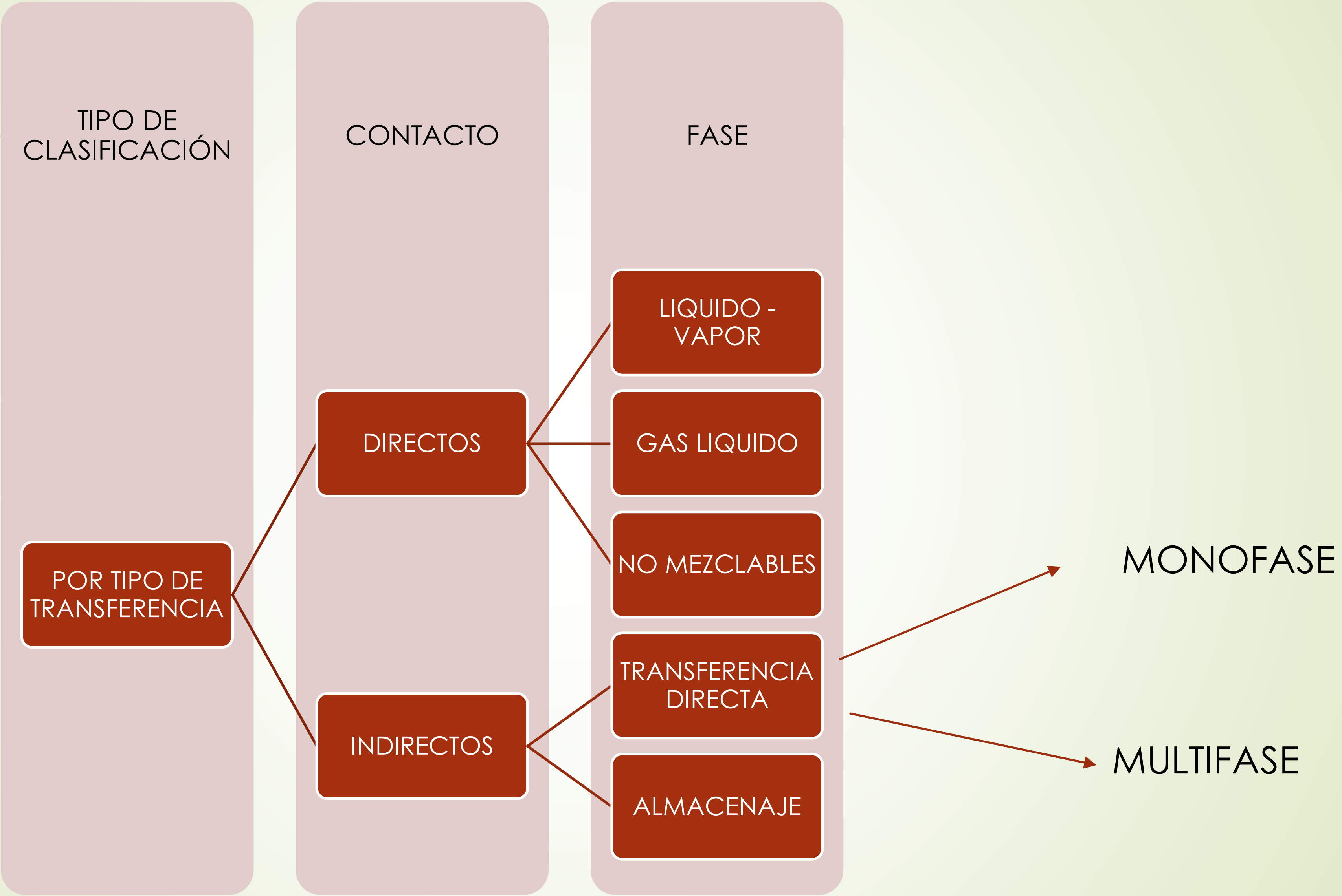
EQUIPOS E INSTALACIONES INDUSTRIALES

PROFESOR: ING. JORGE NOZICA
PROFESOR: ING. HÉCTOR PÉREZ
PROFESOR: ING. LETICIA SIMONCINI

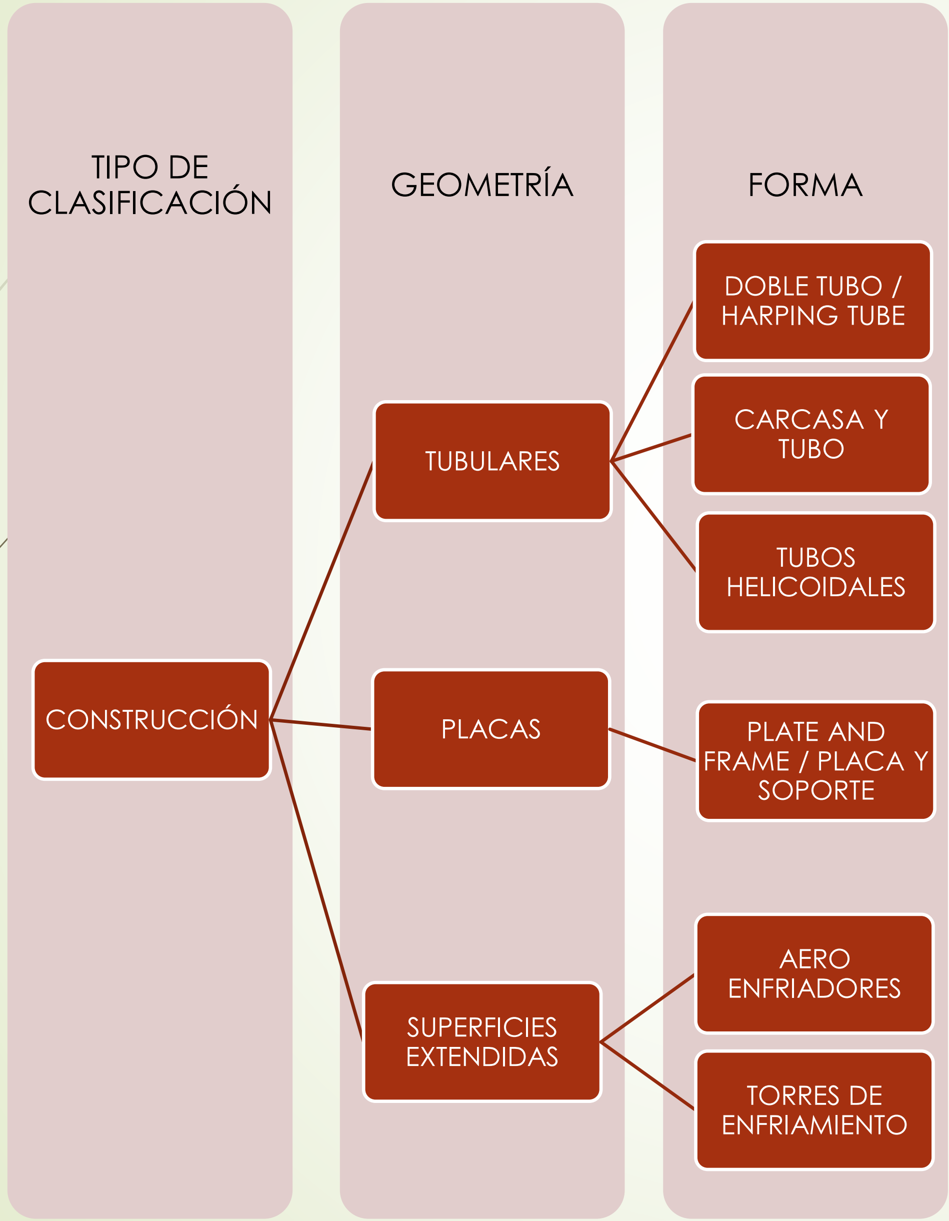
INTERCAMBIADORES DE CALOR

INTERCAMBIADORES DE CALOR CLASIFICACIÓN GENERAL



TIPO DE CLASIFICACIÓN
CONTACTO
FASE
POR TIPO DE TRANSFERENCIA
DIRECTOS
INDIRECTOS
LIQUIDO - VAPOR
GAS LIQUIDO
NO MEZCLABLES
TRANSFERENCIA DIRECTA
ALMACENAJE
MONOFASE
MULTIFASE

