Education Institute for

Equipment & Process Design

Air-cooler Design and Principle

AE-5005

1.Process Specification

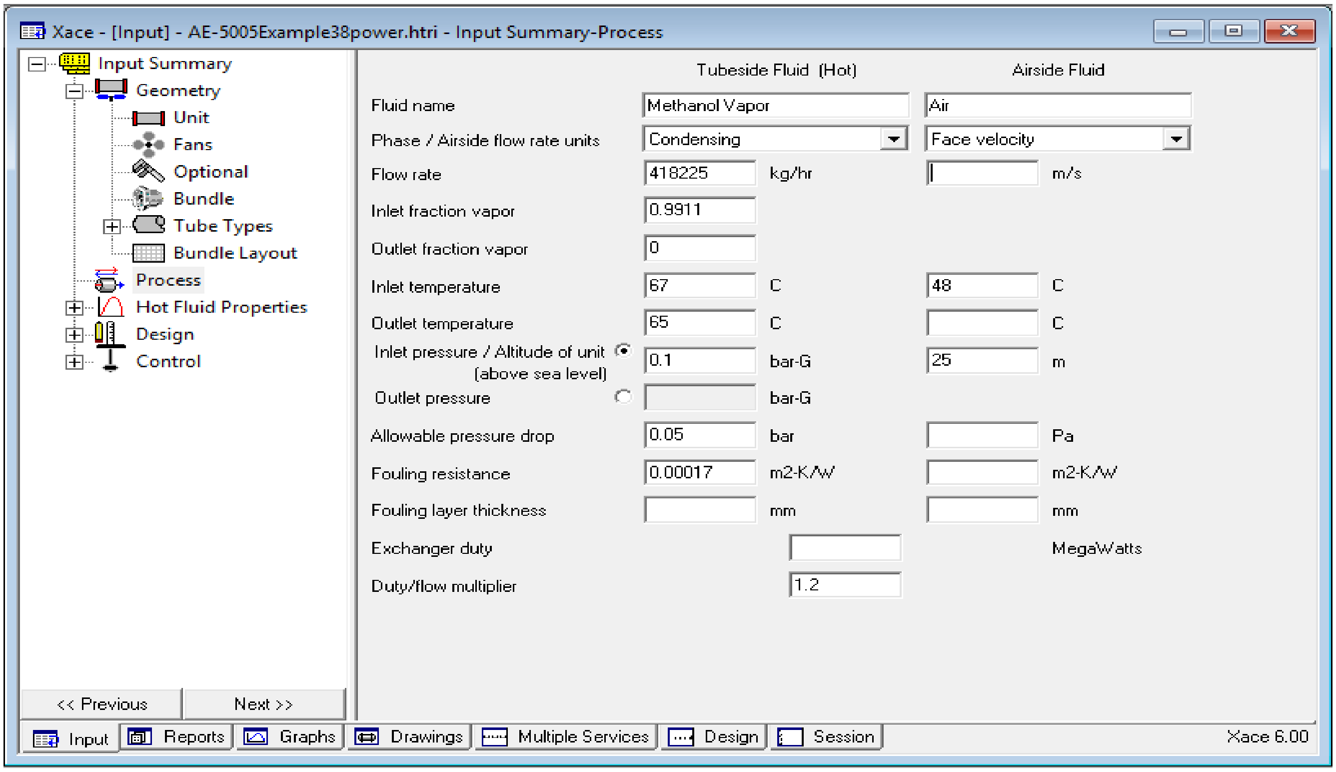
Description	Shell Side		Tube Side		Units
	Inlet	**Outlet**	**Inlet**	**Outlet**	
Fluids			Methanol Vapour		
Quantity: total			418225		kg/h
liquid				418225	kg/h
gas			418225		kg/h
Operating temperature			67	65	°C
Operating pressure			0.1		bar g
Total molecular weight					kg/kmol
Liquid: molecular weight				32.04	kg/kmol
density				750	kg/m³
viscosity				0.332	cP
specific heat capacity				2.831	kJ/kg/°C
thermal conductivity				0.1865	W/m/°C
boiling temperature			67		°C
Gas: molecular weight			32.04		kg/kmol
density			1.29		kg/m³
viscosity			0.011		cP
specific heat capacity			1.537		kJ/kg/°C
thermal conductivity			0.0208		W/m/°C
dew point			67		°C
Latent heat			260.9		kcal/kg
Performance					
Pressure drop, max. allowable/calculated	/		0.05 /		bar
Fouling resistance			0.00017		m²·°C/W

Heating / Cooling Table

Tube side

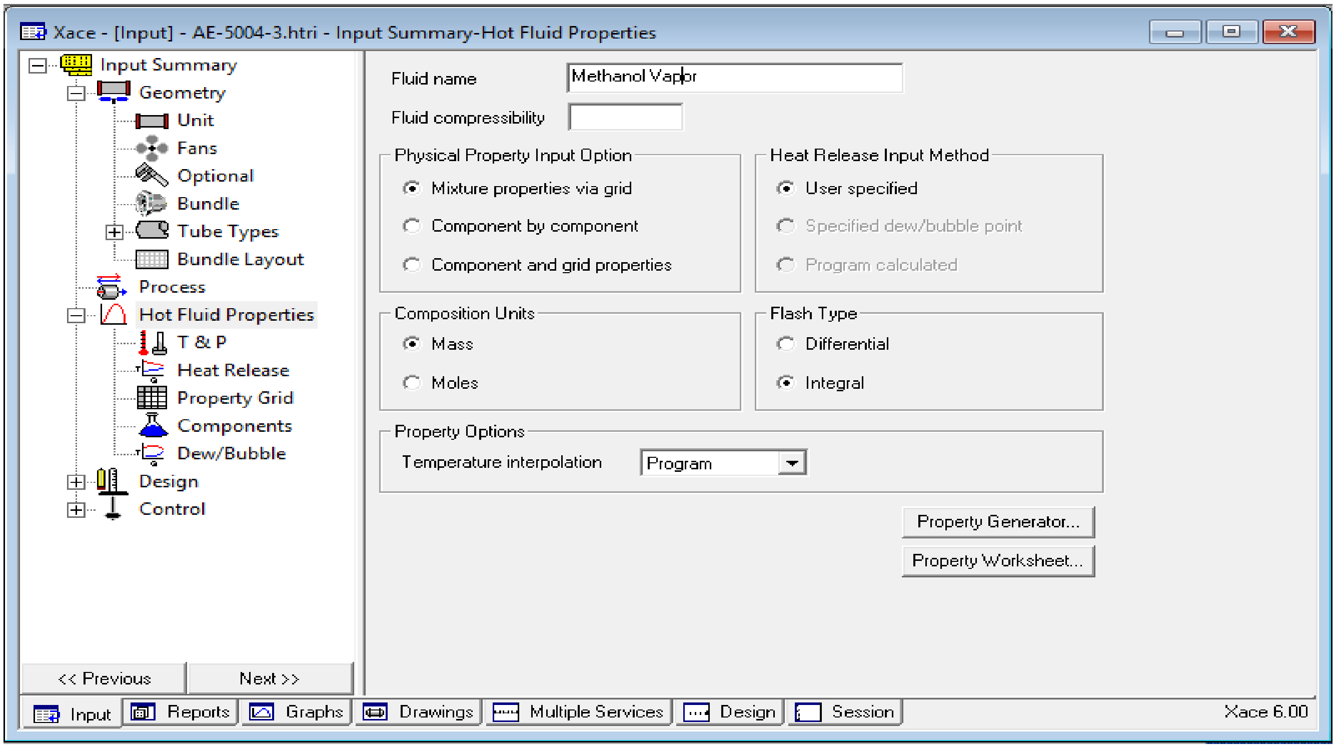
Temperature °C	Gas fraction wt %	Duty profile MW	Liquid density kg/m^3	Liquid viscosity cP	Liquid heat capacity kJ/kg/°C	Liquid thermal conductivity W/m/°C	Surface tension dyn/cm
67	99.11	0.0	748	0.323	2.853	0.1855	19
67	88.03	14.1	748	0.323	2.853	0.1855	19
67	76.95	28.1	748	0.323	2.853	0.1855	19
67	65.87	42.2	748	0.323	2.853	0.1855	19
67	54.78	56.2	748	0.323	2.853	0.1855	19
67	43.70	70.3	748	0.323	2.853	0.1855	19
67	32.62	84.3	748	0.323	2.853	0.1855	19
67	21.54	98.4	748	0.323	2.853	0.1855	19
67	10.45	112.4	748	0.323	2.853	0.1855	19
67	0.00	125.7	748	0.323	2.853	0.1855	19
65	0.00	126.5	750	0.332	2.831	0.1865	19
Temperature °C	Gas fraction wt %	Duty profile MW	Gas density kg/m^3	Gas viscosity cP	Gas heat capacity kJ/kg/°C	Gas thermal conductivity W/m/°C	
67	99.11	0.0	1.29	0.011	1.537	0.0208	
67	88.03	14.1	1.29	0.011	1.537	0.0208	
67	76.95	28.1	1.29	0.011	1.537	0.0208	
67	65.87	42.2	1.29	0.011	1.537	0.0208	
67	54.78	56.2	1.29	0.011	1.537	0.0208	
67	43.70	70.3	1.29	0.011	1.537	0.0208	
67	32.62	84.3	1.29	0.011	1.537	0.0208	
67	21.54	98.4	1.29	0.011	1.537	0.0208	
67	10.45	112.4	1.29	0.011	1.537	0.0208	
67	0.00	125.7					
65	0.00	126.5					

2.Process Input to HTRI



Xace - [Input] - AE-5005Example38power.htri - Input Summary-Process

	Tubeside Fluid (Hot)		Airside Fluid	
Fluid name	Methanol Vapor		Air	
Phase / Airside flow rate units	Condensing		Face velocity	
Flow rate	418225	kg/hr		m/s
Inlet fraction vapor	0.9911			
Outlet fraction vapor	0			
Inlet temperature	67	C	48	C
Outlet temperature	65	C		C
● Inlet pressure / Altitude of unit (above sea level)	0.1	bar-G	25	m
○ Outlet pressure		bar-G		
Allowable pressure drop	0.05	bar		Pa
Fouling resistance	0.00017	m2-K/W		m2-K/W
Fouling layer thickness		mm		mm
Exchanger duty				MegaWatts
Duty/flow multiplier	1.2			



Xace - [Input] - AE-5004-3.htri - Input Summary-Hot Fluid Properties

Fluid name: Methanol Vapor

Fluid compressibility:

Physical Property Input Option
- ● Mixture properties via grid
- ○ Component by component
- ○ Component and grid properties

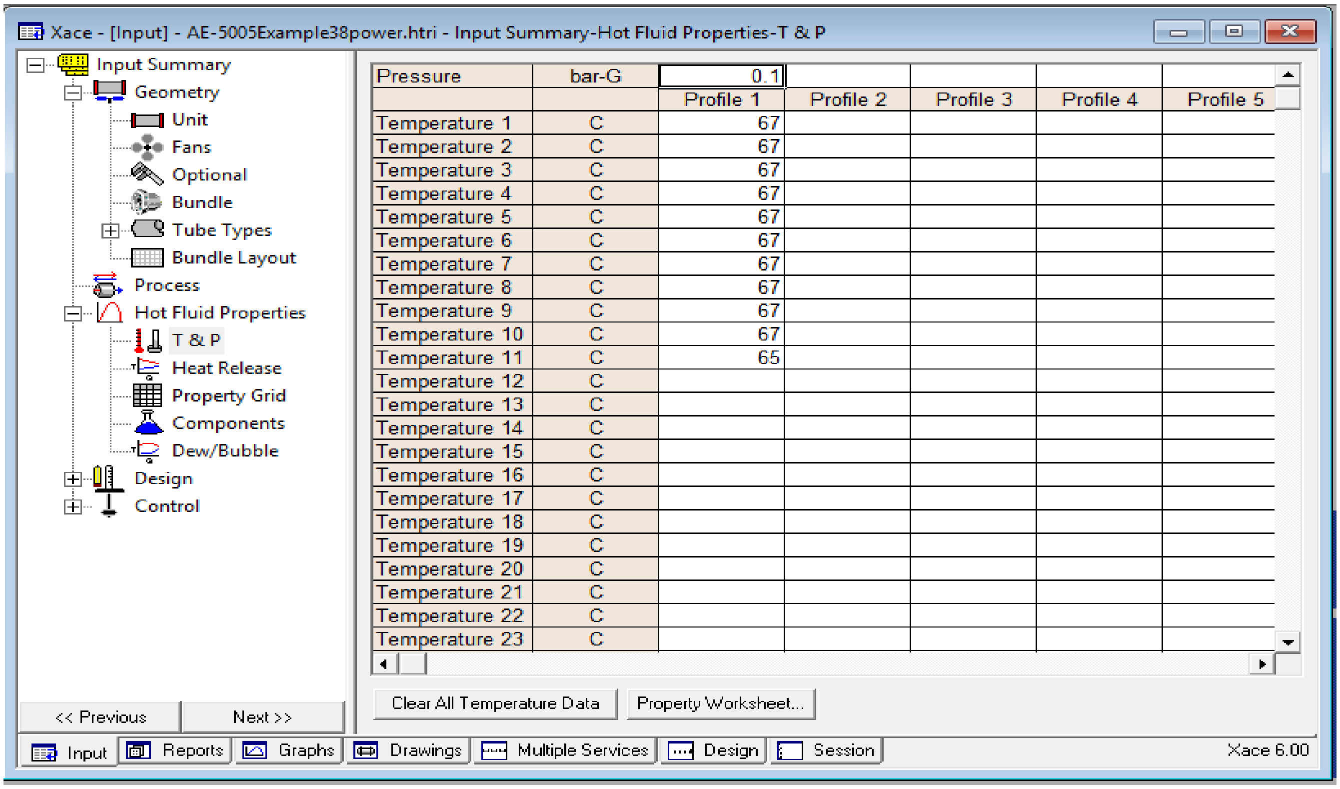
Heat Release Input Method
- ● User specified
- ○ Specified dew/bubble point
- ○ Program calculated

Composition Units
- ● Mass
- ○ Moles

Flash Type
- ○ Differential
- ● Integral

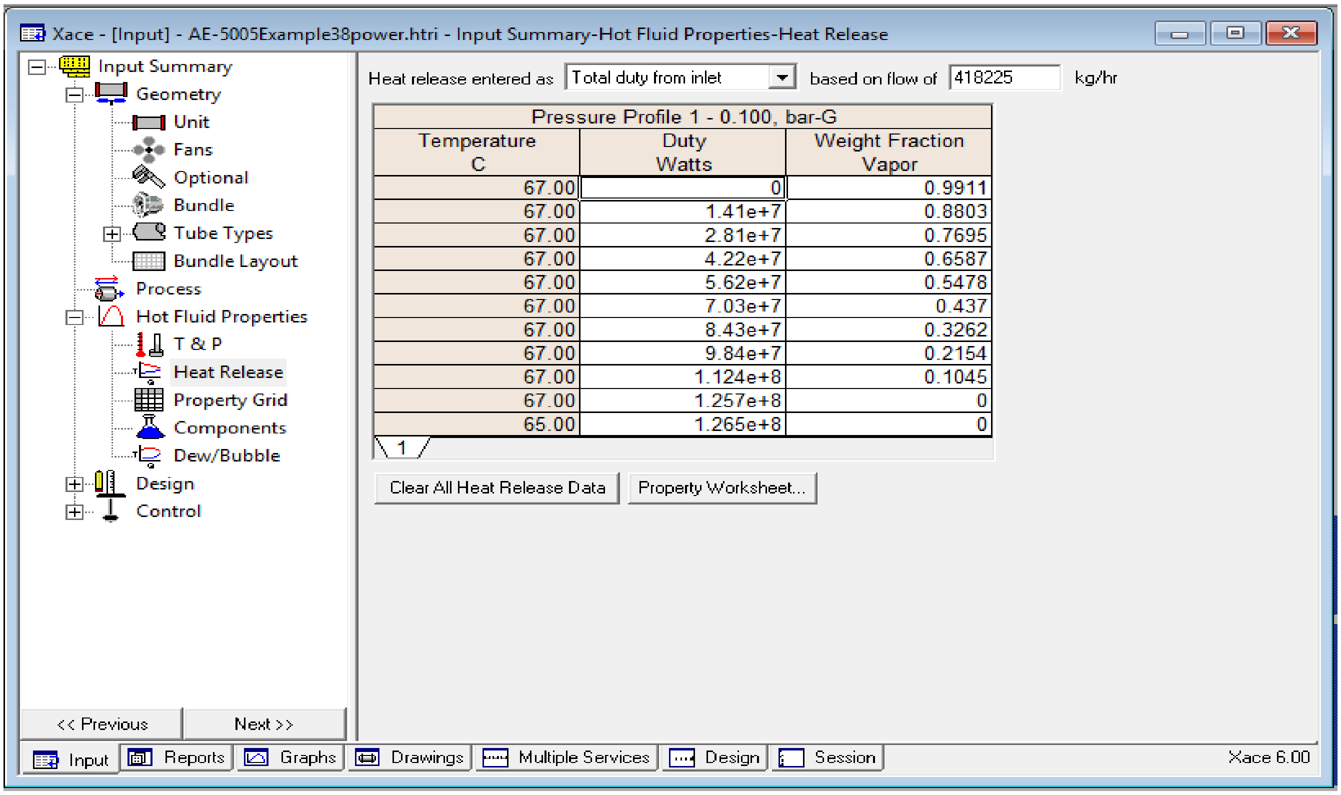
Property Options

Temperature interpolation: Program



Xace - [Input] - AE-5005Example38power.htri - Input Summary-Hot Fluid Properties-T & P

Pressure	bar-G	0.1				
		Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
Temperature 1	C	67				
Temperature 2	C	67				
Temperature 3	C	67				
Temperature 4	C	67				
Temperature 5	C	67				
Temperature 6	C	67				
Temperature 7	C	67				
Temperature 8	C	67				
Temperature 9	C	67				
Temperature 10	C	67				
Temperature 11	C	65				
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					

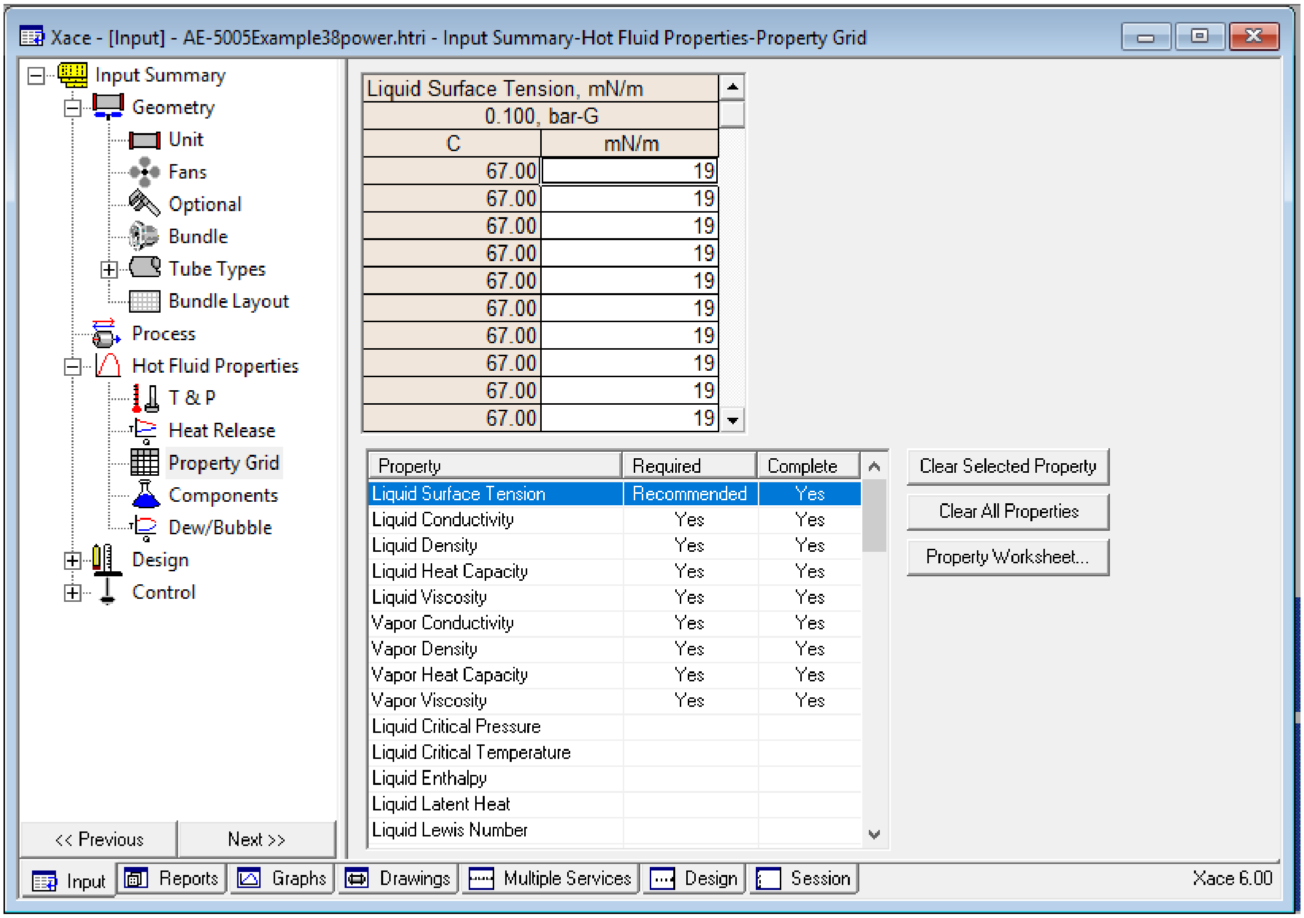


Xace - [Input] - AE-5005Example38power.htri - Input Summary-Hot Fluid Properties-Heat Release

Heat release entered as: Total duty from inlet, based on flow of 418225 kg/hr

Pressure Profile 1 - 0.100, bar-G

Temperature C	Duty Watts	Weight Fraction Vapor
67.00	0	0.9911
67.00	1.41e+7	0.8803
67.00	2.81e+7	0.7695
67.00	4.22e+7	0.6587
67.00	5.62e+7	0.5478
67.00	7.03e+7	0.437
67.00	8.43e+7	0.3262
67.00	9.84e+7	0.2154
67.00	1.124e+8	0.1045
67.00	1.257e+8	0
65.00	1.265e+8	0



Liquid Surface Tension, mN/m	
0.100, bar-G	
C	mN/m
67.00	19
67.00	19
67.00	19
67.00	19
67.00	19
67.00	19
67.00	19
67.00	19
67.00	19
67.00	19

Property	Required	Complete
Liquid Surface Tension	Recommended	Yes
Liquid Conductivity	Yes	Yes
Liquid Density	Yes	Yes
Liquid Heat Capacity	Yes	Yes
Liquid Viscosity	Yes	Yes
Vapor Conductivity	Yes	Yes
Vapor Density	Yes	Yes
Vapor Heat Capacity	Yes	Yes
Vapor Viscosity	Yes	Yes
Liquid Critical Pressure		
Liquid Critical Temperature		
Liquid Enthalpy		
Liquid Latent Heat		
Liquid Lewis Number		

3.Unit data to HTRI

C2.5.3 Air-Cooled Heat Exchanger Configurations

In some situations, the choice of heat exchanger type is critical to proper plant operation; the project engineer must therefore understand advantages and drawbacks associated with various configurations.

C2.5.3.1 Forced-Draft, Horizontal Bundle

Horizontal arrangements are the most common forced-draft design. The size of shop-erected units is limited by transportation restrictions; field-erected units are larger, their size limited only by practicality. Units with average length-to-width ratios ranging from 2–2.5 to 1 require a two-fan design. Large process coolers have two or more fans.

C2.5.3.1 Forced-Draft, Horizontal Bundle, continued

Forced-draft air-cooled heat exchangers with horizontal bundles have these advantages over induced-draft ACHEs:

- Less power is needed to convey air because fans are located in the cool airstream below the bundle.
- Maintenance is easier because fan drives are located below the unit.
- The construction material is not critical because fans are unlikely to overheat unless near a very high temperature bundle or in a recirculation cabin.
- Bundles are located above the plenum chamber, which simplifies assembly of the structure. Disassembly is usually not required to remove bundles for cleaning or repair.

This type of design also has several disadvantages:

- Unless the unit is grade-mounted, underslung walkways are required for motor and fan access.
- The velocity of air escaping from the bundle's top is low—typically 500–700 ft/min (2.5–3.5 m/s)—making the unit susceptible to crosswind effects and inducing external recirculation around the cooler. This problem is accentuated by proximity to tall structures or to other units that are not part of the same continuous bank. Anti-recirculation fences may have to be fitted at considerable expense.

