Process
- Hot Fluid Properties
  - T & P
  - Heat Release
  - Property Grid
  - Components
  - Dew/Bubble

**Nozzles Configuration:**

| Parameter               | Shellside          | Tubeside           |
|-------------------------|--------------------|--------------------|
| Nozzle standard         | 01-ANSI_B36_10.TAE | 02-ANSI_B36_19.TAE |
| Nozzle schedule         | STD                | Sch 5S             |
| Inlet ID                | 304.801            | 448.819 mm         |
| Number at each position | 1                  | 1                  |
| Outlet ID               | 304.801            | 498.451 mm         |
| Number at each position | 1                  | 1                  |
| Liquid outlet ID        |                    |                    |
| Inlet type              |                    | Axial              |
| Outlet type             |                    | Same as inlet      |

**Shellside Nozzle Locations:**

- Radial position on shell of inlet nozzle: Top
- Longitudinal position on shell of inlet nozzle: At front head
- Radial position on shell of outlet nozzle: Opposite side
- Location of nozzle at U-bend: At U-bend

Navigation: << Previous, Next >>

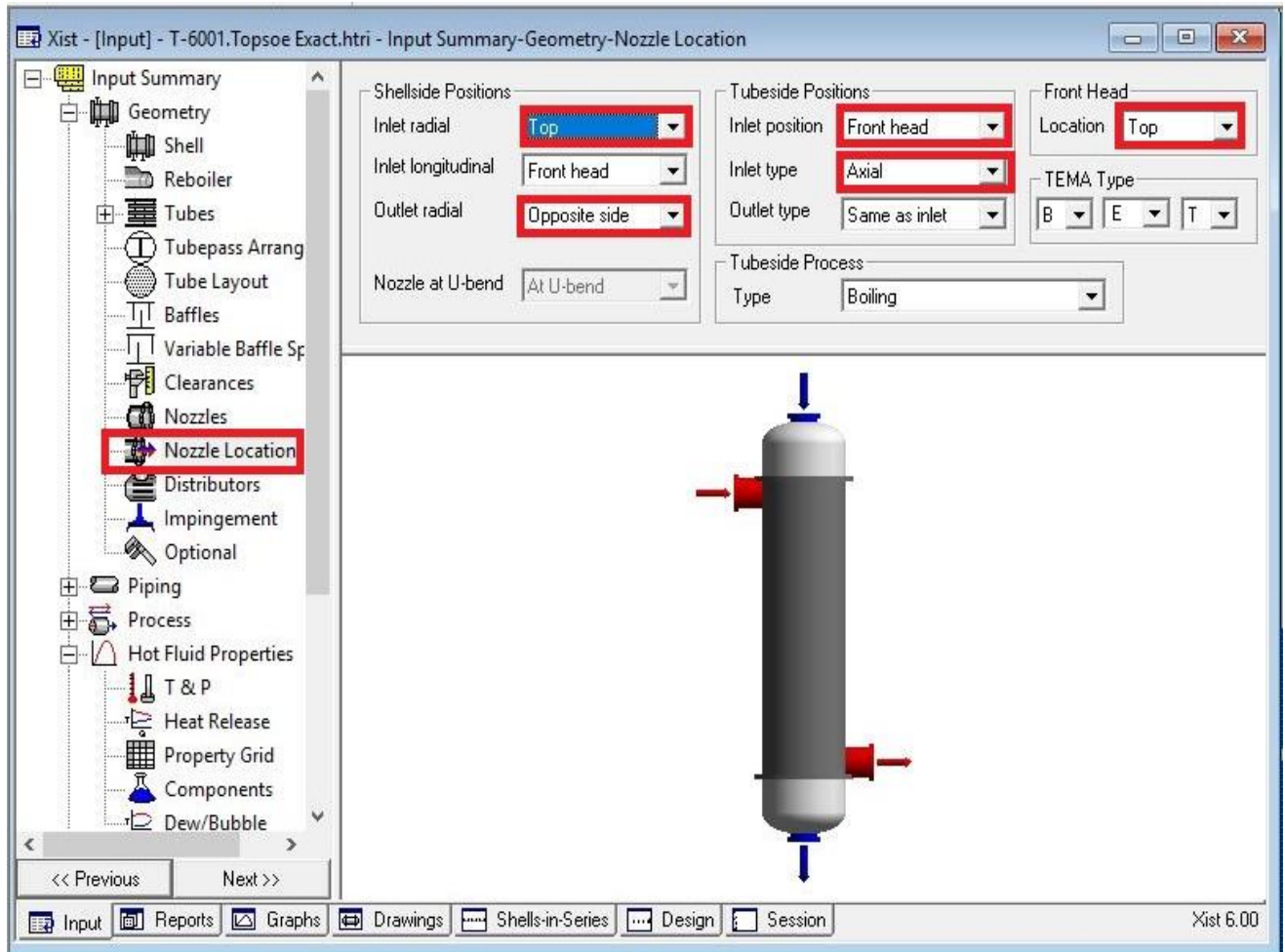
Bottom Bar: Input, Reports, Graphs, Drawings, Shells-in-Series, Design, Session

Version: Xist 6.00



Set nozzle location

- Remember that first sketch is horizontal one but due to some warnings vertical one is selected and therefore the last sketch is put below.





