



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	Gas fraction	Duty profile	Liquid density	Liquid viscosity	Liquid heat capacity	Liquid thermal conductivity	Surface tension
	°C	wt %	MW	kg/m ³	cP	kJ/kg/°C	W/m/°C	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	Gas fraction	Duty profile	Gas density	Gas viscosity	Gas heat capacity	Gas thermal conductivity	
	°C	wt %	MW	kg/m ³	cP	kJ/kg/°C	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

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
 - Hot Fluid Properties
 - Design
 - Control

Tubeside Fluid (Hot)

Fluid name: Methanol Vapor

Phase / Airside flow rate units: Condensing

Flow rate: 418225 kg/hr

Inlet fraction vapor: 0.9911

Outlet fraction vapor: 0

Inlet temperature: 67 C

Outlet temperature: 65 C

Inlet pressure / Altitude of unit (above sea level): 0.1 bar-G

Outlet pressure: bar-G

Allowable pressure drop: 0.05 bar

Fouling resistance: 0.00017 m²-K/W

Fouling layer thickness: mm

Exchanger duty: MegaWatts

Duty/flow multiplier: 1.2

Airside Fluid

Face velocity: m/s

48 C

25 m

Pa

m²-K/W

mm

<< Previous Next >>

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00

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

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
 - Hot Fluid Properties
 - T & P
 - Heat Release
 - Property Grid
 - Components
 - Dew/Bubble
 - Design
 - Control

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

Property Generator...

Property Worksheet...

<< Previous Next >>

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00



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

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
 - Hot Fluid Properties
 - T & P
 - Heat Release
 - Property Grid
 - Components
 - Dew/Bubble
 - Design
 - Control

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					

<< Previous Next >>

Clear All Temperature Data Property Worksheet...

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00

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

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
 - Hot Fluid Properties
 - T & P
 - Heat Release
 - Property Grid
 - Components
 - Dew/Bubble
 - Design
 - Control

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

1 /

Clear All Heat Release Data Property Worksheet...

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00



Xace - [Input] - AE-5005Example38power.htri - Input Summary-Hot Fluid Properties-Property Grid

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
 - Hot Fluid Properties
 - T & P
 - Heat Release
 - Property Grid
 - Components
 - Dew/Bubble
- Design
 - Control

Hot Fluid Properties

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
67.00	19

Property Grid

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		

Clear Selected Property

Clear All Properties

Property Worksheet...

<< Previous Next >>

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00



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.

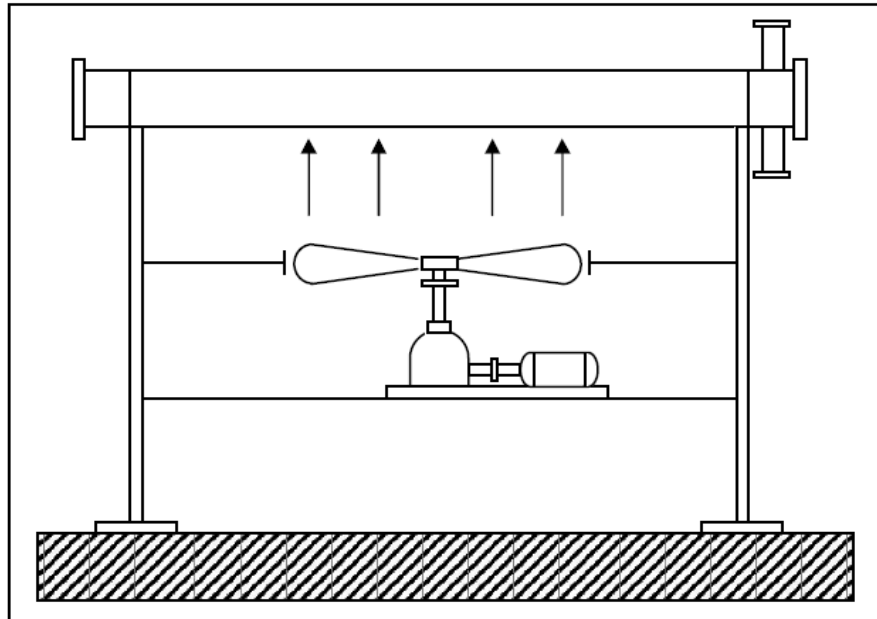


Figure C2.5-1. Forced-draft, horizontal configuration.

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 ($< 5.6\text{ }^{\circ}\text{C}$ ($10\text{ }^{\circ}\text{F}$)) 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

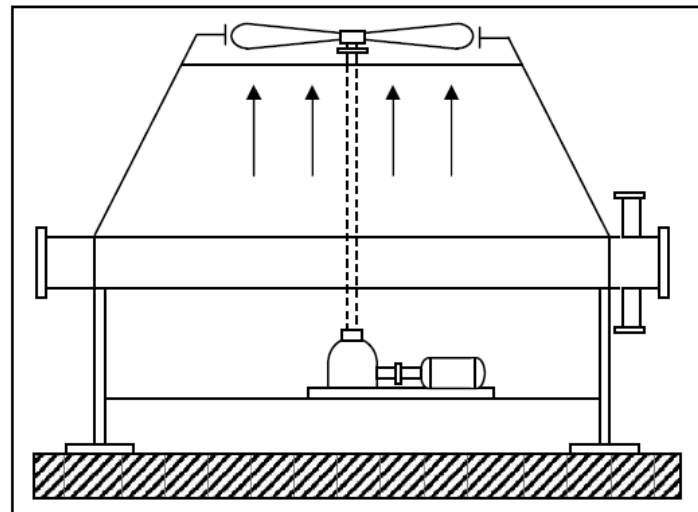


Figure C2.5-2. Induced-draft, horizontal configuration

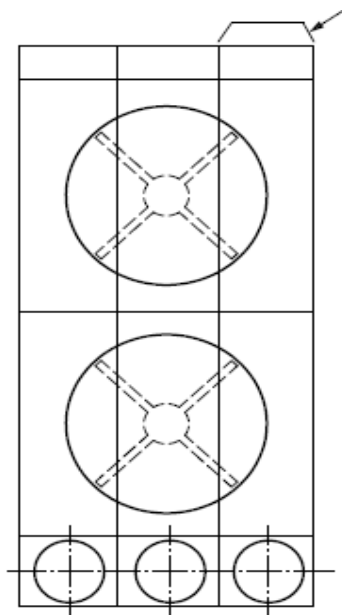


A few disadvantages are also ascribed to this configuration:

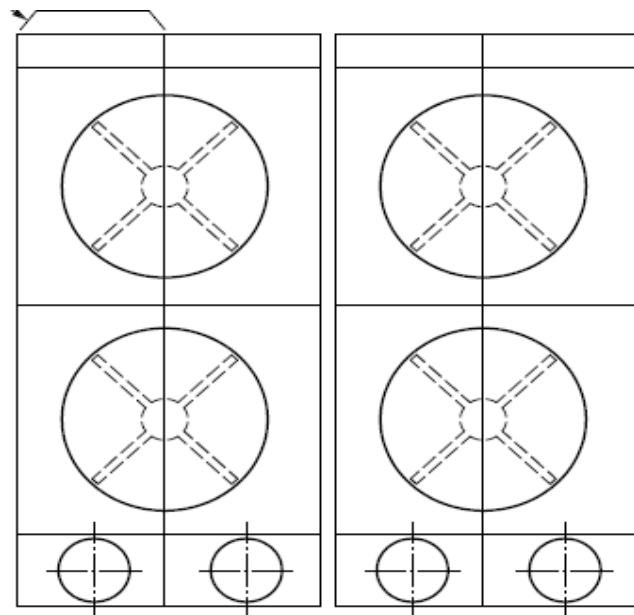
- Except for very low process temperatures (below 158 °F (70 °C)), the gearbox or belt drive system cannot be mounted in the hot airstream.
- Except for those with remote actuation, all autovariable fans have low maximum operating temperatures and are unsuitable for mounting in hot airstreams.
- All 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

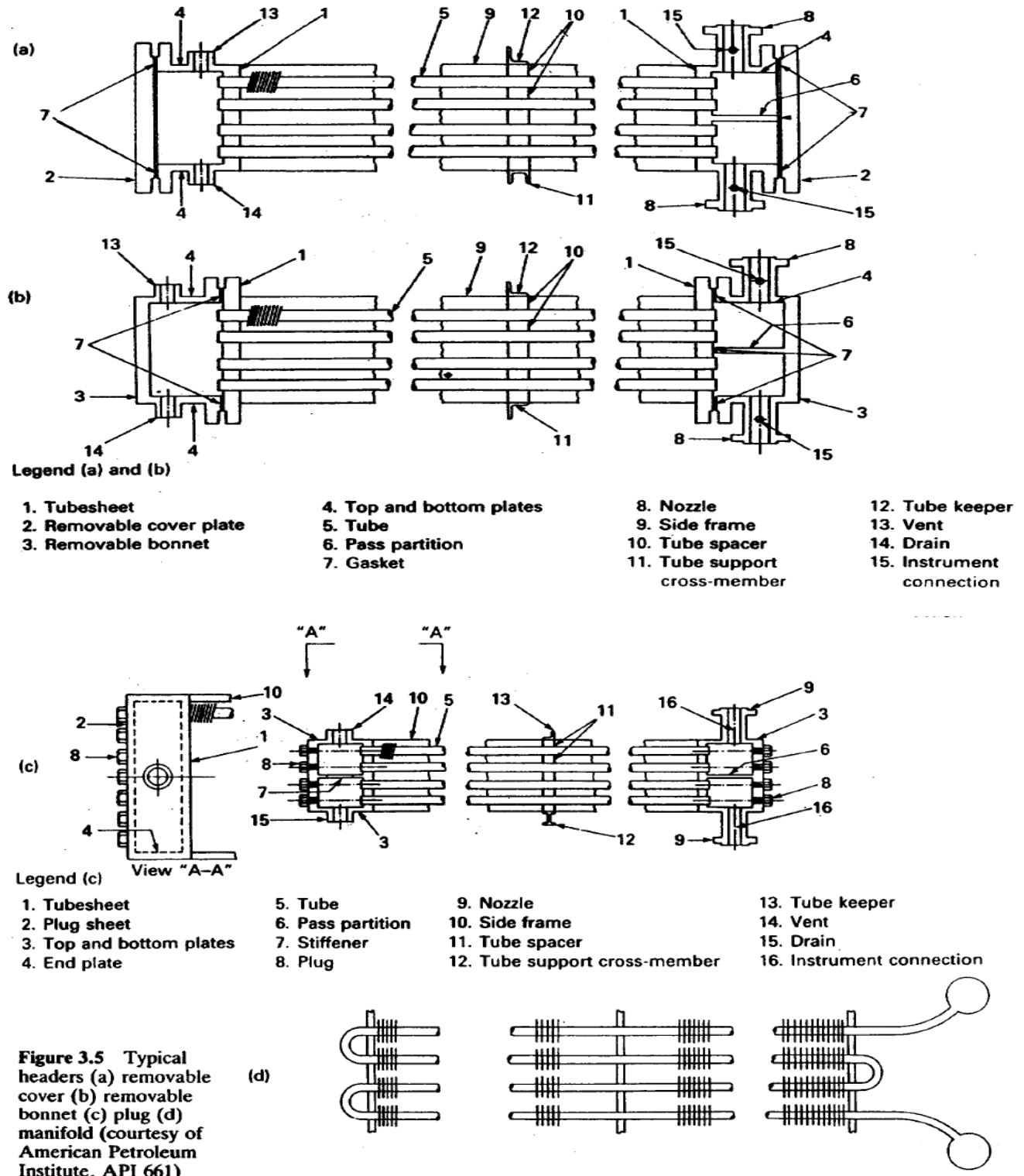
This is similar to a B-type stationary head, or channel, of a shell-and-tube exchanger, shown in Figs. 1.2 and 1.18(d), in which the complete bonnet header is bolted to the tubesheet. Removal of the complete bonnet provides access to the exposed tube ends for cleaning and repair, but nozzle/external 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





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

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
- Hot Fluid Properties
- Design
- Control

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: 202.718 mm Outlet: 102.261 mm

Number of nozzles per bundle: 1

<< Previous Next >>

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00



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]

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

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

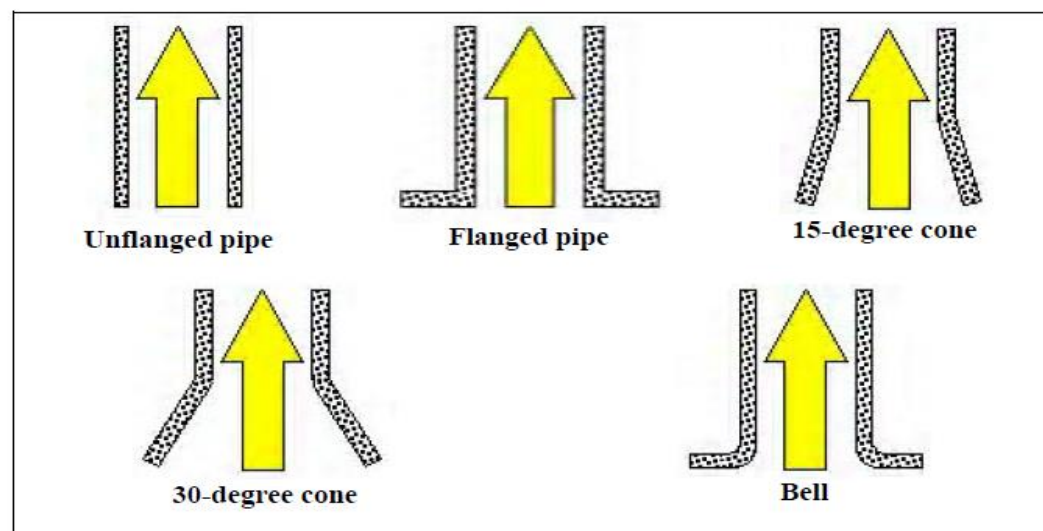


Figure C2.5-7. Fan ring geometries



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

Xace - [Input] - AE-5004-Example.htri - Input Summary-Geometry-Fans

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
- Hot Fluid Properties
- Design
- Control

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 = 1m)

Number of fan shaft lanes per bundle: []

Fan shaft lane width: [] mm

Fan Ring Type

☒ Straight
 ☐ Flanged
 ☐ 15 degree cone
 ☐ 30 degree cone
 ☐ Bell

<< Previous Next >>

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00



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

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

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

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

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

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

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

Drivers

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

$$P_{dr} \geq 1.05 (P_{f1}/E_m)$$

$$P_{dr} \geq 1.10 (P_{f2})$$

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 “wobble strip” that is placed between each row, and runs between each tube. This method allows for support of the tube from the fin tip and is susceptible to movement in the bundle during transportation.