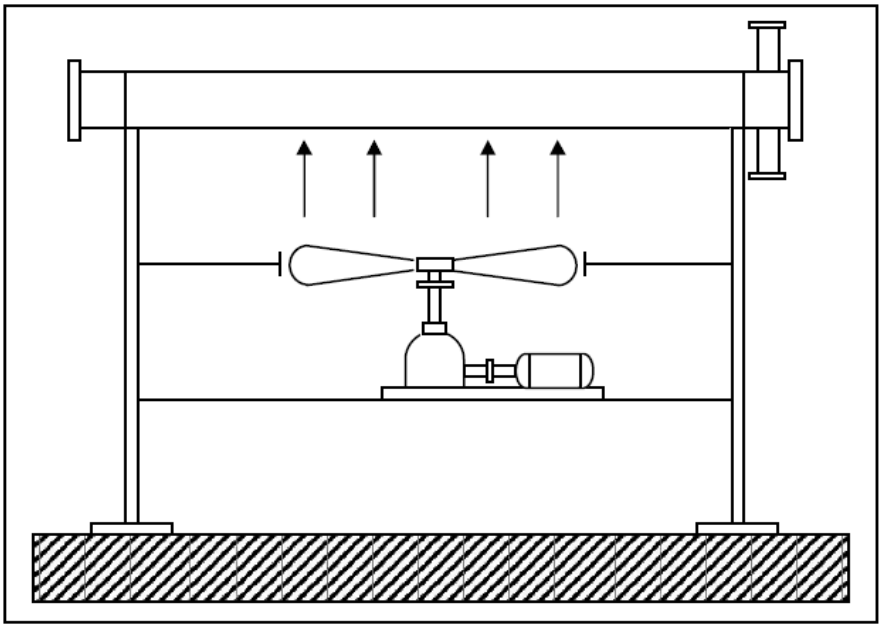


Figure C2.5-1. Forced-draft, horizontal configuration.

C2.5.3.1 Forced-Draft, Horizontal Bundle, continued

- Good airflow distribution is more difficult to achieve than with induced-draft exchangers.
- The bundles are exposed to solar radiation, which increases the heat load. For most cases, the increase in heat load is small (< 2%) and can be neglected. However, for cases where the effective mean temperature difference is low (< 5.6 °C (10 °F)) and the tubeside heat transfer coefficient is low (for example, in laminar single-phase flow), the solar radiation can increase the duty more than 5% and should be included in the performance analysis.

C2.5.3.2 Induced-Draft, Horizontal Bundle

Min. Temp. approach

Forced draft	Induced draft
12 C	8 C

Horizontal induced-draft units, often designed for processes requiring considerable cooling surface, are usually multiple-bay installations.

Advantages typical of this design follow:

- The unit is less susceptible to crosswind because the velocity of air discharging from the fan can reach 32.8 ft/s (10 m/s).
- Cooling air is less likely to recirculate than in other designs.
- The plenum chamber, whether a hood or a flat deck, protects against sudden performance surges caused by rain or hail; it also reduces the effects of solar radiation on the bundle, making horizontal induced-draft units popular in the Middle East.
- Acting as a chimney, the plenum chamber and fan ring provide a higher heat rejection under fan failure conditions.

For close temperature control; i.e. induced draft when +/- 3 C control is required.

C2.5.3.2 Induced-Draft, Horizontal Bundle, continued

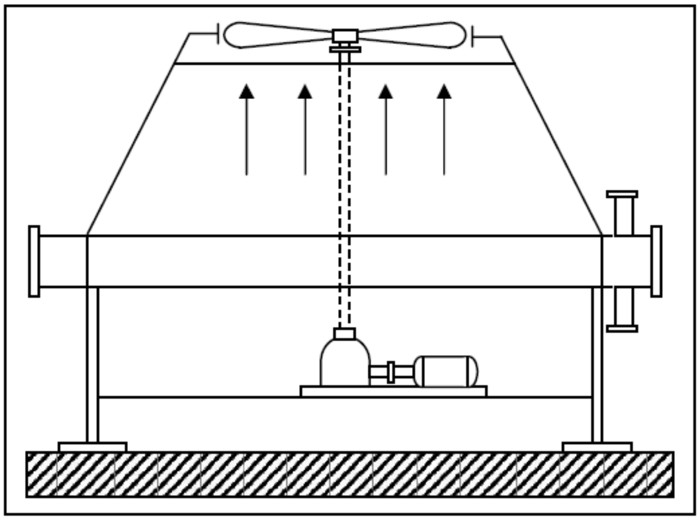


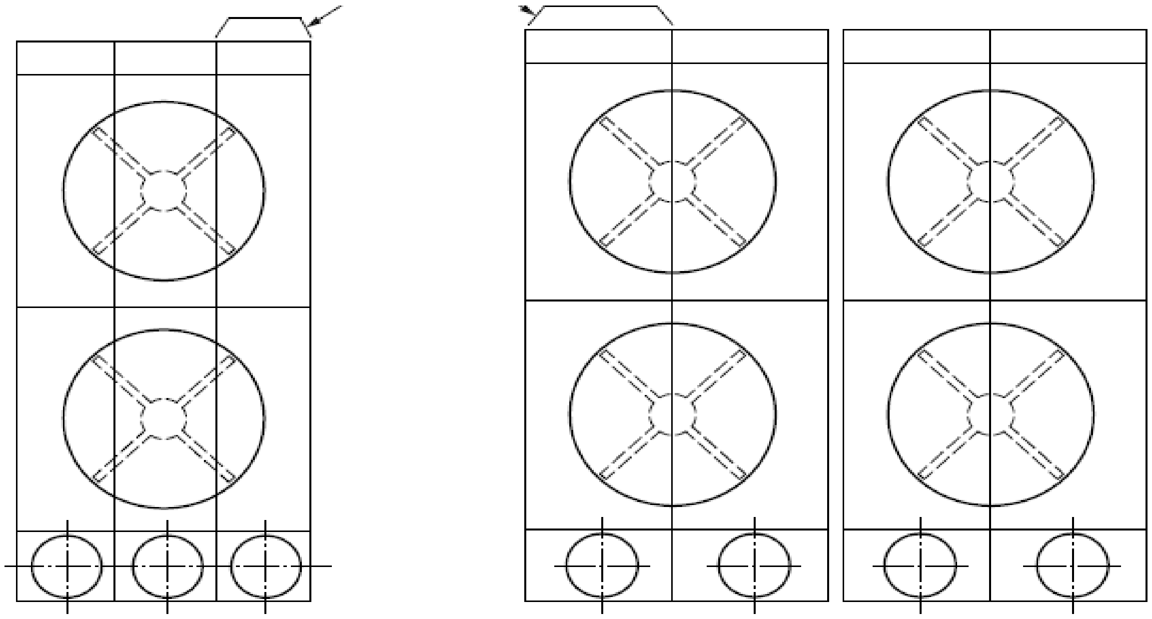
Figure C2.5-2. Induced-draft, horizontal configuration

A few disadvantages are also ascribed to this configuration:

- Except for very low process temperatures (below 158 °F (70 °C)), the gearbox or belt drive system cannot be mounted in the hot airstream.
- Except for those with remote actuation, all autovariable fans have low maximum operating temperatures and are unsuitable for mounting in hot airstreams.
- All fans made of or containing combustible materials (e.g., plastic, rubber) have low temperature limits. The unit must be rated at the maximum process temperature with the motor off to ensure the fan's suitability for service.
- With the fan operating in a warm airstream, the unit's power consumption will be higher for a given thermal performance.

Bay

One or more tube bundles, serviced by two or more fans, including the structure, plenum and other attendant equipment.



a) One-bay b) Two-bay

3.6.3 Headers

Most applications involve straight tubes attached to front and rear box-shaped headers. The front header is akin to the stationary end of a shell-and-tube exchanger to which the inlet nozzles, and outlet nozzles if there are two or more even number of passes, are attached. The rear header is akin to the floating head of a shell-and-tube exchanger and nozzles will only be attached to it if there are one or more odd number of passes. Similar to a shell-and-tube exchanger, pass partition plates, welded-in, divide the headers into passes.

The wide tube pitch, and ligament between adjacent tubes, used in air-cooled heat exchanger design provides thinner tubesheets than those in shell-and-tube exchangers. In an air-cooled heat exchanger using 25.4 mm (1 in) diameter base tubes, for example, the gap between adjacent tubes is about 35 mm (1.375 in), compared with 6.35 mm (0.25 in) in a shell-and-tube exchanger. Minimum thicknesses of ferrous parts are usually 19.05 mm (0.75 in) for tubesheets and plug sheets, 25 mm (1 in) for cover plates and 13 mm (0.5 in) for other plates.

All box-type headers comprise tubesheet, top and bottom plates to which the nozzles are attached, and end plates. As in a shell-and-tube exchanger, pass partition plates are installed if there are two or more tube-side passes. The four sides of the box may be constructed from four plates, or two U-shapes, welded together. Opposite the tubesheet is a removable cover, removable bonnet or a plug sheet, the functions of which are described below and illustrated in Fig. 3.5.

Removable cover plate header

This is similar to an N-type stationary head, or channel, of a shell-and-tube exchanger, shown in Figs. 1.2 and 1.18(c), in which the header is welded to the tubesheet at one end and flanged and bolted to a flat cover at the other end. Removal of the flat cover provides access to the exposed tube ends for cleaning and repair, without breaking the nozzle/external pipe joints. This type of construction is used if cleaning is expected to be frequent, but flanged rectangular shaped openings are prone to leakage at the corners.

Removable bonnet header

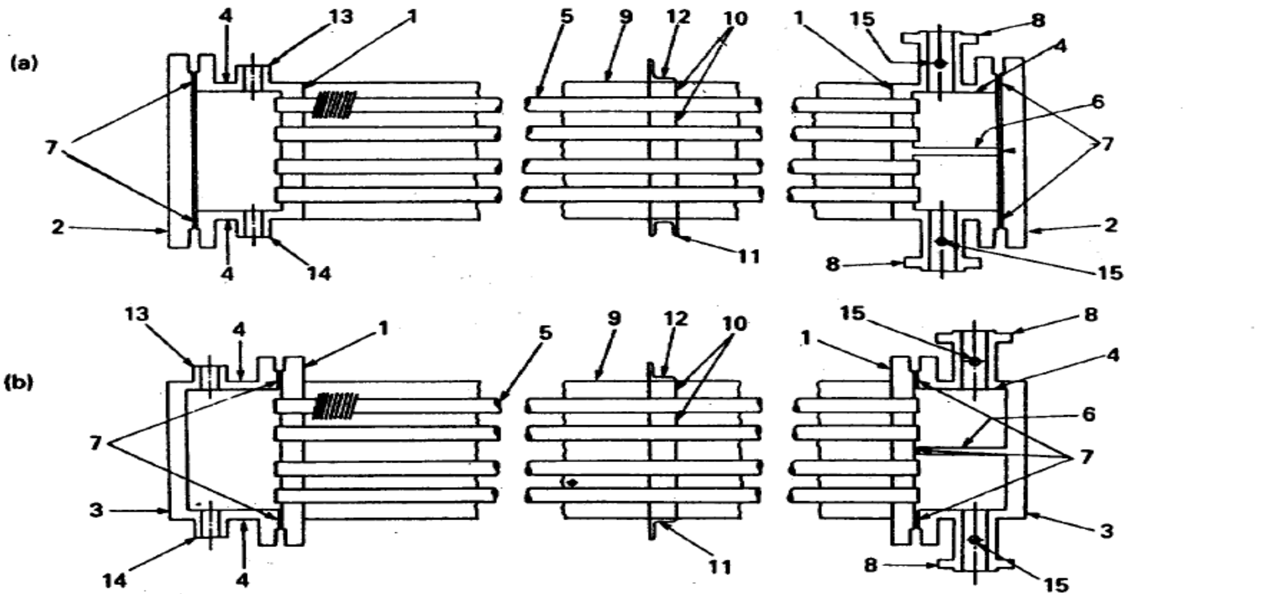
This is similar to a B-type stationary head, or channel, of a shell-and-tube exchanger, shown in Figs. 1.2 and 1.18(d), in which the complete bonnet header is bolted to the tubesheet. Removal of the complete bonnet provides access to the exposed tube ends for cleaning and repair, but nozzle/external pipe joints must be broken first. Although cheaper than the removable cover plate header, the flange is similarly prone to leakage at the corners.

Plug header

The side opposite the tubesheet is fitted with screwed shoulder plugs which coincide with each tube end. The diameter of the plug hole is about 0.8 mm (0.031 in) greater than the tube outside diameter and all operations involving the tube ends, such as cleaning and tube–tubesheet attachment, must be carried out through the plug hole. The plugs have hexagonal heads and the seal between plug shoulder and plug sheet achieved by a solid metal, or metal-jacketed, gasket. Despite the fact that the tube ends cannot be exposed, the plug header is the most common and used for pressures up to at least 300 bar.

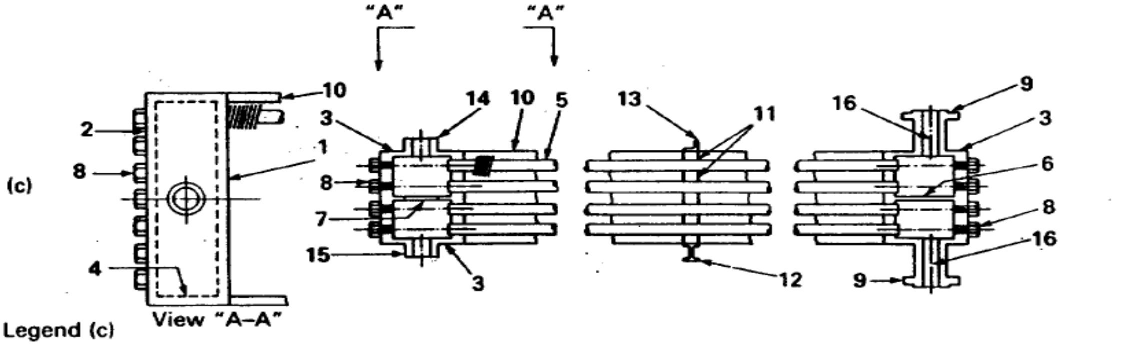
Manifold header

At high pressures, where the plug header is unsuitable, manifold headers are used, in which the base tubes are welded into cylindrical headers at the inlet and outlet. Welded-on U-bends are used to connect one pass



Legend (a) and (b)

1. Tubesheet
2. Removable cover plate
3. Removable bonnet
4. Top and bottom plates
5. Tube
6. Pass partition
7. Gasket
8. Nozzle
9. Side frame
10. Tube spacer
11. Tube support cross-member
12. Tube keeper
13. Vent
14. Drain
15. Instrument connection



Legend (c)

1. Tubesheet
2. Plug sheet
3. Top and bottom plates
4. End plate
5. Tube
6. Pass partition
7. Stiffener
8. Plug
9. Nozzle
10. Side frame
11. Tube spacer
12. Tube support cross-member
13. Tube keeper
14. Vent
15. Drain
16. Instrument connection

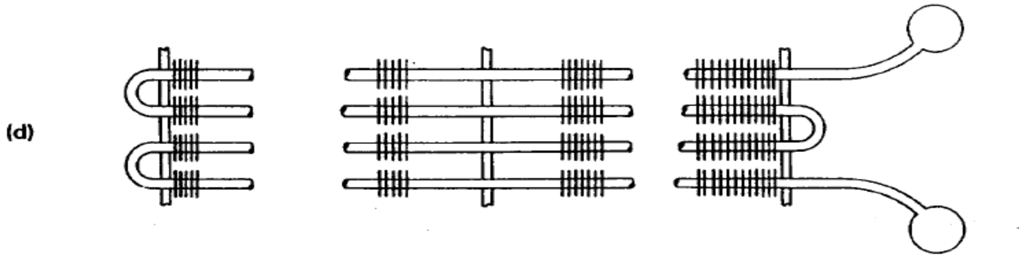
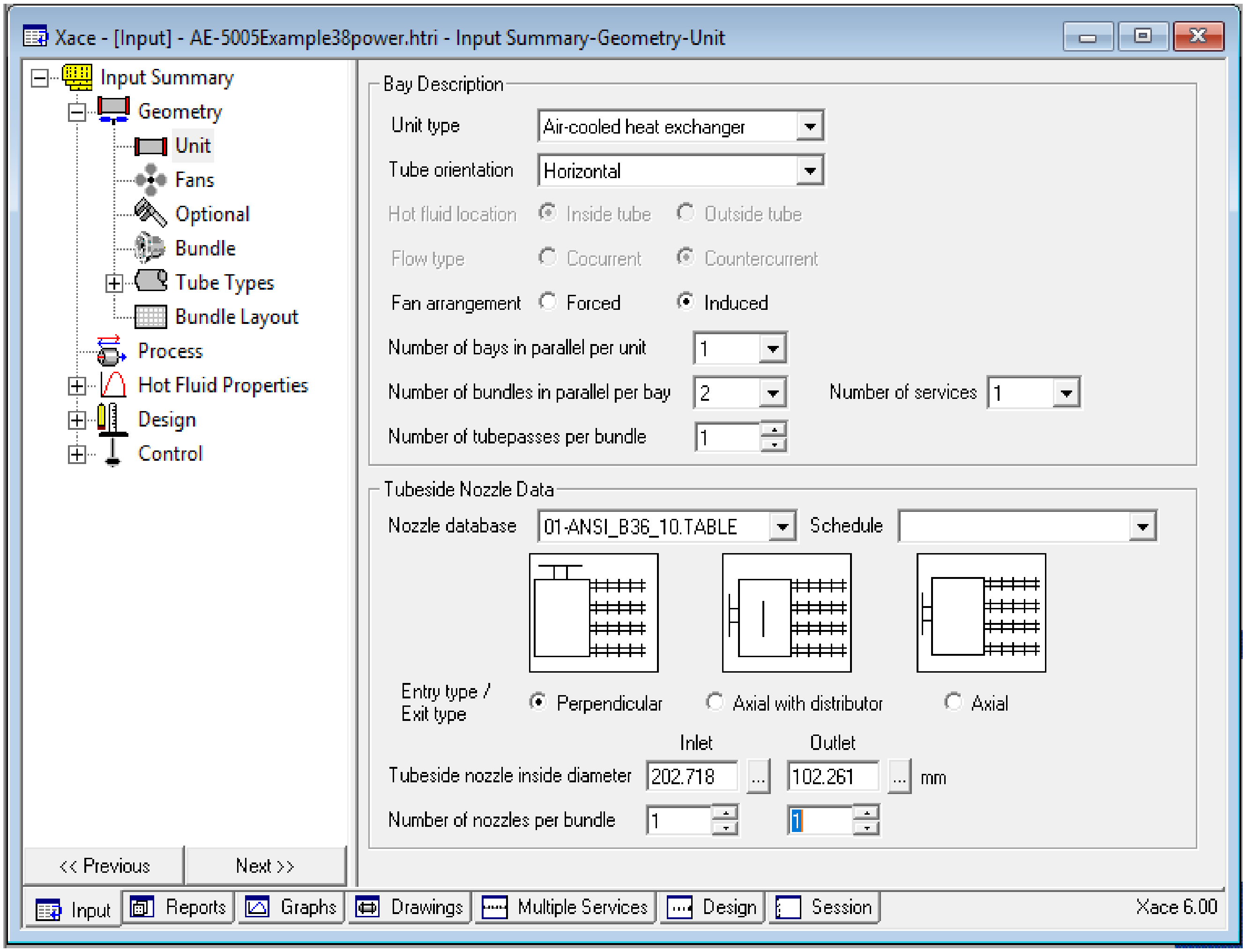


Figure 3.5 Typical headers (a) removable cover (b) removable bonnet (c) plug (d) manifold (courtesy of American Petroleum Institute, API 661)



Xace - [Input] - AE-5005Example38power.htri - Input Summary-Geometry-Unit

Bay Description

Unit type: Air-cooled heat exchanger

Tube orientation: Horizontal

Hot fluid location: ● Inside tube ○ Outside tube

Flow type: ○ Cocurrent ● Countercurrent

Fan arrangement: ○ Forced ● Induced

Number of bays in parallel per unit: 1

Number of bundles in parallel per bay: 2

Number of services: 1

Number of tubepasses per bundle: 1

Tubeside Nozzle Data

Nozzle database: 01-ANSI_B36_10.TABLE

Schedule:

Entry type / Exit type: ● Perpendicular ○ Axial with distributor ○ Axial

	Inlet	Outlet	
Tubeside nozzle inside diameter	202.718	102.261	mm
Number of nozzles per bundle	1	1	

4.Fan Data to HTRI

Table 6 — Radial Clearances

Fan Diameter		**Radial Clearance** mm (in.)	
m	(ft)	Minimum	Maximum
≤ 3.0	(≤ 9)	6.35 ($^{1}/_{4}$)	12.7 ($^{1}/_{2}$)
> 3.0 and ≤ 3.5	(> 9 and ≤ 11)	6.35 ($^{1}/_{4}$)	15.9 ($^{5}/_{8}$)
> 3.5	(> 11)	6.35 ($^{1}/_{4}$)	19.05 ($^{3}/_{4}$)

C2.5.8.1.1
Fan Rings

Air cooler fans are typically enclosed in rings because proper ring design can greatly enhance fan performance. The correlation used to calculate the pressure drop due to fan rings is [1]

$$\Delta P_{ring} = \frac{K\rho_{be}V_{fan}^{2}}{2} \tag{C2.5-9}$$

Experimentally measured K-factor values are tabulated in Table C2.5-1 [1], with ring geometries defined in Figure C2.5-7.

C2.5.8.1.1
Fan Rings,
continued

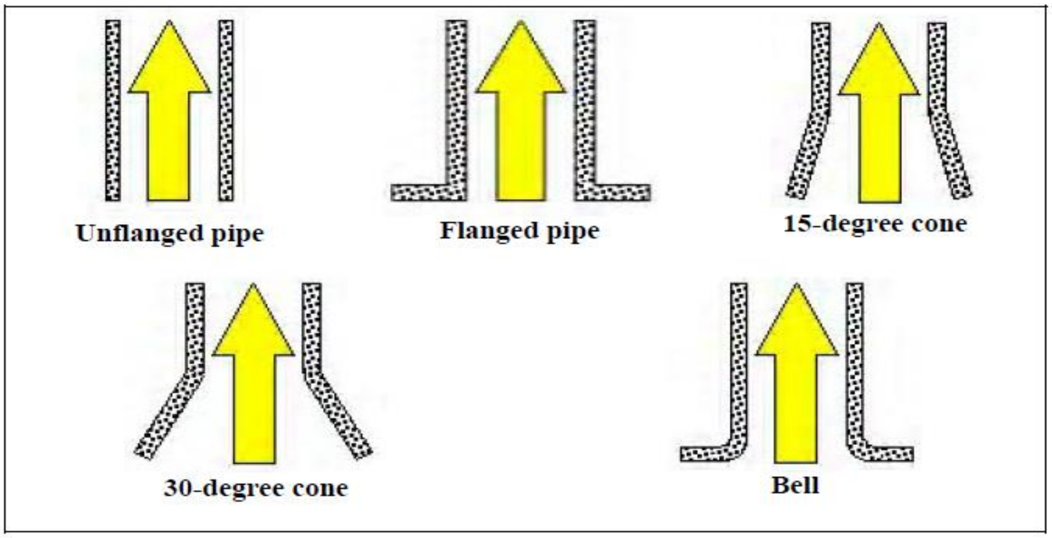
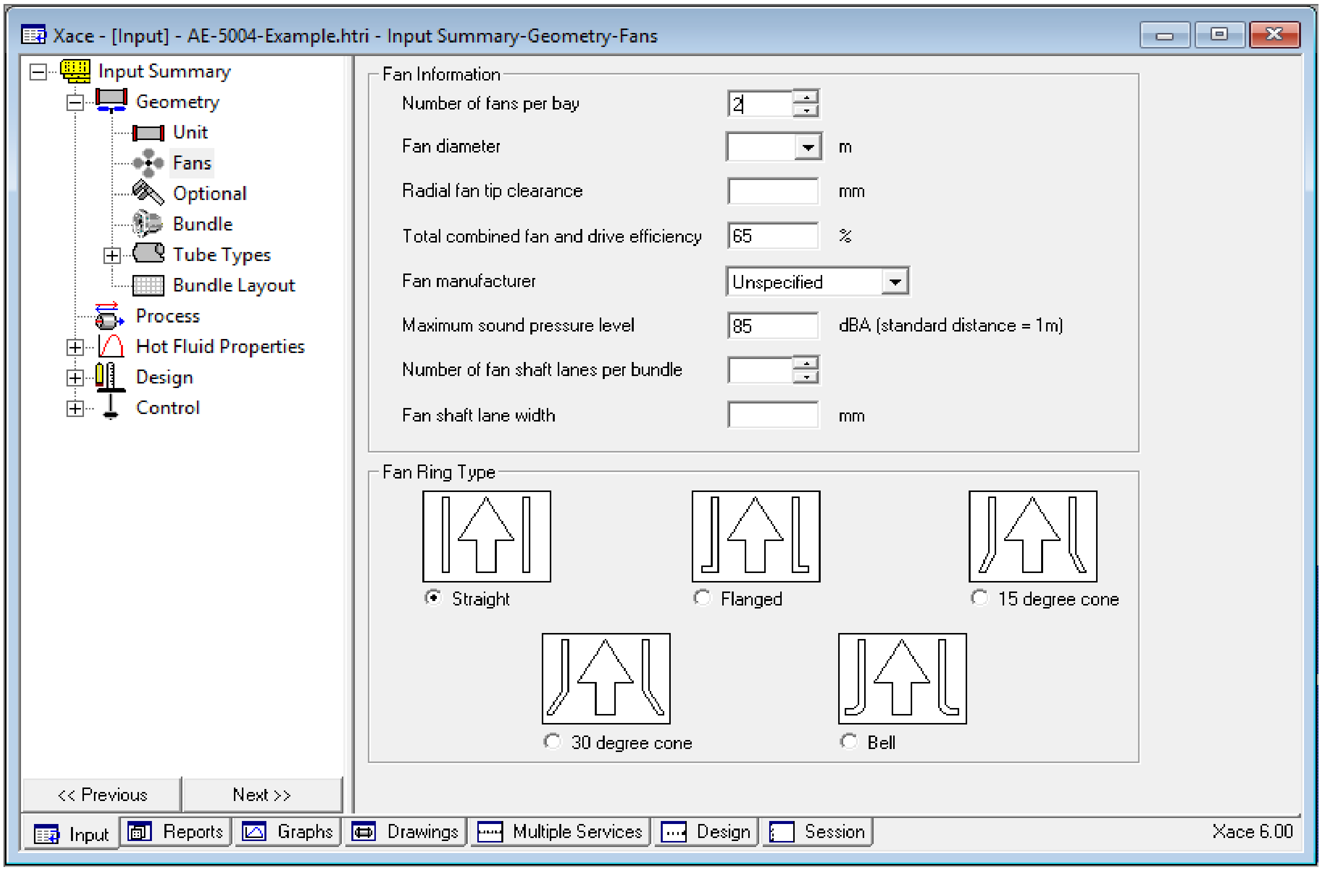


Figure C2.5-7. Fan ring geometries

Table C2.5-1. Fan Ring K-Factors (*K*)

Fan ring type	K-factor
Unflanged pipe	0.90
Flanged pipe	0.50
15-degree cone	0.13
30-degree cone	0.06
Smooth, well-rounded bell	0.05



Fan Information

Number of fans per bay: 2

Fan diameter: m

Radial fan tip clearance: mm

Total combined fan and drive efficiency: 65 %

Fan manufacturer: Unspecified

Maximum sound pressure level: 85 dBA (standard distance = 1 m)

Number of fan shaft lanes per bundle:

Fan shaft lane width: mm

Fan Ring Type

● Straight ○ Flanged ○ 15 degree cone

○ 30 degree cone ○ Bell

5.Optional Data to HTRI

C2.5.8.1.2 Fan Screens or Guards

Like fan rings, fan screens/guards are nearly ubiquitous in air cooler design because they protect both personnel and fans from damage. The equation used to predict pressure drop due to fan screens or guards is

$$\Delta P_{grd} = \frac{K \rho_{be} V_{fan}^{2}}{2} \qquad \text{(C2.5-10)}$$

However, the experimental determination of the fan screen/guard K-factors was based on velocities at the screen/guard. *Xace* uses the velocities at the fan, as demonstrated by Equation (C2.5-10). Thus, the two velocities are related through an intermediate K-factor, K_{int}:

C2.5.8.1.2 Fan Screens or Guards, continued

$$K = K_{\text{int}} \left[\left(\frac{100}{S_{nf}} \right)^{2} - 1 \right] ; 0 < K < 1 \qquad \text{(C2.5-11)}$$

Values of K_{int} depend on the fan ring and are listed in Table C2.5-2 [4].