Results:

Now run and it results with following run messages

Xist - [Reports] - For test.htri - Output Summary

Output Summary

- Run Log
- Data Check Message
- Runtime Messages**
- Final Results
- Shellside Monitor
- Tubeside Monitor
- Vibration
- Rating Data Sheet
- TEMA Spec Sheet
- Property Monitor
- Stream Properties
- Input Reprint

Rating - Horizontal Cocurrent Flow TEMA BET Shell With Single-Segmental Baffles  
Unit ID 100 - **WARNING MESSAGES (CALCULATIONS CONTINUE)**

Wavy stratified flow and partial dryout are expected in horizontal tubes. We recommend increasing flow rate or reducing tube diameter to avoid stratified flow because of its poor heat transfer performance and high uncertainty in predicting boiling heat transfer coefficients in this flow regime.

The critical temperature for the boiling fluid was not entered and has been set to 1000R (default value) for calculation of the mixture correction factor.

The physical properties of the hot fluid have been extrapolated beyond the valid temperature range. Check calculated values.

WARNING-Crossflow velocity at baffle tip exceeds critical velocity, indicating a probability of fluidelastic instability and flow-induced vibration damage. If present, fluidelastic instability can lead to large amplitude vibration and tube damage.

Crossflow velocity exceeds 80% of critical velocity, indicating that fluidelastic instability and flow-induced vibration damage are possible. Fluidelastic instability can lead to large amplitude vibration and tube damage.

WARNING-Bundle entrance velocity exceeds critical velocity, indicating a probability of fluidelastic instability and flow-induced vibration damage. If present, fluidelastic instability can lead to large amplitude vibration and tube damage.

WARNING-Shell entrance velocity exceeds critical velocity, indicating a probability of fluidelastic instability and flow-induced vibration damage. If present, fluidelastic instability can lead to large amplitude vibration and tube damage.

Xvib can be used for a more detailed analysis of individual tubes in the bundle.

The B-stream flow fraction is very low. Check the design.

Transition boiling has been predicted in at least one increment on the tube side. To confirm, check tubeside monitor for increments in transition boiling.

The pressure profiles given for the cold fluid do not cover the operating pressure range of the heat exchanger. The vaporization profile inside of the exchanger for this run may not be accurate since heat release and fluid properties have been extrapolated. It is recommended that the maximum and minimum system pressures be used as reference pressures.

Setting plan error: Channel design pressure is 797.7 and shell design pressure is 652.7 Maximum allowed is 625 psi.