CLASIFICACIÓN DE FABRICACIÓN



TIPO DE CLASIFICACIÓN

GEOMETRÍA

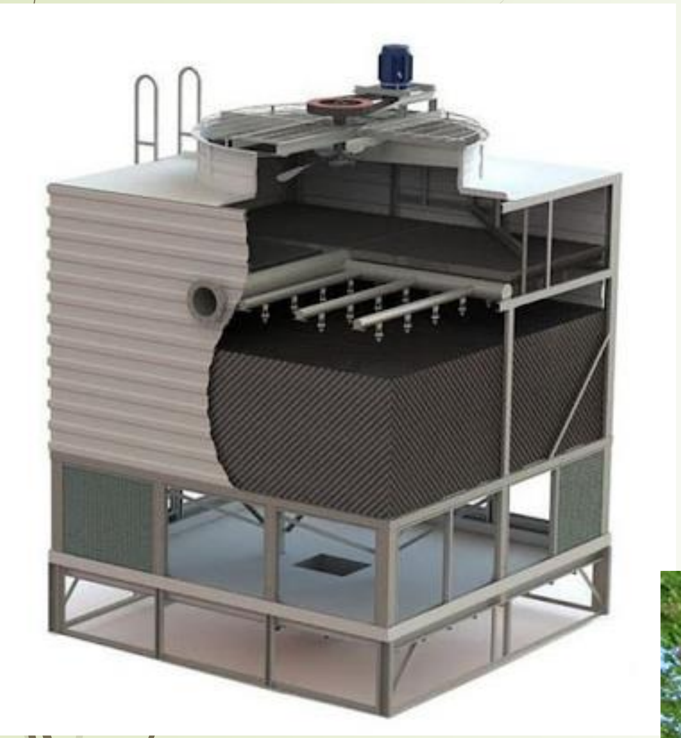
FORMA

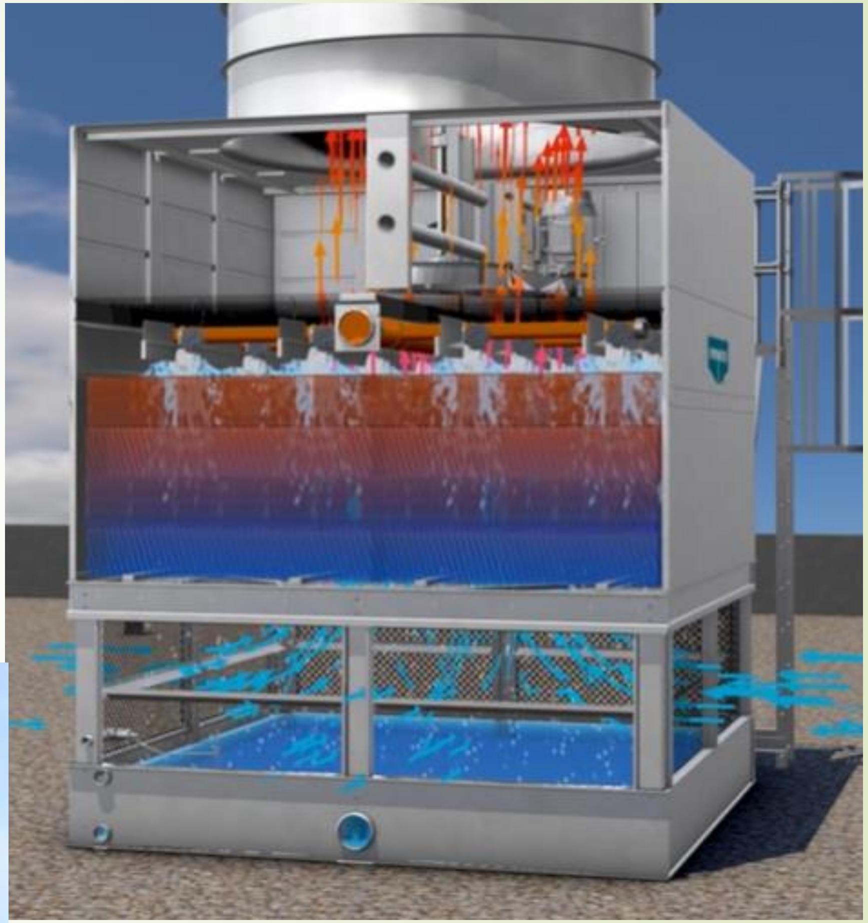
CONSTRUCCIÓN

- TUBULARES
  - DOBLE TUBO / HARPING TUBE
  - CARCASA Y TUBO
  - TUBOS HELICOIDALES
- PLACAS
  - PLATE AND FRAME / PLACA Y SOPORTE
- SUPERFICIES EXTENDIDAS
  - AERO ENFRIADORES
  - TORRES DE ENFRIAMIENTO