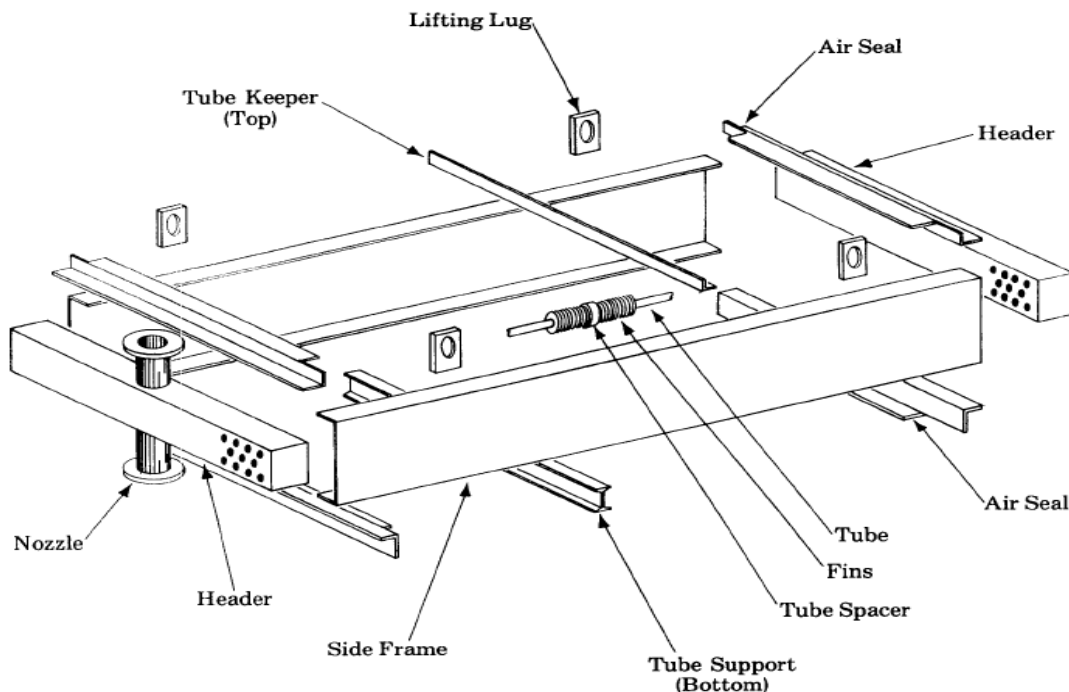
Another common method, utilized by some manufacturers, is to wrap aluminum strips around the perimeter of the tube at designated spots along the length. These strips are stapled to prohibit them from loosening. Again, this provides support from the tip of the fin.

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.

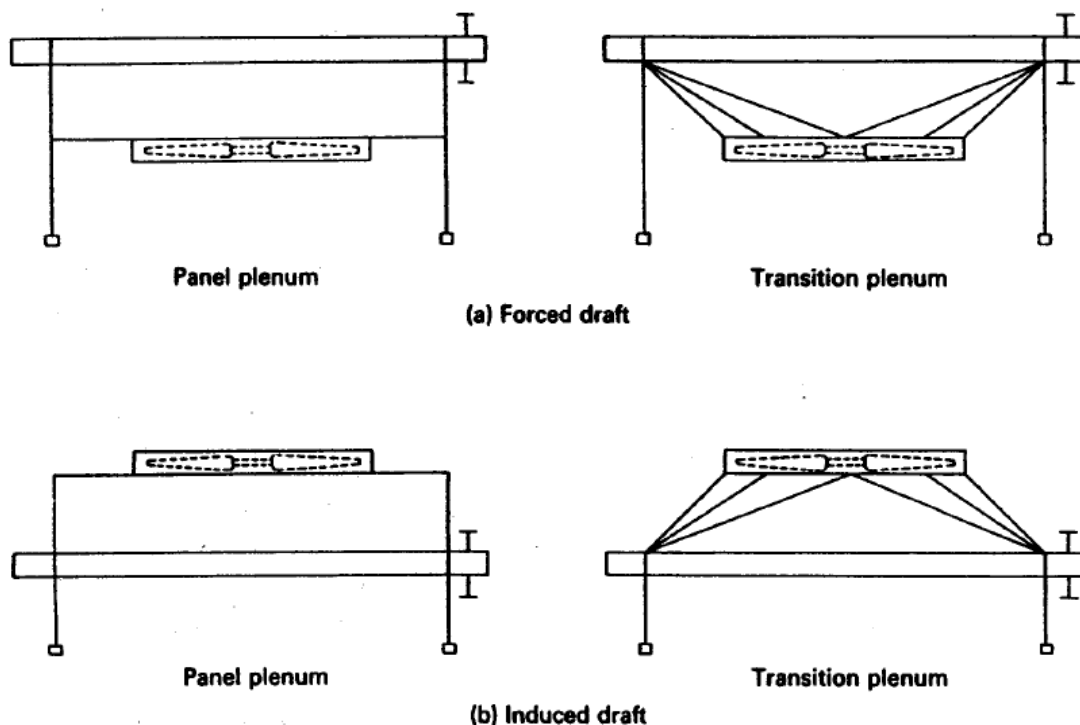
A large deck or one made from welded plates requires bracing. A fabricated fan deck should support 50 lb/ft² (245 kg/m²) and be constructed of 12 gauge steel, 0.109-in. (2.77-mm) minimum thickness.

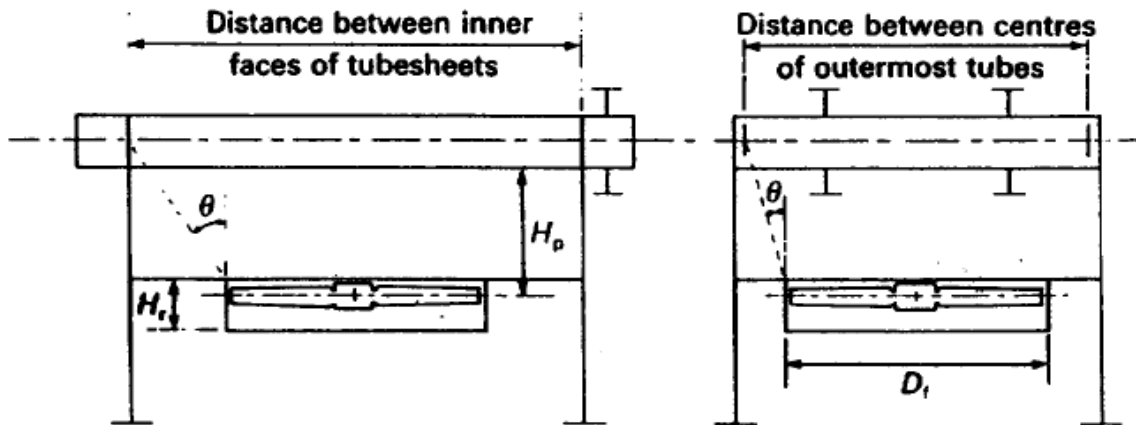
Transition plenums, used primarily in induced-draft designs, are more rigid than the box-type and require no additional fan deck.



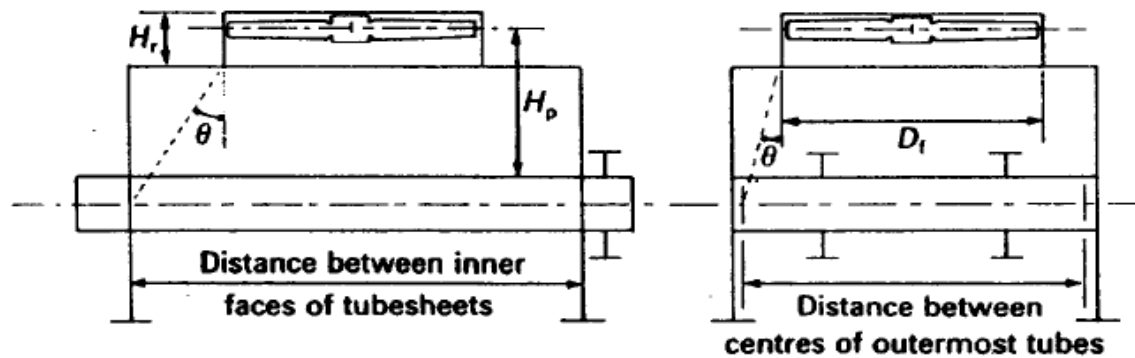
The plenum chamber is constructed of steel sheet with minimum thicknesses of 2 mm (0.075 in) if flat, or 1.6 mm (0.06 in) if ribbed. As shown in Fig. 3.6, panel plenums are box-shaped, which provides a sharp change of section between the plenum entry or exit and the fan ring. As the name implies, transition 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_r = fan ring height, and θ = maximum air dispersion angle (from API 661), defined in Fig. 3.7.





(a) Forced draft



(b) Induced draft

	<i>Forced draught</i>	<i>Induced draught</i>
A_i/A_b (min)	0.4	0.3
H_p/D_t (min)	0.5	0.3
H_i/D_t (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.

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.



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

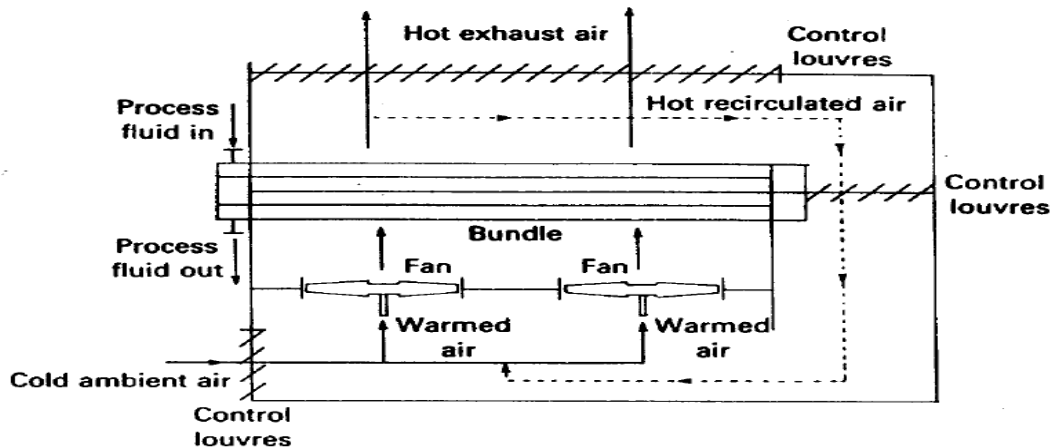
These may be mounted at the cooler base to warm up the inlet air, but must be a separate unit and not part of the process tube bundle. Steam coils are usually employed at start-up to reduce the viscosity of highly viscous fluids.



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.