Input Reports Graphs Drawings Shells-in-Series Design Session

Xist 6.00

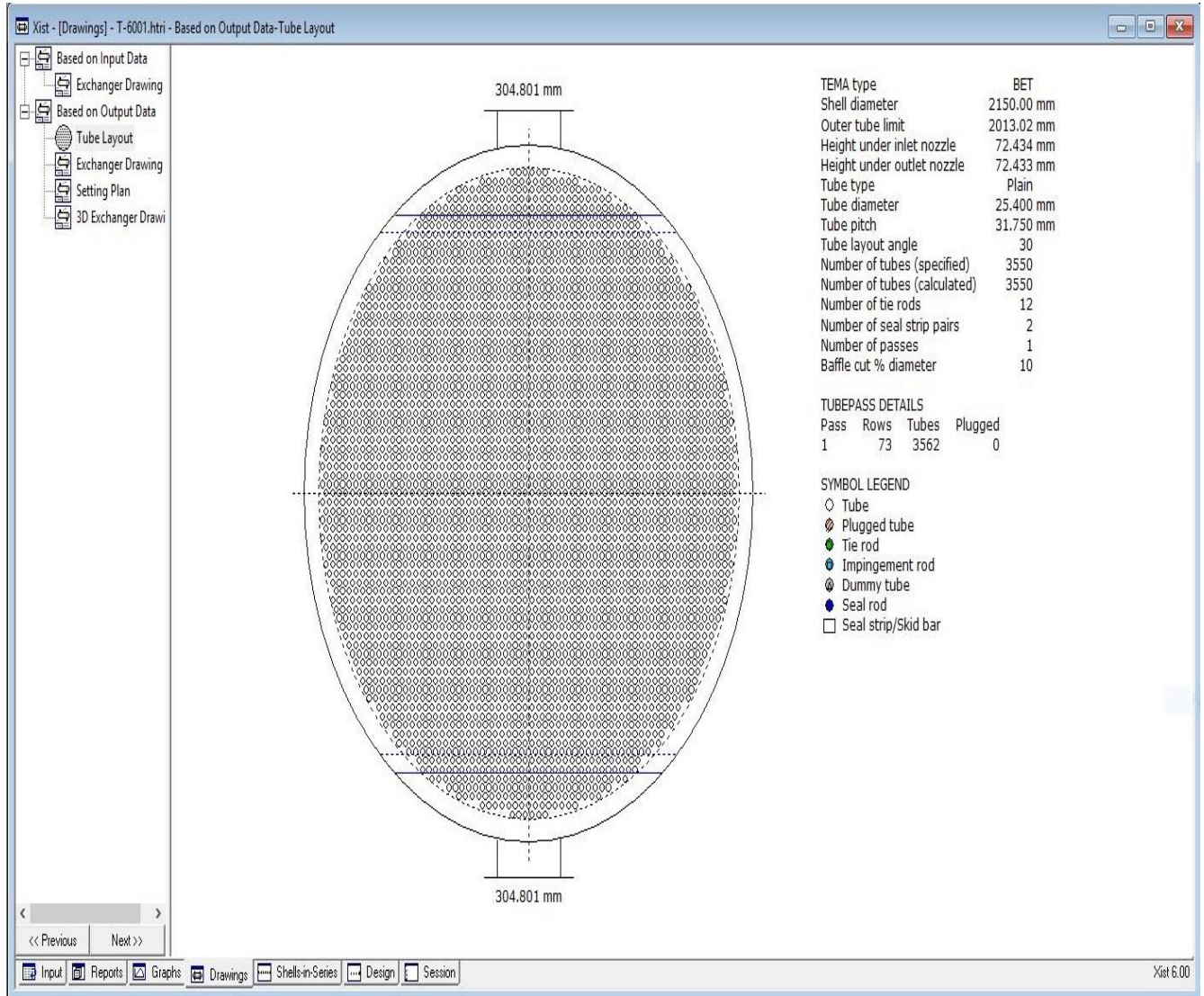




- ▶ Due to flow regime vertical orientation is selected and the warning disappears.
- ▶ By looking at oversize factor and  $dp$  around shell side it appears that shell ID should be increased.
- ▶ At first it is increased to 1700 mm and then to 2000. The resultant is that  $dp$  decreases to a good point but not satisfactory but oversize factor reaches to -30 %. For now, it seems better to increase tube length 9.75m which results in an increase in oversize factor by 32.5 % but  $dp$  increases to 0.25. As for next step the segmental baffle is changed to double segmental baffle to decrease  $dp$  to 0.07. Cross-pass is decreased from 25 to 20 to not only pass minimum TEMA baffle spacing limit but also increase B-stream.

Now it is time to increase oversize factor. For doing so at first shell ID is increased to 2150 and as a result, oversize factor increases to 4.5%. So, tube length is increased to 12.1 m to increase its oversize factor and this results in 17% oversize factor.

In order to eliminate two warnings in next pages about 800 tubes were eliminated and during elimination since the surface area is reduced the oversize factor is also reduced therefore tube length is increased to 13m to counteract that.





### Runtime Messages

Page 1

Released to the following HTRI Member Company:

*mekpco*  
*Behrouzi*

Xist E Ver. 6.00 8/10/2022 12:25 SN: Vals100+

**MEKPCO Units**

Rating - Vertical Cocurrent Flow TEMA BET Shell With Double-Segmental Baffles

#### Unit ID 100 - WARNING MESSAGES (CALCULATIONS CONTINUE)

Based on the existing correlations, some pressure recovery may be expected on the tube side. The pressure drop was set to zero for printout purposes.

**WARNING-Bundle entrance velocity exceeds critical velocity, indicating a probability of fluidelastic instability and flow-induced vibration damage. If present, fluidelastic instability can lead to large amplitude vibration and tube damage.**

**WARNING-Shell entrance velocity exceeds critical velocity, indicating a probability of fluidelastic instability and flow-induced vibration damage. If present, fluidelastic instability can lead to large amplitude vibration and tube damage.**

The areas in the window for multi-segmental baffles are not equal. Check the specified baffle cut and overlap. The program uses the average window area for calculating shellside pressure drop and heat transfer.

Transition boiling has been predicted in at least one increment on the tube side. To confirm, check tubeside monitor for increments in transition boiling.

The pressure profiles given for the cold fluid do not cover the operating pressure range of the heat exchanger. The vaporization profile inside of the exchanger for this run may not be accurate since heat release and fluid properties have been extrapolated. It is recommended that the maximum and minimum system pressures be used as reference pressures.

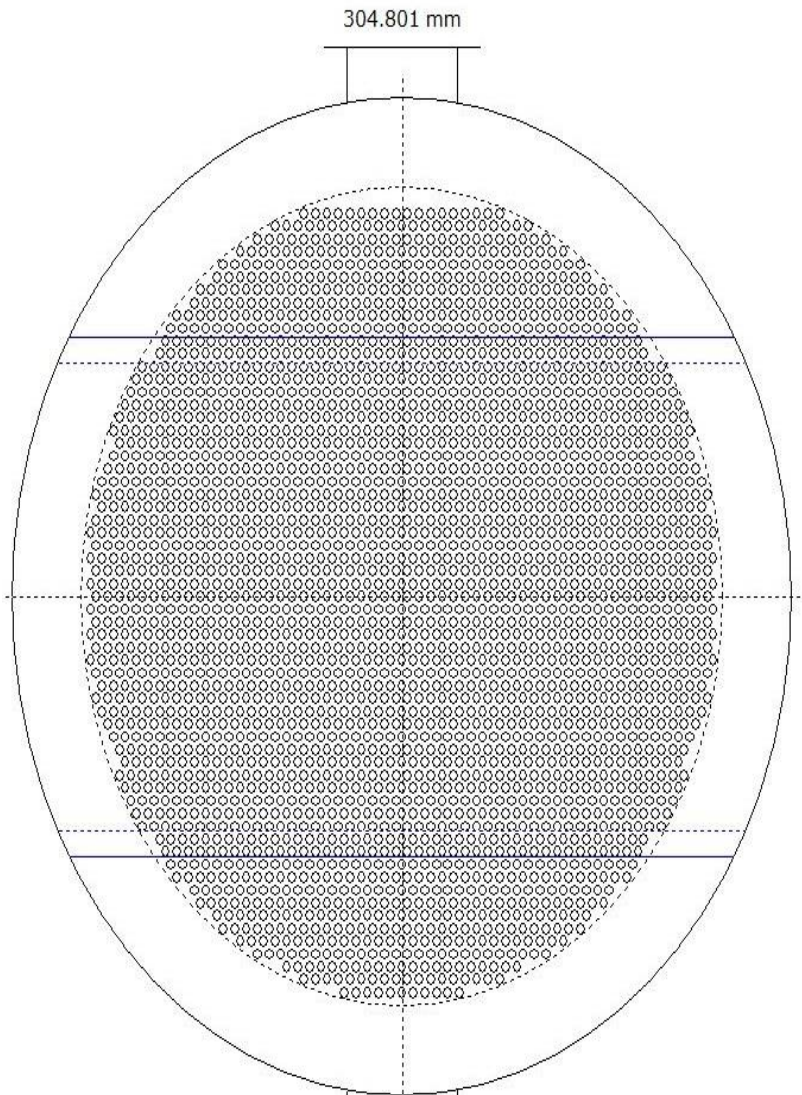
Setting plan error: Channel design pressure is 797.7 and shell design pressure is 652.7 Maximum allowed is 625 psi.