CONTACTO DIRECTO

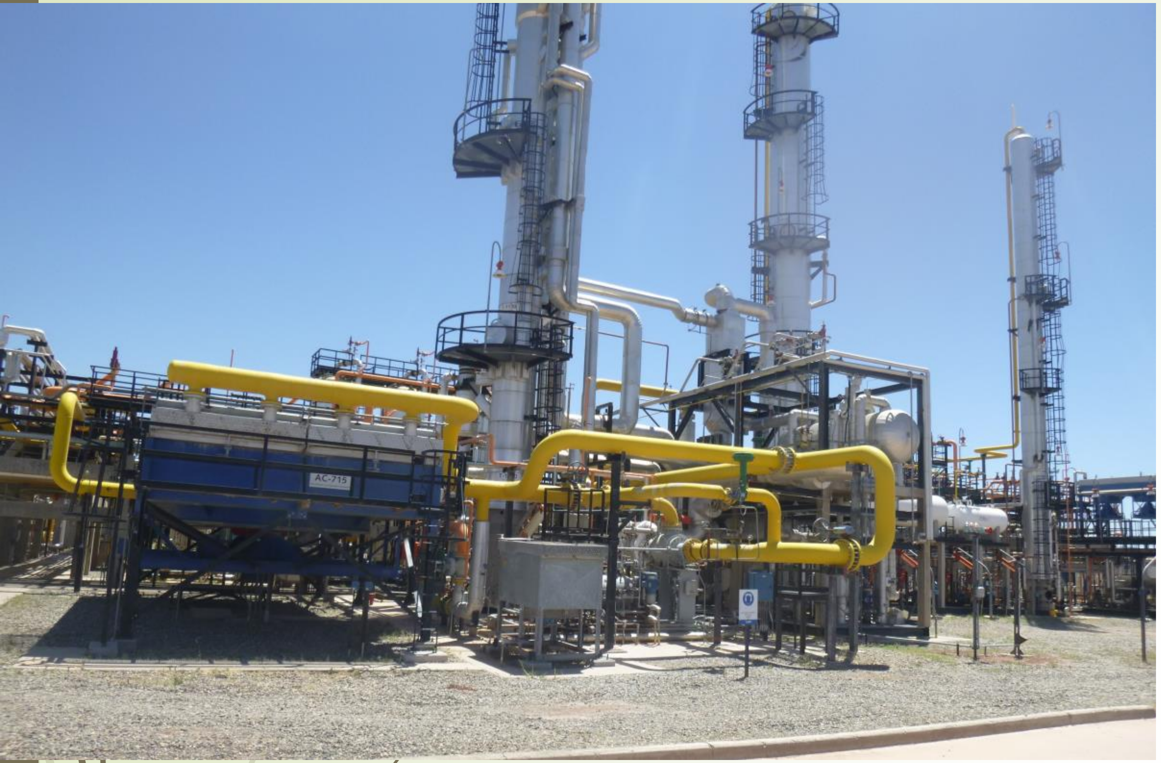
- TORRE DE ENFRIAMIENTO – COOLING TOWER

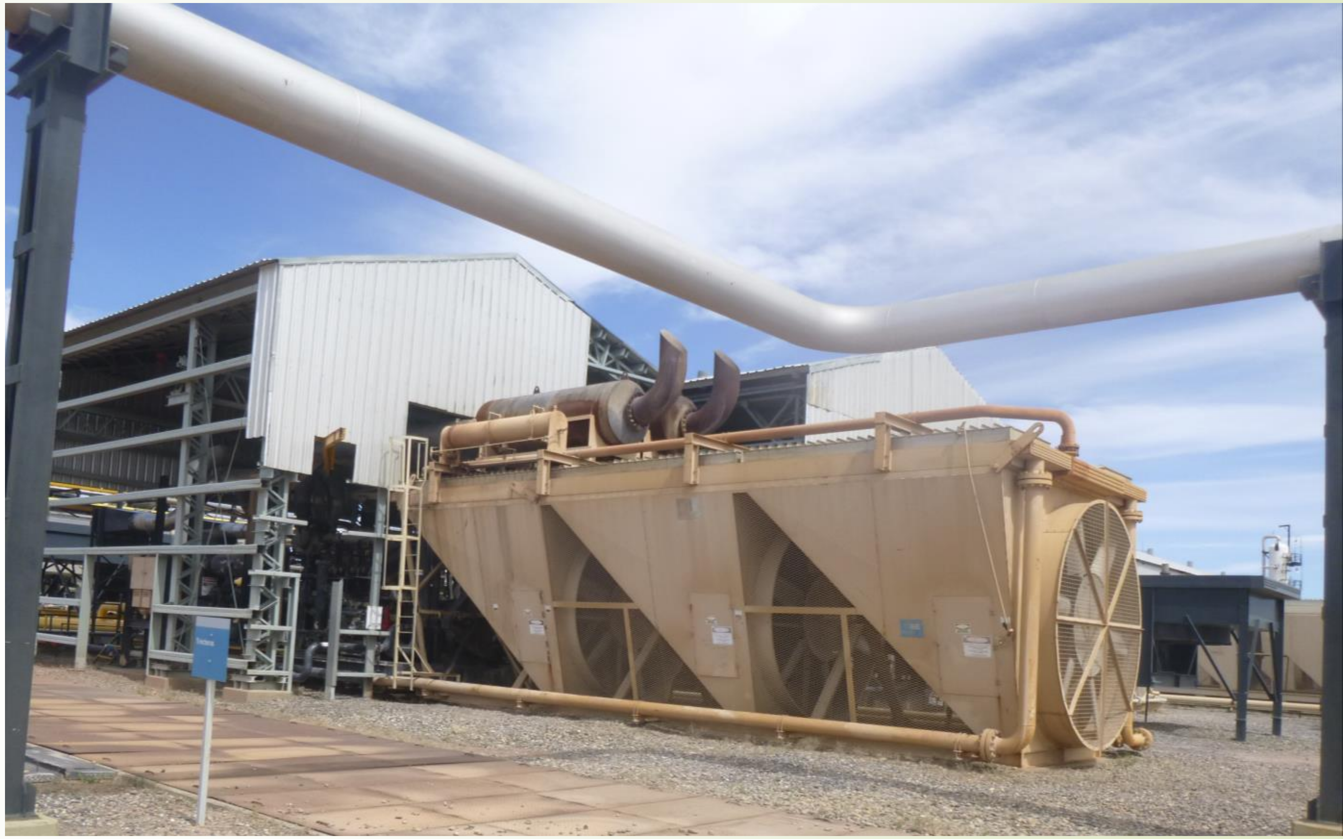


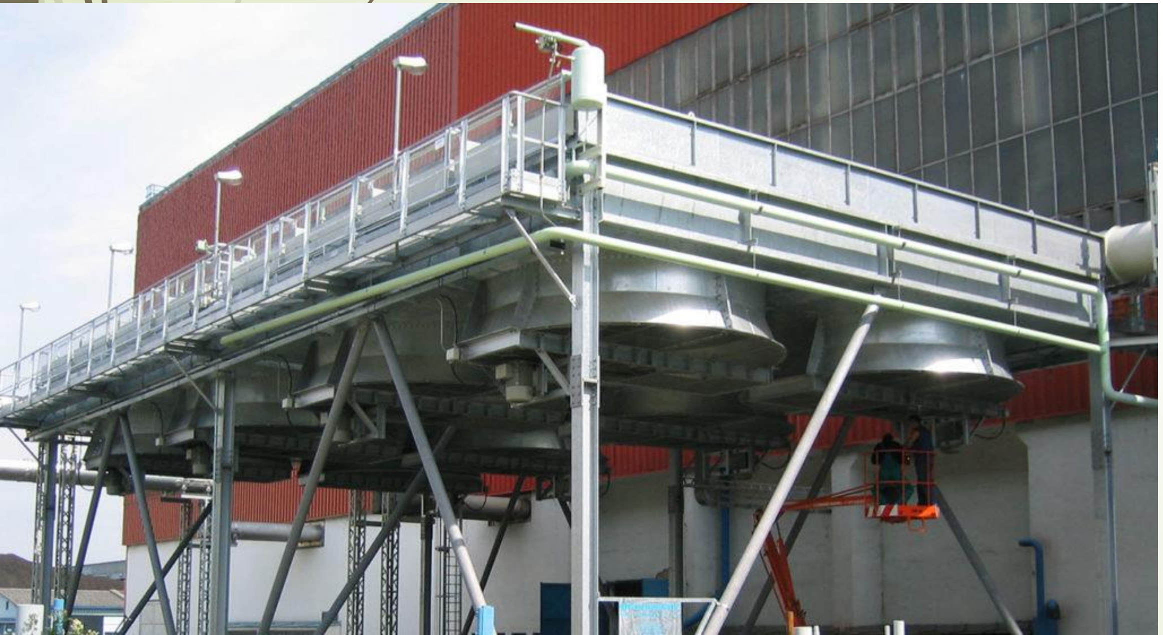


CONTACTO INDIRECTO

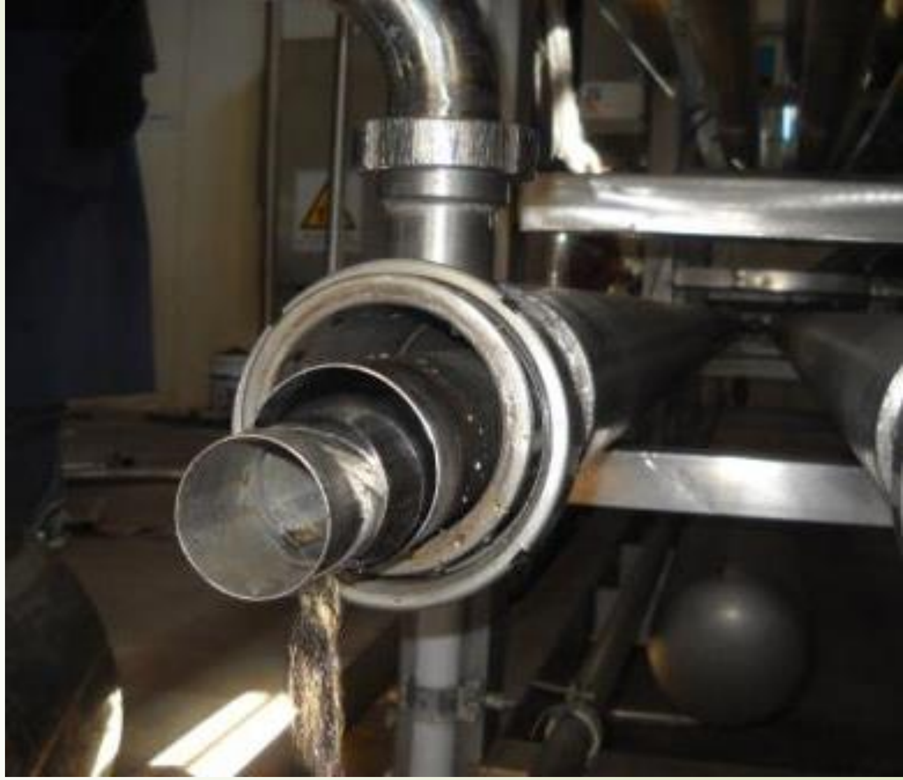
- AERO ENFRIADORES



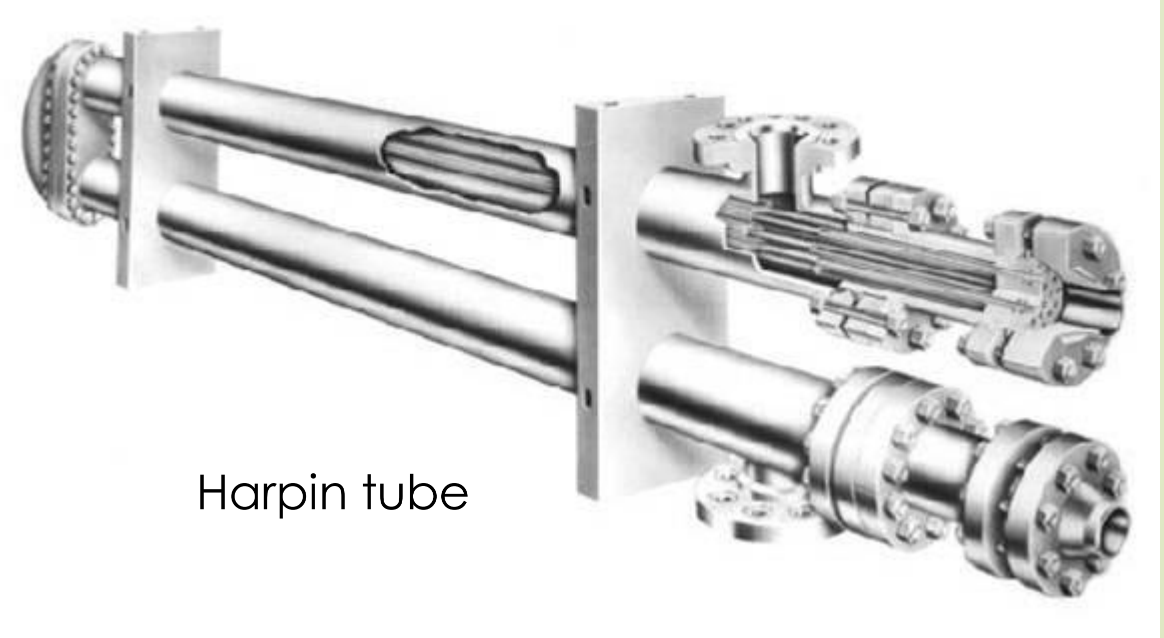




INTERCAMBIADORES TUBO EN TUBO Y HARPIN TUBE

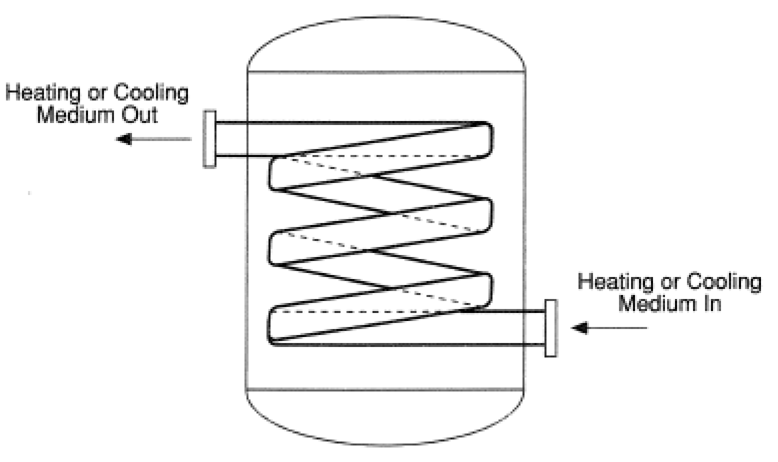


Doble ánulo

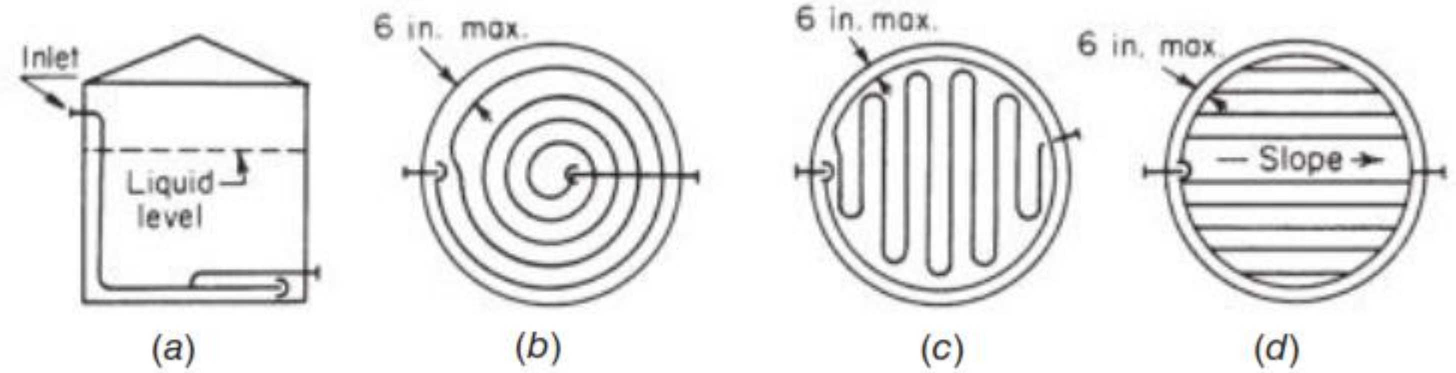


Harpin tube