Table C2.5-2. Fan Screen or Guard Intermediate K-Factors (K_{int})

Fan ring type	**Intermediate K-factor**
Unflanged pipe, forced draft	0.23
Unflanged pipe, induced draft	0.33
Unflanged cone, 15° taper	0.15
Unflanged cone, 30° taper	0.15
Unflanged dual cone, 45° into 15° taper	0.15
Smooth, well-rounded bell	0.13

C2.5.8.1.6
Hail Screens

Hail screens are positioned at the top of an air cooler and act as the first line of defense against structural damage, particularly hail. They are used with both forced and induced draft geometries. In the forced draft configuration, hail screens protect the bundle, whereas in induced draft, they shield the fan. Hail screen pressure drop is calculated with

$$\Delta P_{hs} = \frac{K\rho_{be}V_{fan}^2}{2} \qquad \text{(C2.5-26)}$$

$$K = 0.752879 - 0.00789865S_{nf}\,;\ 0 < K < 1 \qquad \text{(C2.5-27)}$$

Drivers

For electric motor drivers, the minimum required driver rated shaft power (*P*dr) shall be calculated as follows:

*P*dr ≥ 1.05 (*P*f1/*E*m)

*P*dr ≥ 1.10 (*P*f2)

Where

*P*dr is driver rated shaft power;

*P*f1 is fan shaft power operating at specified minimum design temperature with blade angle set for design dry-bulb temperature;

*E*m is mechanical efficiency of the power transmissions;

*P*f2 is fan shaft power operating at design dry-bulb temperature.

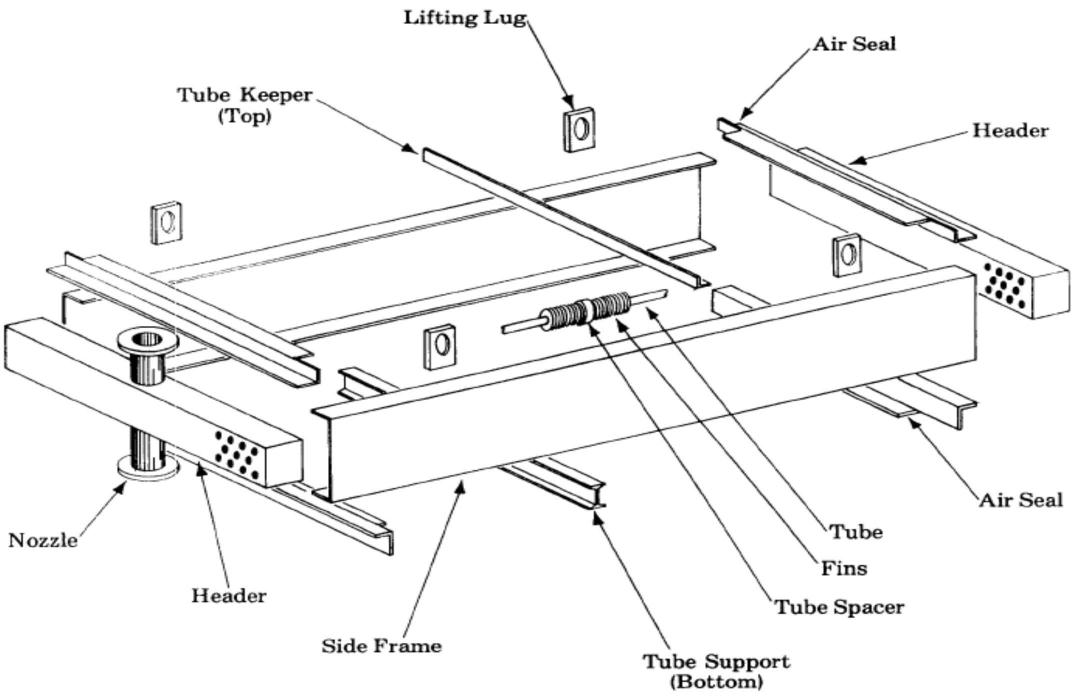
These requirements apply to fixed-pitch, variable-pitch and variable-speed fans unless otherwise specified.

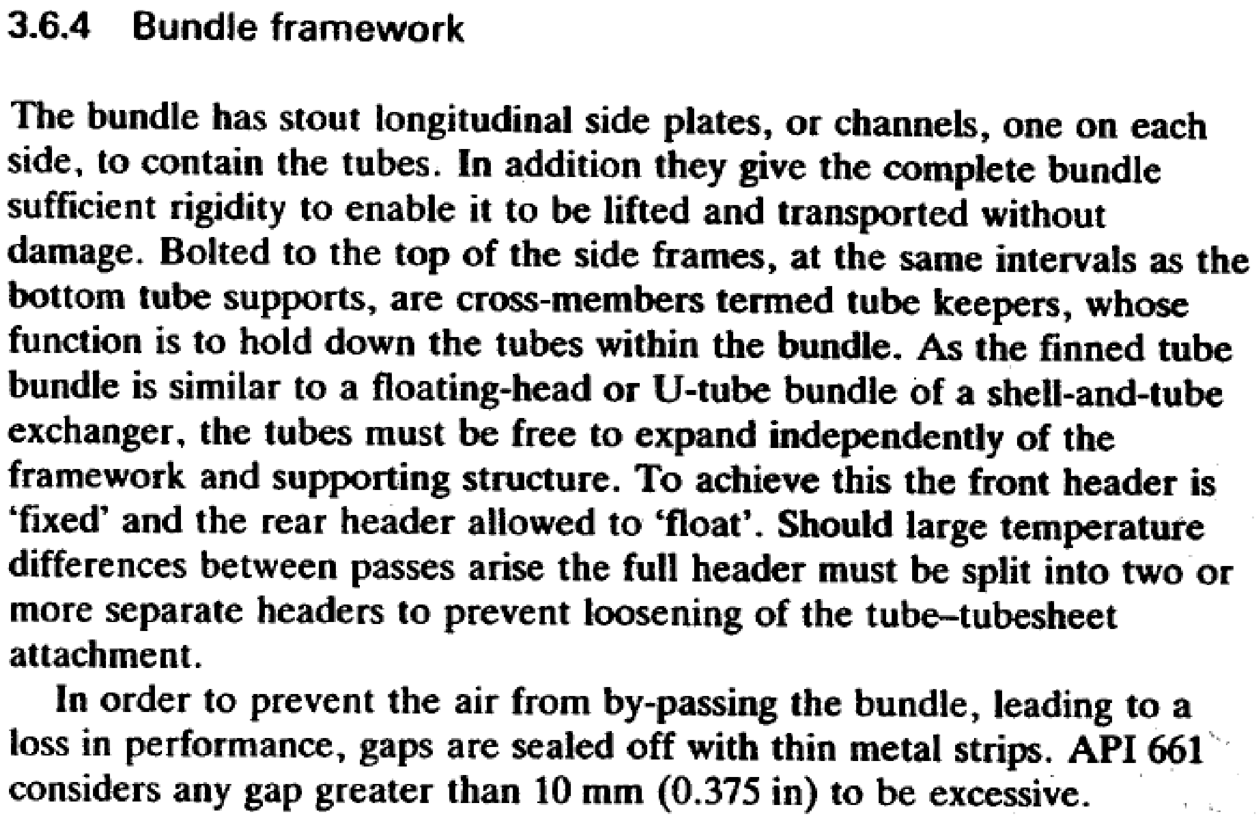
Once installed in the bundle, the tubes must be supported to prohibit intermeshing of the fins, and "bunching" of the tubes, which allows for openings in the tube that allow channeling of the airflow. Several means of tube support are utilized dependent on manufacture.

The most common tube support is provided by a "wiggle strip" that is place between each row, and runs between each tube. This method allow for support of the tube from the fin tip and is susceptible to movement in the bundle during transportation.

Another common method, utilized by some manufacturers, is to wrap aluminum strips around the perimeter of the tube at designated spots along the length. These strips are stapled to prohibit them from loosening. Again, this provides support from the tip of the fin.
A third method is the scalloped channel. This method provides a strip, normally fabricated from aluminum that cradles each tube and runs the entire width of the bundle.
The scalloped channel is formed to provide both supports from the fin tip, and to the tube wall. Based on the configuration, it is not able to move after inserted, and also provides a means of keeping the tubes spaced properly.
Tube support can also be provided by cast zinc collars. This method requires a zinc collar to be poured at each support spot on the tube. This method, while providing excellent support, is normally cost prohibitive.

Typical Bundle configuration





3.6.4 Bundle framework

The bundle has stout longitudinal side plates, or channels, one on each side, to contain the tubes. In addition they give the complete bundle sufficient rigidity to enable it to be lifted and transported without damage. Bolted to the top of the side frames, at the same intervals as the bottom tube supports, are cross-members termed tube keepers, whose function is to hold down the tubes within the bundle. As the finned tube bundle is similar to a floating-head or U-tube bundle of a shell-and-tube exchanger, the tubes must be free to expand independently of the framework and supporting structure. To achieve this the front header is 'fixed' and the rear header allowed to 'float'. Should large temperature differences between passes arise the full header must be split into two or more separate headers to prevent loosening of the tube–tubesheet attachment.

In order to prevent the air from by-passing the bundle, leading to a loss in performance, gaps are sealed off with thin metal strips. API 661 considers any gap greater than 10 mm (0.375 in) to be excessive.

C2.5.6 Plenum, Fan Deck, and Fan Ring Construction

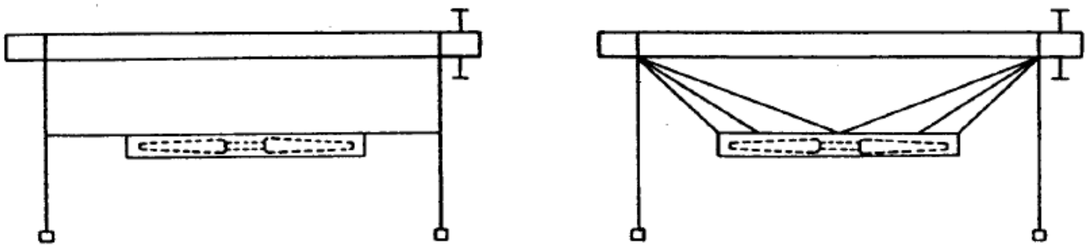
Plenums, either box- or transition-type, are constructed of ribbed 14 gauge steel sheets, 0.083-in. (2.1-mm) minimum thickness.

A large deck or one made from welded plates requires bracing. A fabricated fan deck should support 50 lb/ft^2 (245 kg/m^2) and be constructed of 12 gauge steel, 0.109-in. (2.77-mm) minimum thickness.

Transition plenums, used primarily in induced-draft designs, are more rigid than the box-type and require no additional fan deck.

The plenum chamber is constructed of steel sheet with minimum thicknesses of 2 mm (0.075 in) if flat, or 1.6 mm (0.06 in) if ribbed. As shown in Fig. 3.6, panel plenums are box-shaped, which provides a sharp change of section between the plenum entry or exit and the fan ring. As the name implies, transition plenums shown in Fig. 3.6 provide a gradual instead of a sharp change in cross-section between entry or exit and the fan ring.

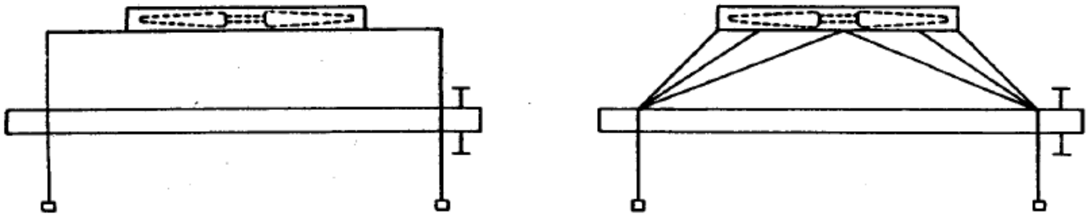
Although simple in appearance, the design of plenum chambers has been the subject of considerable research. The objective has been to produce a uniform air flow across the bundle to achieve maximum fan efficiency and pressure recovery at minimum fan power requirements. Although there are no standard proportions, typical plenum proportions are given below, where A_b = bundle exposed cross-sectional area normal to air flow (i.e. face area), A_f = fan ring cross-sectional area, D_f = nominal fan diameter, H_p = distance between the plane of the fan and the bundle, H_f = fan ring height, and θ = maximum air dispersion angle (from API 661), defined in Fig. 3.7.



Panel plenum

Transition plenum

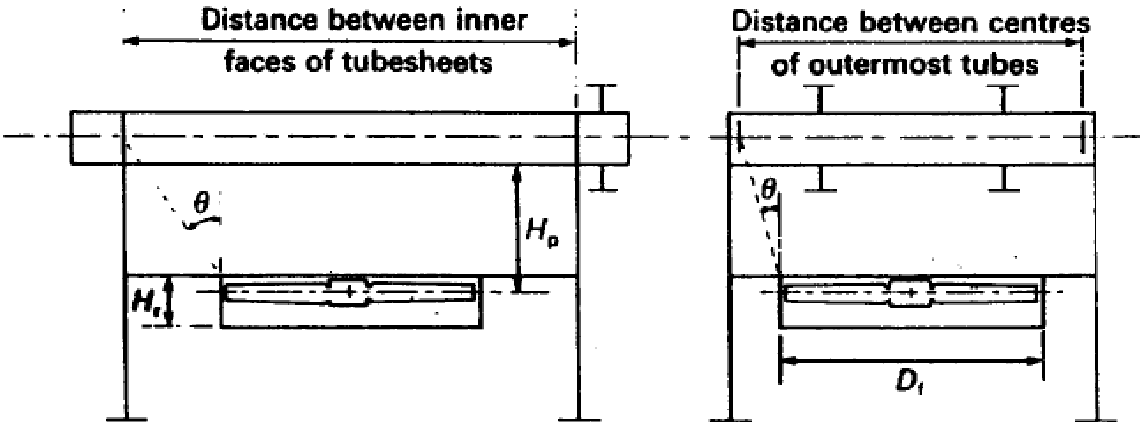
(a) Forced draft



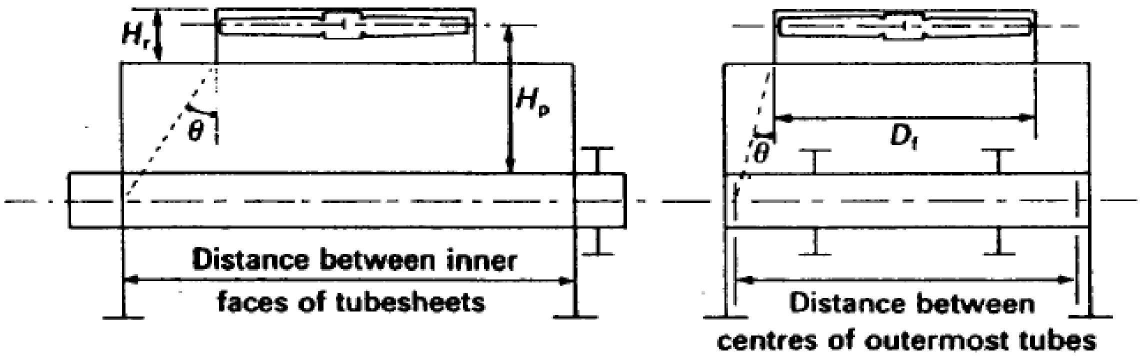
Panel plenum

Transition plenum

(b) Induced draft



(a) Forced draft



(b) Induced draft

	Forced draught	*Induced draught*
A_f/A_b (min)	0.4	0.3
H_p/D_f (min)	0.5	0.3
H_r/D_f (min)	0.16	0.16
θ (max)	45°	45°

As expected, better performance is achieved if the air discharges into a plenum of square, rather than rectangular, cross-section. A further improvement is obtained if the plenum corners are rounded off by curved plates.

3.7 Temperature control

Several methods are used to control the performance of air-cooled heat exchangers to meet variations in weather and process requirements. Air-cooled heat exchangers operating in extremely cold climates require particular attention. Each case must be considered on its merits to decide on the best method of control. Rubin (1982) and Monroe (1983) state the case for variable pitch fan blades to achieve significant fan power reduction.

3.7.1 By-pass

Control devices are installed which enable part of the process fluid to by-pass the unit. This method has the advantages of low initial cost and close, continuous, control but does not reduce fan power consumption.

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3.7.1 By-pass

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3.7.4 Variable-pitch fans

The pitch of each fan blade may be altered manually to suit the prevailing operating conditions, which will reduce fan power consumption. Although fan design permits the alteration of fan-blade pitch to be carried out rapidly, the control is of a coarse, stepwise nature.

Automatic variable-pitch blades provide close, continuous, control but at greater capital cost.

3.7.5 Control for low air temperature

In extremely cold environments, overcooling of the process fluid may cause it to freeze. This may lead to tube rupture, which in turn may necessitate an expensive shutdown for repair. Air-cooled heat exchangers have operated at temperatures of −50 °C and several methods are used to prevent overcooling of the process stream.

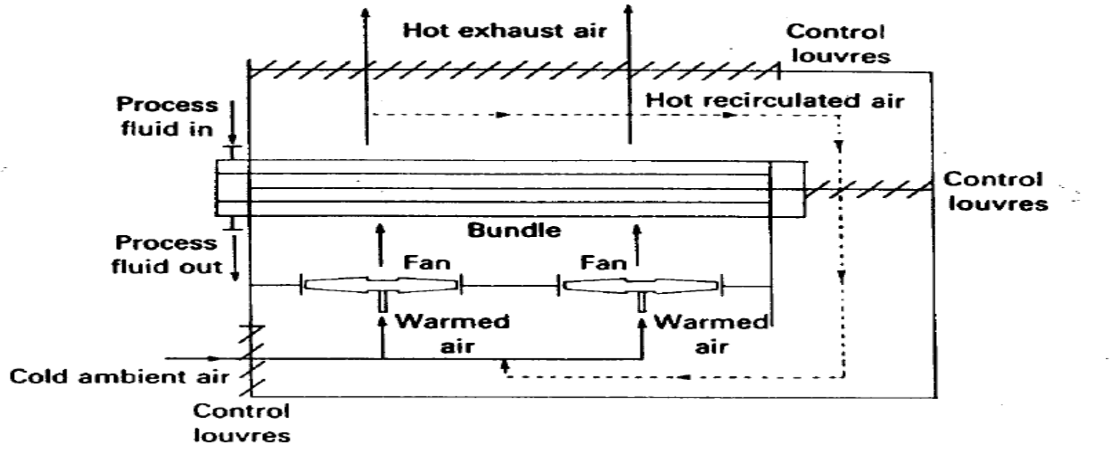
Steam coils

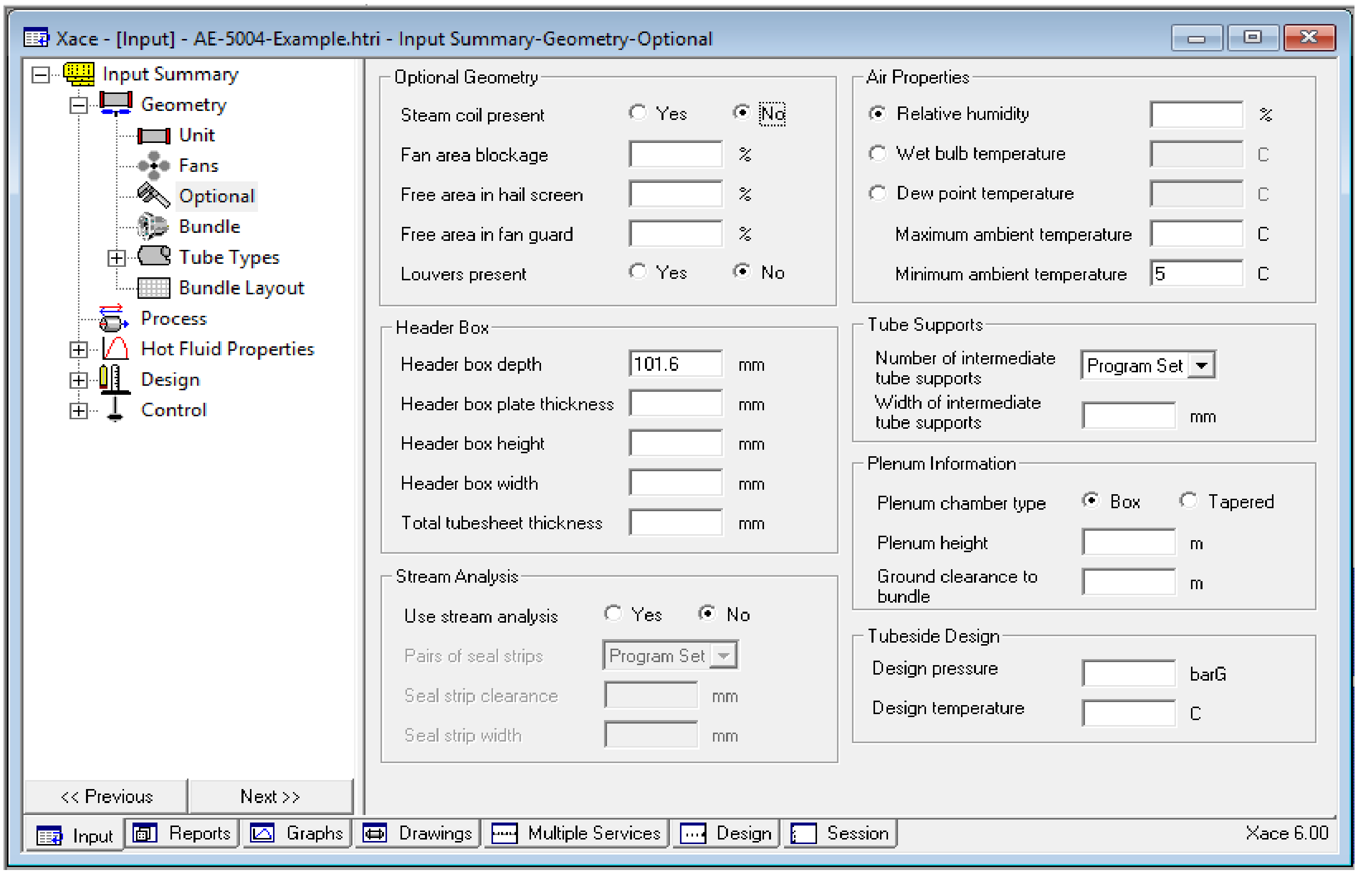
These may be mounted at the cooler base to warm up the inlet air, but must be a separate unit and not part of the process tube bundle. Steam coils are usually employed at start-up to reduce the viscosity of highly viscous fluids.