Xace - [Input] - AE-5004-Example.htri - Input Summary-Geometry-Optional

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
- Hot Fluid Properties
- Design
- Control

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 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

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 C

Tube Supports

Number of intermediate tube supports

Width of intermediate tube supports mm

Plenum Information

Plenum chamber type ☒ Box ☐ Tapered

Plenum height m

Ground clearance to bundle m

Tube Side Design

Design pressure barG

Design temperature C

<< Previous Next >>

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00





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

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - Bundle Layout
- Process
- Hot Fluid Properties
- Design
- Control

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
-----	---

<< Previous Next >>

Input Reports Graphs Drawings Multiple Services Design Session

Xace 6.00



- ### Figure 7 — Fan Dispersion Angle



7. Tube type Input to HTRI

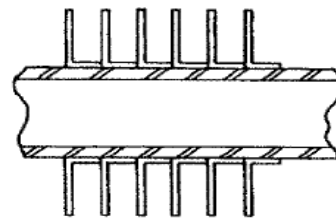
Fin Types

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.

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



L-FOOTED TENSION

Knurled L-footed fin:

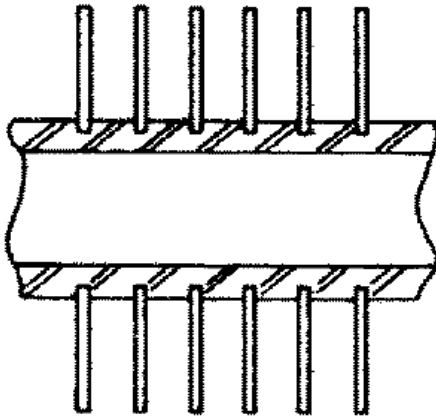
Again, this process is very similar to the L-footed tension wound fin, but utilizes knurling wheels that actually knurl the fin foot into the tube. This allows for a tighter bond between the tube and the fin, and reduces the likelihood of a corrosion film between the two.

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.

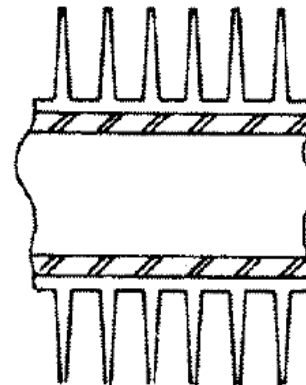
The embedded fin is normally used for services greater than 350 degrees and less than 750 degrees F.

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

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

Typical tube pitches 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

Input Summary

- Geometry
 - Unit
 - Fans
 - Optional
 - Bundle
 - Tube Types
 - TubeType1
 - Tube Geom
 - High Fin
 - FJ Curves
 - Bundle Layout
- Process
- Hot Fluid Properties
- Design
- Control

Tube Geometry | High Fin | FJ Curves

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

Flow direction: Upward arrow

Navigation: << Previous, Next >>

Bottom bar: Input, Reports, Graphs, Drawings, Multiple Services, Design, Session

Xace 6.00



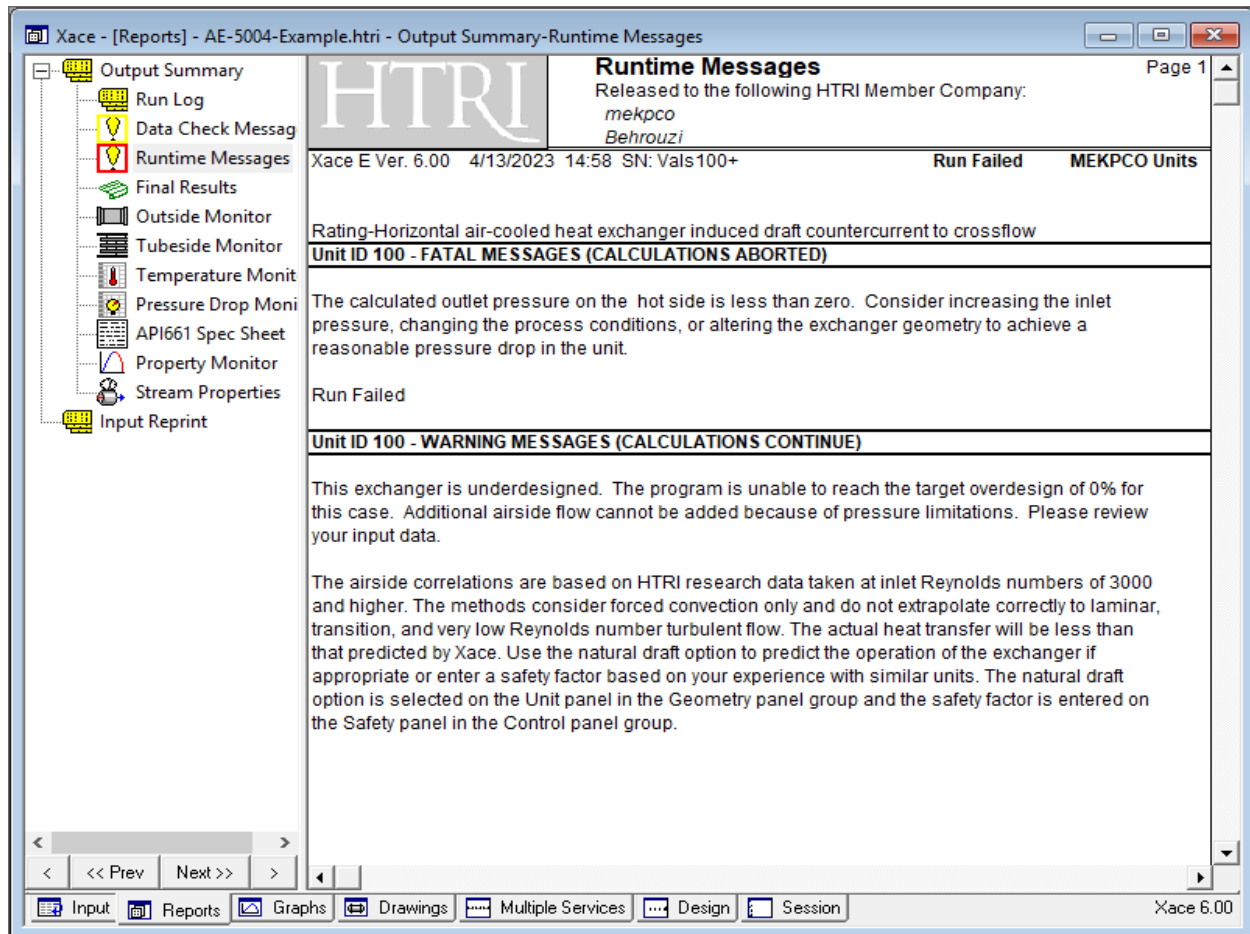
TYPICAL VALUES FOR INPUT INTO Xace FOR 1" TUBES						
	IMPERIAL UNITS (INCHES)			METRIC UNITS (mm)		
	L-FIN	G-FIN (embedded)	EXTRU. FIN	L-FIN	G-FIN (embedded)	EXTRU. FIN
No. of fins per unit length	11	11	10	433	433	393.7
Fin root diameter	1.032	1	1.066	26.213	25.4	27.076
Fin height	0.609	0.625	0.592	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 14 BWG	0.1199 0.0913	0.1320 0.1045	0.1199 0.0913	3.046 2.319	3.353 2.654	3.046 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 6.00



Results



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 summary 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)



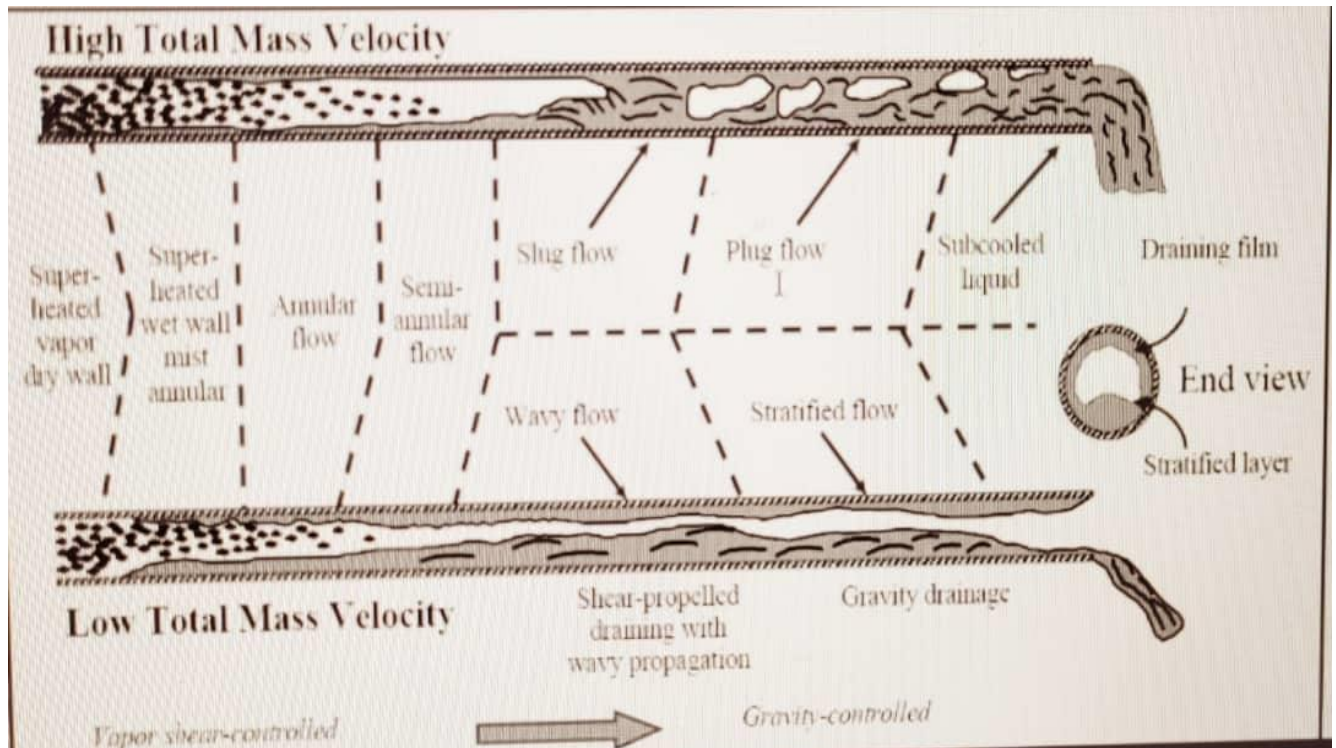
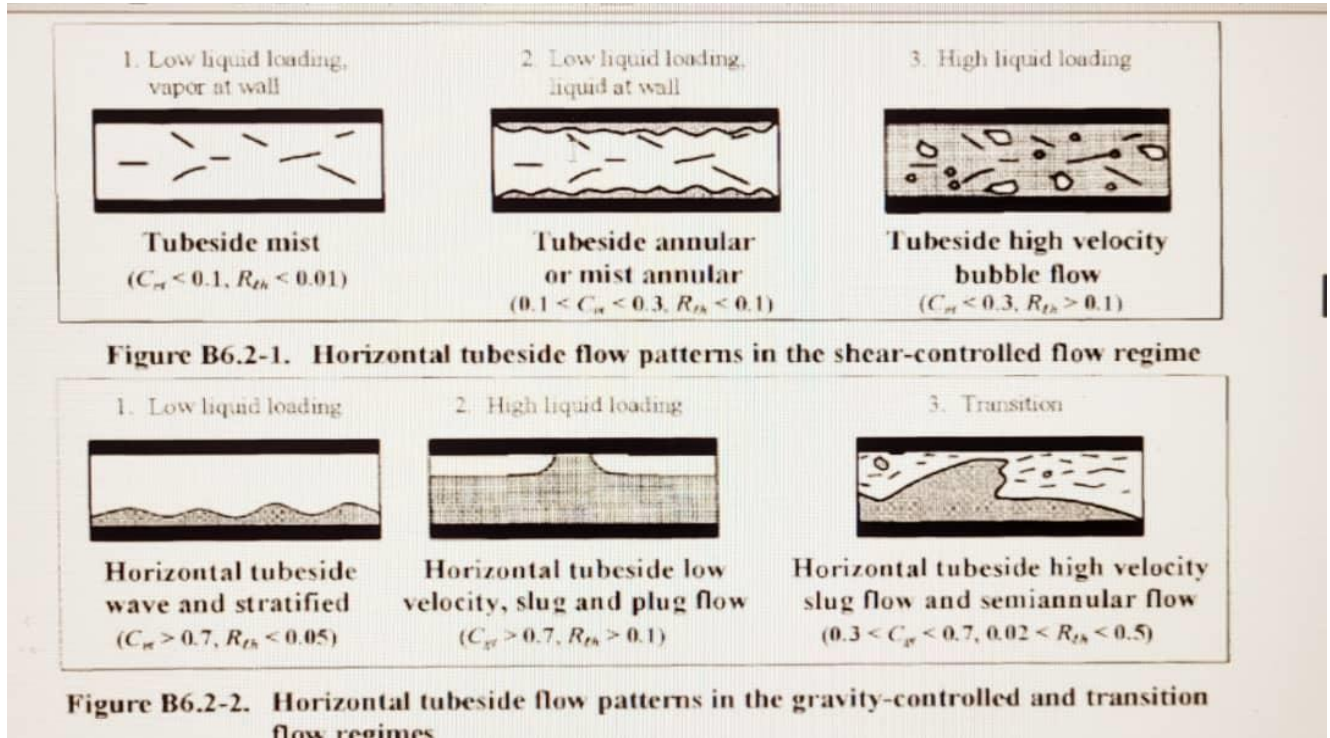
Now we stop here and try to change some parameters to optimise the required driver power.