INTERCAMBIADORES DE CALOR ANILLOS TUBULARES

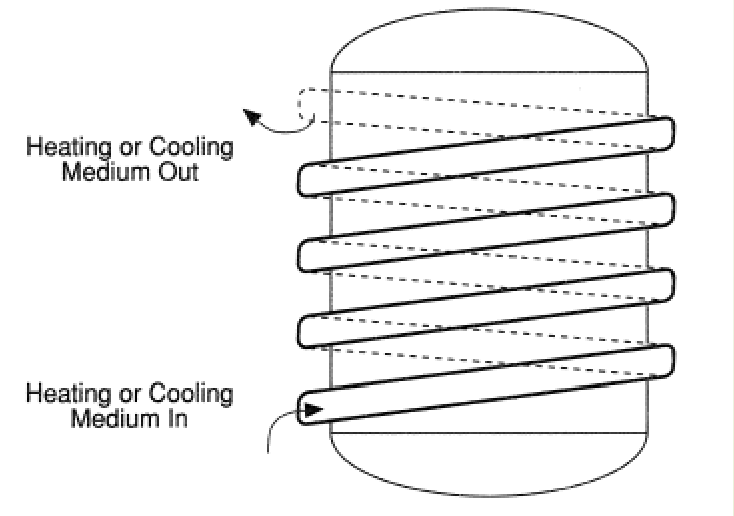

Heating or Cooling Medium Out
Heating or Cooling Medium In

TANQUE CON ANILLO INTERIOR
INTERNAL COIL

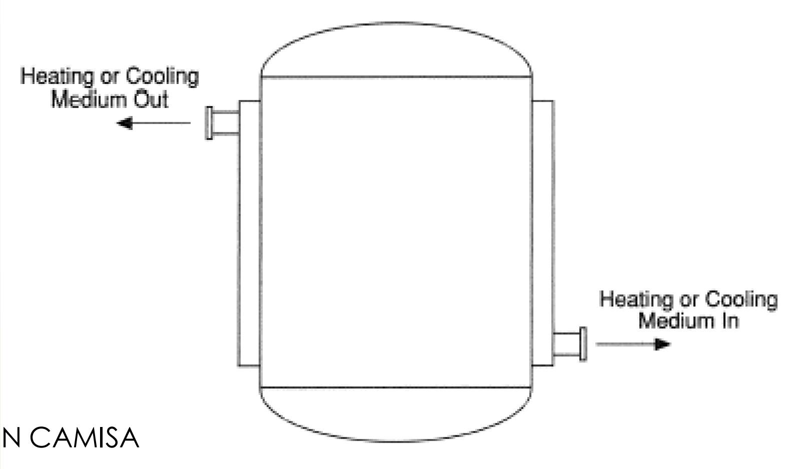

Inlet
Liquid level
6 in. max.
6 in. max.
6 in. max.
Slope

(a) (b) (c) (d)

FIG. 11-29a Typical coil designs for good bottom coverage. (*a*) Elevated inlet on spiral coil. (*b*) Spiral with recircling ring. (*c*) Hairpin with encircling ring. (*d*) Ring header type.