Air recirculation

In this method, which is used with forced-draft units, some of the hot exhaust air is ducted back to warm up the incoming cold air. The principle of this method is shown in Fig. 3.9.

As an alternative, one fan in a bay is arranged to supply air in the opposite direction to the remainder. It draws in hot exhaust air to mix with the inlet cold air.





Optional Geometry

Steam coil present	○ Yes	● No
Fan area blockage		%
Free area in hail screen		%
Free area in fan guard		%
Louvers present	○ Yes	● No

Header Box

Header box depth	101.6	mm
Header box plate thickness		mm
Header box height		mm
Header box width		mm
Total tubesheet thickness		mm

Stream Analysis

Use stream analysis	○ Yes	● No
Pairs of seal strips	Program Set	
Seal strip clearance		mm
Seal strip width		mm

Air Properties

● Relative humidity		%
○ Wet bulb temperature		C
○ Dew point temperature		C
Maximum ambient temperature		C
Minimum ambient temperature	5	C

Tube Supports

Number of intermediate tube supports	Program Set	
Width of intermediate tube supports		mm

Plenum Information

Plenum chamber type	● Box	○ Tapered
Plenum height		m
Ground clearance to bundle		m

Tubeside Design

Design pressure		barG
Design temperature		C

6.Bundle Data to HTRI

7.2.3 Fans and Fan Hubs

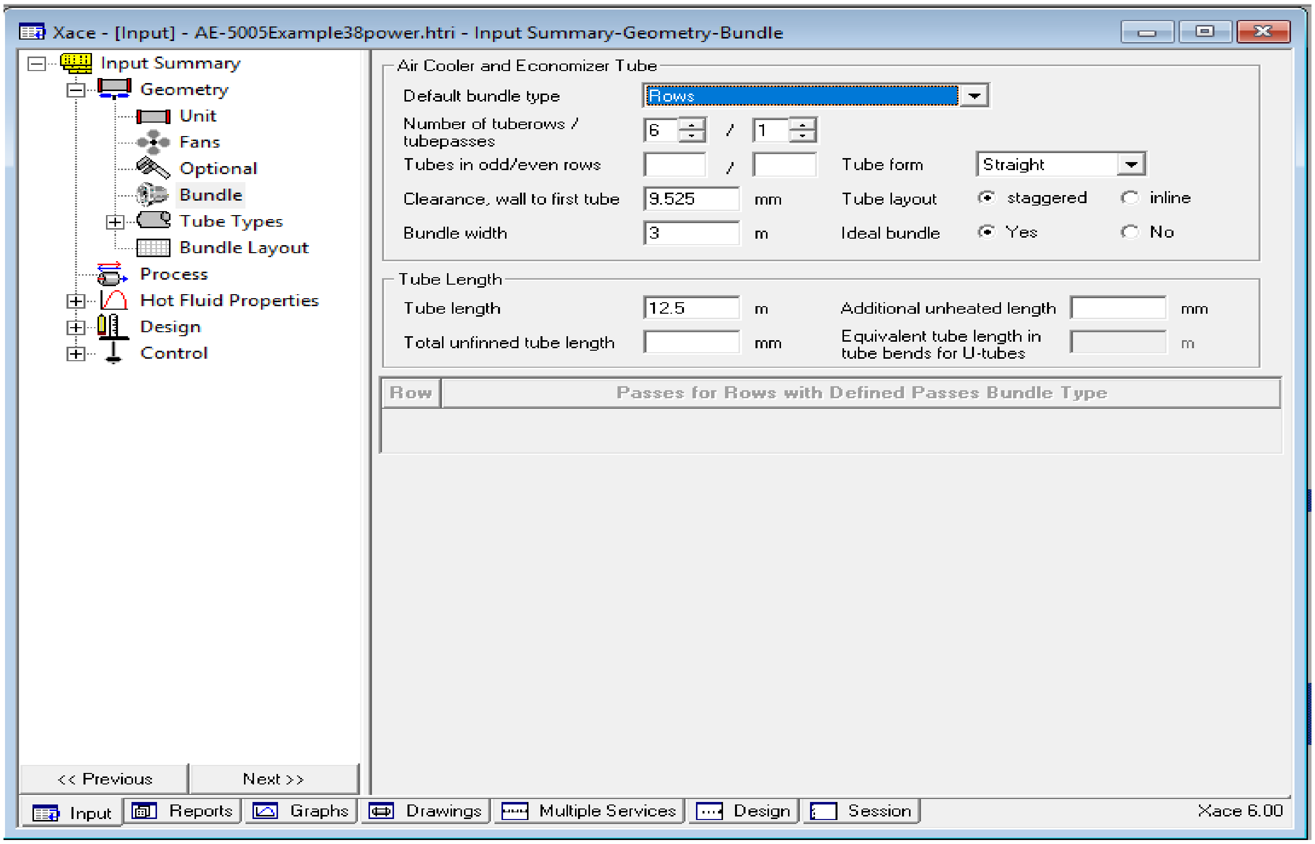
7.2.3.1 Two or more fans aligned in the direction of tube length shall be provided for each bay, except that single-fan arrangements may be used if agreed by the Purchaser.

7.2.3.2 Fans shall be of the axial flow type.

7.2.3.3 Each fan shall be sized such that the area occupied by the fan is at least 40 % of the bundle face area served by that fan (the bundle face area being the nominal width of the bundle or bundles multiplied by the nominal tube length).

7.2.3.4 Each fan shall be located such that its dispersion angle shall not exceed 45 degrees at the bundle centerline, as shown in Figure 7.

7.2.3.5 The fan tip speed shall not exceed the maximum value specified by the fan manufacturer for the selected fan type. Fan tip speed shall not exceed 60 m/s (12,000 ft/min) unless approved by the Purchaser. In no case shall the fan tip speed exceed 80 m/s (16,000 ft/min). Noise limitations can require lower speeds.



Xace - [Input] - AE-5005Example38power.htri - Input Summary-Geometry-Bundle

Air Cooler and Economizer Tube

Default bundle type: Rows

Number of tuberows / tubepasses: 6 / 1

Tubes in odd/even rows: /

Tube form: Straight

Clearance, wall to first tube: 9.525 mm

Tube layout: ● staggered ○ inline

Bundle width: 3 m

Ideal bundle: ● Yes ○ No

Tube Length

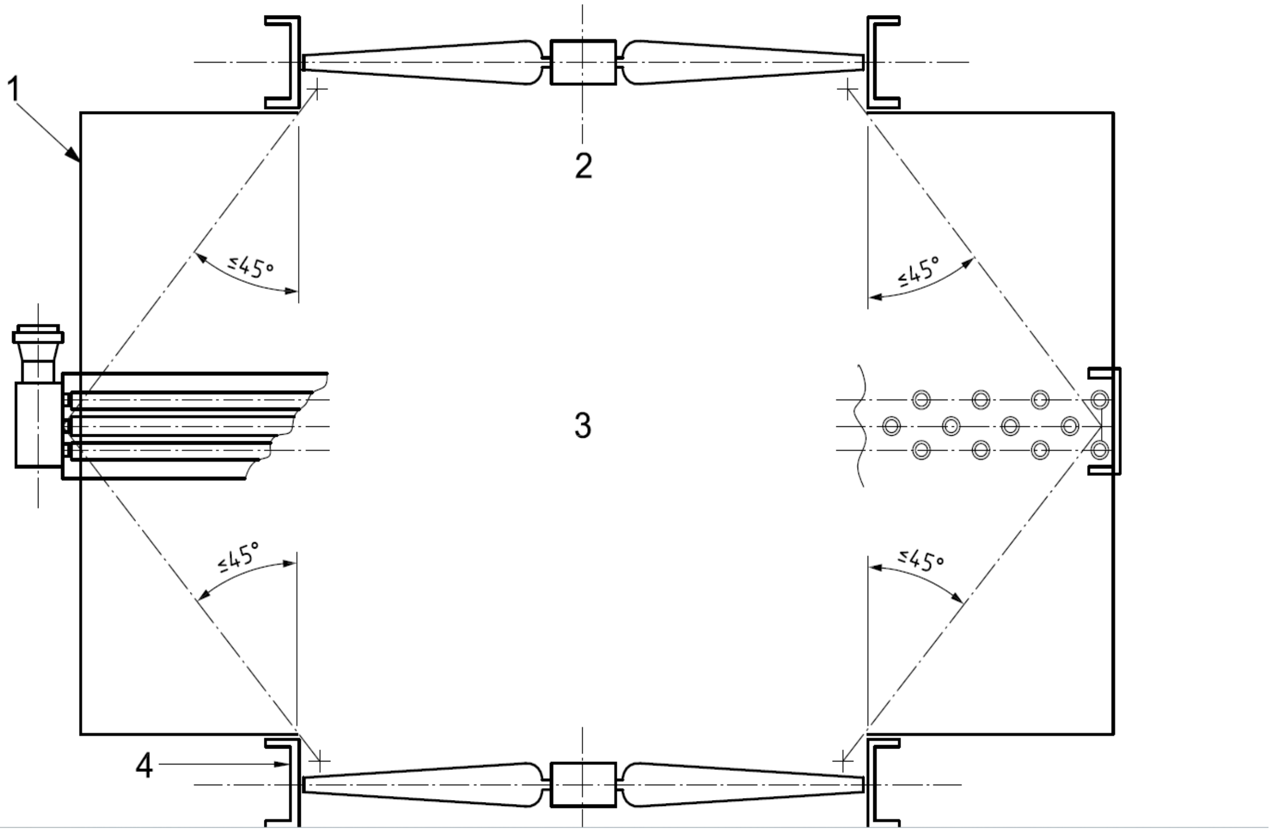
Tube length: 12.5 m

Additional unheated length: mm

Total unfinned tube length: mm

Equivalent tube length in tube bends for U-tubes: m

Row	Passes for Rows with Defined Passes Bundle Type



Key

1	plenum	5	forced draught
2	induced draught	6	side
3	centerline of bundle	7	front
4	fan ring		

Figure 7 — Fan Dispersion Angle

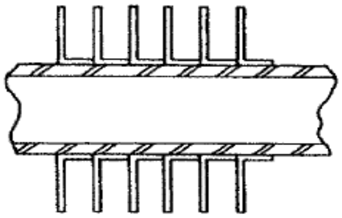
7.Tube type Input to HTRI

Fin Types

Fins can be attached to the tubes in a number of ways:

L-footed Tension wound

The most common fin type utilized in the air-cooled heat exchanger design is the L-footed tension wound aluminum fin. The fin is produced by wrapping an aluminum strip, that is footed at the base, around the tube. This process is done by holding tension on the fin at all times. The ends of the fins are stapled to prohibit the aluminum fin from unraveling, and loosing the contact between the fin foot and the tube. This contact is critical to the operation of the air cooler, since the heat is transferred from the tube wall, through the fin, to the surrounding ambient air.



L-FOOTED TENSION

The L-footed tension wound fin is normally used in services where the tube wall temperature does not exceed 350 degrees, and air side corrosion is not extremely high. At the higher tube wall temperature, due to the difference in material between the tube and the fin, the fin will not maintain contact with the tube, therefore loosing cooling efficiency of the air cooler. This fin is also susceptible to air side corrosion creating a film between the tube and fin, creating the same problem. Coatings to the fins, or special in

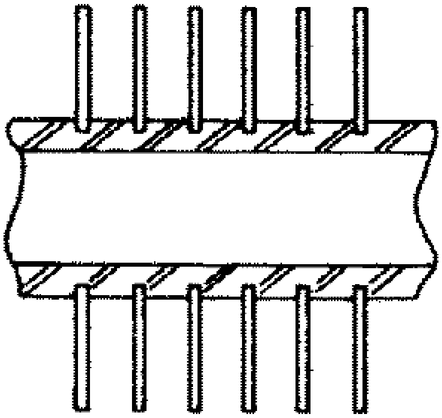
Knurled L-footed fin:

Again, this process is very similar to the L-footed tension wound fin, but utilizes knurling wheels that actually knurl the fin foot into the tube. This allows for a tighter bond between the tube and the fin, and reduces the likelihood of a corrosion film between the two.

L-footed fins with slits cut into the fin:

By cutting a slit into the fin, more air turbulence can be created, due to the interruption of the air boundary layer. This in turn increases the airside heat transfer coefficient with a modest increase in the airside pressure drop and the fan horsepower.

Embedded



EMBEDDED

In high temperature applications, an embedded process is employed to attach the fin to the tube wall. In this process, a groove is actually cut into the tube, the fin strip inserted, and the tube material then “plowed” back against the fin to bond it to the tube. Separation of the fin and tube due to corrosion or temperature differentials are not a factor with the fin type.

Since the fin does not employ a “foot”, this leaves the tube totally exposed to airside corrosion factors. In addition, due to the groove cut into the tube, a thicker tube wall thickness must be used to avoid over-pressuring the tube.

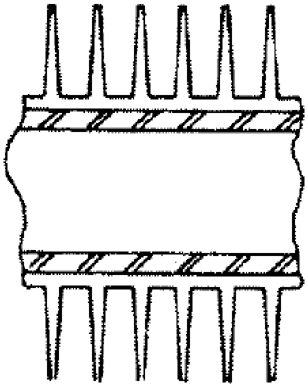
The embedded fin is normally used for services greater than 350 degrees and less than 750 degrees F.

Extruded

For applications where atmospheric corrosion is critical, the extruded fin tube provides the best protection.

The extruded fin is produced by inserting the tube into an aluminum sleeve and then extruding the fins from the aluminum sleeve. Since the tube is totally covered by the aluminum sleeve, the tube wall is protected from outside corrosion, and the bond between the fin and the tube remains tight.

The extruded fin tube is good for tube wall temperature up to 650 degrees F. This is the most expensive fin tube to produce.



EXTRUDED

TUBESIZE AND PITCH

1. The normal tube diameter is 1.0" od. Consider carefully if using a different diameter

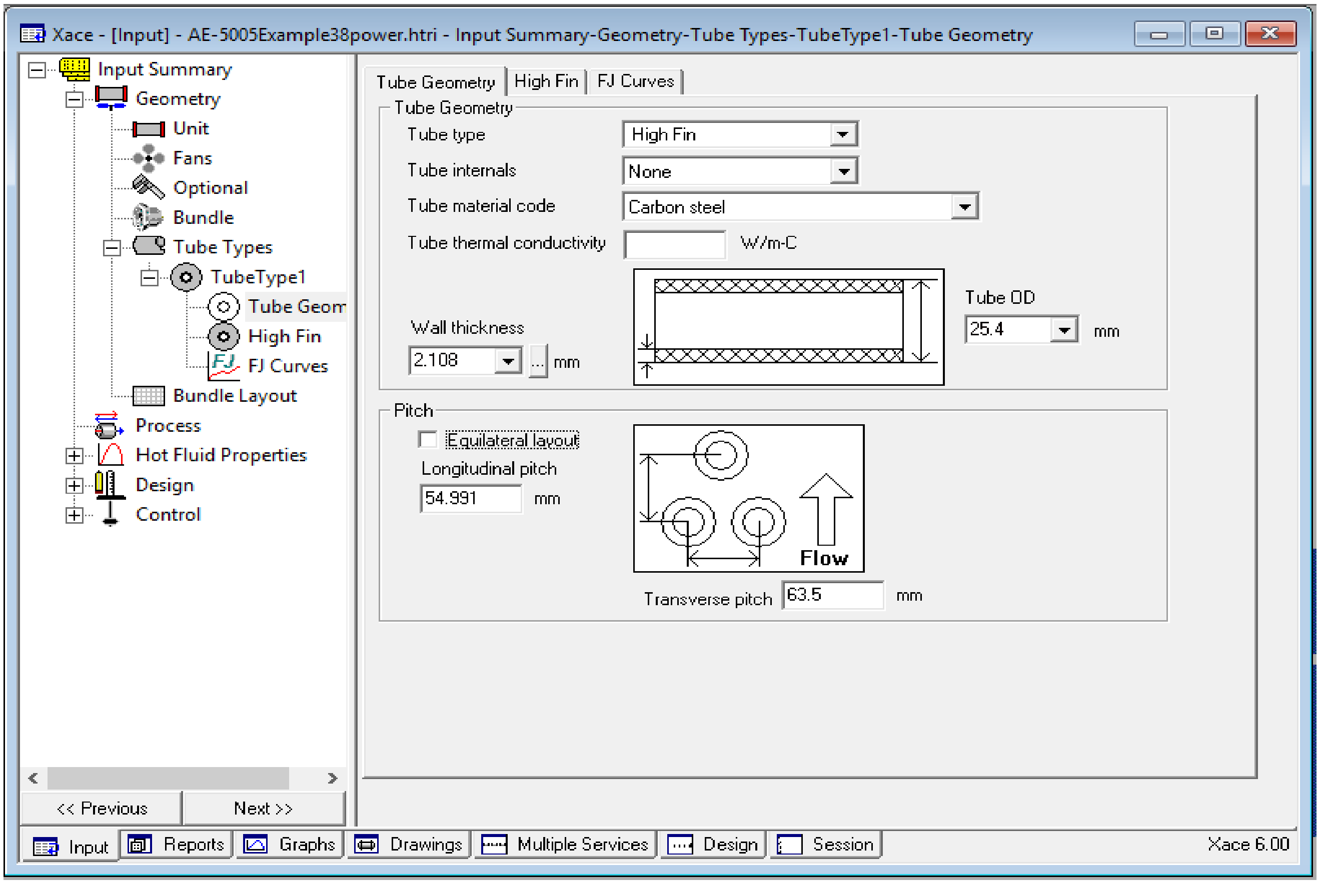
Typical tubepitches are given below

Metric

Tube Dia (ins)	Fin Dia (ins)	Transverse Pitch (mm)
1.0	2.25	60 / 63.5 / 67
1.25	2.5	67 / 70 / 73
1.5	2.75	73 / 76

British

Tube Dia (ins)	Fin Dia (ins)	Transverse Pitch (ins) (min / max)
1.0	2.25	2.375 / 2.625
1.25	2.5	2.625 / 2.875
1.5	2.75	2.875 / 3.0



Xace - [Input] - AE-5005Example38power.htri - Input Summary-Geometry-Tube Types-TubeType1-Tube Geometry

Tube Geometry

Tube type: High Fin

Tube internals: None

Tube material code: Carbon steel

Tube thermal conductivity: W/m-C

Wall thickness: 2.108 mm

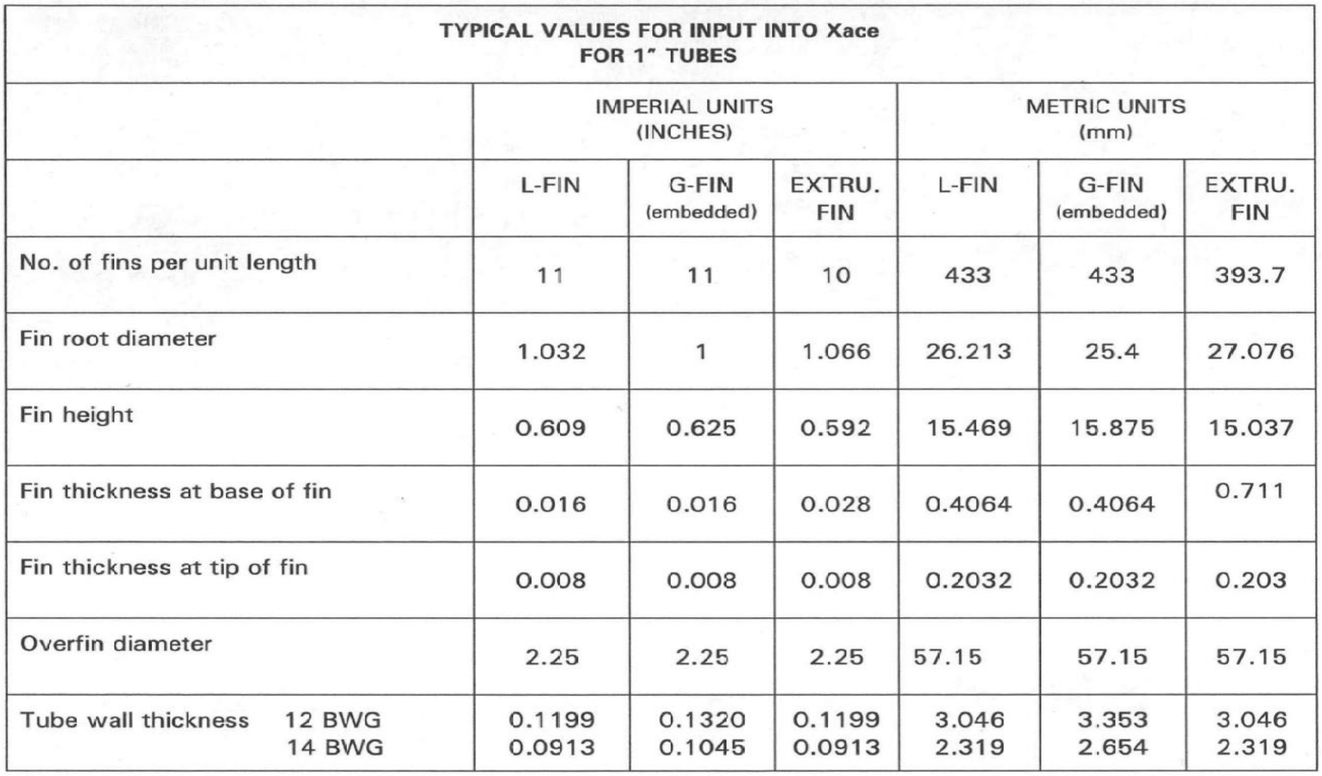
Tube OD: 25.4 mm

Pitch

☐ Equilateral layout

Longitudinal pitch: 54.991 mm

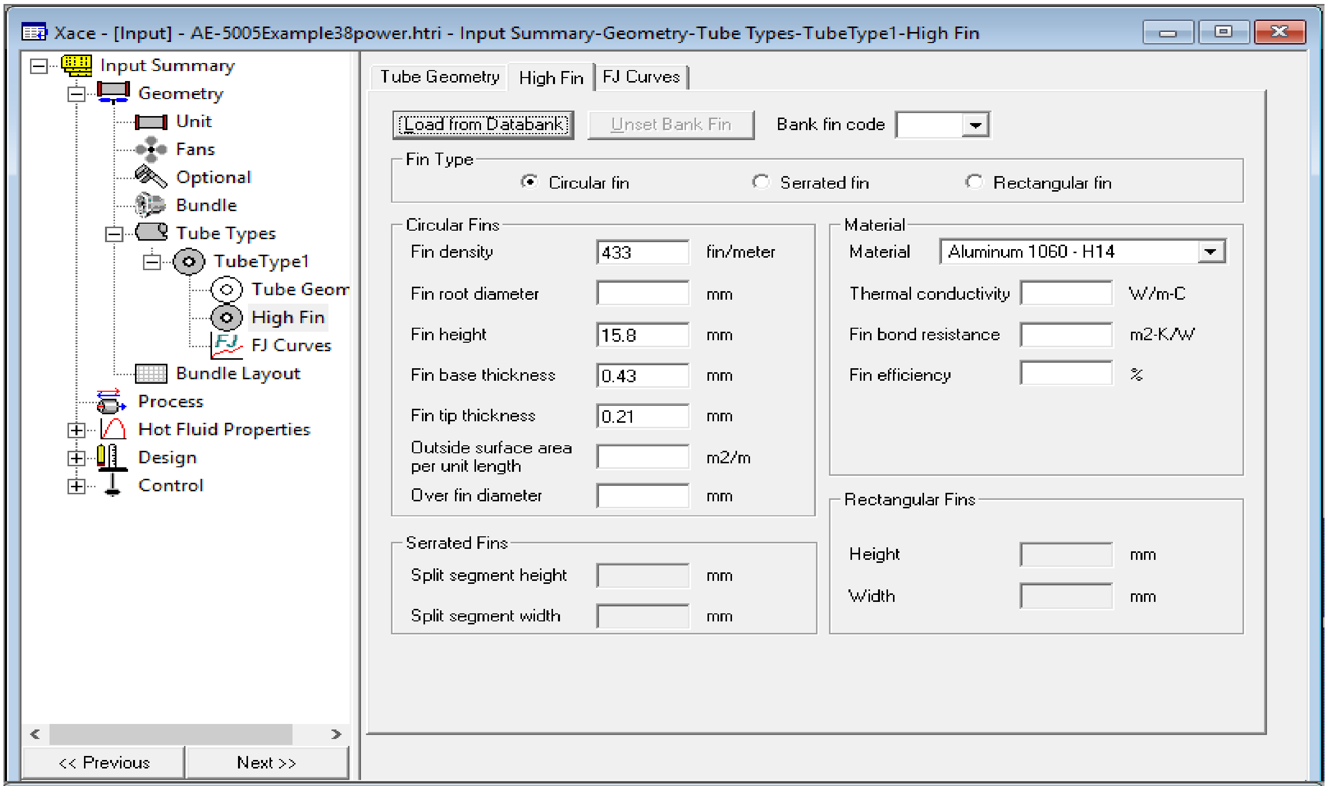
Transverse pitch: 63.5 mm



TYPICAL VALUES FOR INPUT INTO Xace
FOR 1" TUBES

	IMPERIAL UNITS (INCHES)			METRIC UNITS (mm)		
	L-FIN	G-FIN (embedded)	EXTRU. FIN	L-FIN	G-FIN (embedded)	EXTRU. FIN
No. of fins per unit length	11	11	10	433	433	393.7
Fin root diameter	1.032	1	1.066	26.213	25.4	27.076
Fin height	0.609	0.625	0.592	15.469	15.875	15.037
Fin thickness at base of fin	0.016	0.016	0.028	0.4064	0.4064	0.711
Fin thickness at tip of fin	0.008	0.008	0.008	0.2032	0.2032	0.203
Overfin diameter	2.25	2.25	2.25	57.15	57.15	57.15
Tube wall thickness 12 BWG	0.1199	0.1320	0.1199	3.046	3.353	3.046
14 BWG	0.0913	0.1045	0.0913	2.319	2.654	2.319

The tubes exposed to the passage of air usually have fins that form an extended surface. This surface compensates for the low film coefficient of air at atmospheric pressure and the usually low velocities across the bundle. The base tube is typically round and composed of material suited for such process considerations as corrosion, pressure, and temperature limitations. Whether helical or plate, the fins are usually made of aluminum to improve thermal conductivity and lessen fabrication costs. Very high temperature applications require steel fins, however.