| <b>HTRI</b>   |                 | <b>Output Summary</b>                          |                    |               |                     | Page 1 |
|---|-----------------|--|--------------------|---------------|---------------------|--------|
|   |                 | Released to the following HTRI Member Company: |                    |               |                     |        |
|   |                 | <i>mekpco</i>                                  |                    |               |                     |        |
|   |                 | <i>Behrouzi</i>                                |                    |               |                     |        |
| Xist E Ver. 6.00 8/10/2022 12:25 SN: Vals100+                                 |                 |  |                    |               | <b>MEKPCO Units</b> |        |
| Rating - Vertical Cocurrent Flow TEMA BET Shell With Double-Segmental Baffles |                 |  |                    |               |                     |        |
| See Data Check Messages Report for Warning Messages.                          |                 |  |                    |               |                     |        |
| See Runtime Message Report for Warning Messages.                              |                 |  |                    |               |                     |        |
| Process Conditions  |                 | Hot Shellside                                  |                    | Cold Tubeside |                     |        |
| Fluid name  |                 |  | MPS                |               | NGS                 |        |
| Flow rate   | (kg/hr)         |  | 255865             |               | 588610              |        |
| Inlet/Outlet Y  | (Wt. frac vap.) | 1.000  | 0.000              | 0.260         | 0.552               |        |
| Inlet/Outlet T  | (Deg C)         | 240.00   | 240.00             | 168.00        | 226.00              |        |
| Inlet P/Avg   | (bar-G)         | 32.700   | 32.665             | 43.301        | 43.301              |        |
| dP/Allow.   | (bar)           | 0.071  | 0.100              | 0.000         | 0.100               |        |
| Fouling   | (m2-K/W)        |  | 0.000250           |               | 0.000170            |        |
| Exchanger Performance   |                 |  |                    |               |                     |        |
| Shell h   | (W/m2-K)        | 8542.09  | Actual U           | (W/m2-K)      | 382.48              |        |
| Tube h  | (W/m2-K)        | 624.89   | Required U         | (W/m2-K)      | 327.36              |        |
| Hot regime  | (--)            | Gravity  | Duty               | (MegaWatts)   | 61.9613             |        |
| Cold regime   | (--)            | Tran   | Area               | (m2)          | 6604.08             |        |
| EMTD  | (Deg C)         | 28.7   | Overdesign         | (%)           | 16.84               |        |
| Shell Geometry  |                 |  | Baffle Geometry    |               |                     |        |
| TEMA type   | (--)            | BET  | Baffle type        | (--)          | Double-Seg.         |        |
| Shell ID  | (mm)            | 2150.00  | Baffle cut         | (Pct Dia.)    | 10.00               |        |
| Series  | (--)            | 1  | Baffle orientation | (--)          | Perpend.            |        |
| Parallel  | (--)            | 2  | Central spacing    | (mm)          | 544.424             |        |
| Orientation   | (deg)           | 90.00  | Crosspasses        | (--)          | 20                  |        |
| Tube Geometry   |                 |  | Nozzles            |               |                     |        |
| Tube type   | (--)            | Plain  | Shell inlet        | (mm)          | 304.801             |        |
| Tube OD   | (mm)            | 25.400   | Shell outlet       | (mm)          | 304.801             |        |
| Length  | (m)             | 12.192   | Inlet height       | (mm)          | 72.434              |        |
| Pitch ratio   | (--)            | 1.2500   | Outlet height      | (mm)          | 72.433              |        |
| Layout  | (deg)           | 30   | Tube inlet         | (mm)          | 448.819             |        |
| Tubecount   | (--)            | 3550   | Tube outlet        | (mm)          | 498.451             |        |
| Tube Pass   | (--)            | 1  |                    |               |                     |        |



After eliminations of tubes, it results like below:



|                              |            |
|------------------------------|------------|
| TEMA type                    | BET        |
| Shell diameter               | 2150.00 mm |
| Outer tube limit             | 1766.29 mm |
| Height under inlet nozzle    | 237.612 mm |
| Height under outlet nozzle   | 209.714 mm |
| Tube type                    | Plain      |
| Tube diameter                | 25.400 mm  |
| Tube pitch                   | 31.750 mm  |
| Tube layout angle            | 30         |
| Number of tubes (specified)  | 2711       |
| Number of tubes (calculated) | 2711       |
| Number of tie rods           | 12         |
| Number of seal strip pairs   | 2          |
| Number of passes             | 1          |
| Baffle cut % diameter        | 24         |