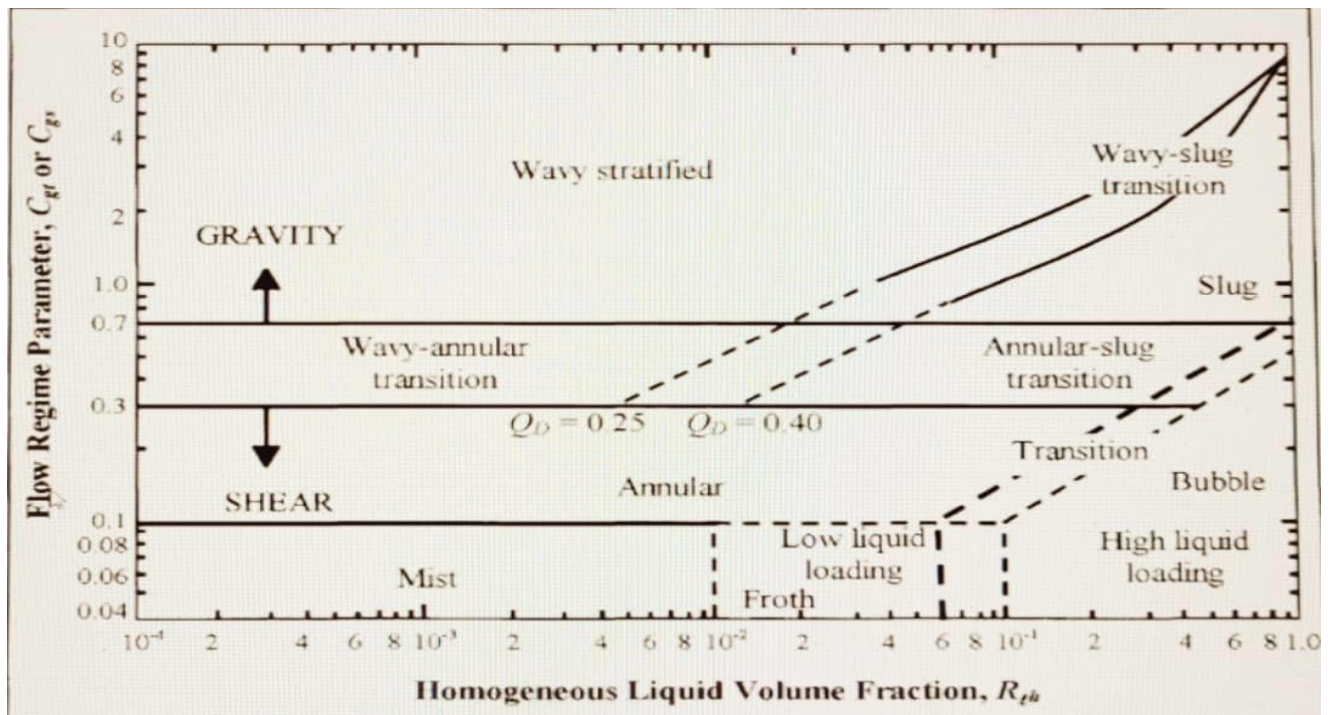
Actions	Pressure drops	Driver Power
Increasing fan efficiency to 75%	164.9	33.6 (38.78)
Changing fan ring type to cone 30	133.9	28.43 (32.83)

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.

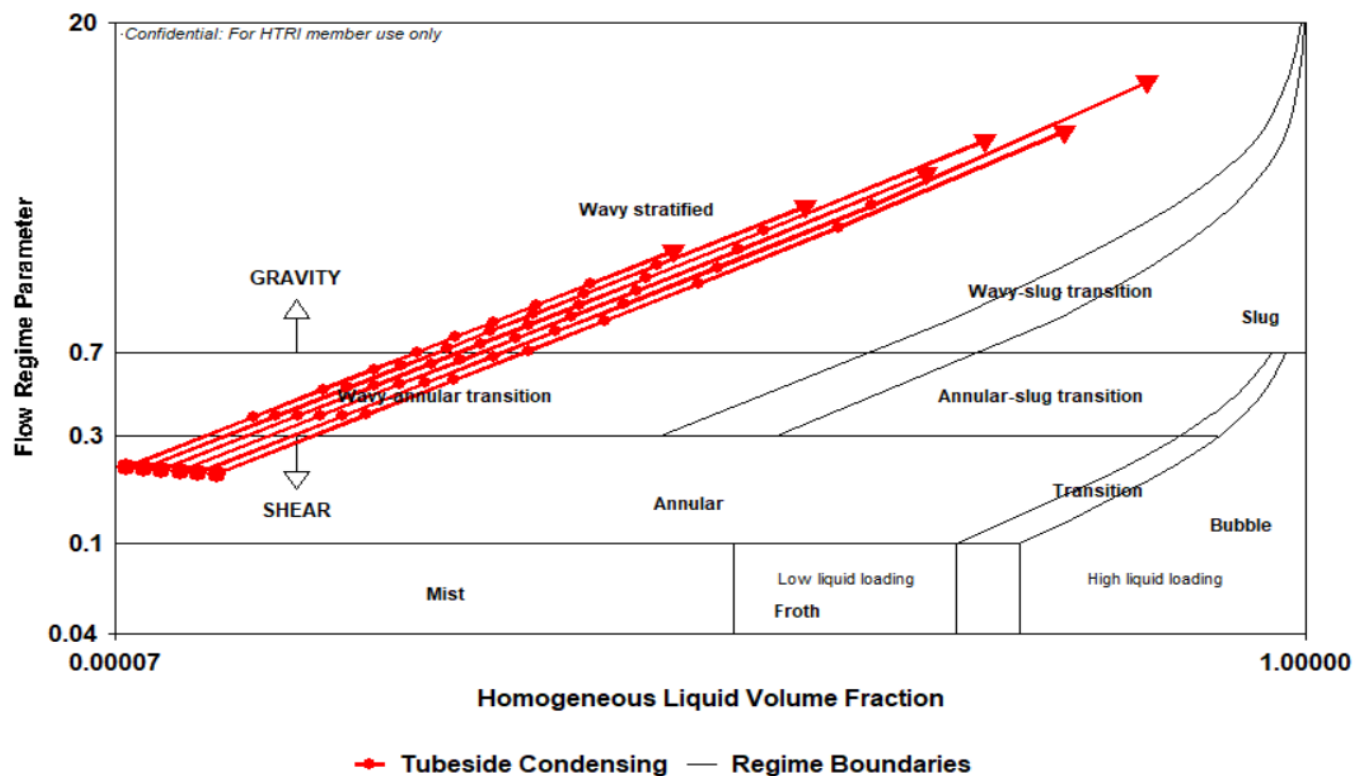


How it is interpreted





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-condensibles are present.

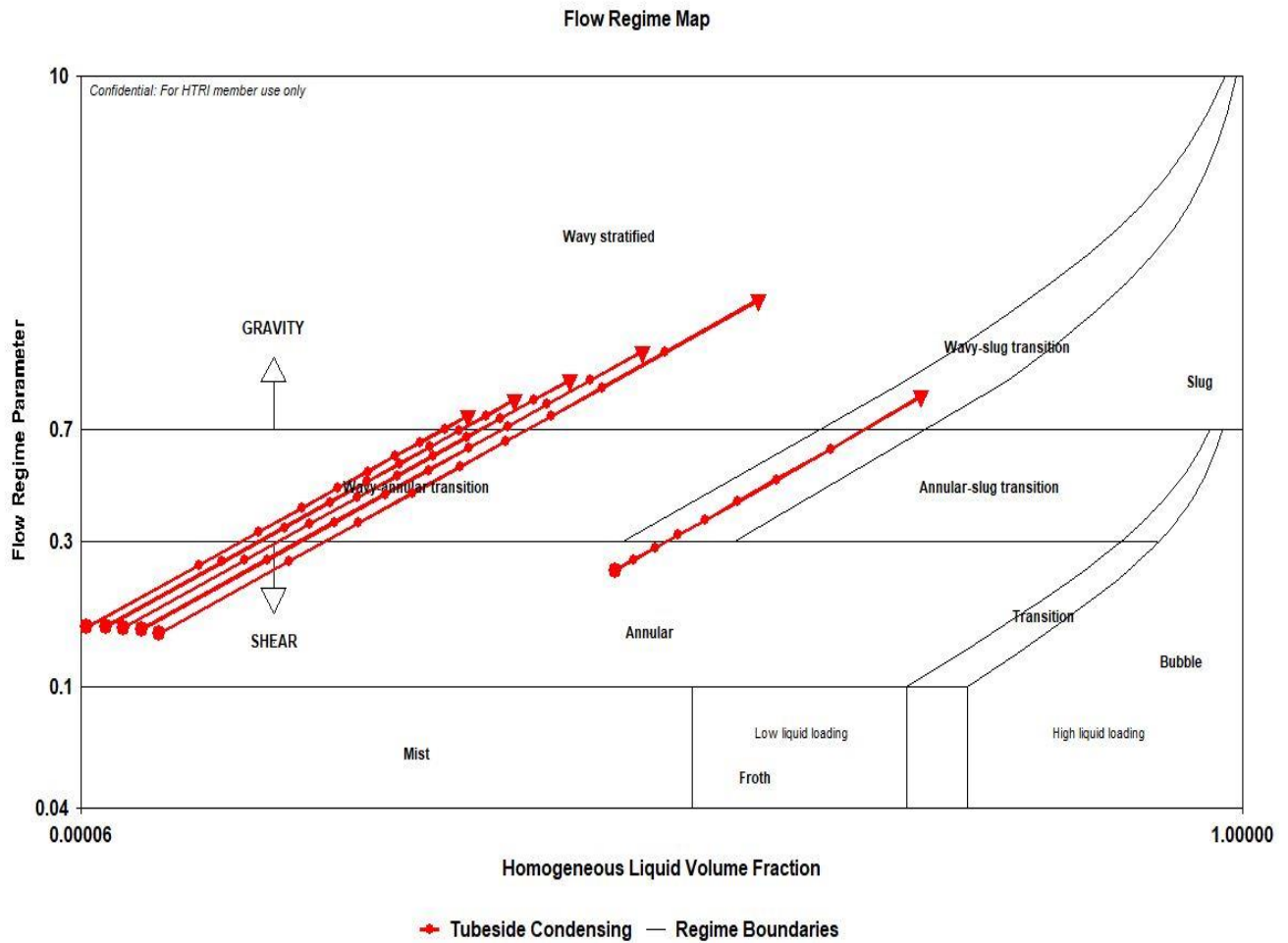
The effect of tube inclination contributes to an approximate average increase of only 20 percent in the tube-side heat transfer coefficient on the average tube side heat transfer. HTRI therefore recommends inclining tubeside condensers in gravity-flow about 3 degrees towards the draining condensate end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