Xace - [Input] - AE-5005Example38power.htri - Input Summary-Geometry-Tube Types-TubeType1-High Fin

Bank fin code

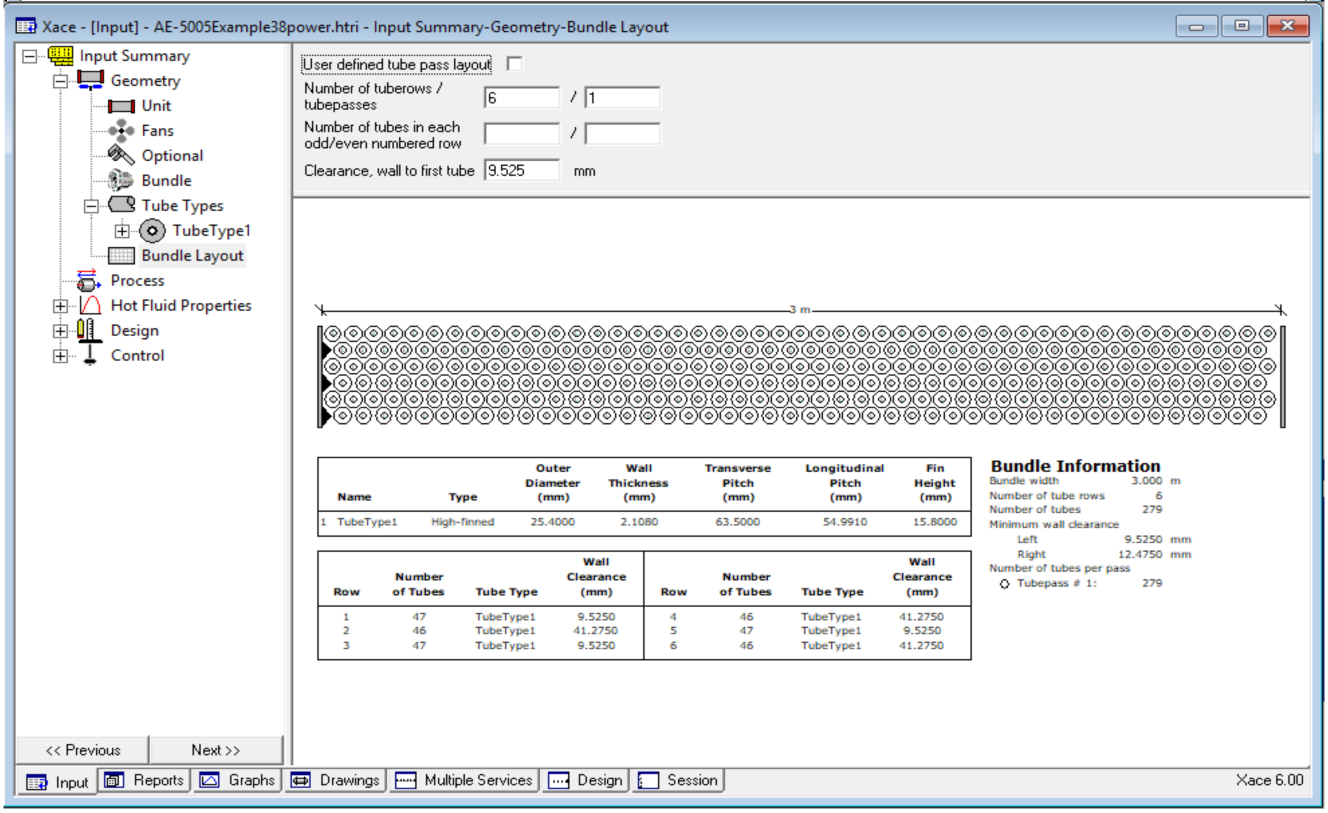
Fin Type
● Circular fin ○ Serrated fin ○ Rectangular fin

Circular Fins
Fin density 433 fin/meter
Fin root diameter mm
Fin height 15.8 mm
Fin base thickness 0.43 mm
Fin tip thickness 0.21 mm
Outside surface area per unit length m2/m
Over fin diameter mm

Material
Material Aluminum 1060 - H14
Thermal conductivity W/m-C
Fin bond resistance m2-K/W
Fin efficiency %

Serrated Fins
Split segment height mm
Split segment width mm

Rectangular Fins
Height mm
Width mm



Xace - [Input] - AE-5005Example38power.htri - Input Summary-Geometry-Bundle Layout

User defined tube pass layout ☐
Number of tuberows / tubepasses 6 / 1
Number of tubes in each odd/even numbered row /
Clearance, wall to first tube 9.525 mm

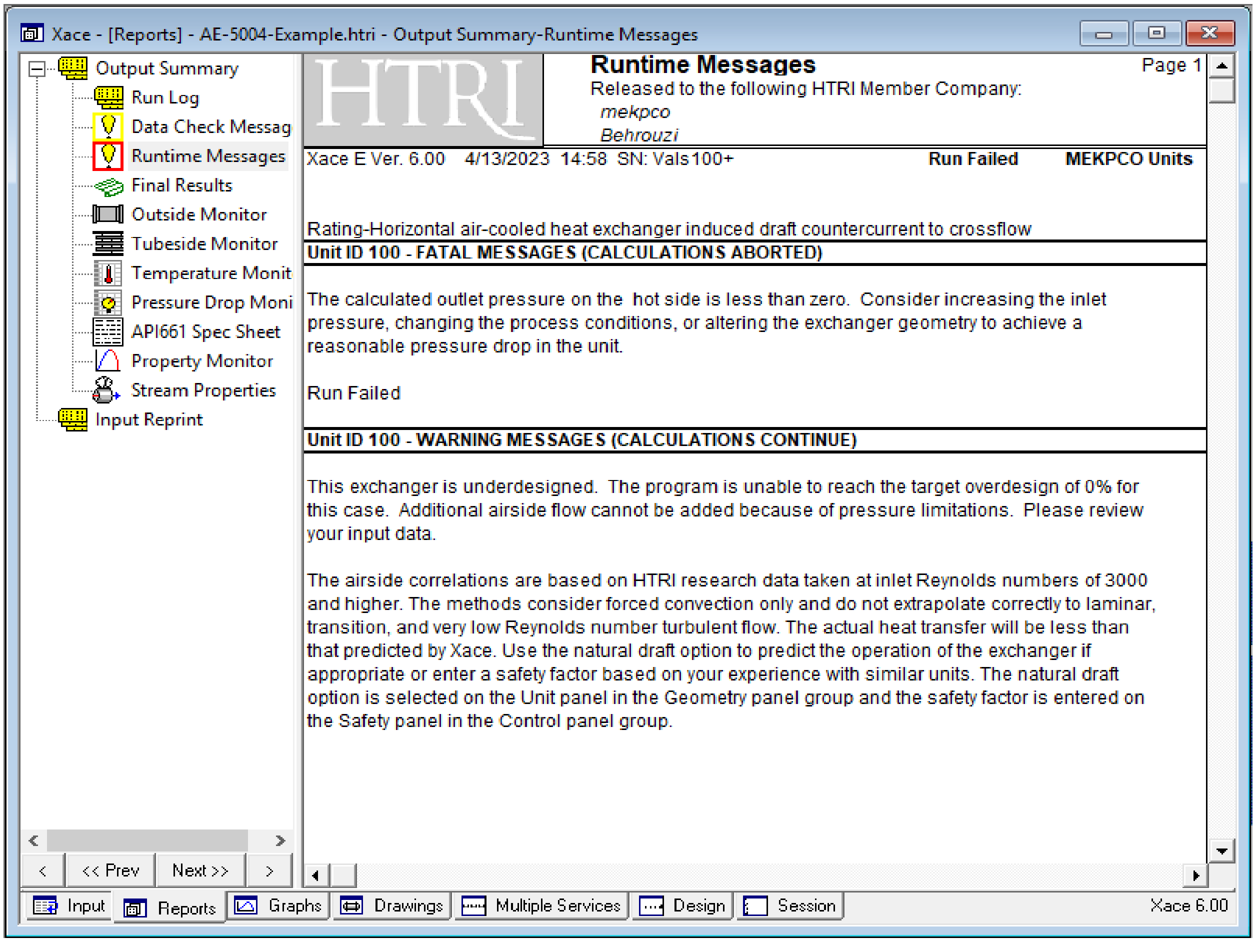
	Name	Type	Outer Diameter (mm)	Wall Thickness (mm)	Transverse Pitch (mm)	Longitudinal Pitch (mm)	Fin Height (mm)
1	TubeType1	High-finned	25.4000	2.1080	63.5000	54.9910	15.8000

Row	Number of Tubes	Tube Type	Wall Clearance (mm)	Row	Number of Tubes	Tube Type	Wall Clearance (mm)
1	47	TubeType1	9.5250	4	46	TubeType1	41.2750
2	46	TubeType1	41.2750	5	47	TubeType1	9.5250
3	47	TubeType1	9.5250	6	46	TubeType1	41.2750

Bundle Information

Bundle width	3.000	m
Number of tube rows	6	
Number of tubes	279	
Minimum wall clearance		
Left	9.5250	mm
Right	12.4750	mm
Number of tubes per pass		
○ Tubepass # 1:	279	

Results



Runtime Messages Page 1

Released to the following HTRI Member Company:

mekpco

Behrouzi

Xace E Ver. 6.00 4/13/2023 14:58 SN: Vals100+ **Run Failed** **MEKPCO Units**

Rating-Horizontal air-cooled heat exchanger induced draft countercurrent to crossflow

Unit ID 100 - FATAL MESSAGES (CALCULATIONS ABORTED)

The calculated outlet pressure on the hot 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)

This exchanger is underdesigned. The program is unable to reach the target overdesign of 0% for this case. Additional airside flow cannot be added because of pressure limitations. Please review your input data.

The airside correlations are based on HTRI research data taken at inlet Reynolds numbers of 3000 and higher. The methods consider forced convection only and do not extrapolate correctly to laminar, transition, and very low Reynolds number turbulent flow. The actual heat transfer will be less than that predicted by Xace. Use the natural draft option to predict the operation of the exchanger if appropriate or enter a safety factor based on your experience with similar units. The natural draft option is selected on the Unit panel in the Geometry panel group and the safety factor is entered on the Safety panel in the Control panel group.

Since 1 bay was selected, which is very low for such high flow, the software failed to run. Thus, the number of bays is increased to 2 and the program is run again. The summery of the actions are provided below.

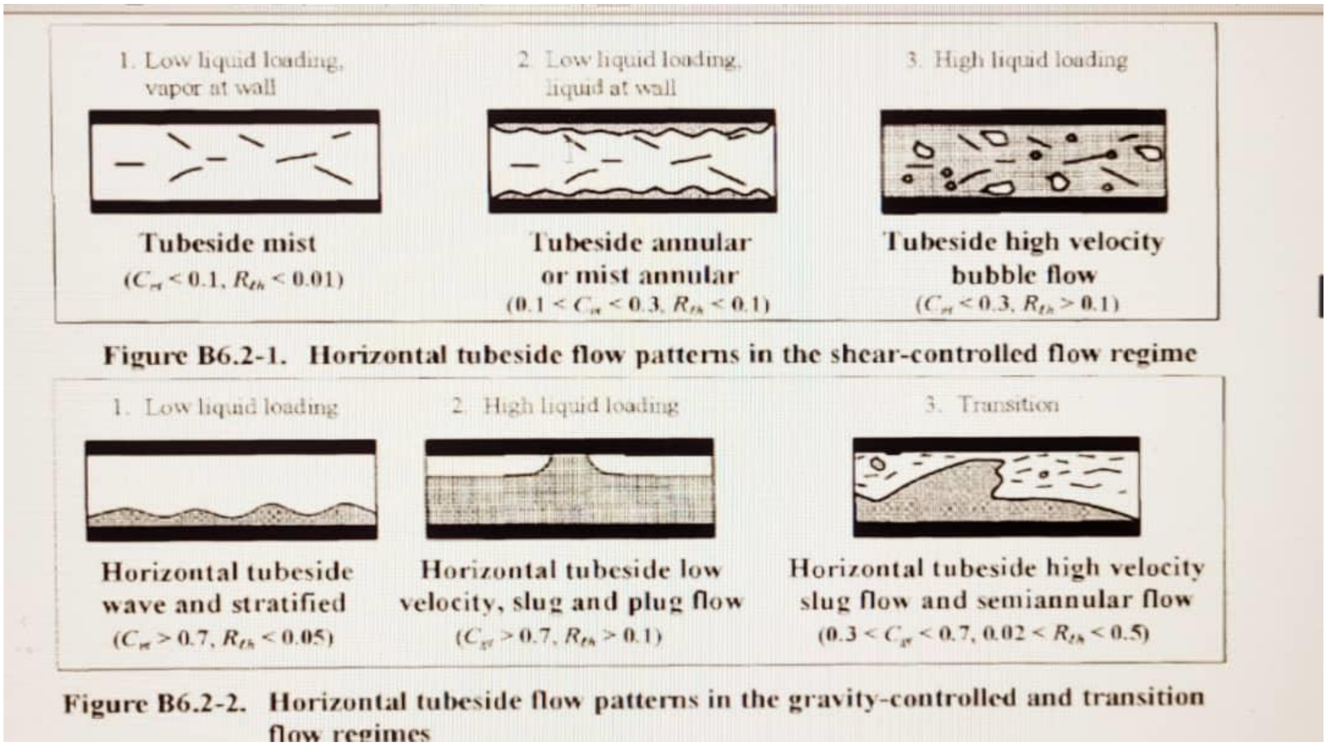
Number of bays	Pressure drop	Driver Power
1-5	Failed	Failed
6-10	Underdesigned	Underdesigned
12	533855	69821215
15	10797	28983
18	3163	4138
21	1661.5	1508
24	939	616
27	590	296
30	430	180
33	318	111
36	259	80
39	205	55
40	192	49
41	179	44.46
42	165	38 (44)

Now we stop here and try to change some parameters to optimise the required driver power.

Actions	Pressure drops	Driver Power
Increasing fan efficiency to 75%	164.9	33.6 (38.78)
Changing fan ring type to cone 30	133.9	28.43 (32.83)

Now one of the parameters that should be taken into account is the flow regime. To find out how it looks like graph tab is clicked and then Flow regime map is selected.

How it is interpreted



1. Low liquid loading, vapor at wall

2. Low liquid loading, liquid at wall

3. High liquid loading

Tubeside mist
($C_{gt} < 0.1$, $R_{th} < 0.01$)

Tubeside annular or mist annular
($0.1 < C_{gt} < 0.3$, $R_{th} < 0.1$)

Tubeside high velocity bubble flow
($C_{gt} < 0.3$, $R_{th} > 0.1$)

Figure B6.2-1. Horizontal tubeside flow patterns in the shear-controlled flow regime

1. Low liquid loading

2. High liquid loading

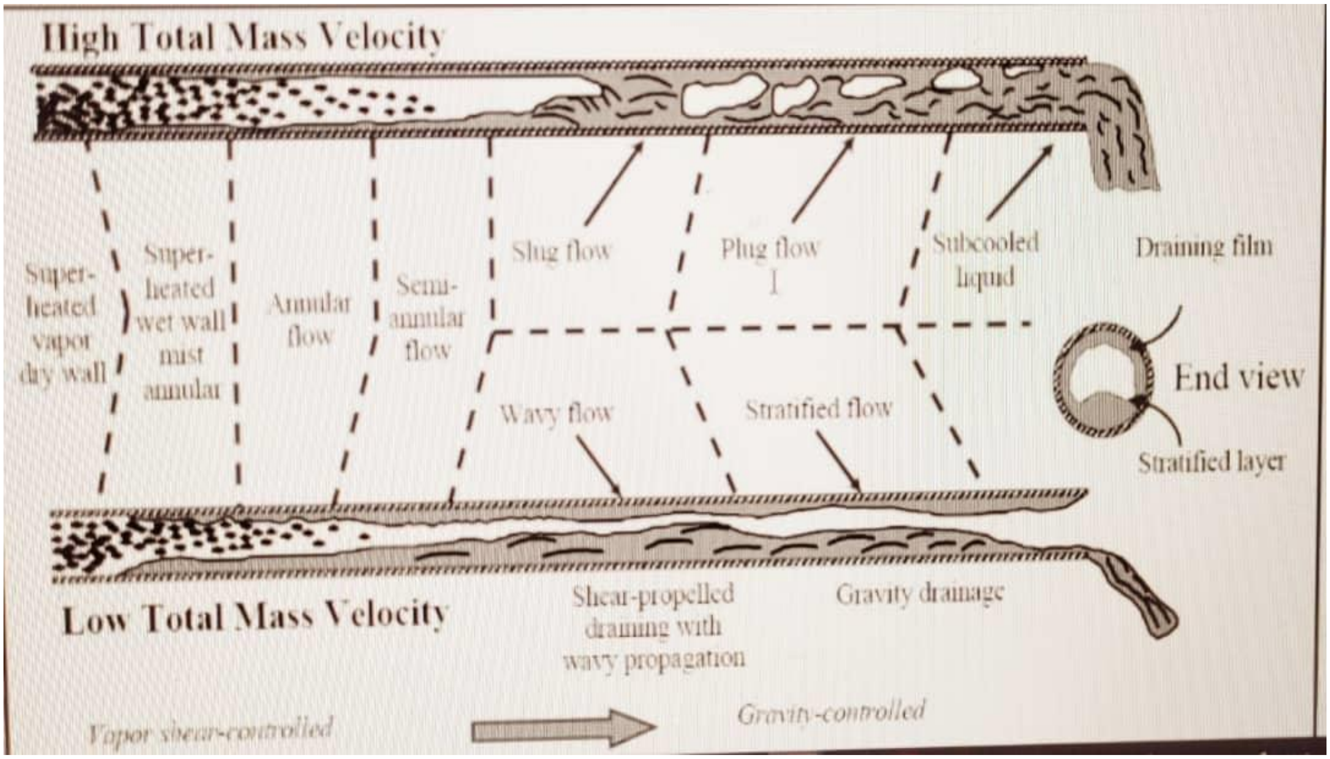
3. Transition

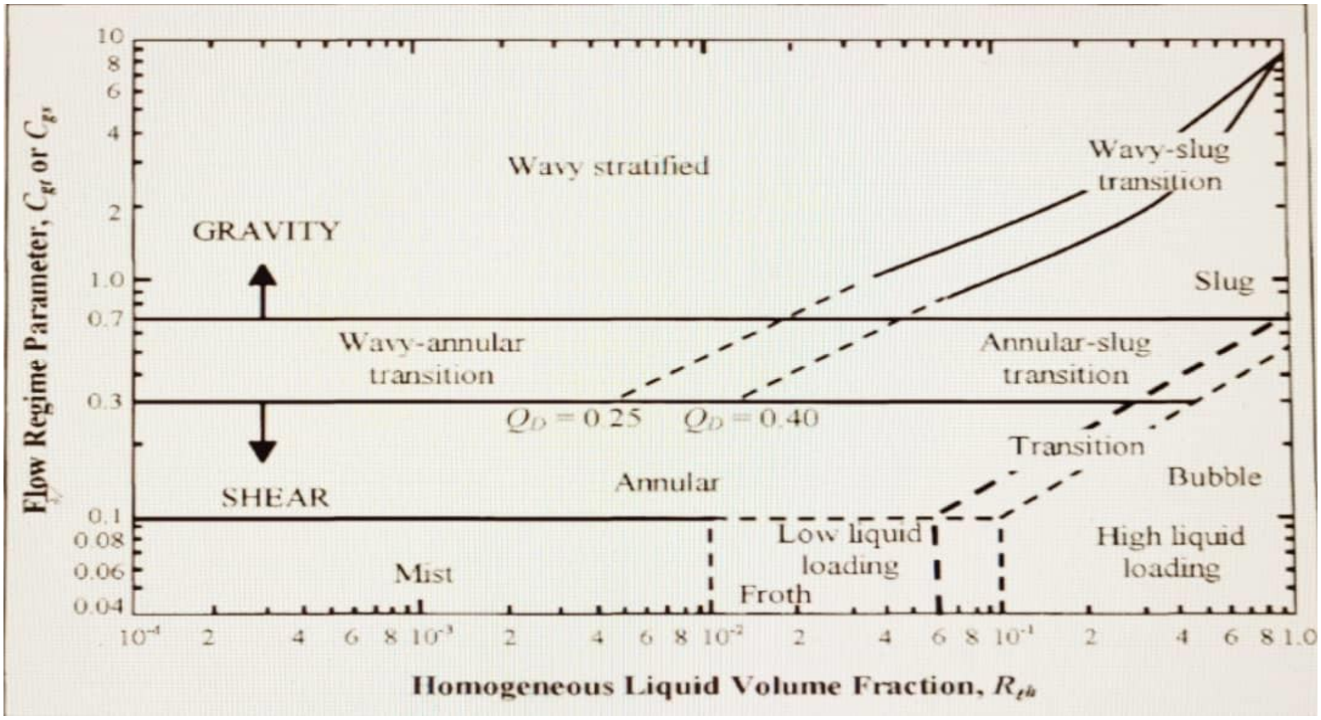
Horizontal tubeside wave and stratified
($C_{gt} > 0.7$, $R_{th} < 0.05$)

Horizontal tubeside low velocity, slug and plug flow
($C_{gt} > 0.7$, $R_{th} > 0.1$)

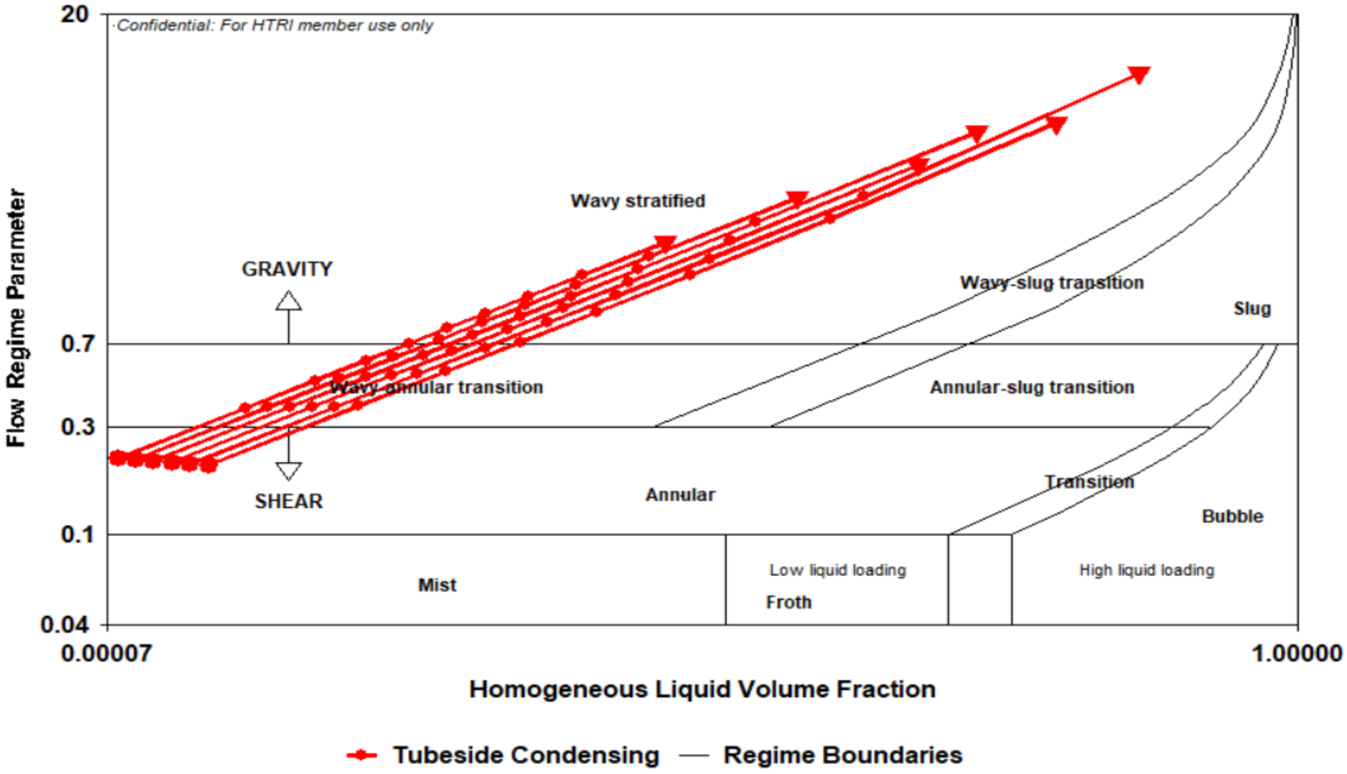
Horizontal tubeside high velocity slug flow and semiannular flow
($0.3 < C_{gt} < 0.7$, $0.02 < R_{th} < 0.5$)