Heating or Cooling Medium Out
Heating or Cooling Medium In

TANQUE CON HEMIANILLO
EXTERIOR
LIMPET COIL

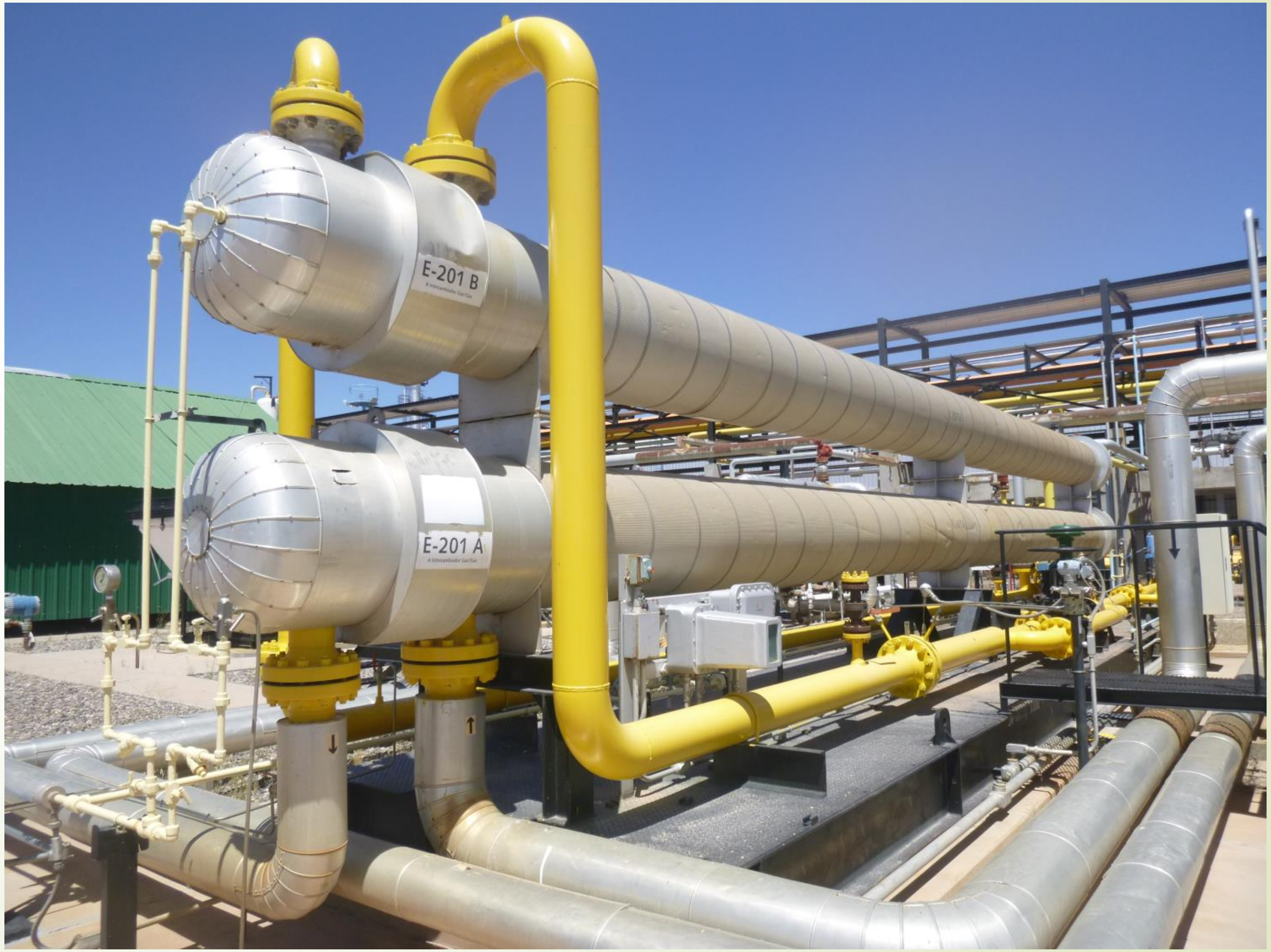

Heating or Cooling Medium Out
Heating or Cooling Medium In

TANQUE CON CAMISA

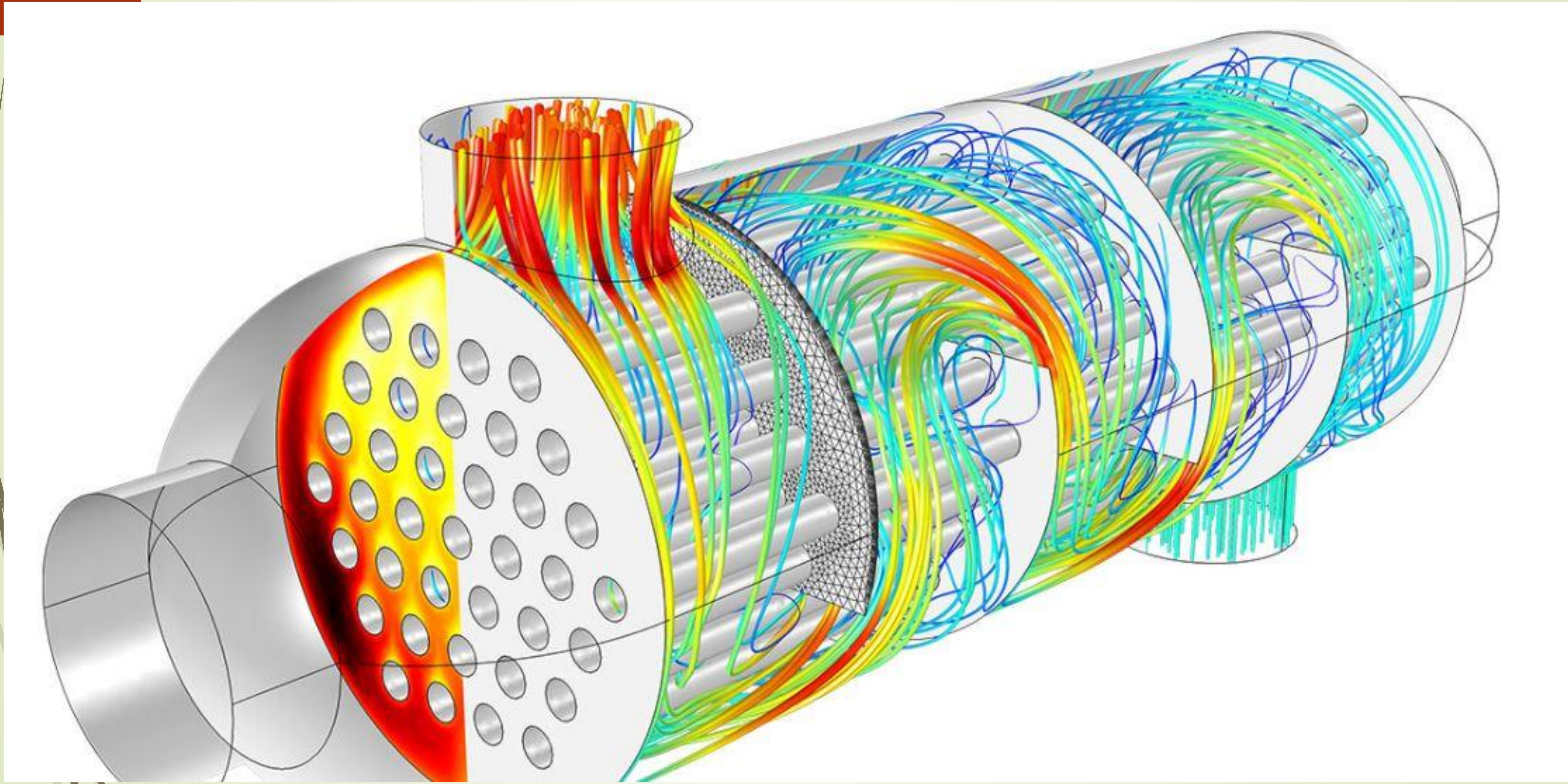
INTERCAMBIADORES DE CALOR

- INTERCAMBIADOR DE CALOR

CARCASA Y TUBO (C&T)


E-201 B
E-201 A

INTERCAMBIADOR C&T



DISEÑO TÈRMICO Y DISEÑO MECÁNICO

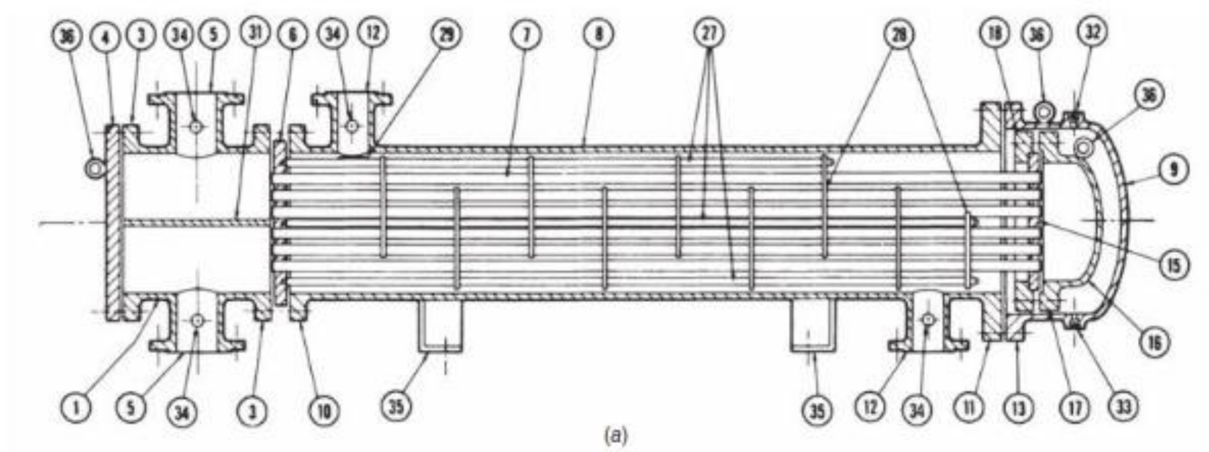
DISEÑO TÉRMICO

- Coeficientes peliculares (hio – ho) – función de nª adimensionales
- Coeficiente global U (tabla 11-3 / 11-4 / 11-5 Perry 's Chemical Engineers Handbook)
- Resistencias adicionales (fouling factors)
- Diferencia de temperatura efectiva (ΔTln)
- Área de intercambio
- Carga térmica Q = U x A x DT (kcal/h / kw)
- Pre dimensionamiento geométrico de tubos y carcasa
- Pérdida de carga
- Condiciones de operación: Temperaturas, presiones, tipo de fluidos

DISEÑO TÈRMICO Y DISEÑO MECÁNICO

- DISEÑO MECÁNICO
  - Espesores de carcasa
  - Verificación de tubos (tabla 11-12 Perry's Chemical Engineers Handbook)
  - Tube sheet (placa porta tubos)
  - Bafles
  - Bridas
  - Pernos
  - Aislación

NORMAS TEMA


36
4
3
34
5
31
6
34
12
29
7
8
27
28
18
36
32
36
9
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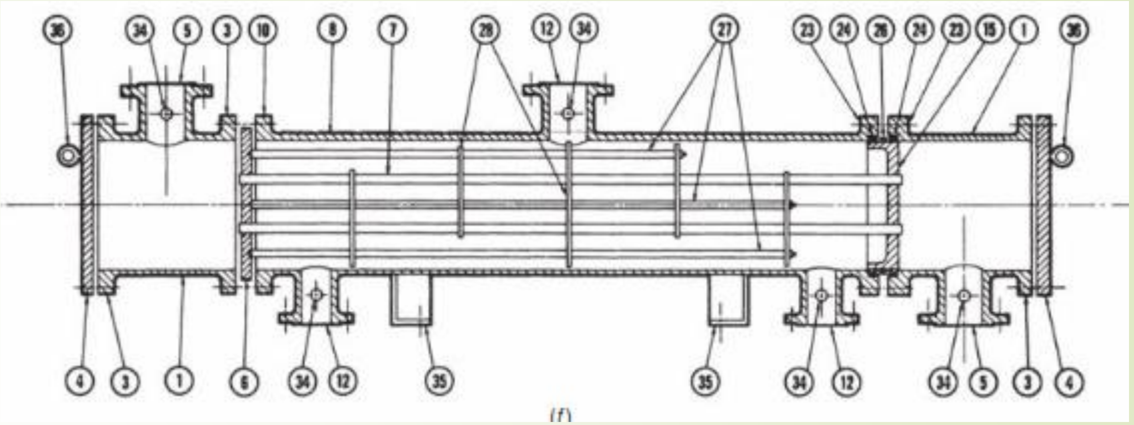
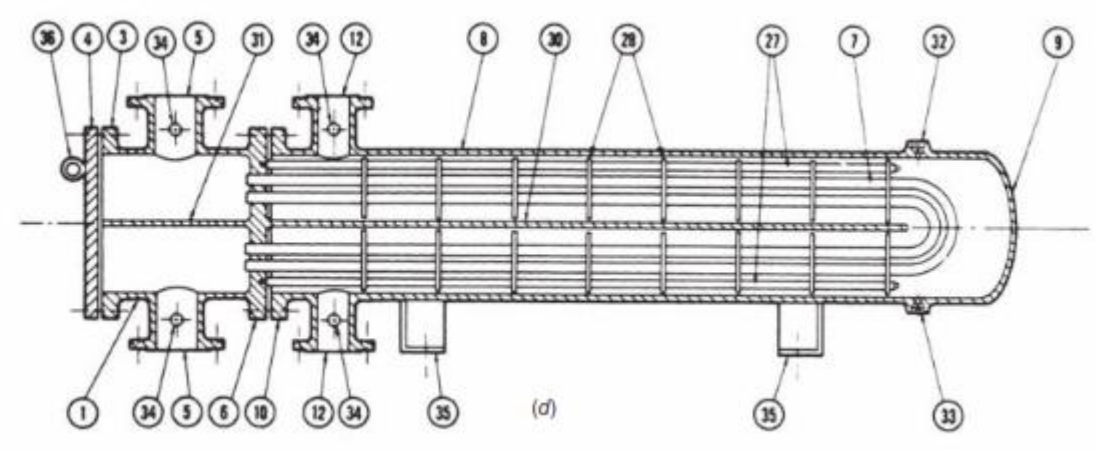
16
1
5
34
3
10
35
35
12
34
11
13
17
33
(a)


36
34
5
3
10
8
7
28
12
34
27
23
24
26
24
23
15
1
36
4
3
1
6
34
12
35
35
34
12
34
5
3
4
(f)