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

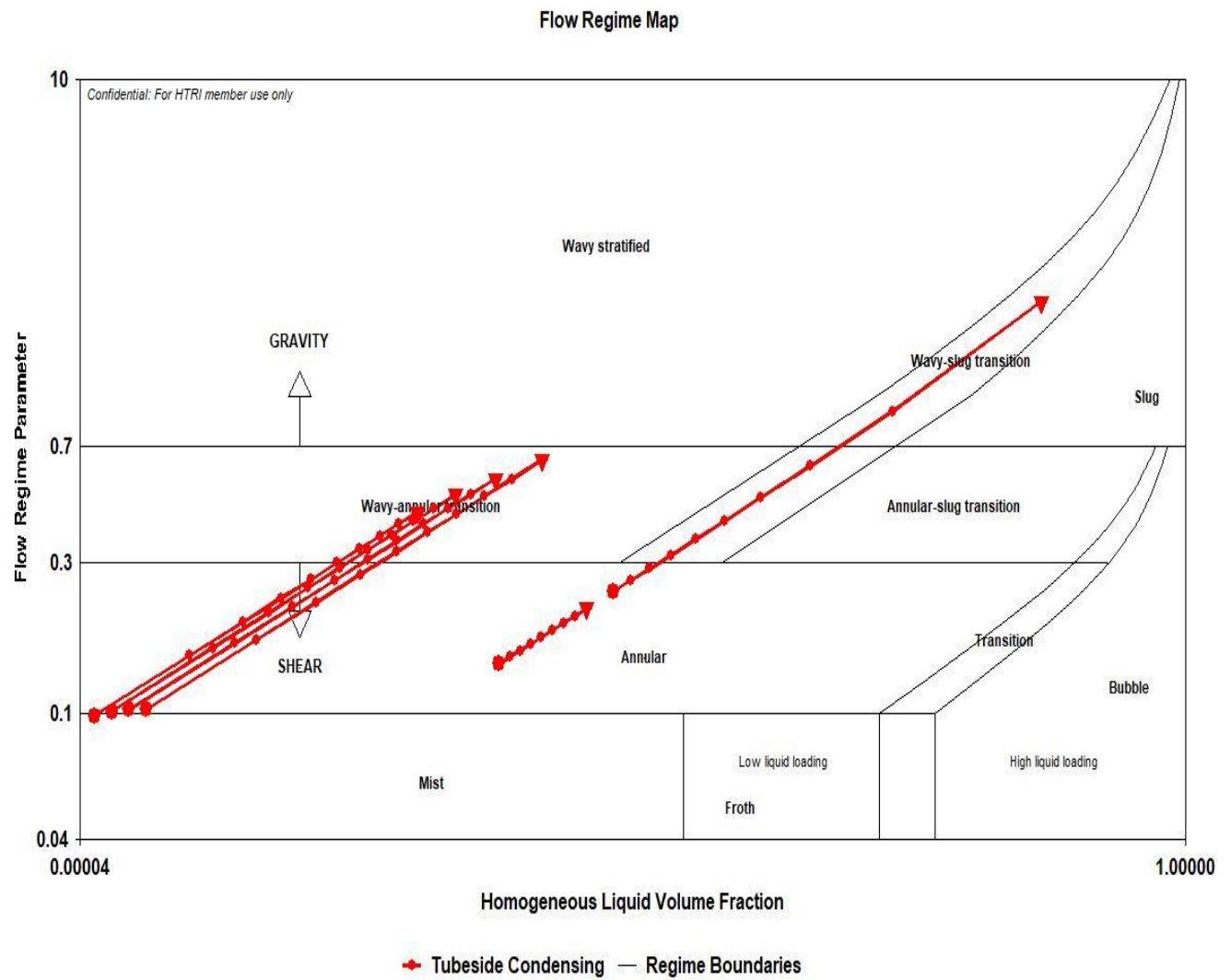
Actions	Pressure drop	Driver Power
Changing from one pass to two passes	114.3	21.81(25.18)
Changing from two pass to 3 passes (4-1-1)	112	21.14(24.41)
Changing 3 passes orientation from (4-1-1) to (3-2-1)	112	21.15(24.41)
Force separation	129	26.9(31.05)
Get back to (4-1-1)	113	21.5 (25)



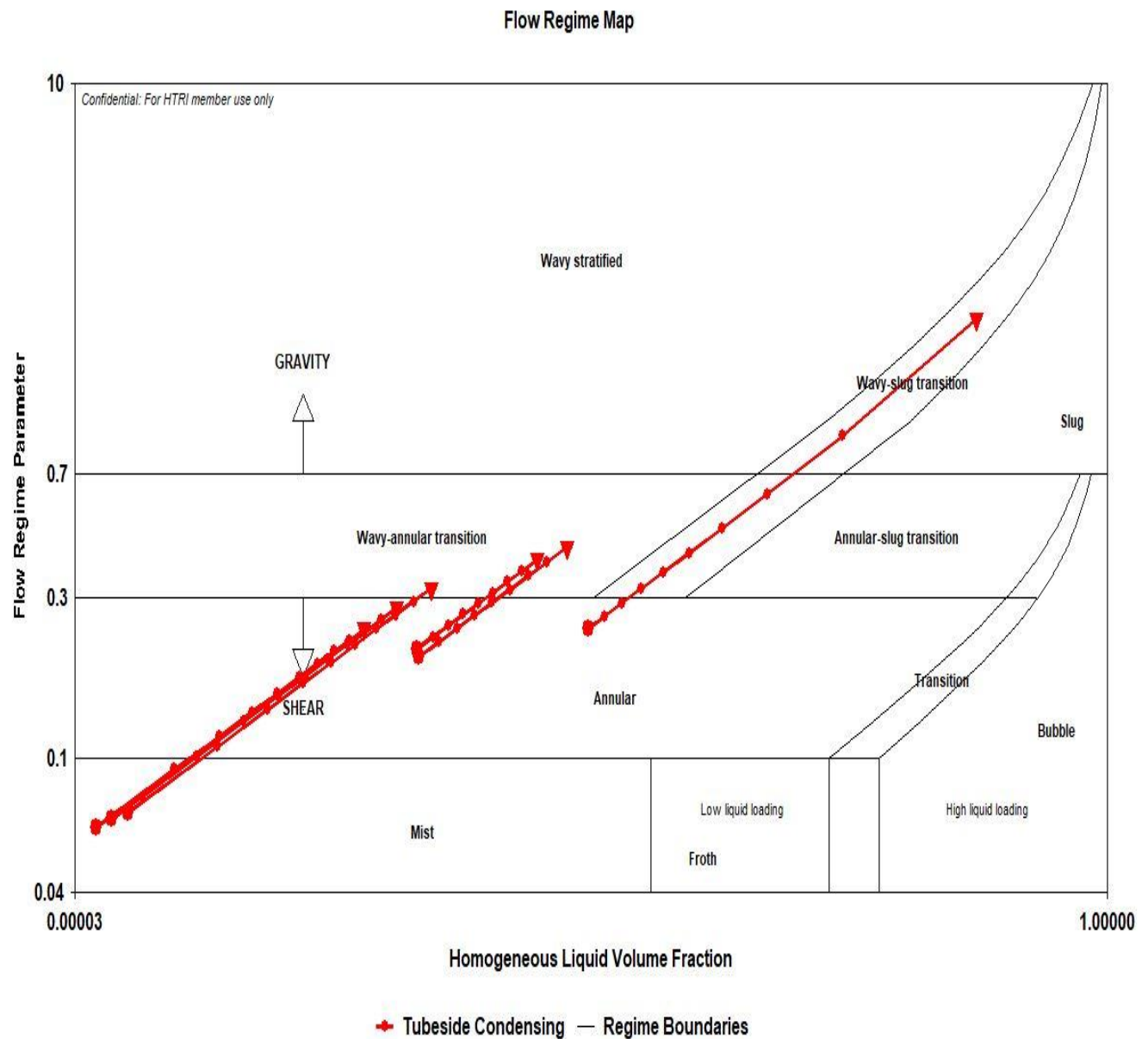
Now let's see the impacts of the steps on flow regime:



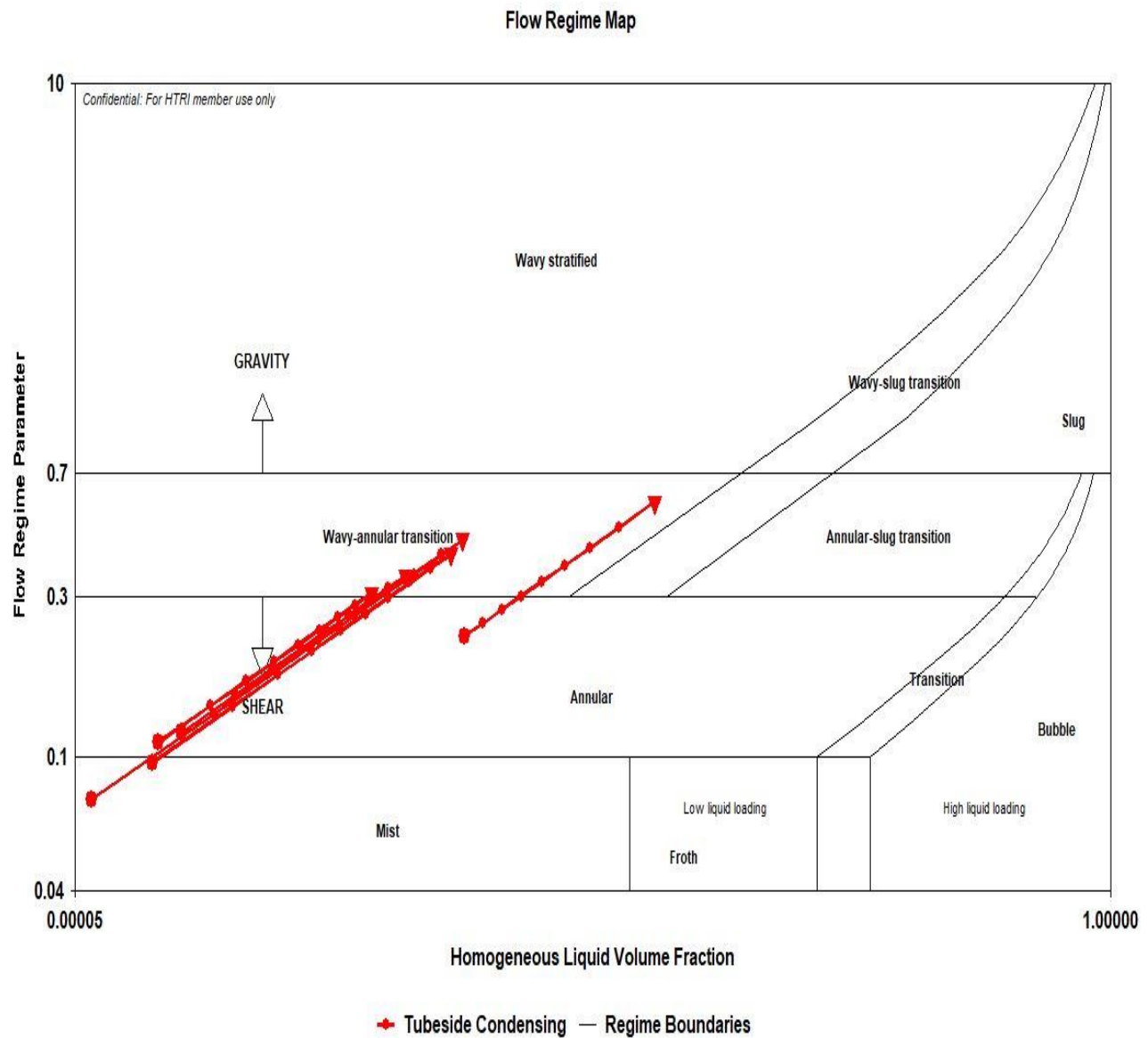
Two-passes with the orientation of 5-1



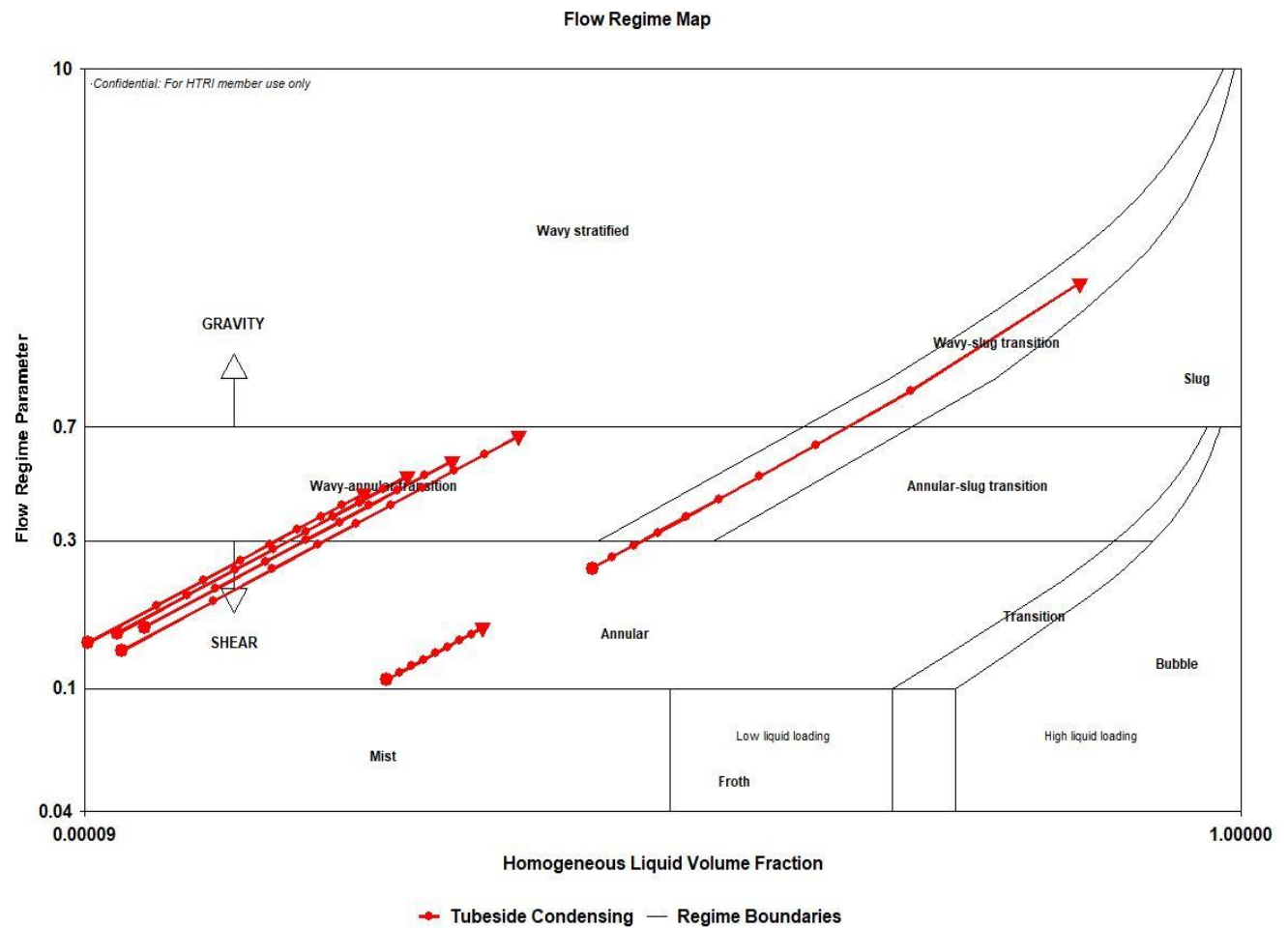
Three passes with the orientation of 4-1-1