Figure B6.2-2. Horizontal tubeside flow patterns in the gravity-controlled and transition flow regimes





Flow Regime Map



Notes:

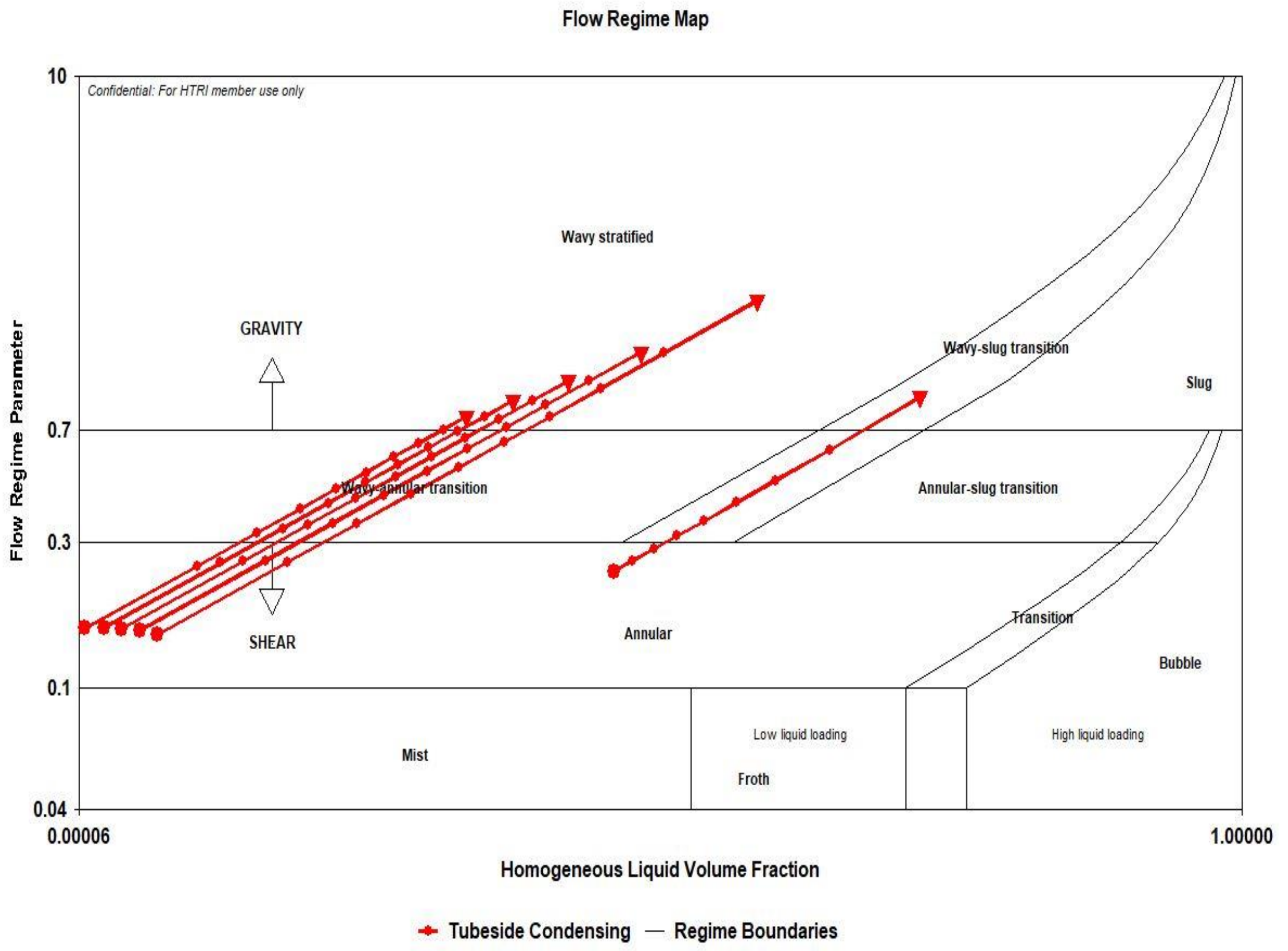
Only the last tube-pass in a multipass condenser should be in gravity-controlled flow. Remember that in gravity-controlled flow, the vapor-phase heat transfer coefficient can become very low especially when non-condensible are present.

The effect of tube inclination contributes to an approximate avarage increase of only 20 percent in the tube-side heat transfer coefficient on the avarage tube side heat transfer. HTRI therefore recommends inclining tubeside condensers in gravity-flow about 3 degrees towards the draining condensate end to prevent condensate back flow.

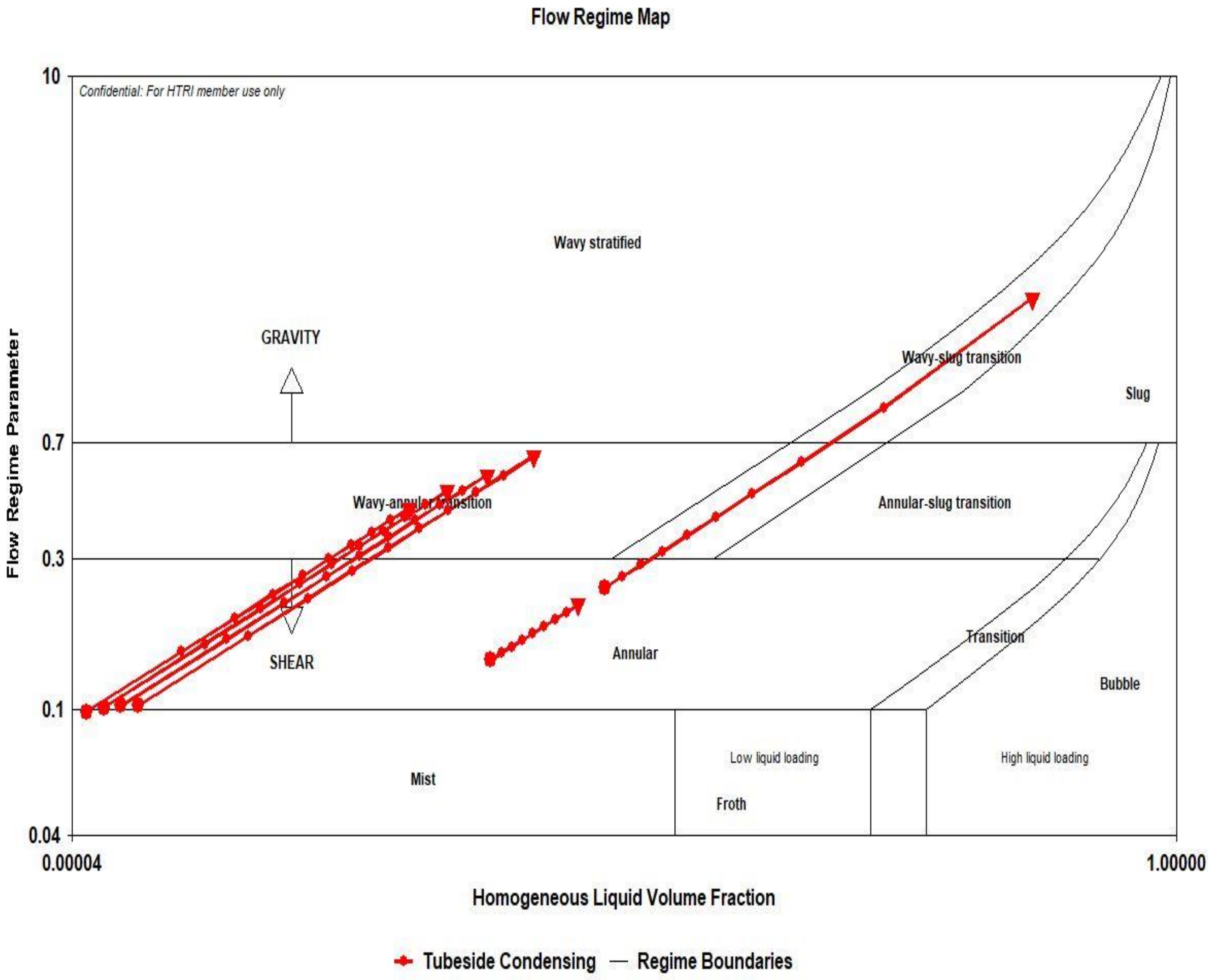
So, in order to adjust the flow regime, map we perform the following actions:

Actions	**Pressure drop**	**Driver Power**
Changing from one pass to two passes	114.3	21.81(25.18)
Changing from two pass to 3 passes (4-1-1)	112	21.14(24.41)
Changing 3 passes orientation from (4-1-1) to (3-2-1)	112	21.15(24.41)
Force seperation	129	26.9(31.05)
Get back to (4-1-1)	113	21.5 (25)

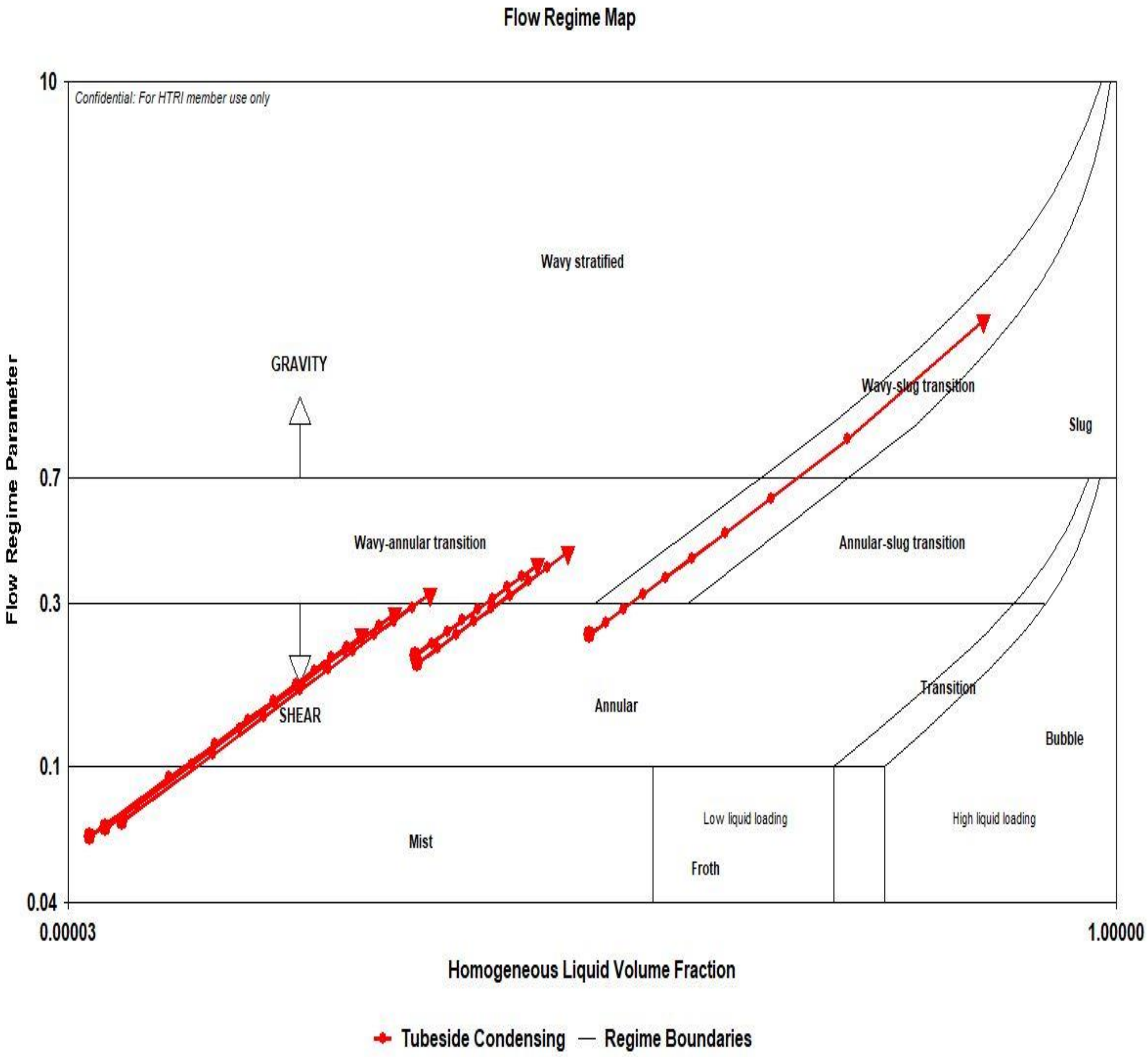
Now let's see the impacts of the steps on flow regime:



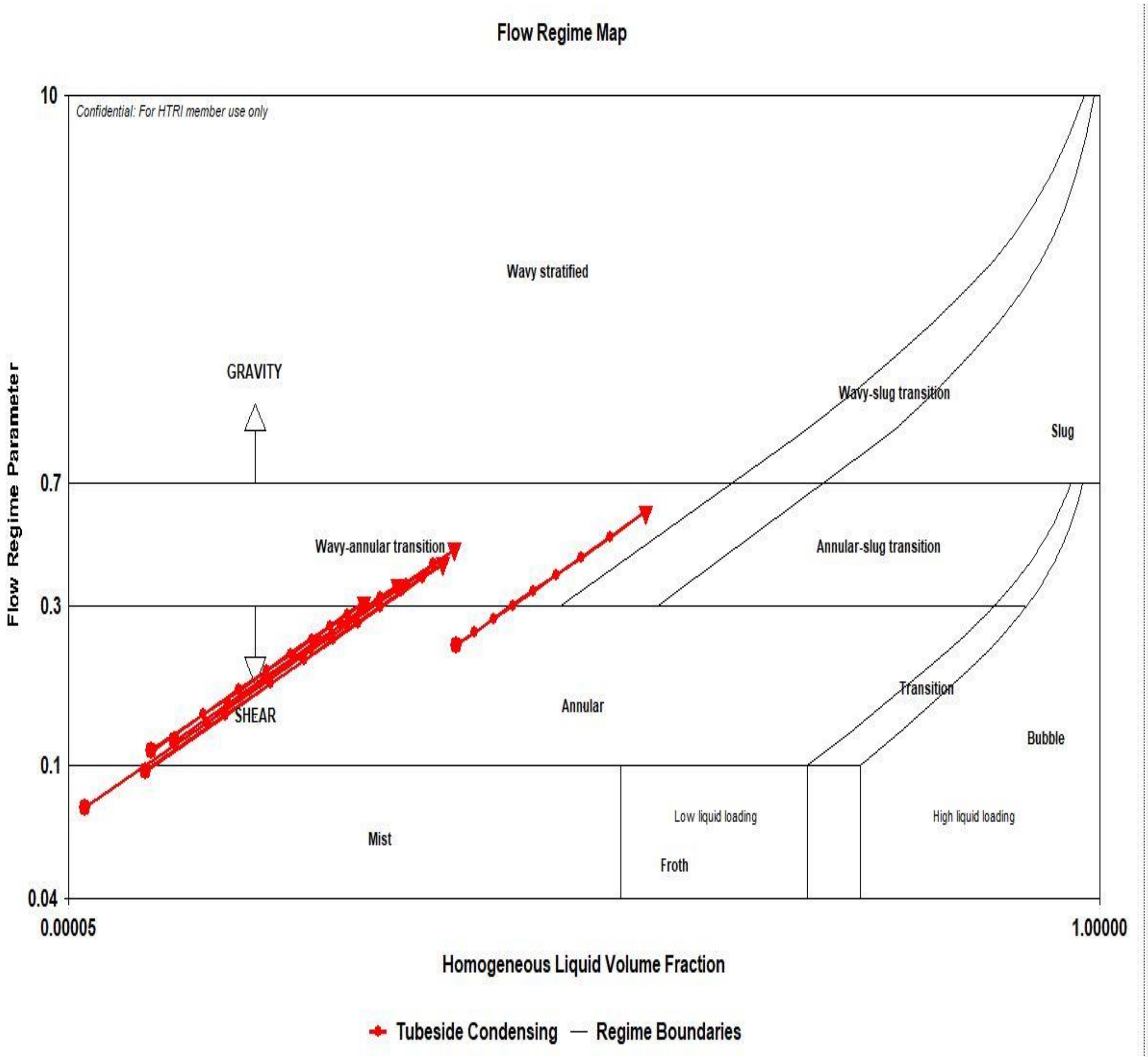
Two-passes with the orientation of 5-1



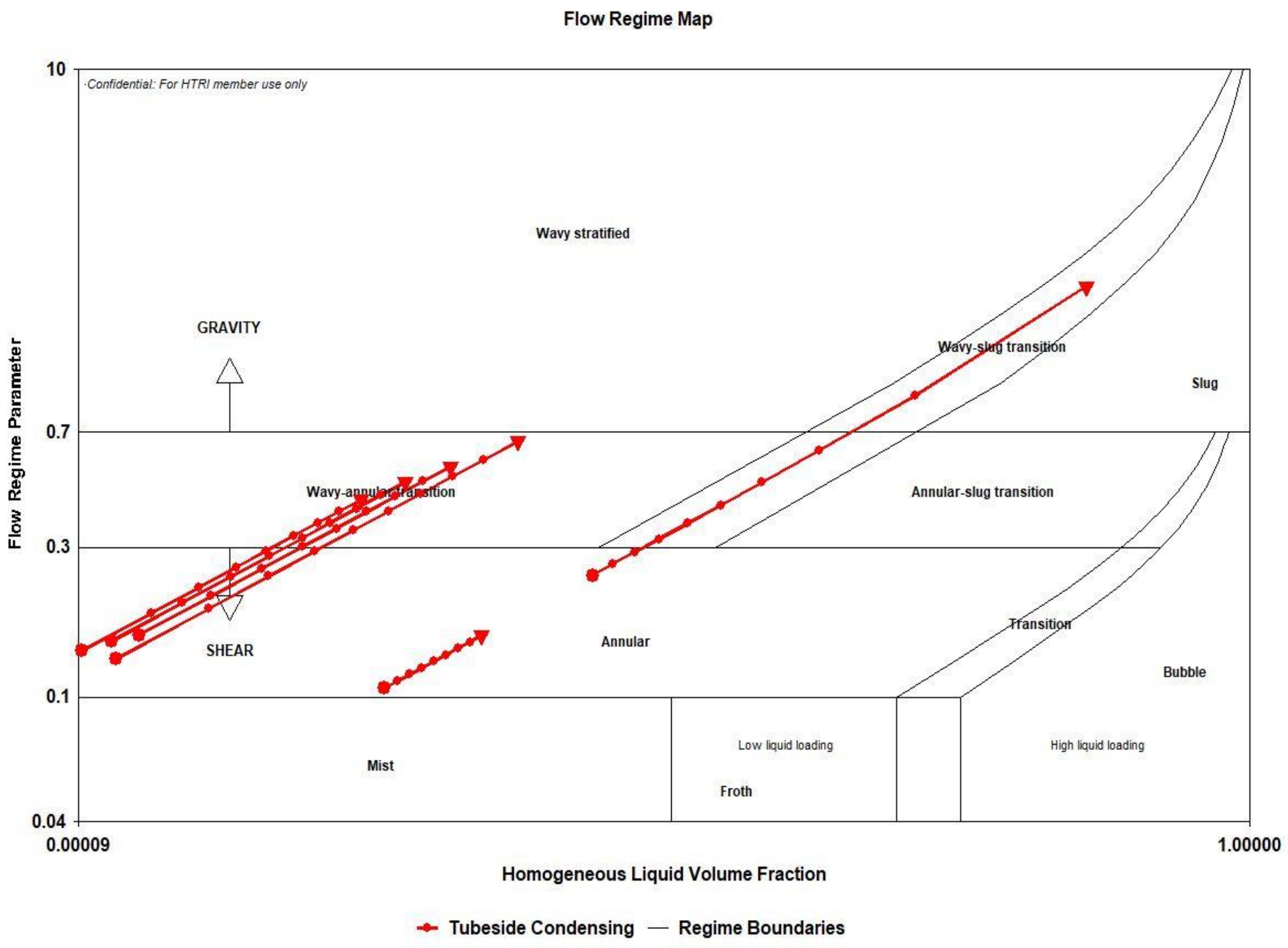
Three passes with the orientation of 4-1-1



Three passes with the orientation of 3-2-1



Three passes with the orientation of 3-2-1 in Force

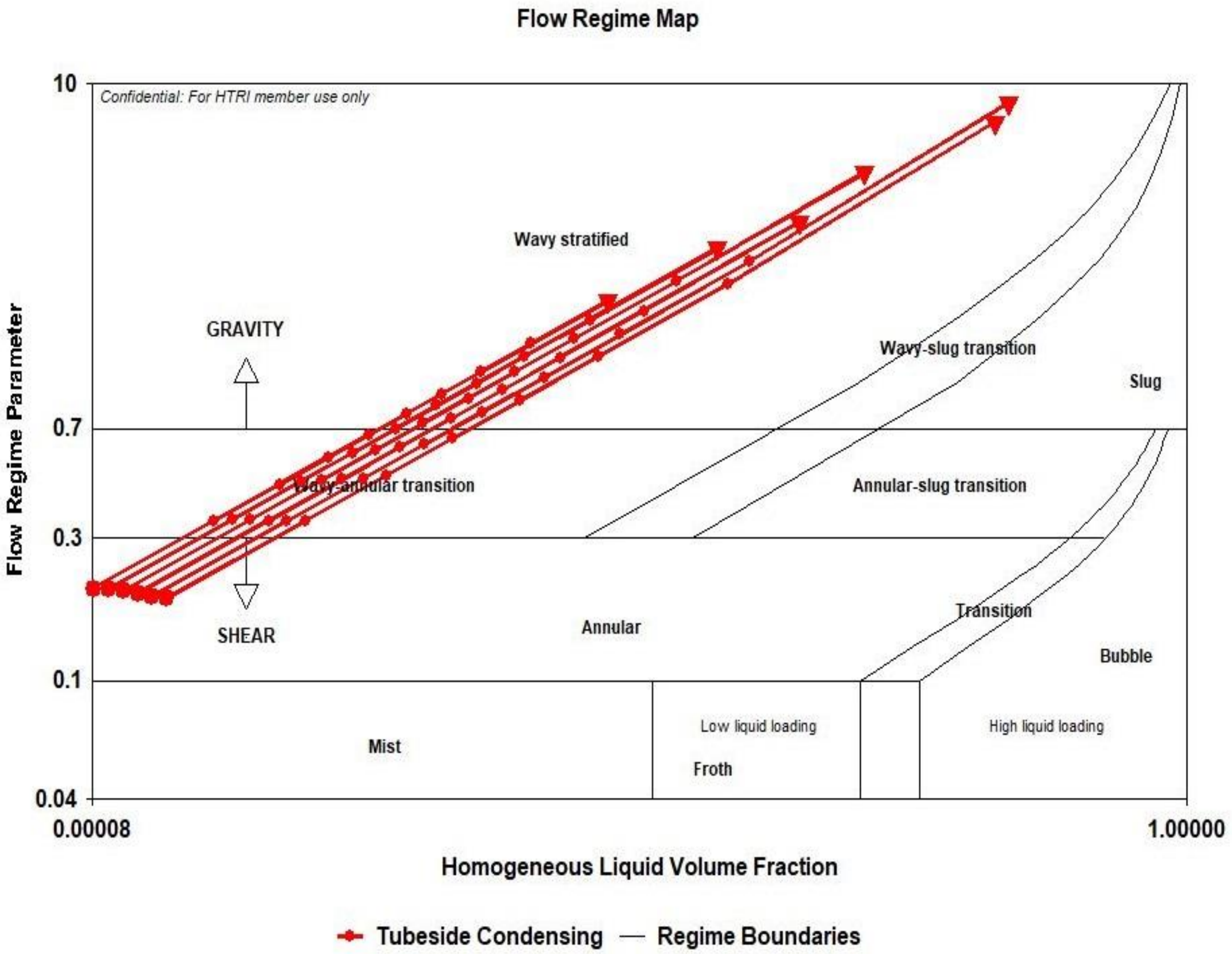


Three passes with the orientation of 4-1-1 in Force

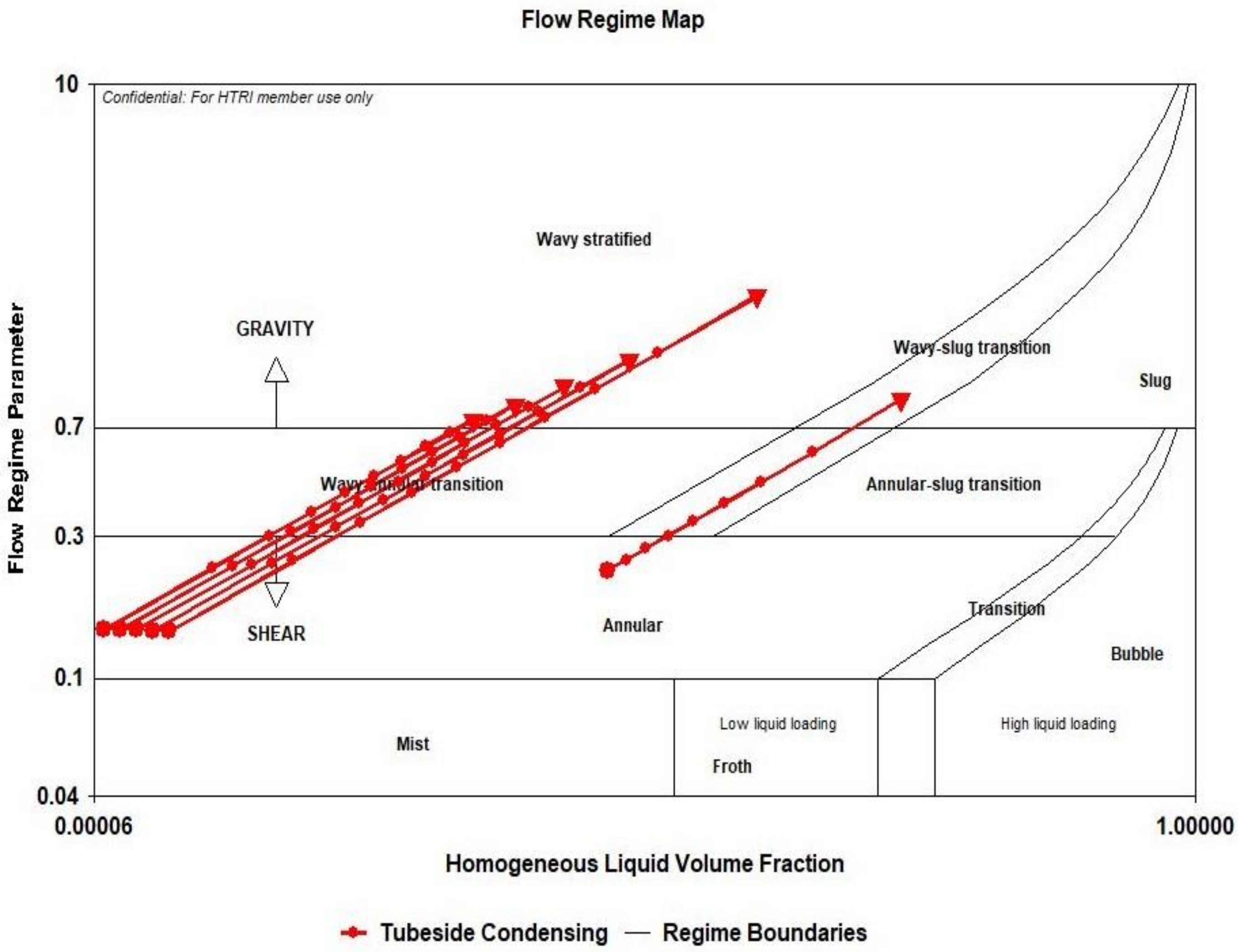
Now Let’s choose another path and start with 39 bays, aiming to design air-cooler with maximum driver fan of 45 kw.