36
4
3
34
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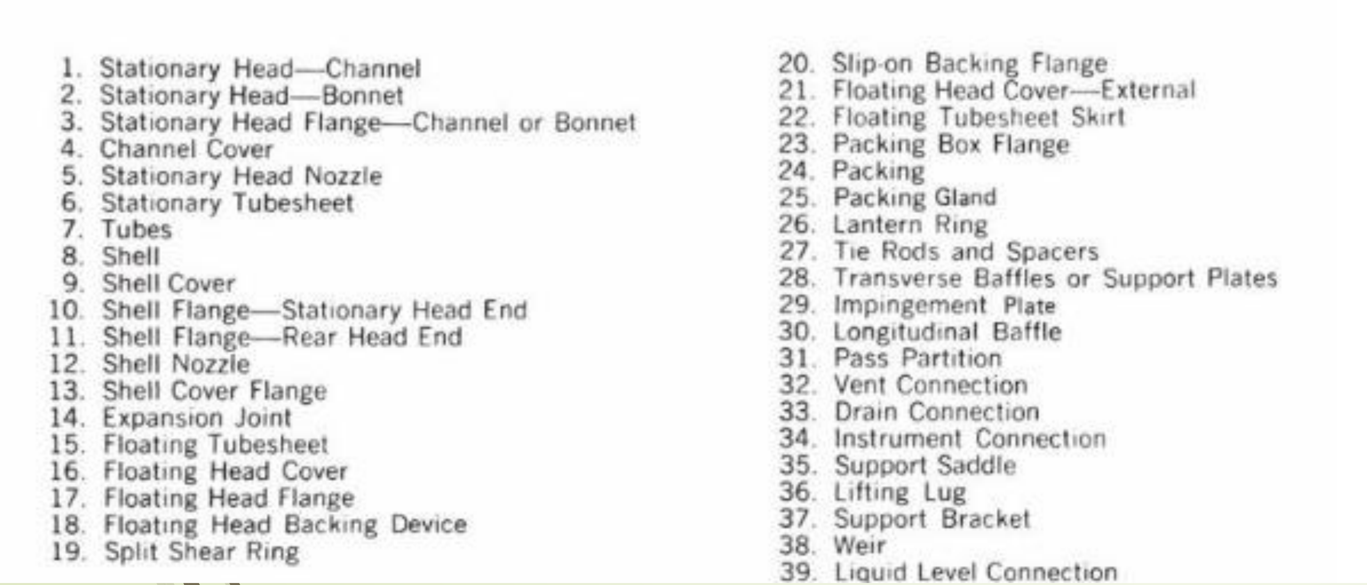
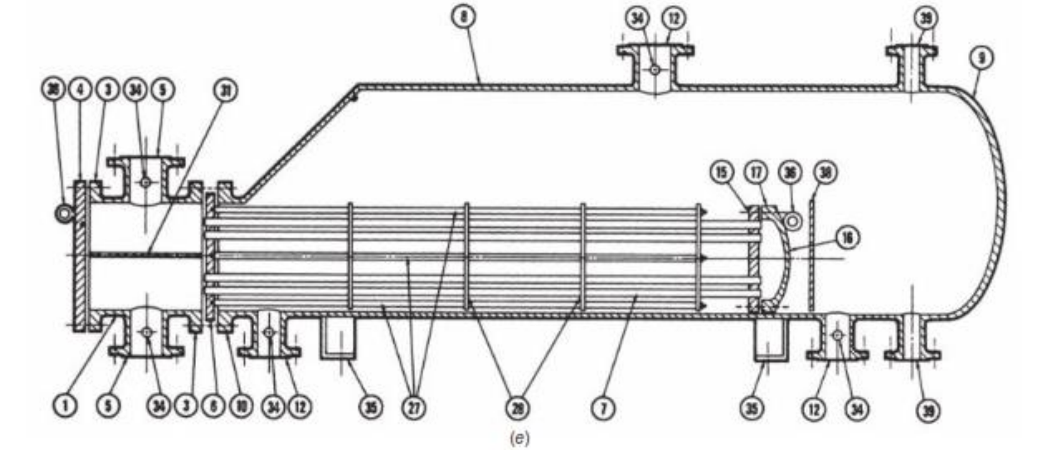
31
34
12
8
30
28
27
7
32
9
1
34
5
6
10
12
34
35
(d)
35
33



1. Stationary Head—Channel
2. Stationary Head—Bonnet
3. Stationary Head Flange—Channel or Bonnet
4. Channel Cover
5. Stationary Head Nozzle
6. Stationary Tubesheet
7. Tubes
8. Shell
9. Shell Cover
10. Shell Flange—Stationary Head End
11. Shell Flange—Rear Head End
12. Shell Nozzle
13. Shell Cover Flange
14. Expansion Joint
15. Floating Tubesheet
16. Floating Head Cover
17. Floating Head Flange
18. Floating Head Backing Device
19. Split Shear Ring
20. Slip-on Backing Flange
21. Floating Head Cover—External
22. Floating Tubesheet Skirt
23. Packing Box Flange
24. Packing
25. Packing Gland
26. Lantern Ring
27. Tie Rods and Spacers
28. Transverse Baffles or Support Plates
29. Impingement Plate
30. Longitudinal Baffle
31. Pass Partition
32. Vent Connection
33. Drain Connection
34. Instrument Connection
35. Support Saddle
36. Lifting Lug
37. Support Bracket
38. Weir
39. Liquid Level Connection


8
34
12
39
9
36
4
3
34
5
31
15
17
36
38
16
1
5
34
3
6
10
34
12
35
27
28
7
35
12
34
39
(e)

Alcance y Nomenclatura de Norma TEMA

- DIÁMETRO DE CARCASA 100" (2540mm)
- Pd < 3000 psi (210 bar)
- Espesor de carcasa 3" (76mm)

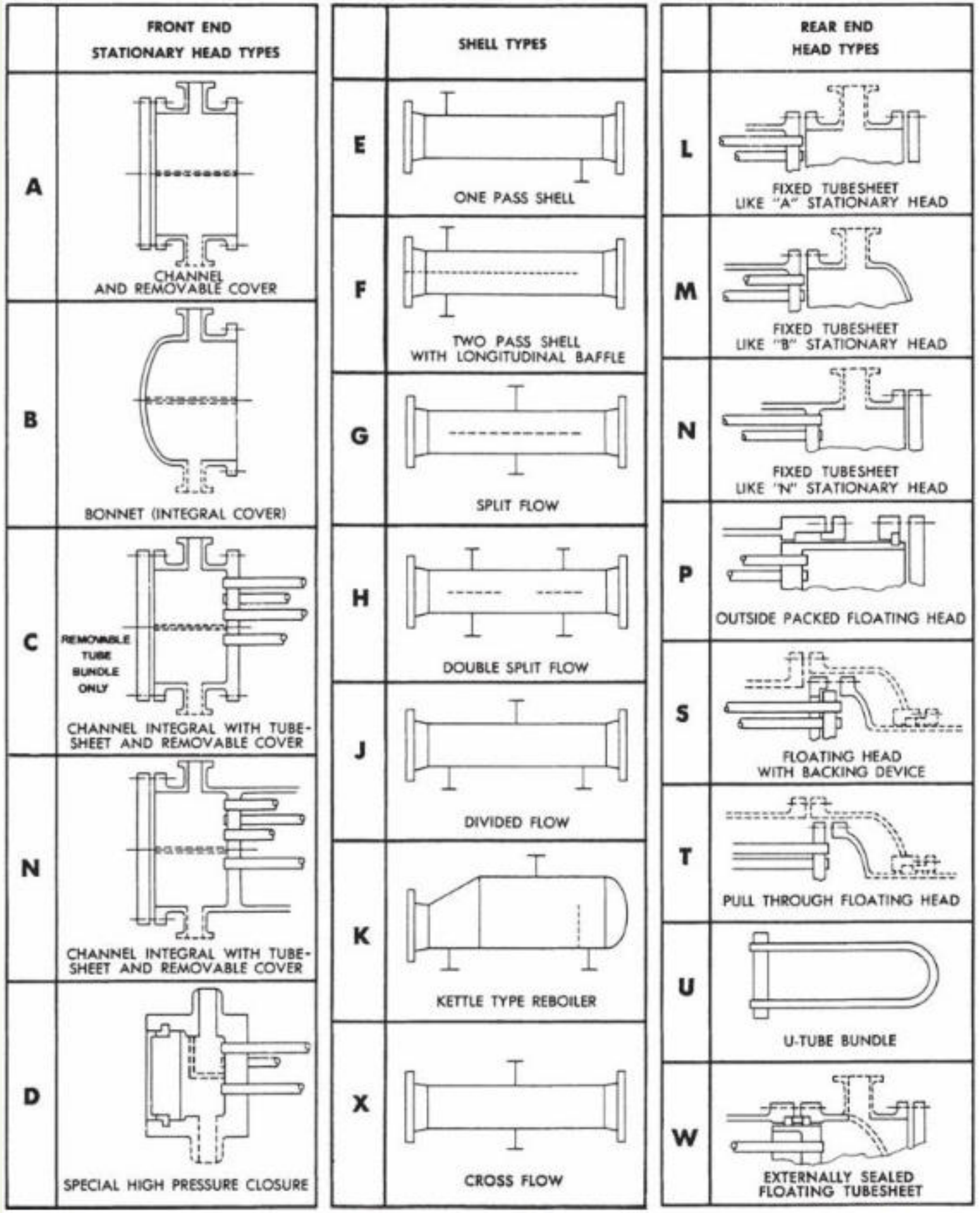
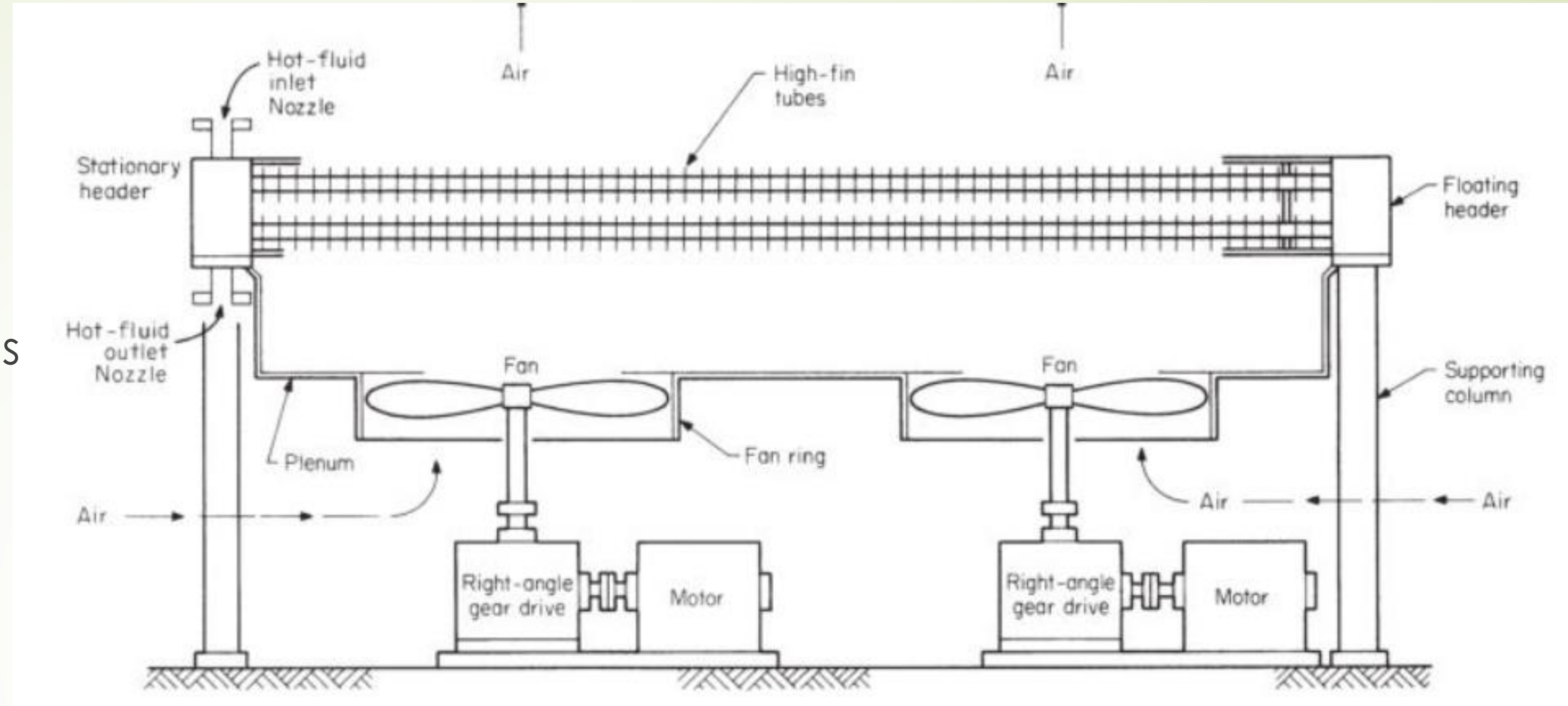