Three passes with the orientation of 3-2-1



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



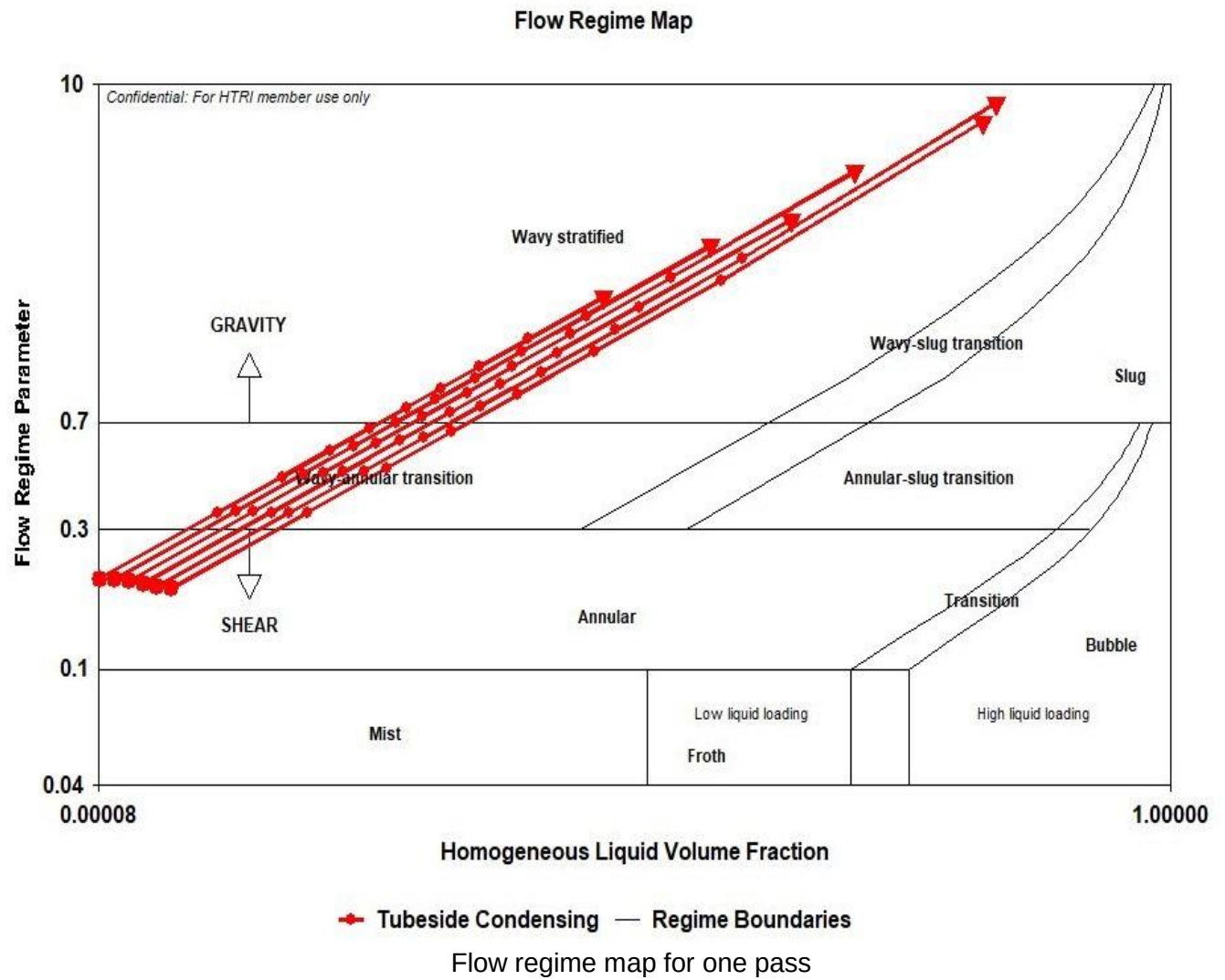
Three passes with the orientation of 4-1-1 in Force



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

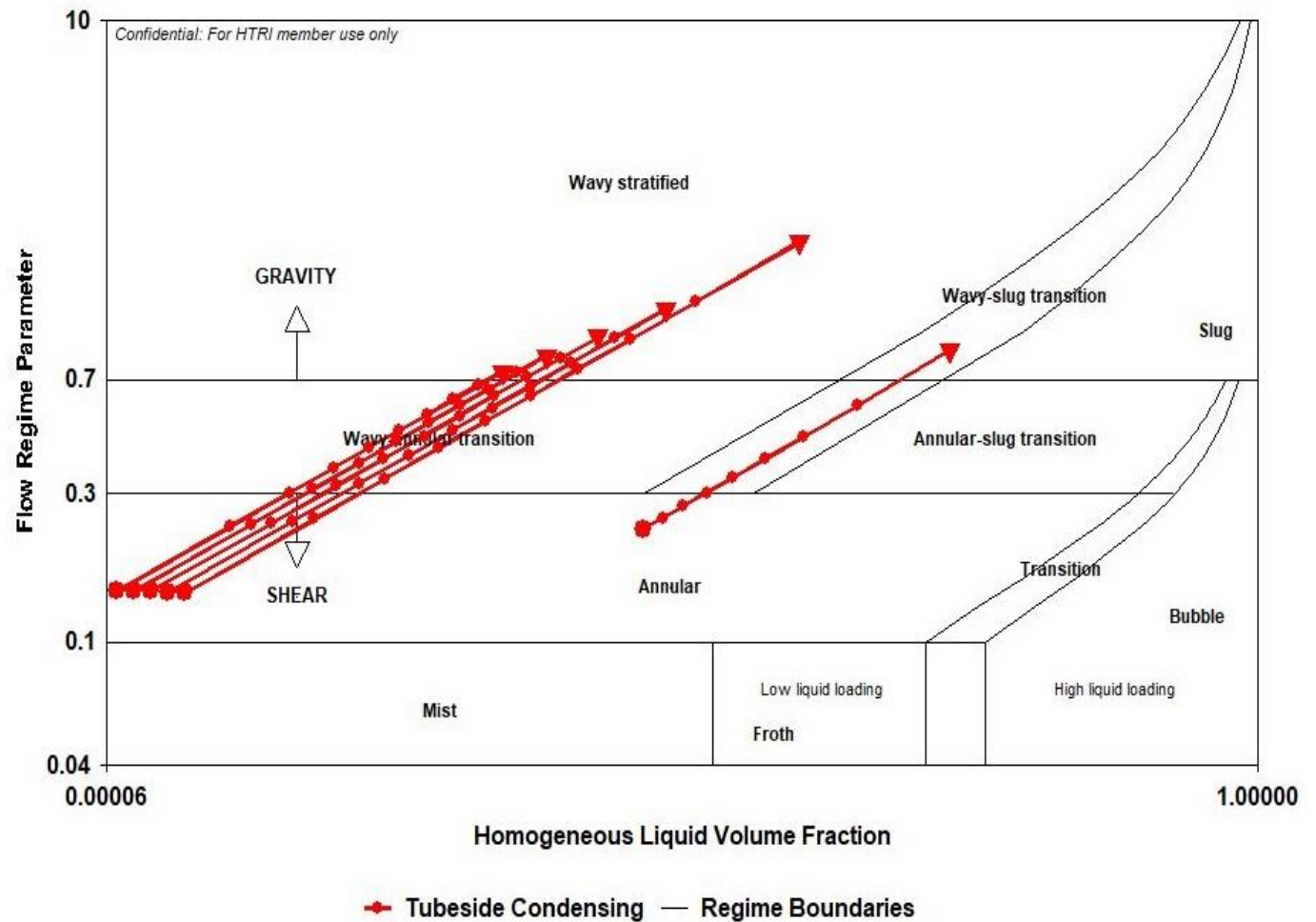
The following actions are taken which is summarized below:

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 orientation	133.8	28.33 (32.7)
Force	132	27.95 (32.27)