The following actions are taken which is summarized below:

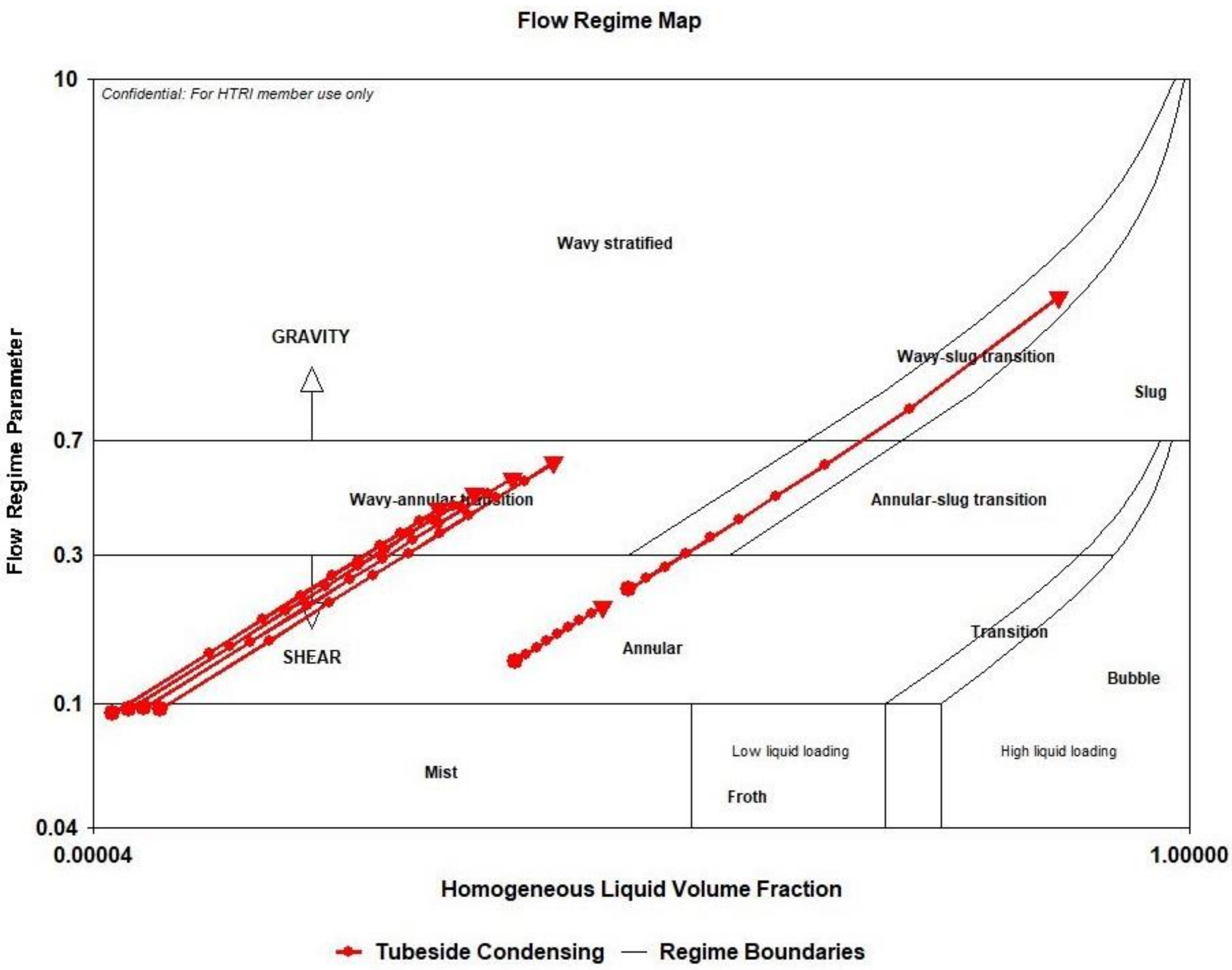
Actions	Pressure drops	Driver Power
Choosing 39 bays	205	
Changing fan ring type to cone 30	165	46.51
Changing fan efficiency from 65% to 75%	165	40.31(46.54)
Increasing the number of passes to 2 passes	136.8	29.4(34)
Increasing the number of passes to 3 passes with 4-1-1 oriantation	133.8	28.33 (32.7)
Force	132	27.95 (32.27)



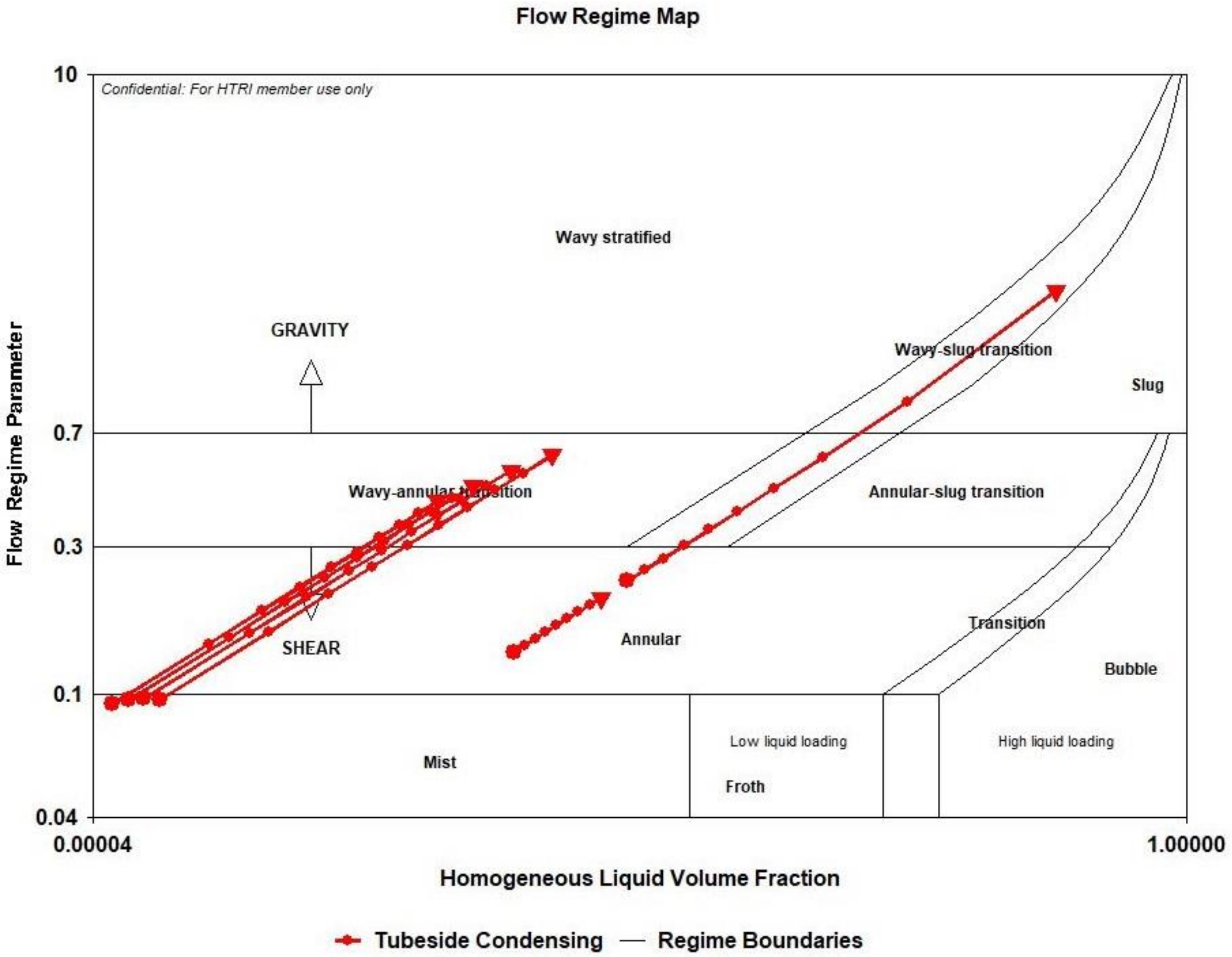
Flow regime map for one pass



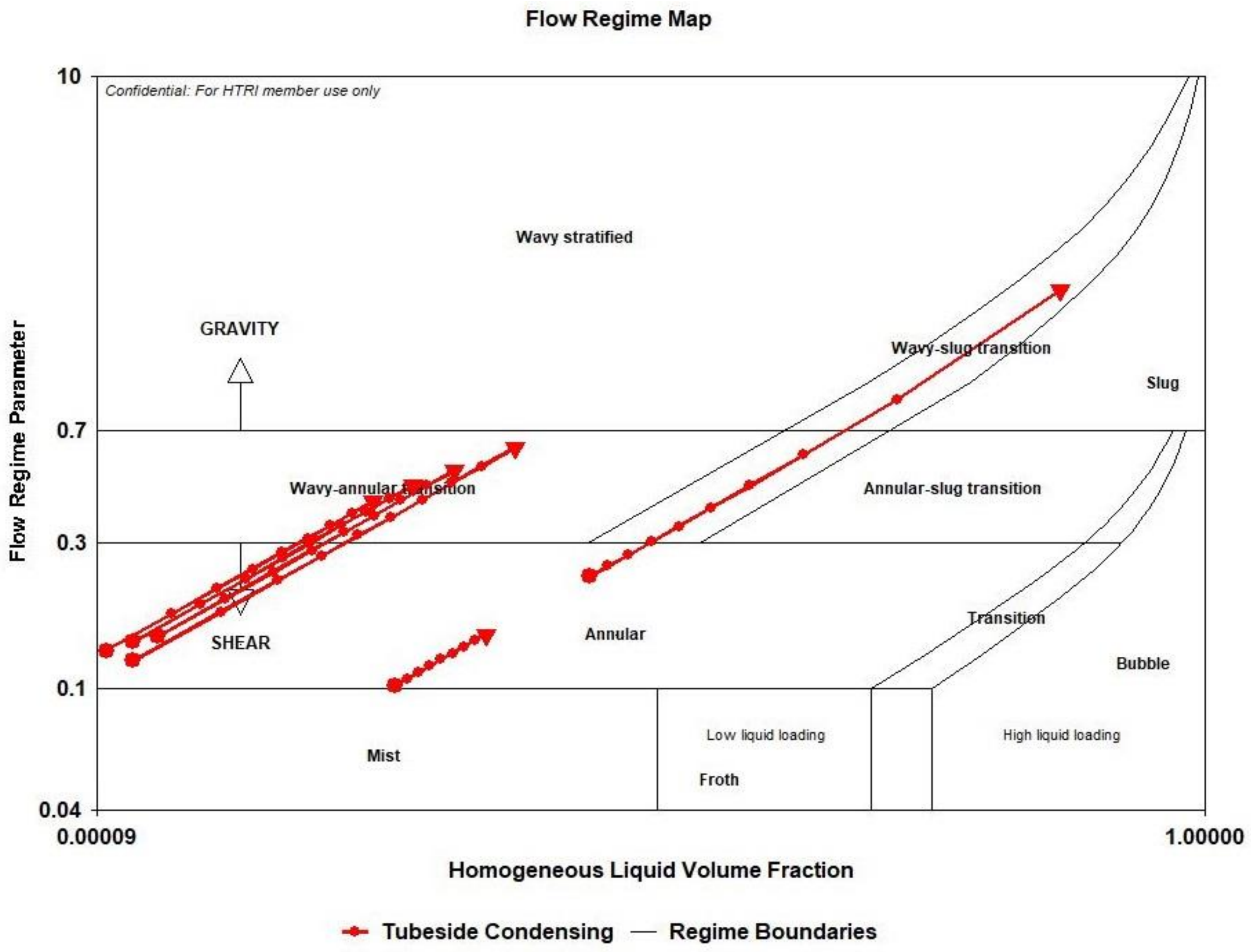
Flow regime for two passes



Flow regime for three passes



Flow regime for three passes in Force

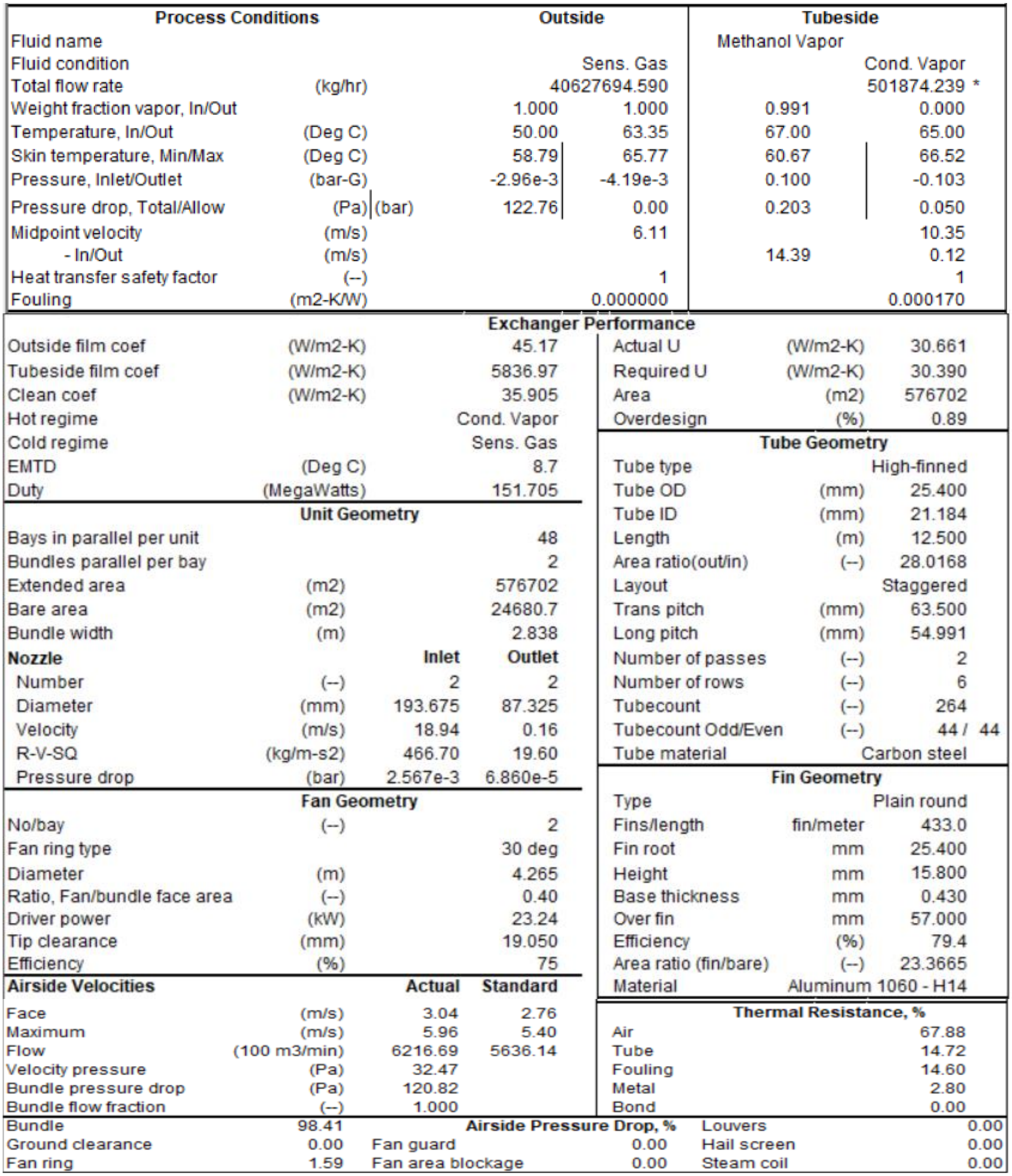

Flow Regime Map
Confidential: For HTRI member use only
10
0.7
0.3
0.1
0.04
Flow Regime Parameter
0.00009
1.00000
Homogeneous Liquid Volume Fraction
Wavy stratified
GRAVITY
SHEAR
Wavy-annular transition
Wavy-slug transition
Slug
Annular-slug transition
Annular
Transition
Bubble
Mist
Low liquid loading
Froth
High liquid loading
Tubeside Condensing
Regime Boundaries

Vendor Thermal Calculation

Differences in assumptions:

Parameter	Me	Vendor
Temprature	48	50
Inlet Nozzle		193.67
Outlet Nozzle		87.32
Tube passes	4-1-1	5-1
Tubes in odd/even rows	46	44
Total unfinned tube length	0	78

Results:



Process Conditions		**Outside**		**Tubeside**	
Fluid name				Methanol Vapor	
Fluid condition			Sens. Gas		Cond. Vapor
Total flow rate	(kg/hr)		40627694.590		501874.239 *
Weight fraction vapor, In/Out		1.000	1.000	0.991	0.000
Temperature, In/Out	(Deg C)	50.00	63.35	67.00	65.00
Skin temperature, Min/Max	(Deg C)	58.79	65.77	60.67	66.52
Pressure, Inlet/Outlet	(bar-G)	-2.96e-3	-4.19e-3	0.100	-0.103
Pressure drop, Total/Allow	(Pa) | (bar)	122.76	0.00	0.203	0.050
Midpoint velocity	(m/s)		6.11		10.35
- In/Out	(m/s)			14.39	0.12
Heat transfer safety factor	(--)		1		1
Fouling	(m2-K/W)		0.000000		0.000170

Exchanger Performance

Outside film coef	(W/m2-K)	45.17
Tubeside film coef	(W/m2-K)	5836.97
Clean coef	(W/m2-K)	35.905
Hot regime		Cond. Vapor
Cold regime		Sens. Gas
EMTD	(Deg C)	8.7
Duty	(MegaWatts)	151.705

Actual U	(W/m2-K)	30.661
Required U	(W/m2-K)	30.390
Area	(m2)	576702
Overdesign	(%)	0.89

Unit Geometry

Bays in parallel per unit			48
Bundles parallel per bay			2
Extended area	(m2)		576702
Bare area	(m2)		24680.7
Bundle width	(m)		2.838
Nozzle		**Inlet**	**Outlet**
Number	(--)	2	2
Diameter	(mm)	193.675	87.325
Velocity	(m/s)	18.94	0.16
R-V-SQ	(kg/m-s2)	466.70	19.60
Pressure drop	(bar)	2.567e-3	6.860e-5

Tube Geometry

Tube type		High-finned
Tube OD	(mm)	25.400
Tube ID	(mm)	21.184
Length	(m)	12.500
Area ratio(out/in)	(--)	28.0168
Layout		Staggered
Trans pitch	(mm)	63.500
Long pitch	(mm)	54.991
Number of passes	(--)	2
Number of rows	(--)	6
Tubecount	(--)	264
Tubecount Odd/Even	(--)	44 / 44
Tube material		Carbon steel

Fan Geometry

No/bay	(--)	2
Fan ring type		30 deg
Diameter	(m)	4.265
Ratio, Fan/bundle face area	(--)	0.40
Driver power	(kW)	23.24
Tip clearance	(mm)	19.050
Efficiency	(%)	75

Fin Geometry

Type		Plain round
Fins/length	fin/meter	433.0
Fin root	mm	25.400
Height	mm	15.800
Base thickness	mm	0.430
Over fin	mm	57.000
Efficiency	(%)	79.4
Area ratio (fin/bare)	(--)	23.3665
Material		Aluminum 1060 - H14

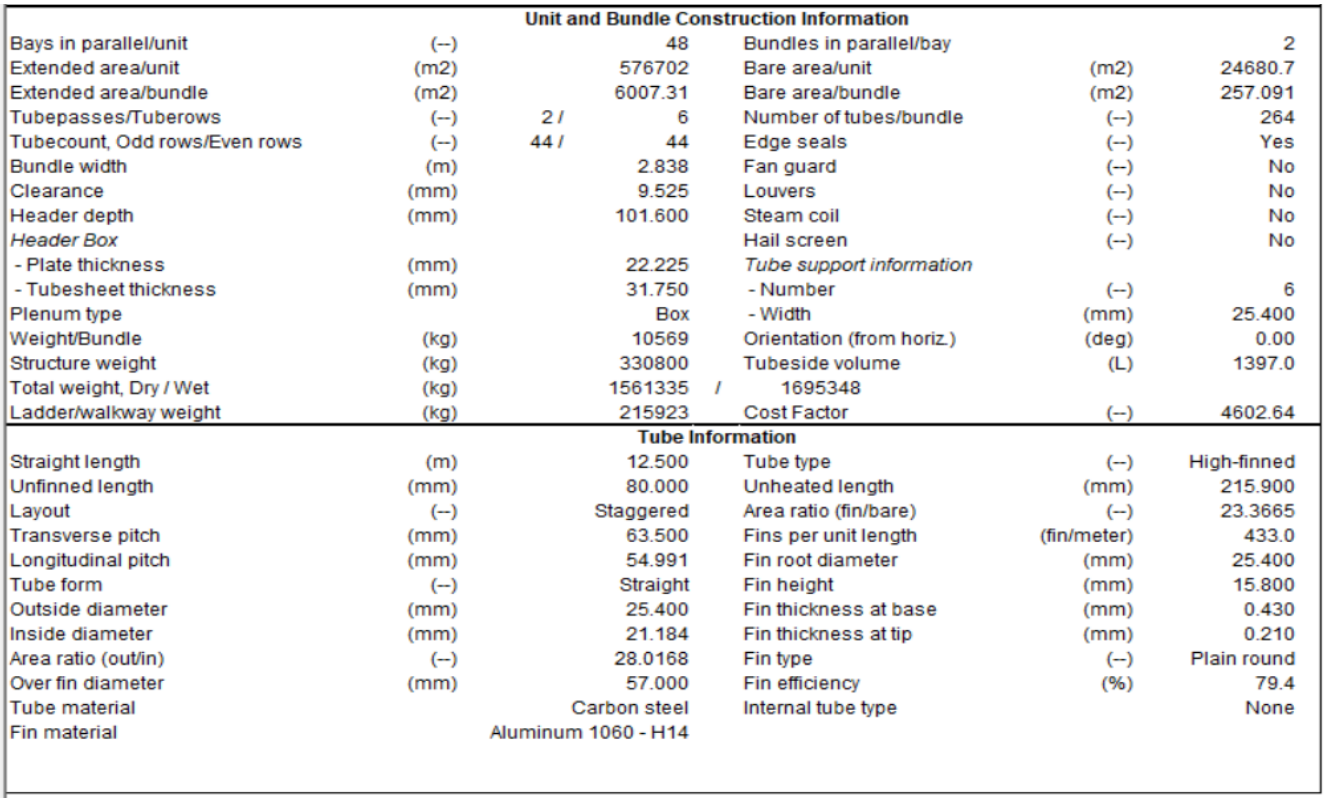
Airside Velocities		**Actual**	**Standard**
Face	(m/s)	3.04	2.76
Maximum	(m/s)	5.96	5.40
Flow	(100 m3/min)	6216.69	5636.14
Velocity pressure	(Pa)	32.47	
Bundle pressure drop	(Pa)	120.82	
Bundle flow fraction	(--)	1.000	