FRONT END STATIONARY HEAD TYPES
A
CHANNEL AND REMOVABLE COVER
B
BONNET (INTEGRAL COVER)
C
REMOVABLE TUBE BUNDLE ONLY
CHANNEL INTEGRAL WITH TUBE-SHEET AND REMOVABLE COVER
N
CHANNEL INTEGRAL WITH TUBE-SHEET AND REMOVABLE COVER
D
SPECIAL HIGH PRESSURE CLOSURE
SHELL TYPES
E
ONE PASS SHELL
F
TWO PASS SHELL WITH LONGITUDINAL BAFFLE
G
SPLIT FLOW
H
DOUBLE SPLIT FLOW
J
DIVIDED FLOW
K
KETTLE TYPE REBOILER
X
CROSS FLOW
REAR END HEAD TYPES
L
FIXED TUBESHEET LIKE "A" STATIONARY HEAD
M
FIXED TUBESHEET LIKE "B" STATIONARY HEAD
N
FIXED TUBESHEET LIKE "N" STATIONARY HEAD
P
OUTSIDE PACKED FLOATING HEAD
S
FLOATING HEAD WITH BACKING DEVICE
T
PULL THROUGH FLOATING HEAD
U
U-TUBE BUNDLE
W
EXTERNALLY SEALED FLOATING TUBESHEET

FIG. 11-35 TEMA-type designations for shell-and-tube heat exchangers. (*Standards of Tubular Exchanger Manufacturers Association, 6th ed., 1978.*)

Aero enfriadores

- Superficies extendidas finas
- Coeficientes peliculares muy disímiles

$hoAoe \approx hiAi$


Hot-fluid inlet Nozzle
Air
High-fin tubes
Air
Stationary header
Floating header
Hot-fluid outlet Nozzle
Fan
Fan
Supporting column
Plenum
Fan ring
Air
Air
Air
Right-angle gear drive
Motor
Right-angle gear drive
Motor

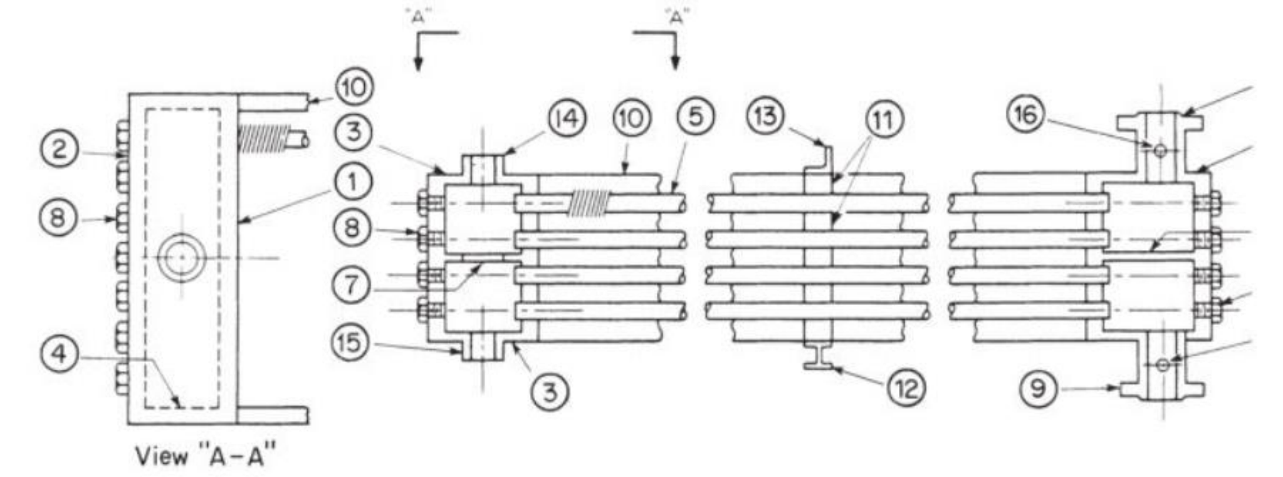

"A"
"A"
2
8
4
10
3
1
8
7
15
14
10
5
13
11
16
3
12
9
View "A–A"

FIG. 11-44 Typical construction of a tube bundle with plug headers: (1) tube sheet; (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. (*API Standard 661.*)