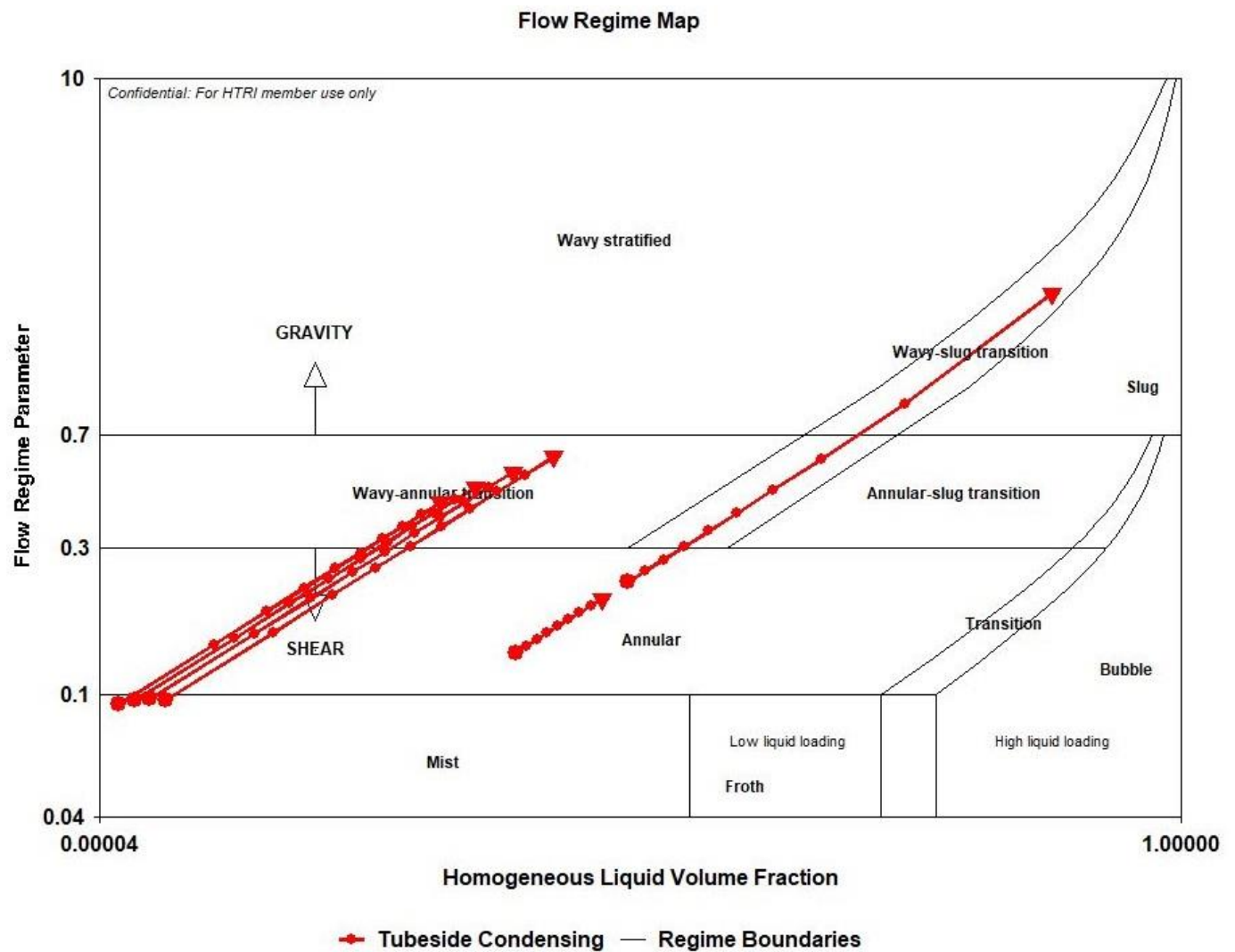




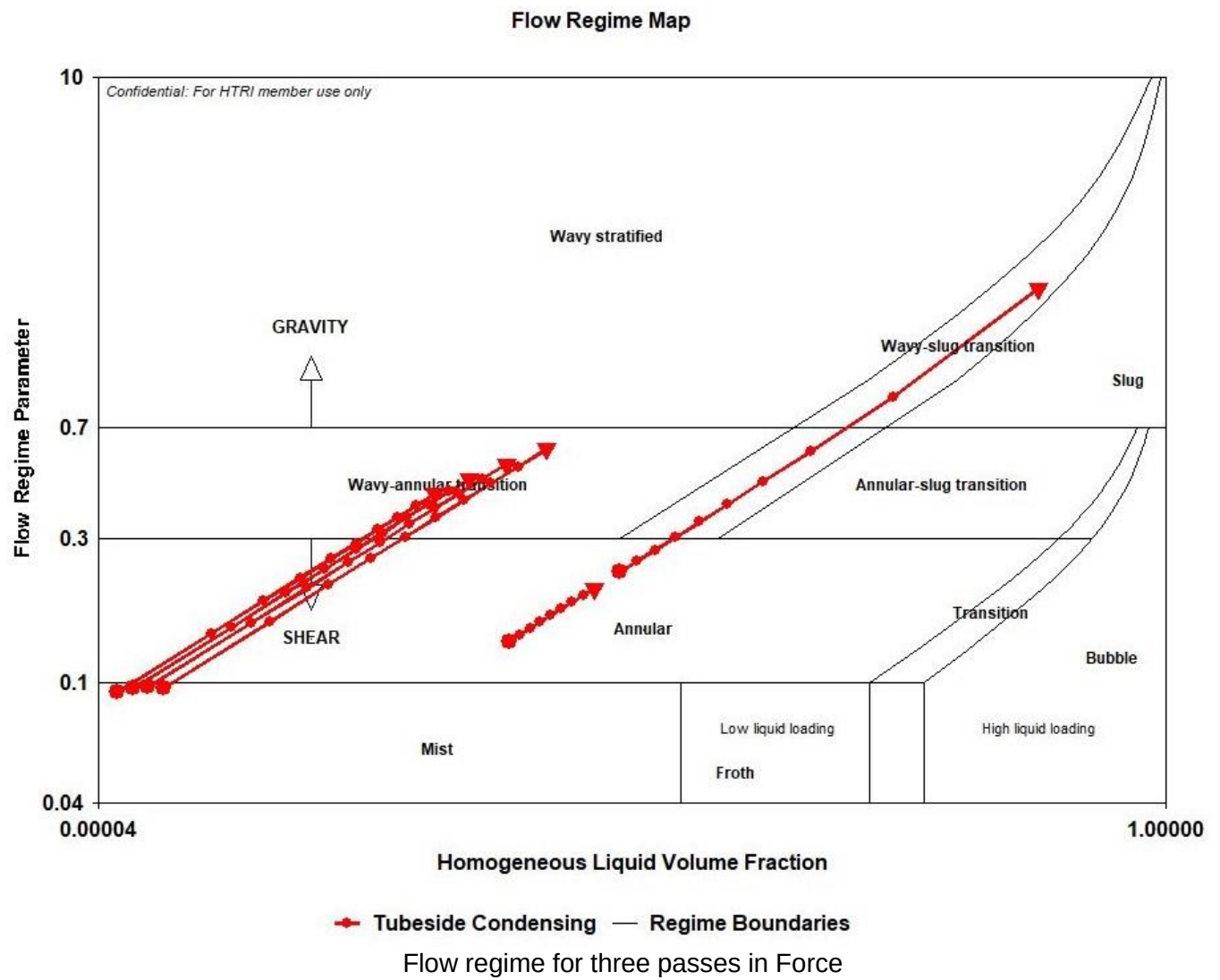
Flow Regime Map

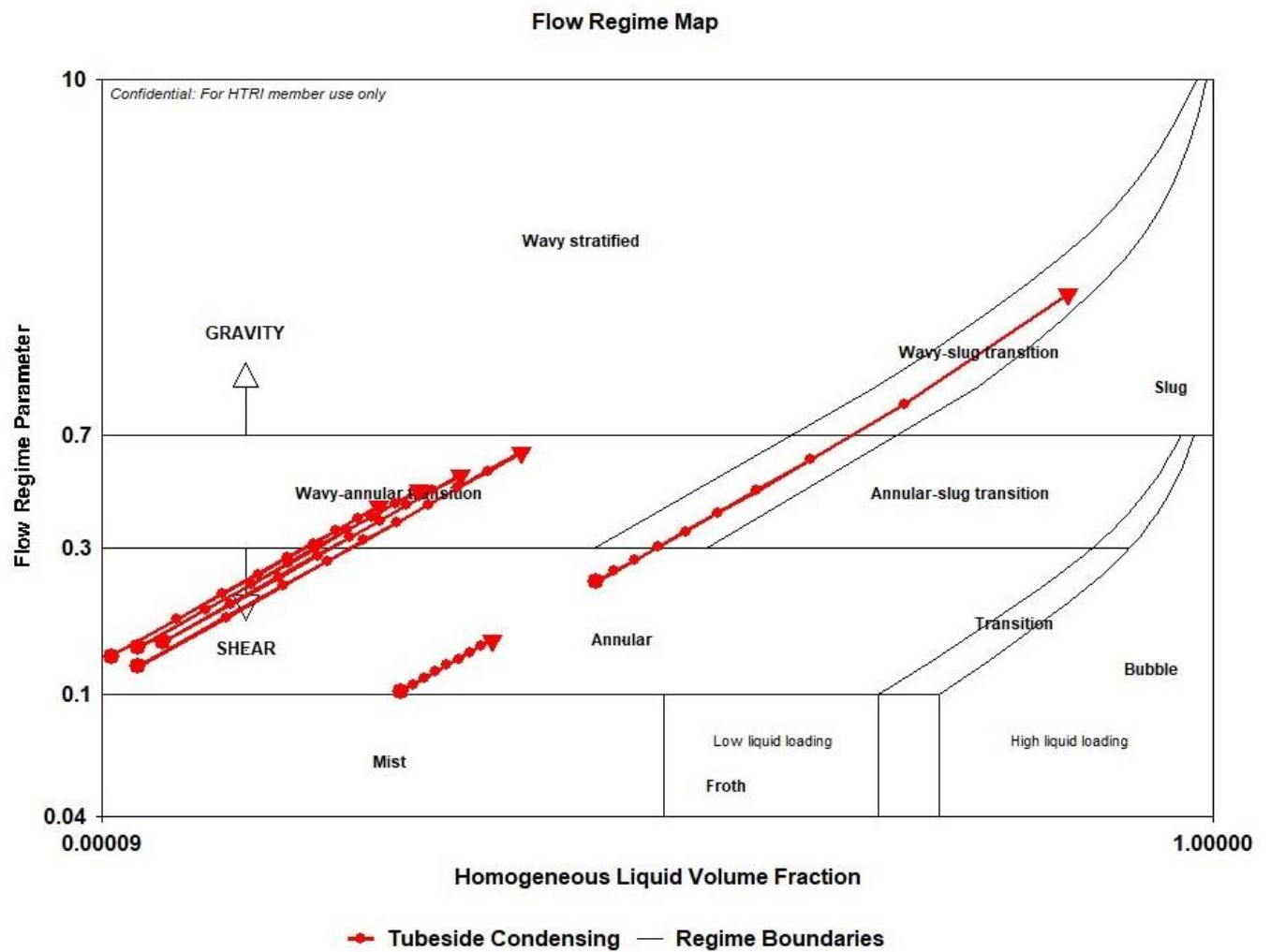


Flow regime for two passes



Flow regime for three passes







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				Sens. Gas		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	Actual U	(W/m2-K)	30.661	
Tubeside film coef		(W/m2-K)	5836.97	Required U	(W/m2-K)	30.390	
Clean coef		(W/m2-K)	35.905	Area	(m2)	576702	
Hot regime			Cond. Vapor	Overdesign	(%)	0.89	
Cold regime			Sens. Gas	Tube Geometry			
EMTD		(Deg C)	8.7	Tube type	High-finned		
Duty		(MegaWatts)	151.705	Tube OD	(mm)	25.400	
Unit Geometry				Tube ID	(mm)	21.184	
Bays in parallel per unit			48	Length	(m)	12.500	
Bundles parallel per bay			2	Area ratio(out/in)	(--)	28.0168	
Extended area		(m2)	576702	Layout	Staggered		
Bare area		(m2)	24680.7	Trans pitch	(mm)	63.500	
Bundle width		(m)	2.838	Long pitch	(mm)	54.991	
Nozzle		Inlet	Outlet	Number of passes	(--)	2	
Number		(--)	2	Number of rows	(--)	6	
Diameter		(mm)	193.675	Tubecount	(--)	264	
Velocity		(m/s)	18.94	Tubecount Odd/Even	(--)	44 / 44	
R-V-SQ		(kg/m-s2)	466.70	Tube material	Carbon steel		
Pressure drop		(bar)	2.567e-3	6.860e-5	Fin Geometry		
Fan Geometry				Type	Plain round		
No/bay		(--)	2	Fins/length	fin/meter	433.0	
Fan ring type			30 deg	Fin root	mm	25.400	
Diameter		(m)	4.265	Height	mm	15.800	
Ratio, Fan/bundle face area		(--)	0.40	Base thickness	mm	0.430	
Driver power		(kW)	23.24	Over fin	mm	57.000	
Tip clearance		(mm)	19.050	Efficiency	(%)	79.4	
Efficiency		(%)	75	Area ratio (fin/bare)	(--)	23.3665	
Airside Velocities		Actual	Standard	Material	Aluminum 1060 - H14		
Face		(m/s)	3.04	2.76	Thermal Resistance, %		
Maximum		(m/s)	5.96	5.40	Air	67.88	
Flow		(100 m3/min)	6216.69	5636.14	Tube	14.72	
Velocity pressure		(Pa)	32.47		Fouling	14.60	
Bundle pressure drop		(Pa)	120.82		Metal	2.80	
Bundle flow fraction		(--)	1.000		Bond	0.00	
Airside Pressure Drop, %				Louvers	0.00		
Bundle		98.41	Fan guard	0.00	Hail screen	0.00	
Ground clearance		0.00	Fan area blockage	0.00	Steam coil	0.00	
Fan ring		1.59					

Education Institute for
Equipment & Process Design



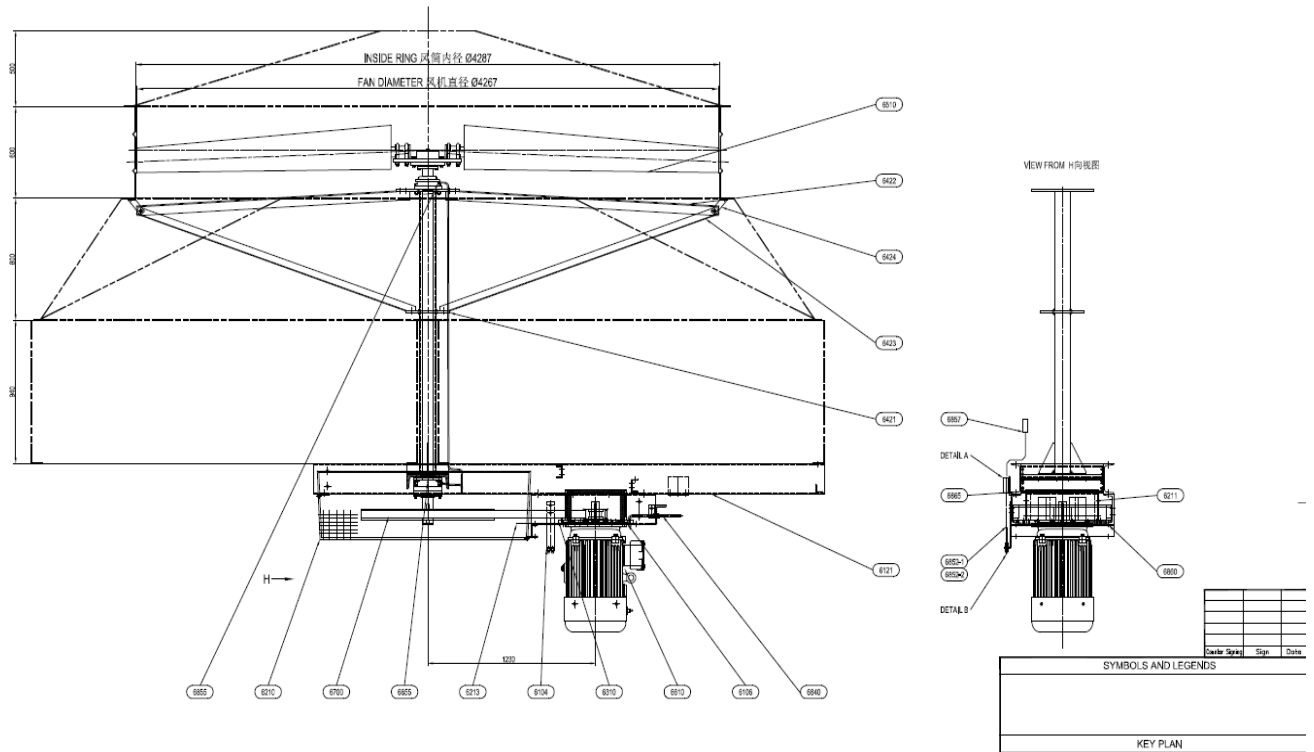
Unit and Bundle Construction Information					
Bays in parallel/unit	(--)	48	Bundles in parallel/bay		2
Extended area/unit	(m2)	576702	Bare area/unit	(m2)	24680.7
Extended area/bundle	(m2)	6007.31	Bare area/bundle	(m2)	257.091
Tube passes/Tuberows	(--)	2 / 6	Number of tubes/bundle	(--)	264
Tube count, 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	Tube side volume	(L)	1397.0
Total weight, Dry / Wet	(kg)	1561335 / 1695348	Cost Factor	(--)	4602.64
Ladder/walkway weight	(kg)	215923			
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/fin)	(--)	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			Tube side	Outside
Midpoint j-factor			(--)	0.0068
Heat transfer		Wall Correction	(--)	1.0000
		Row Correction	(--)	1.0000
Midpoint f-factor			(--)	0.0000
Pressure drop		Wall Correction	(--)	0.0000
		Row Correction	(--)	1.0029
Reynolds number		Inlet	(--)	35743
		Midpoint	(--)	37109
		Outlet	(--)	5973
Fouling layer thickness			(mm)	0.000
Input minimum velocity			(m/s)	0.000
Input maximum velocity			(m/s)	
Input minimum wall temperature			(Deg C)	
Input maximum wall temperature			(Deg C)	