Thermal Resistance, %

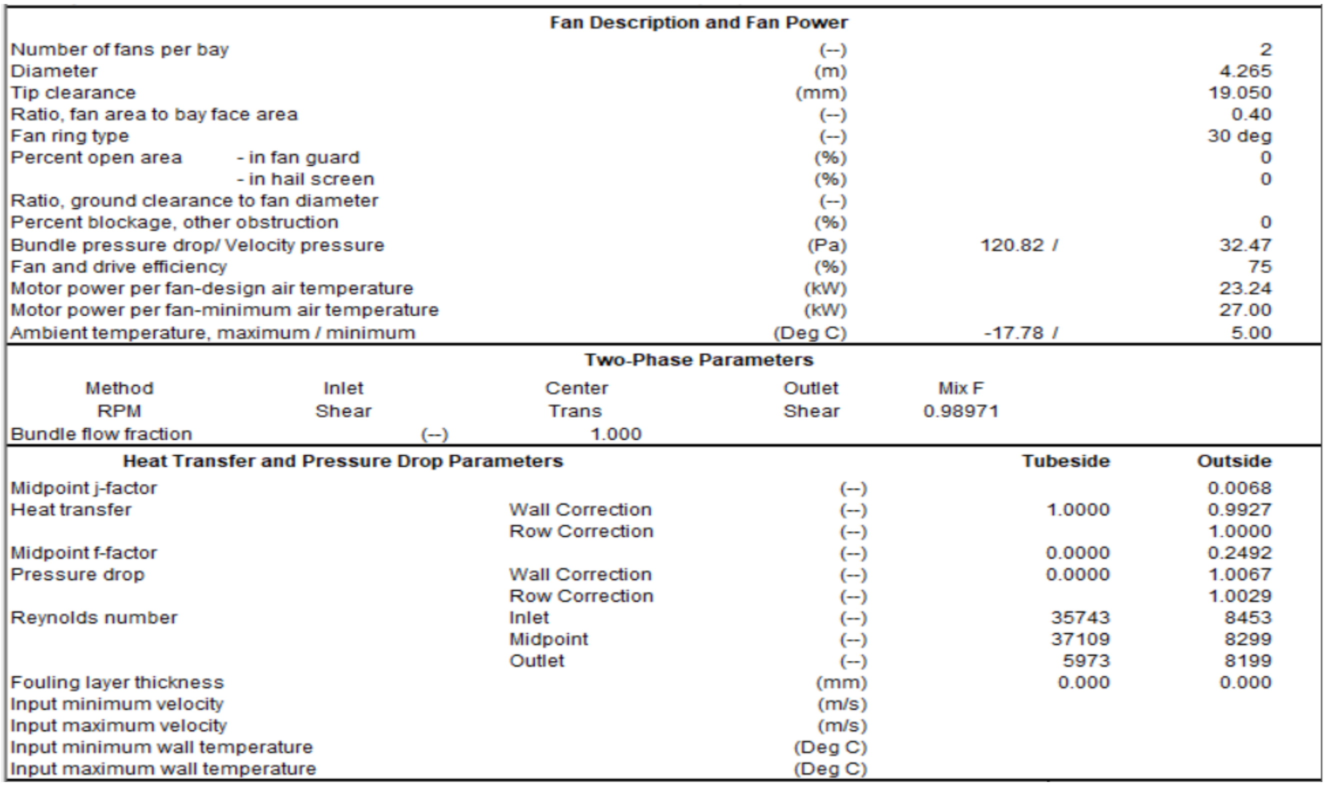
Air	67.88
Tube	14.72
Fouling	14.60
Metal	2.80
Bond	0.00

Airside Pressure Drop, %

Bundle	98.41			Louvers	0.00
Ground clearance	0.00	Fan guard	0.00	Hail screen	0.00
Fan ring	1.59	Fan area blockage	0.00	Steam coil	0.00



Unit and Bundle Construction Information						
Bays in parallel/unit	(--)		48	Bundles in parallel/bay		2
Extended area/unit	(m2)		576702	Bare area/unit	(m2)	24680.7
Extended area/bundle	(m2)		6007.31	Bare area/bundle	(m2)	257.091
Tubepasses/Tuberows	(--)	2 /	6	Number of tubes/bundle	(--)	264
Tubecount, Odd rows/Even rows	(--)	44 /	44	Edge seals	(--)	Yes
Bundle width	(m)		2.838	Fan guard	(--)	No
Clearance	(mm)		9.525	Louvers	(--)	No
Header depth	(mm)		101.600	Steam coil	(--)	No
Header Box				Hail screen	(--)	No
- Plate thickness	(mm)		22.225	*Tube support information*		
- Tubesheet thickness	(mm)		31.750	- Number	(--)	6
Plenum type			Box	- Width	(mm)	25.400
Weight/Bundle	(kg)		10569	Orientation (from horiz.)	(deg)	0.00
Structure weight	(kg)		330800	Tubeside volume	(L)	1397.0
Total weight, Dry / Wet	(kg)		1561335 /	1695348		
Ladder/walkway weight	(kg)		215923	Cost Factor	(--)	4602.64
Tube Information						
Straight length	(m)		12.500	Tube type	(--)	High-finned
Unfinned length	(mm)		80.000	Unheated length	(mm)	215.900
Layout	(--)		Staggered	Area ratio (fin/bare)	(--)	23.3665
Transverse pitch	(mm)		63.500	Fins per unit length	(fin/meter)	433.0
Longitudinal pitch	(mm)		54.991	Fin root diameter	(mm)	25.400
Tube form	(--)		Straight	Fin height	(mm)	15.800
Outside diameter	(mm)		25.400	Fin thickness at base	(mm)	0.430
Inside diameter	(mm)		21.184	Fin thickness at tip	(mm)	0.210
Area ratio (out/in)	(--)		28.0168	Fin type	(--)	Plain round
Over fin diameter	(mm)		57.000	Fin efficiency	(%)	79.4
Tube material			Carbon steel	Internal tube type		None
Fin material			Aluminum 1060 - H14			

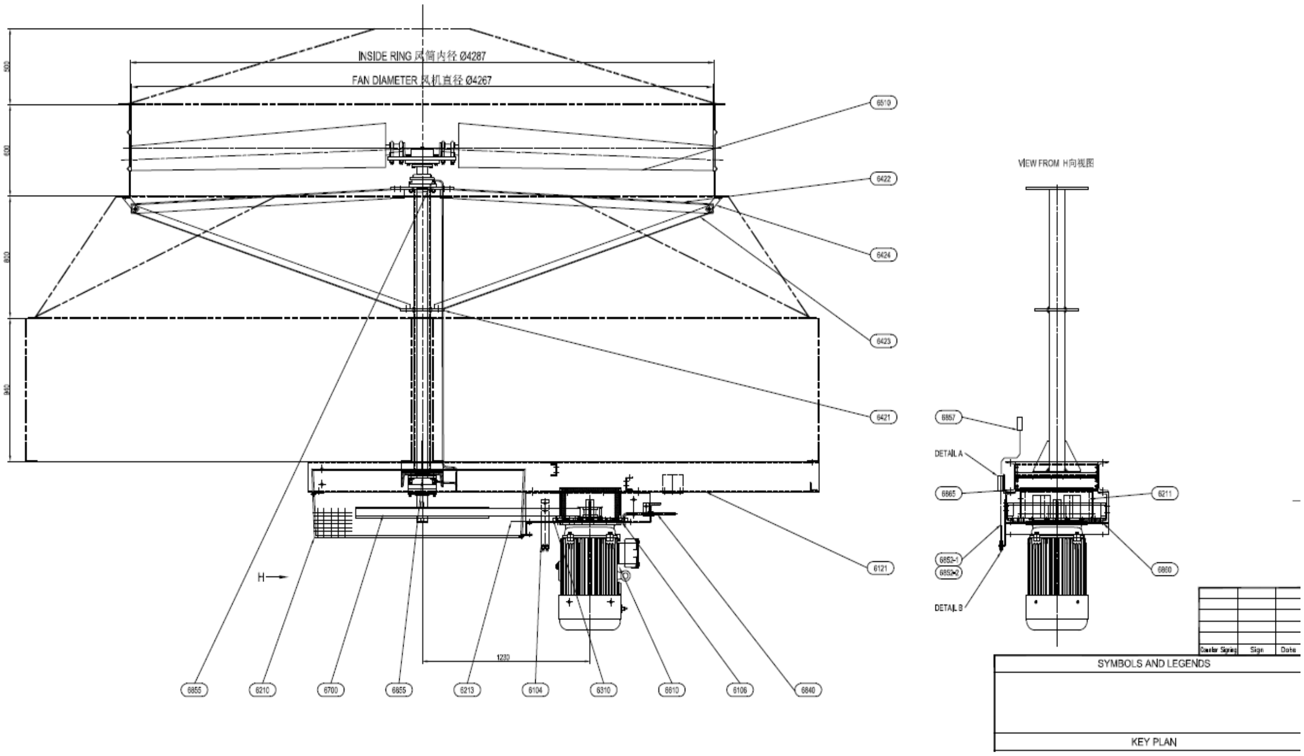


Fan Description and Fan Power				
Number of fans per bay		(--)		2
Diameter		(m)		4.265
Tip clearance		(mm)		19.050
Ratio, fan area to bay face area		(--)		0.40
Fan ring type		(--)		30 deg
Percent open area	- in fan guard	(%)		0
	- in hail screen	(%)		0
Ratio, ground clearance to fan diameter		(--)		
Percent blockage, other obstruction		(%)		0
Bundle pressure drop/ Velocity pressure		(Pa)	120.82 /	32.47
Fan and drive efficiency		(%)		75
Motor power per fan-design air temperature		(kW)		23.24
Motor power per fan-minimum air temperature		(kW)		27.00
Ambient temperature, maximum / minimum		(Deg C)	-17.78 /	5.00

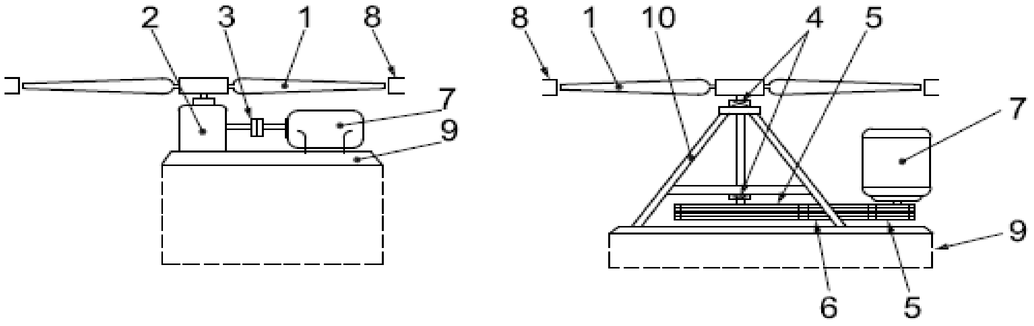
Two-Phase Parameters				
Method	Inlet	Center	Outlet	Mix F
RPM	Shear	Trans	Shear	0.98971
Bundle flow fraction	(--)	1.000		

Heat Transfer and Pressure Drop Parameters			**Tubeside**	**Outside**
Midpoint j-factor		(--)		0.0068
Heat transfer	Wall Correction	(--)	1.0000	0.9927
	Row Correction	(--)		1.0000
Midpoint f-factor		(--)	0.0000	0.2492
Pressure drop	Wall Correction	(--)	0.0000	1.0067
	Row Correction	(--)		1.0029
Reynolds number	Inlet	(--)	35743	8453
	Midpoint	(--)	37109	8299
	Outlet	(--)	5973	8199
Fouling layer thickness		(mm)	0.000	0.000
Input minimum velocity		(m/s)		
Input maximum velocity		(m/s)		
Input minimum wall temperature		(Deg C)		
Input maximum wall temperature		(Deg C)		

Drawings

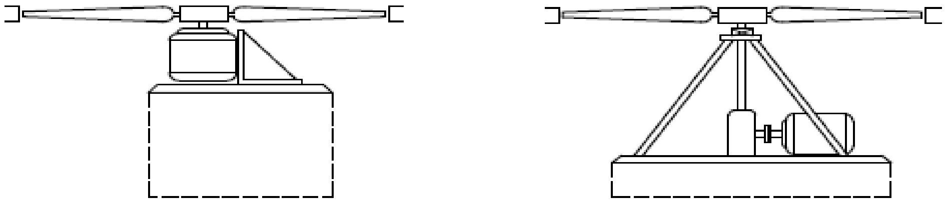


6865	0	CLAMPING PLATE 卡板 280X68X40
6860	0	CLAMPING PLATE FOR MOTOR SUPPORT 电机架卡板 400X55X40
6857	0	STRAIGHT COUPLING FOR TUBE 6/8 直连接头 <S.S 不锈钢>
6855	0	MALE STUD COUPLING FOR TUBE 6/8 外螺纹连接头 THREAD 螺纹 : 1/8" NPT <S.S 不锈钢>
6852	2	TUBE 管子 6/8 <S.S 不锈钢> LENGTH 长度 : 3 M
6852	1	TUBE 管子 6/8 <S.S 不锈钢> LENGTH 长度 : 2 M
6851	0	WALL PENETRATION FEMALE 1/8" NPT WITH RING FOR TUBE 6/8 <S.S> 1/8"NPT内螺纹接头 配密封圈 <不锈钢>
6840	0	TENSIONING 调整螺杆
6822	0	SUPPORT FOR VIBRATION SWITCH 振动开关支架
6821	0	VIBRATION SWITCH 振动开关 : 3171EX MR DPCO SILVER
6700	0	TRANSMISSION UNIT 传动单元
6610	0	MOTOR 电机 TYPE 型号: YB2E-225S-4WF1-37KW DOL 50HZ
6510	0	FAN UNIT 风机 TYPE 型号: Y-TF42.7L6-N37
6424	0	STIFFENER FASTENING 加强撑连接件
6423	0	LOWER STIFFENER 下加强撑
6422	0	UPPER STIFFENER 上加强撑
6421	0	BEARING SUPPORT 轴承支架
6310	0	SUPPORT FOR FLANGE MOTOR 法兰式安装电机支架
6213	0	DRIVE BELTS GUARD 驱动皮带护板
6211	0	ACCOUSTIC COVER 隔音罩
6210	0	DRIVEN PULLEY GUARD 从动皮带轮防护罩
6121	0	FAN AND DRIVE SUPPORT 风机及驱动支架
6106	0	MOTOR SUPPORT STRUCTURE 电机支撑架
6104	0	LUBRICATION PIPING SUPPORT 润滑油管支架
PART 件号	REP 序号	DESCRIPTION 描述



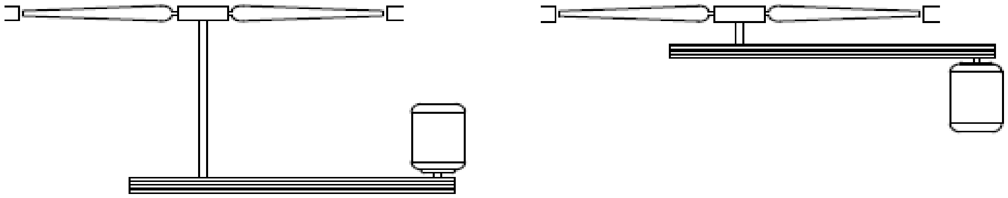
a) Direct right-angle gear drive

b) Belt drive



c) Direct motor drive

d) Right-angle gear drive with fan support



e) Suspended belt drive, motor shaft down

f) Suspended belt drive, motor shaft up

Key

1	fan	6	belt drive
2	gear box	7	motor
3	coupling	8	fan ring
4	bearing	9	base plate
5	sheave	10	fan support

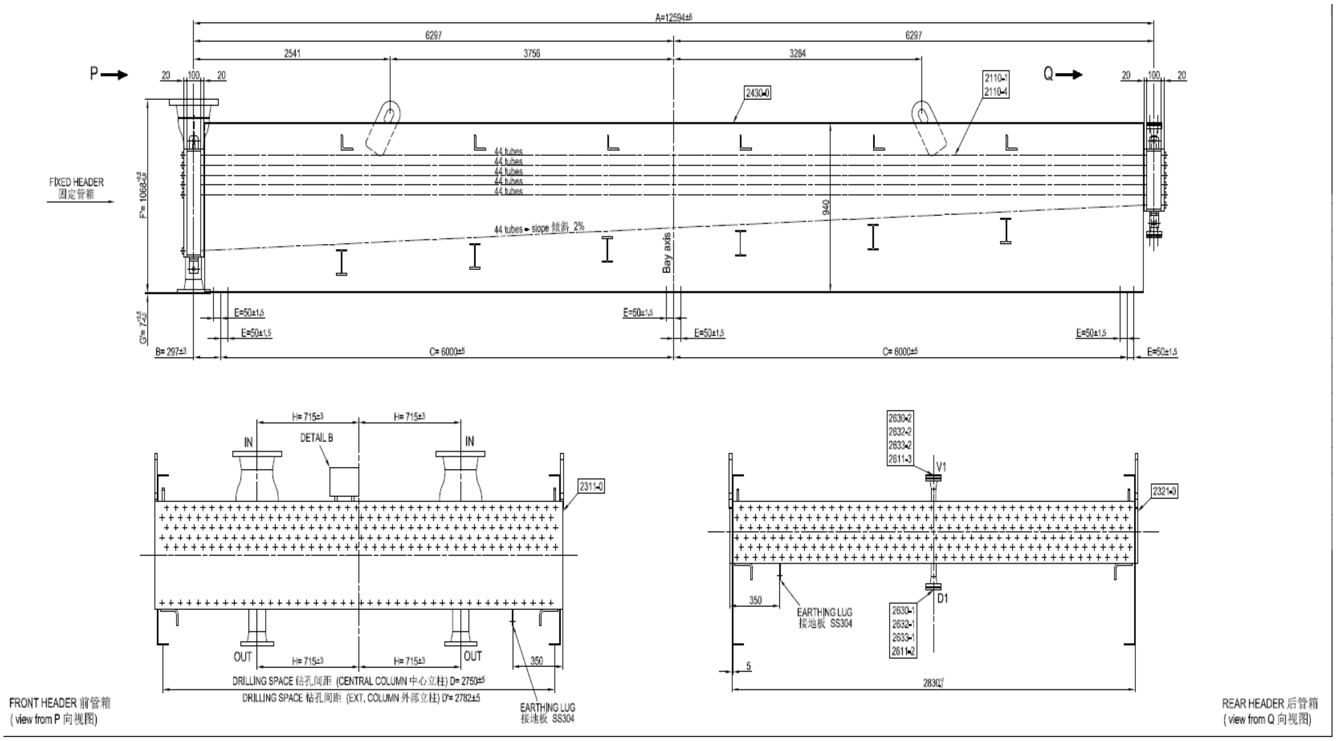
Figure 8 — Typical Drive Arrangements

Note from API-661:

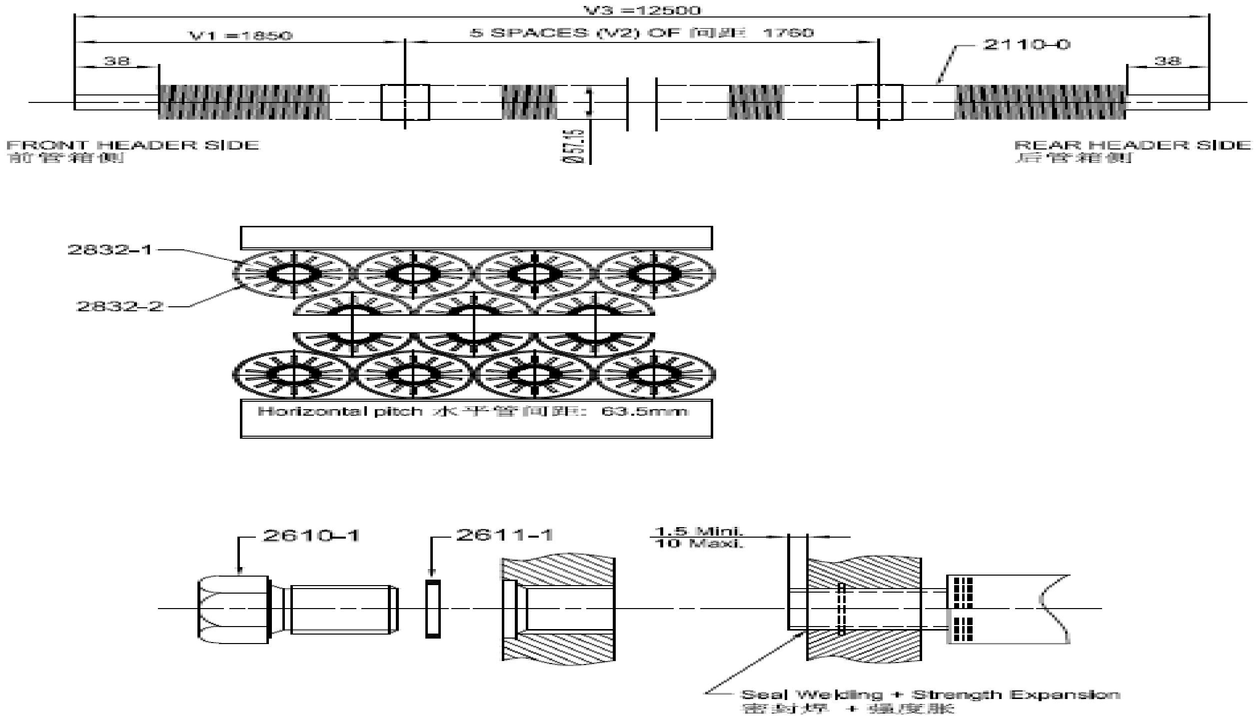
1. V-belt drive assemblies suspended from the structure may be used with motor drivers rated not higher than 30 kW (40 hp).

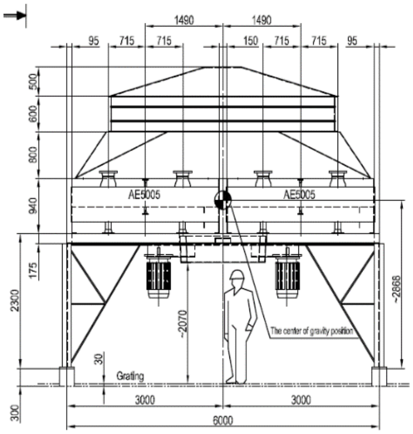
2. High-torque type positive-drive-belt drive assemblies suspended from the structure may be used with motor drivers rated not higher than 45 kW (60 hp).

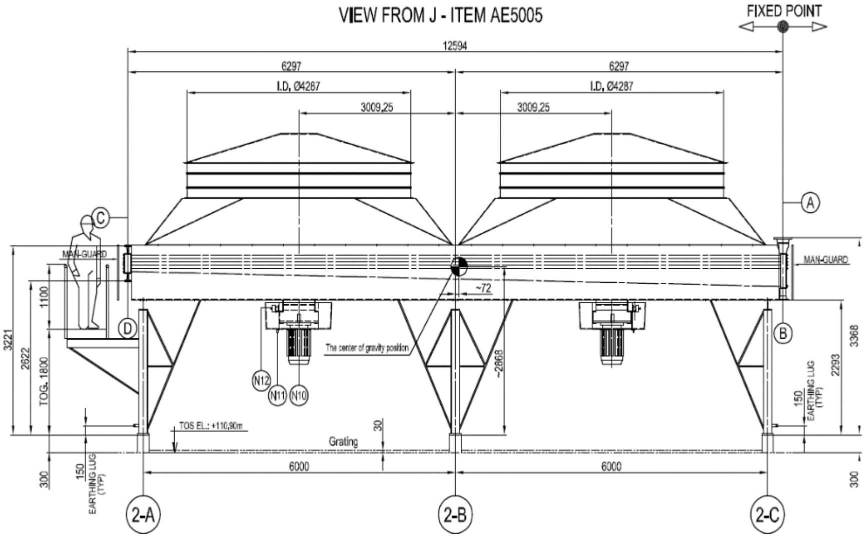
3. Electric motors rated higher than 45 kW (60 hp) shall use gear drives; smaller motors may use gear drives.



TUBE BUNDLE LAYOUT 管束外形图




1490
1490
95
715
715
150
715
715
95
500
600
800
940
AE5005
AE5005
175
2300
~2070
~2868
The center of gravity position
30
Grating
3000
3000
6000
300


VIEW FROM J - ITEM AE5005
FIXED POINT
12594
6297
6297
I.D, Ø4287
I.D, Ø4287
3009,25
3009,25
A
C
MAN-GUARD
MAN-GUARD
~72
D
B
The center of gravity position
N12
N11
N10
~2868
3221
2622
1100
TOG. 1800
3368
2293
150
EARTHING LUG (TYP)
TOS EL.: +110,90m
30
Grating
6000
6000
300
150
EARTHING LUG (TYP)
300
2-A
2-B
2-C