TUBEPASS DETAILS

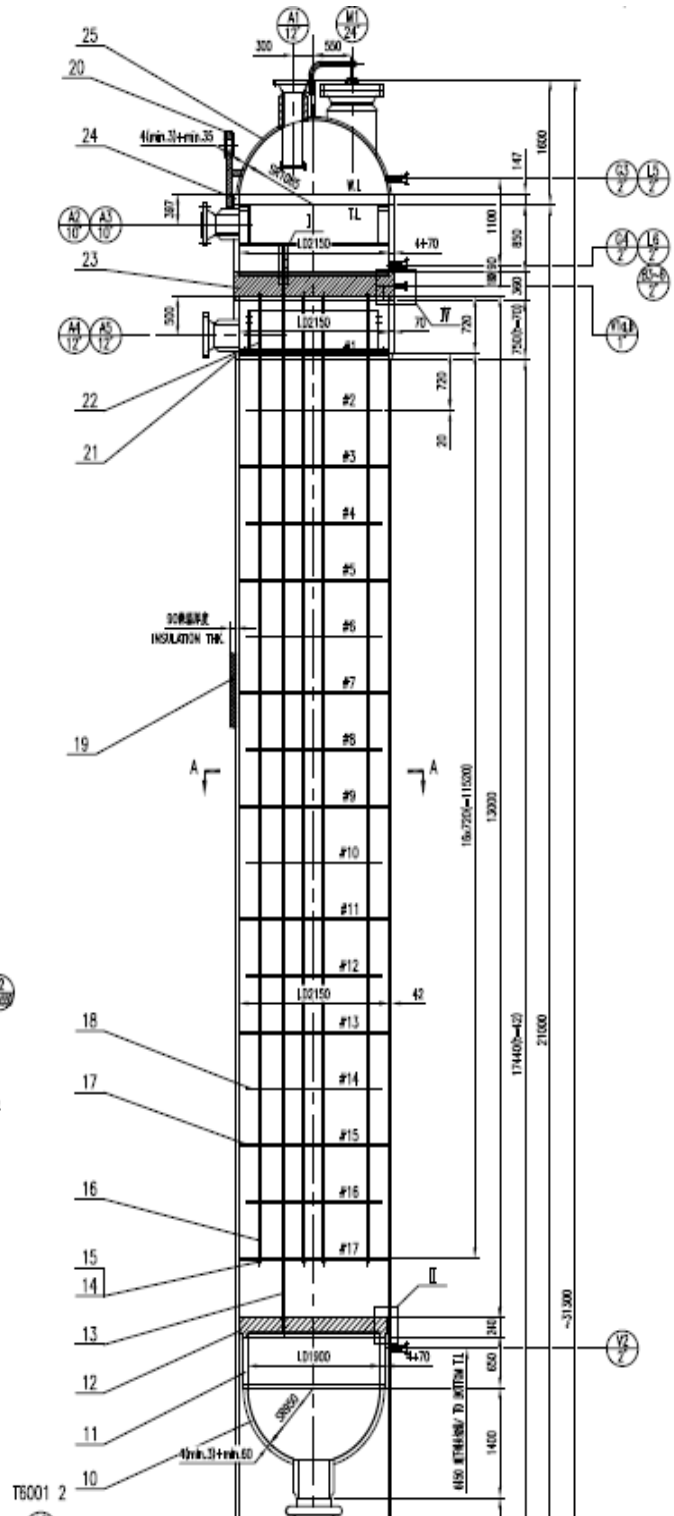
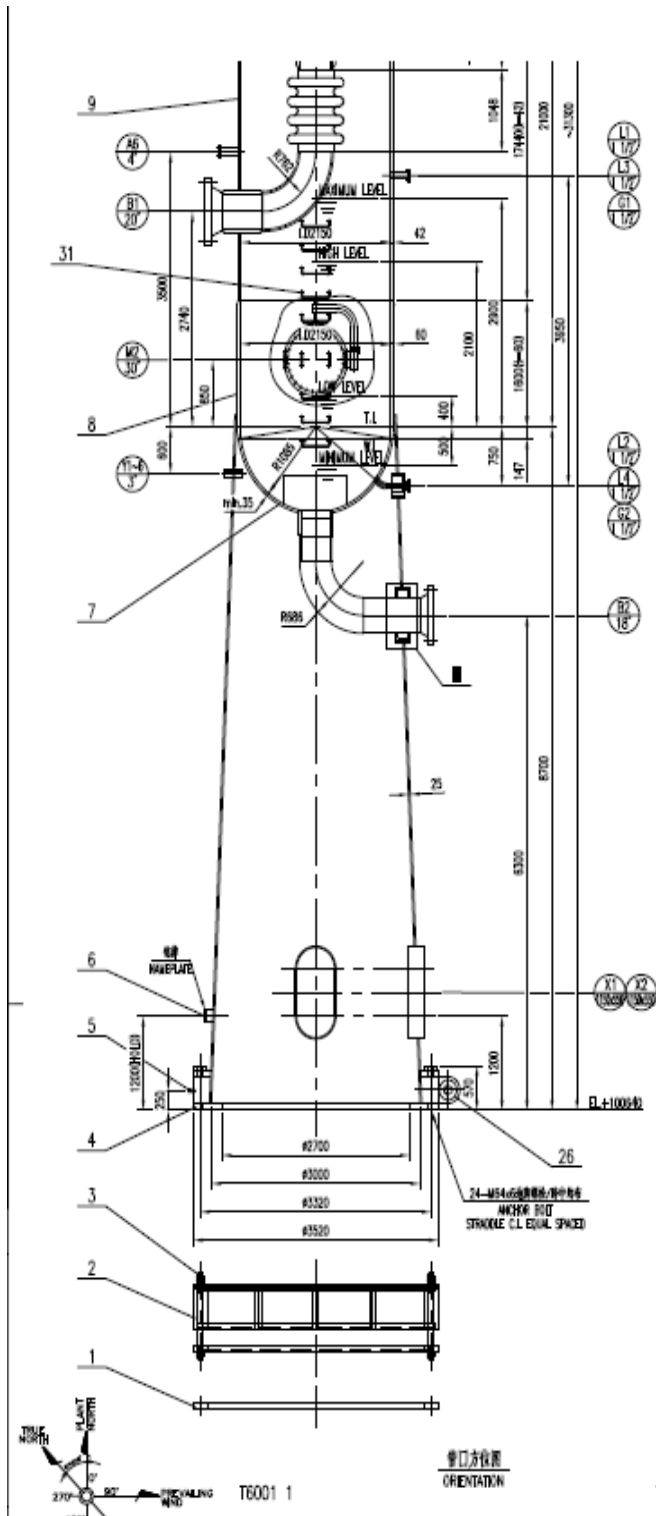
| Pass | Rows | Tubes | Plugged |
|------|------|-------|---------|
| 1    | 62   | 2723  | 0       |