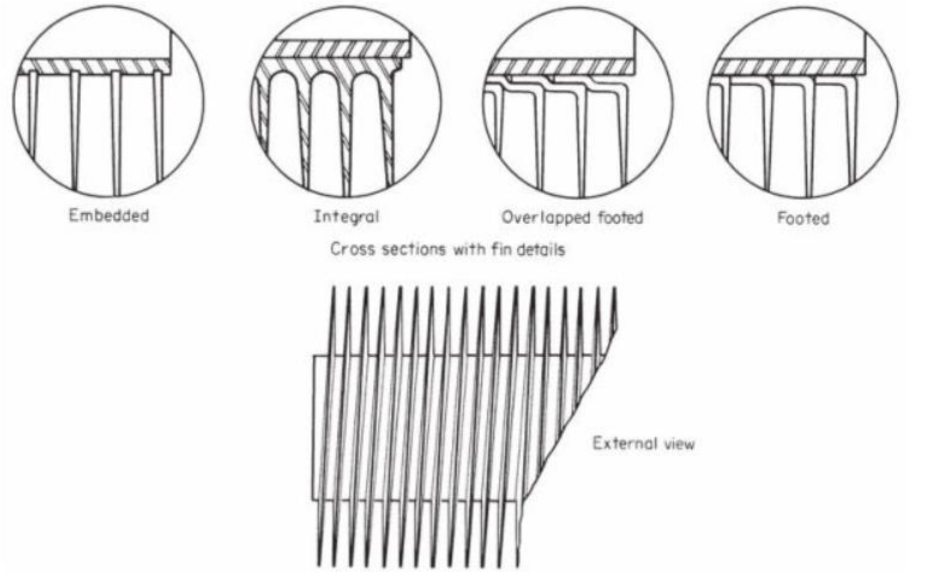
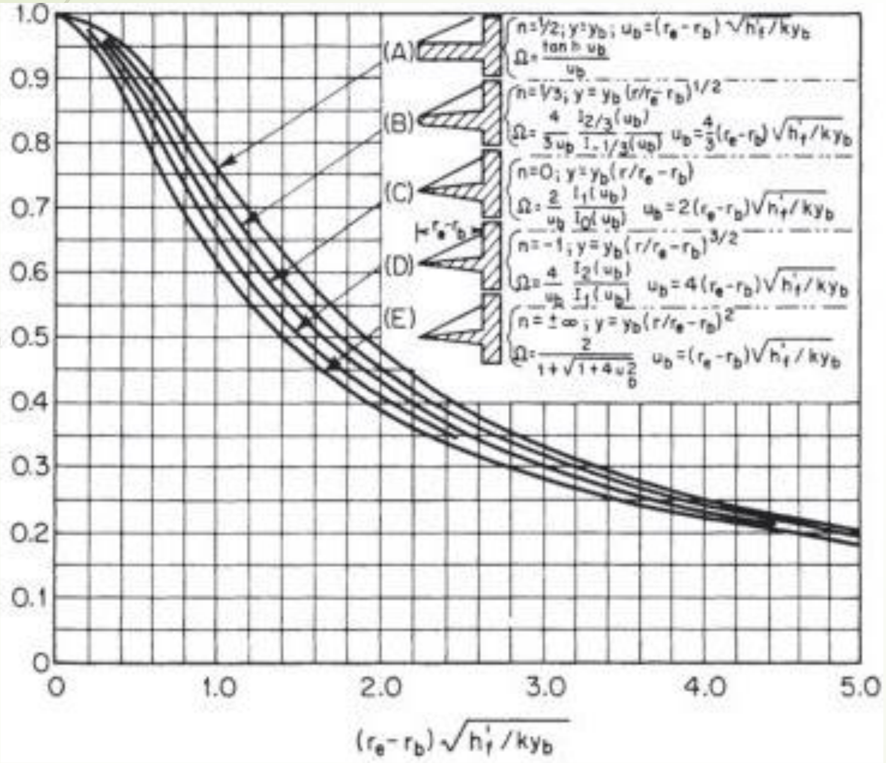
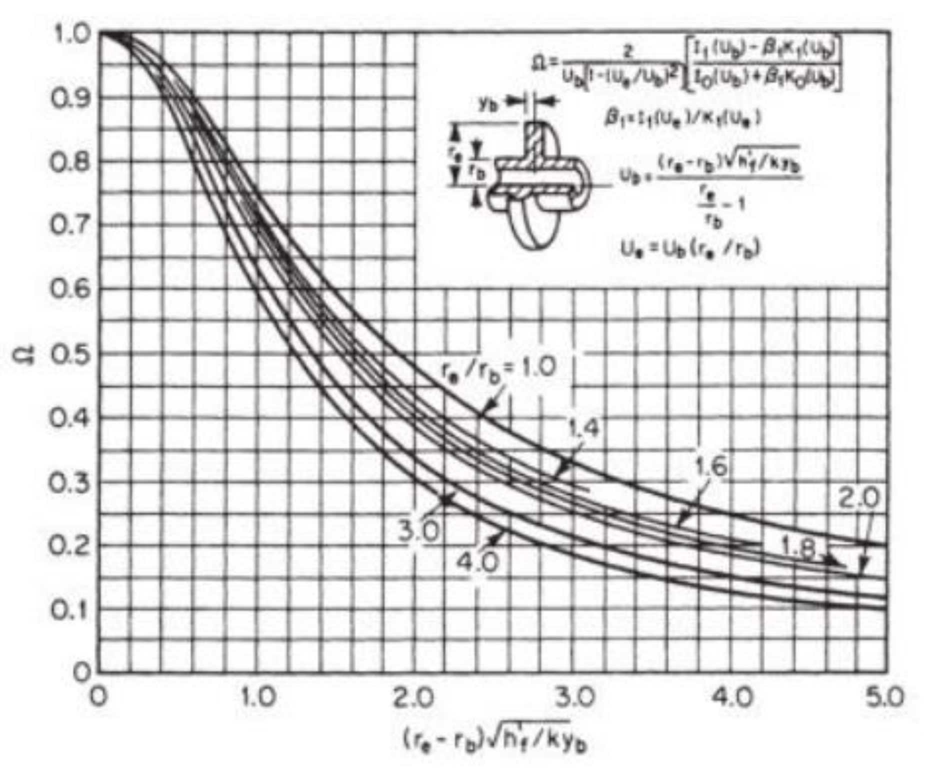

Embedded
Integral
Overlapped footed
Footed
Cross sections with fin details
External view

FIG. 11-45 Finned-tube construction.

$$A_{oe} = A_{uf} + A_f \Omega$$

Aoe: área efectiva de transferencia total
Auf: árae d etransferencia de tubo liso
Af: área de aletas
Ω: eficiencia de aleta





Q = UxAoex ΔT efectivo
ΔTe = ΔTln x f
F= factor de corrección de diferencia de temperatura (ajuste a modelo de flujo)
F=0,91 1 paso
F=0,96 2 pasos
F=0,99 3 pasos (Perry’s)

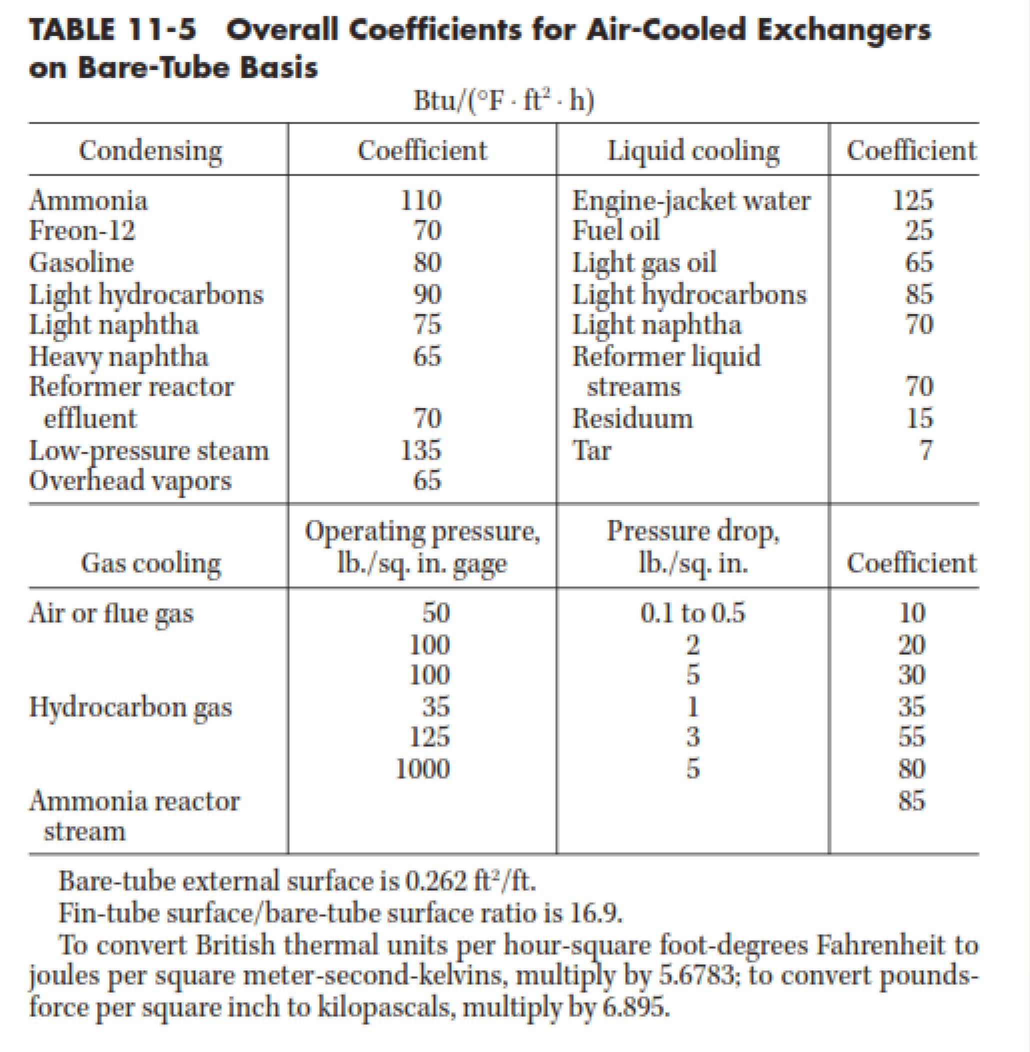


TABLE 11-5 Overall Coefficients for Air-Cooled Exchangers on Bare-Tube Basis

Btu/(°F · ft² · h)

Condensing	Coefficient	Liquid cooling	Coefficient
Ammonia	110	Engine-jacket water	125
Freon-12	70	Fuel oil	25
Gasoline	80	Light gas oil	65
Light hydrocarbons	90	Light hydrocarbons	85
Light naphtha	75	Light naphtha	70
Heavy naphtha	65	Reformer liquid streams	70
Reformer reactor effluent	70	Residuum	15
Low-pressure steam	135	Tar	7
Overhead vapors	65		

Gas cooling	Operating pressure, lb./sq. in. gage	Pressure drop, lb./sq. in.	Coefficient
Air or flue gas	50	0.1 to 0.5	10
	100	2	20
	100	5	30
Hydrocarbon gas	35	1	35
	125	3	55
	1000	5	80
Ammonia reactor stream			85

Bare-tube external surface is 0.262 ft²/ft.

Fin-tube surface/bare-tube surface ratio is 16.9.

To convert British thermal units per hour-square foot-degrees Fahrenheit to joules per square meter-second-kelvins, multiply by 5.6783; to convert pounds-force per square inch to kilopascals, multiply by 6.895.