Drawings



PART 件号	REP 序号	DESCRIPTION 描述
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

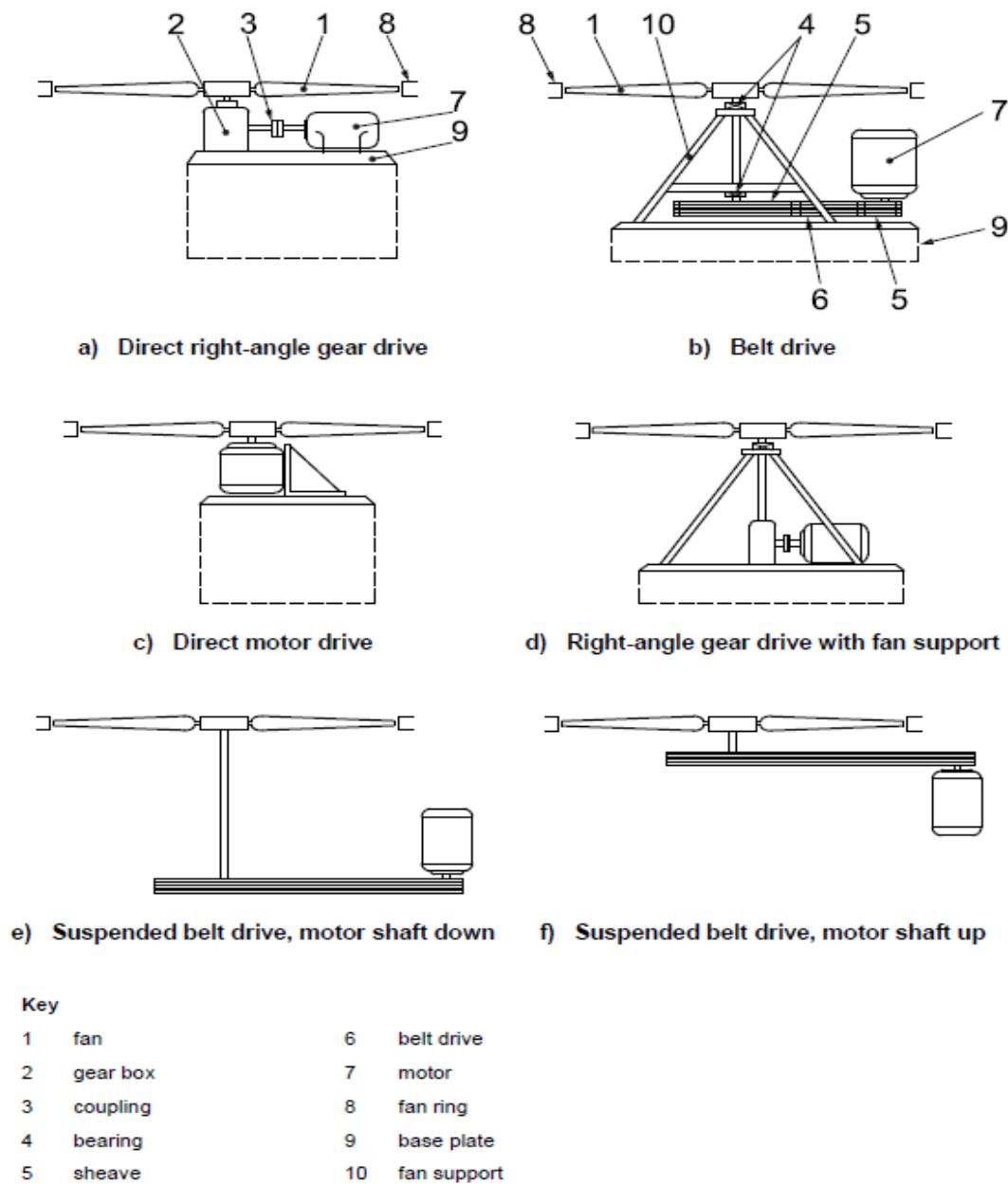
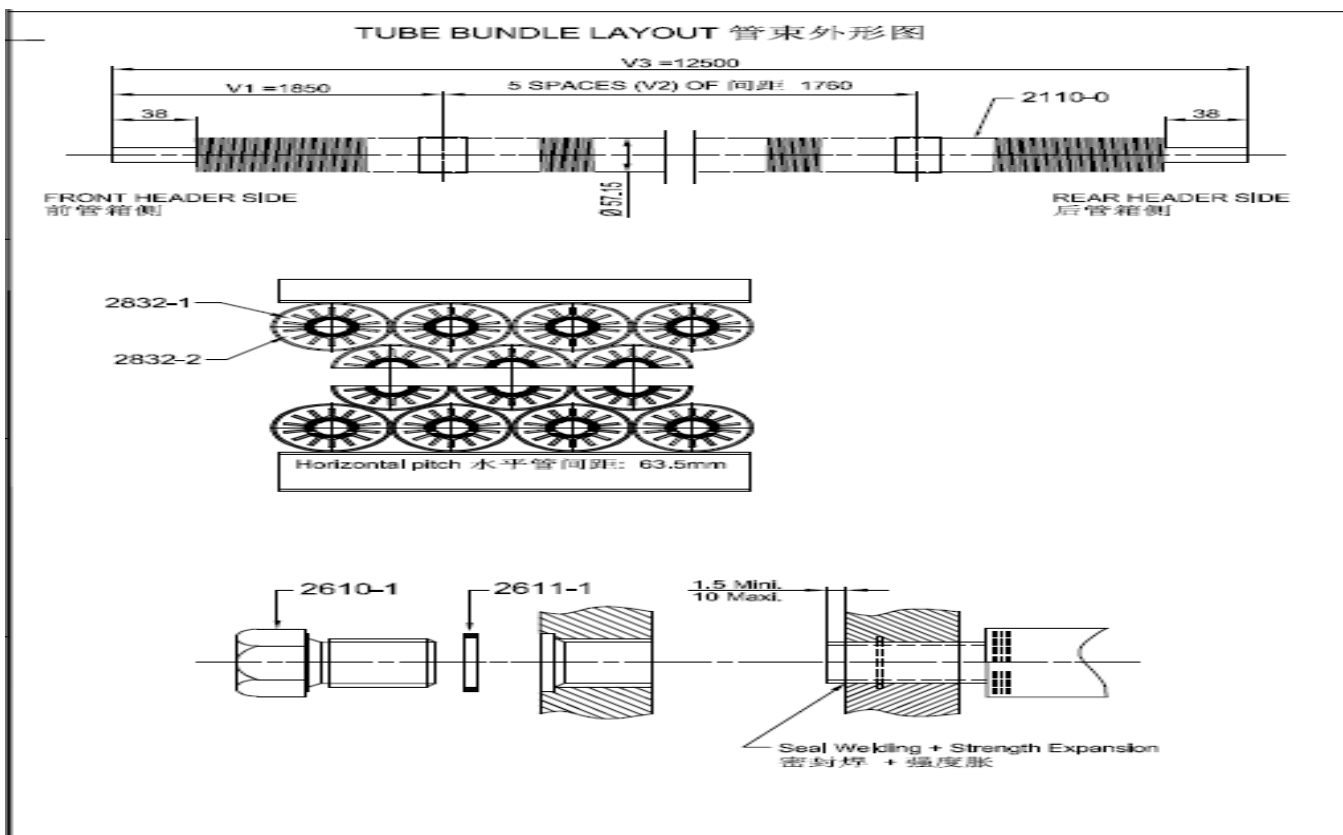
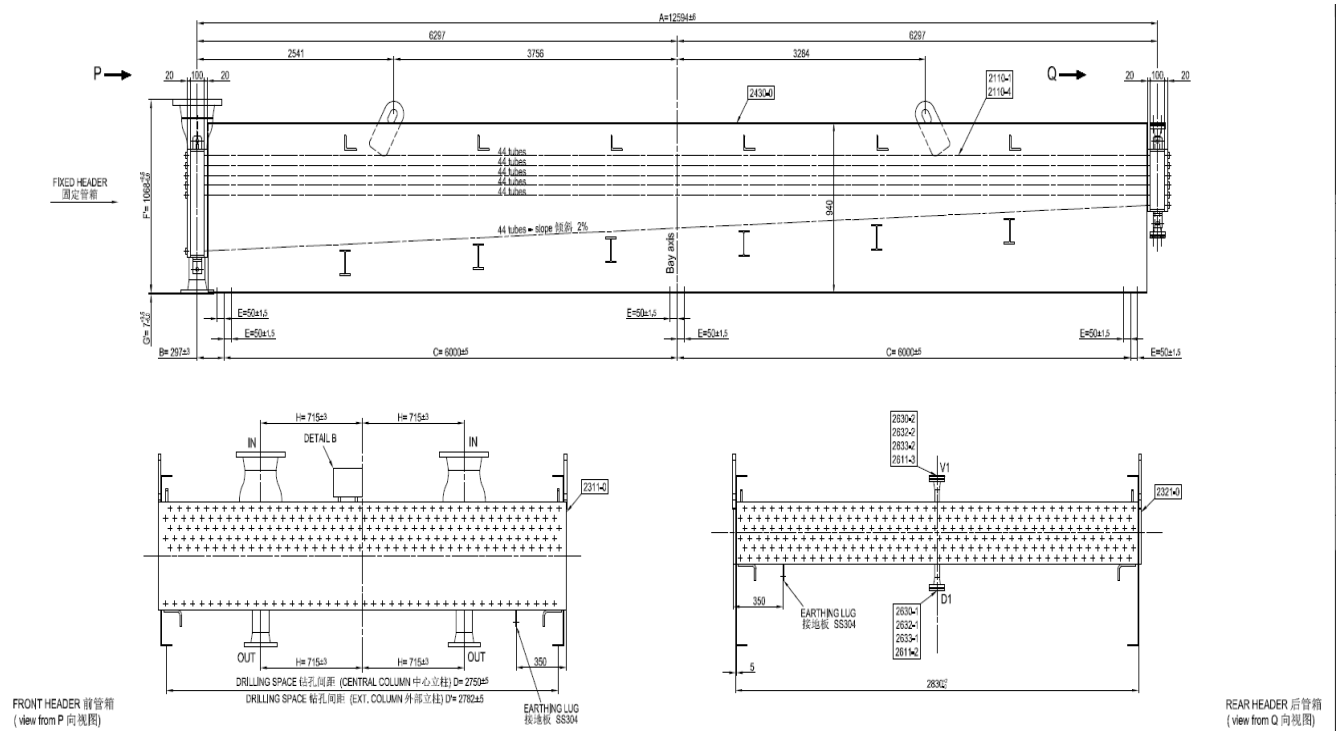


Figure 8 — Typical Drive Arrangements



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.



Education Institute for
Equipment & Process Design