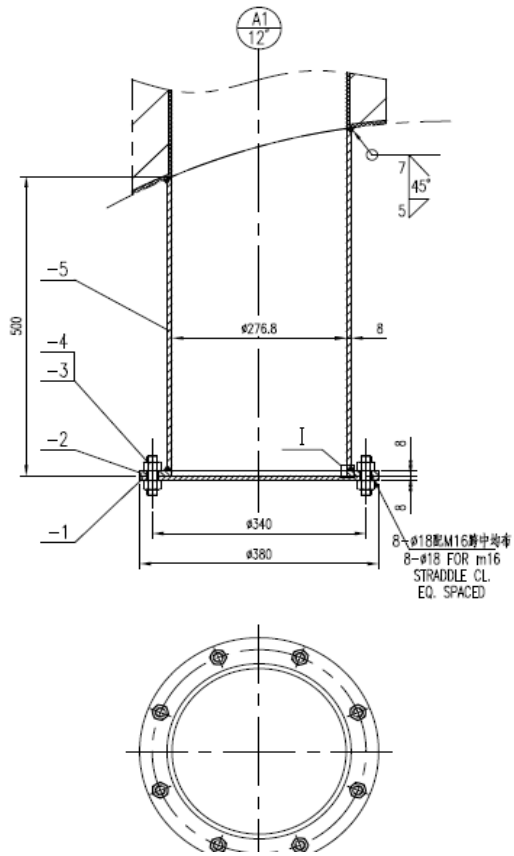
SYMBOL LEGEND

- Tube
- ⊗ Plugged tube
- Tie rod
- ⊕ Impingement rod
- ⊙ Dummy tube
- Seal rod
- Seal strip/Skid bar

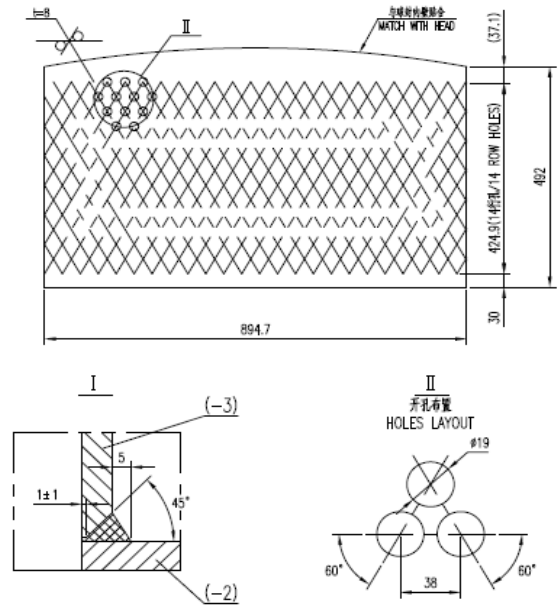


| <b>HTRI</b>   |                 | <b>Output Summary</b>                          |                    |                |                     | Page 1   |
|---|-----------------|--|--------------------|----------------|---------------------|----------|
|   |                 | Released to the following HTRI Member Company: |                    |                |                     |          |
|   |                 | <i>mekpco</i>                                  |                    |                |                     |          |
|   |                 | <i>Behrouzi</i>                                |                    |                |                     |          |
| Xist E Ver. 6.00 8/4/2022 14:48 SN: Vals100+                                  |                 |  |                    |                | <b>MEKPCO Units</b> |          |
| Rating - Vertical Cocurrent Flow TEMA BET Shell With Double-Segmental Baffles |                 |  |                    |                |                     |          |
| See Data Check Messages Report for Warning Messages.                          |                 |  |                    |                |                     |          |
| See Runtime Message Report for Warning Messages.                              |                 |  |                    |                |                     |          |
| Process Conditions  |                 | Hot Shellside                                  |                    | Cold Tubeside  |                     |          |
| Fluid name  |                 |  | MPS                |                |                     | NGS      |
| Flow rate   | (kg/hr)         |  | 255865             |                |                     | 588610   |
| Inlet/Outlet Y  | (Wt. frac vap.) | 1.000  | 0.000              | 0.260          |                     | 0.552    |
| Inlet/Outlet T  | (Deg C)         | 240.00   | 240.00             | 168.00         |                     | 226.00   |
| Inlet P/Avg   | (bar-G)         | 32.700   | 32.685             | 43.301         |                     | 43.301   |
| dP/Allow.   | (bar)           | 0.031  | 0.100              | 0.000          |                     | 0.100    |
| Fouling   | (m2-K/W)        |  | 0.000250           |                |                     | 0.000170 |
| Exchanger Performance   |                 |  |                    |                |                     |          |
| Shell h   | (W/m2-K)        | 8547.50  | Actual U           | (W/m2-K)       |                     | 437.67   |
| Tube h  | (W/m2-K)        | 754.51   | Required U         | (W/m2-K)       |                     | 401.61   |
| Hot regime  | (-)             | Gravity  | Duty               | (MegaWatts)    |                     | 61.9613  |
| Cold regime   | (-)             | Tran   | Area               | (m2)           |                     | 5392.86  |
| EMTD  | (Deg C)         | 28.6   | Overdesign         | (%)            |                     | 8.98     |
| Shell Geometry  |                 |  | Baffle Geometry    |                |                     |          |
| TEMA type   | (-)             | BET  | Baffle type        | (-)            | Double-Seg.         |          |
| Shell ID  | (mm)            | 2150.00  | Baffle cut         | (Pct Dia.)     | 24.00               |          |
| Series  | (-)             | 1  | Baffle orientation | (-)            | Perpend.            |          |
| Parallel  | (-)             | 2  | Central spacing    | (mm)           | 662.976             |          |
| Orientation   | (deg)           | 90.00  | Crosspasses        | (-)            | 18                  |          |
| Tube Geometry   |                 |  | Nozzles            |                |                     |          |
| Tube type   | (-)             | Plain  | Shell inlet        | (mm)           | 304.801             |          |
| Tube OD   | (mm)            | 25.400   | Shell outlet       | (mm)           | 304.801             |          |
| Length  | (m)             | 13.000   | Inlet height       | (mm)           | 237.612             |          |
| Pitch ratio   | (-)             | 1.2500   | Outlet height      | (mm)           | 209.714             |          |
| Layout  | (deg)           | 30   | Tube inlet         | (mm)           | 448.819             |          |
| Tubecount   | (-)             | 2711   | Tube outlet        | (mm)           | 498.451             |          |
| Tube Pass   | (-)             | 1  |                    |                |                     |          |
| Thermal Resistance, %   |                 | Velocities, m/s                                |                    | Flow Fractions |                     |          |
| Shell   | 5.12            | Shellside                                      | 2.06               | A              |                     | 0.016    |
| Tube  | 69.55           | Tubeside                                       | 1.81               | B              |                     | 0.840    |
| Fouling   | 19.86           | Crossflow                                      | 0.93               | C              |                     | 0.014    |
| Metal   | 5.46            | Window   | 0.82               | E              |                     | 0.130    |
|   |                 |  |                    | F              |                     | 0.000    |

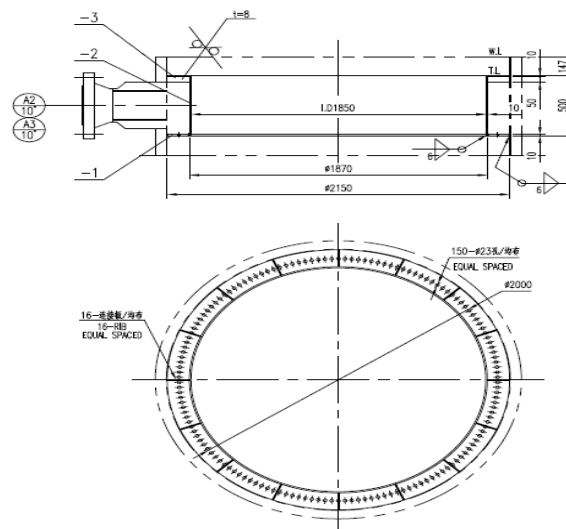




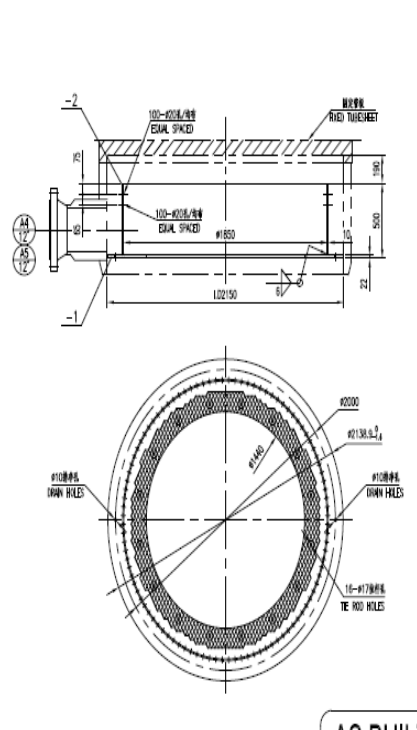
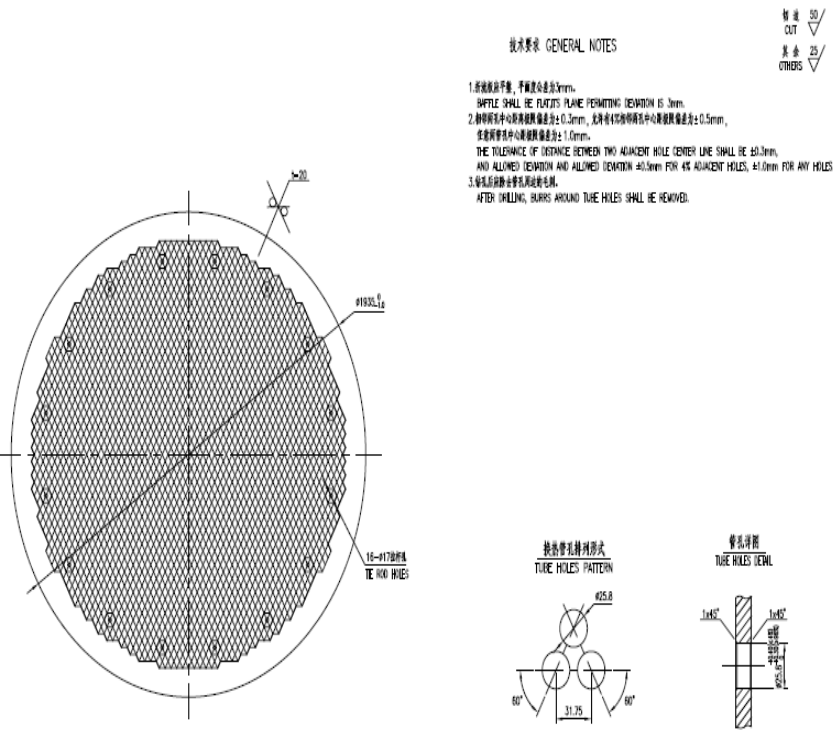
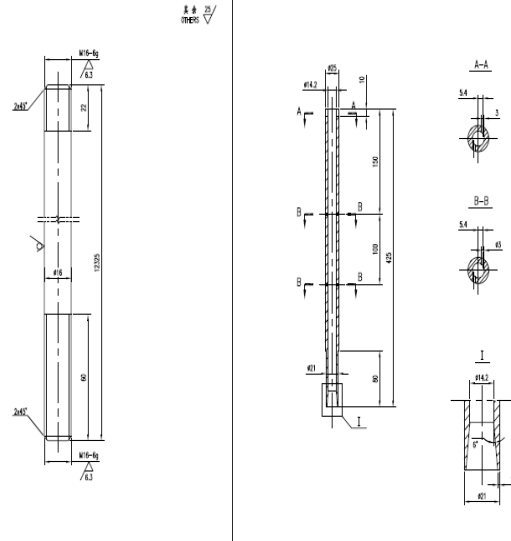
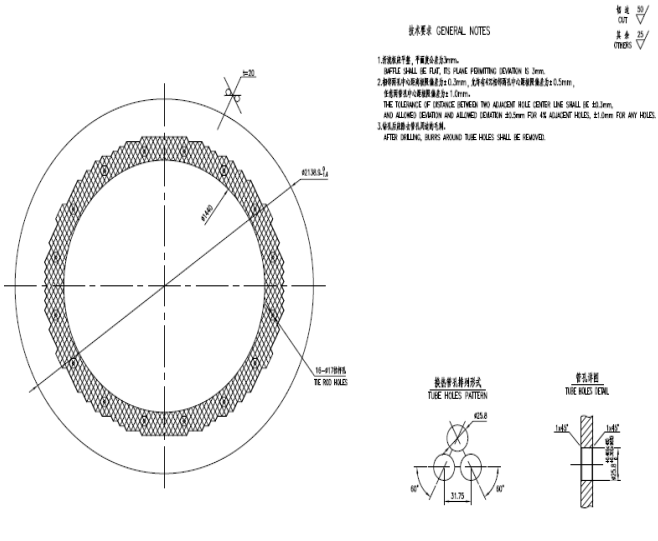
筛孔筒节 (PN-5) 展开图  
CYLINDER (PN-5) DETAIL



|    |   |    |              |      |
|----|---|----|--------------|------|
| -5 | 筛孔筒节 t=8<br>CYLINDER                                    | 1  | SA-240 304L  |      |
| -4 | ASME B18.2.4.6M-2010<br>重型螺母 M16<br>HEAVY HEX NUT       | 16 | SA-194 Gr.8  | 0.05 |
| -3 | ASME B18.31.1M-2008<br>全螺攻螺柱 M16x70<br>CONTINUOUS STUDS | 8  | SA-193 Gr.B8 | 0.11 |
| -2 | 环板 <math>\phi 380/\phi 276.8</math> t=8<br>CYLINDER     | 1  | SA-240 304L  |      |
| -1 | 盖板 <math>\phi 380 \times 8</math><br>COVER PLATE        | 1  | SA-240 304L  |      |







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