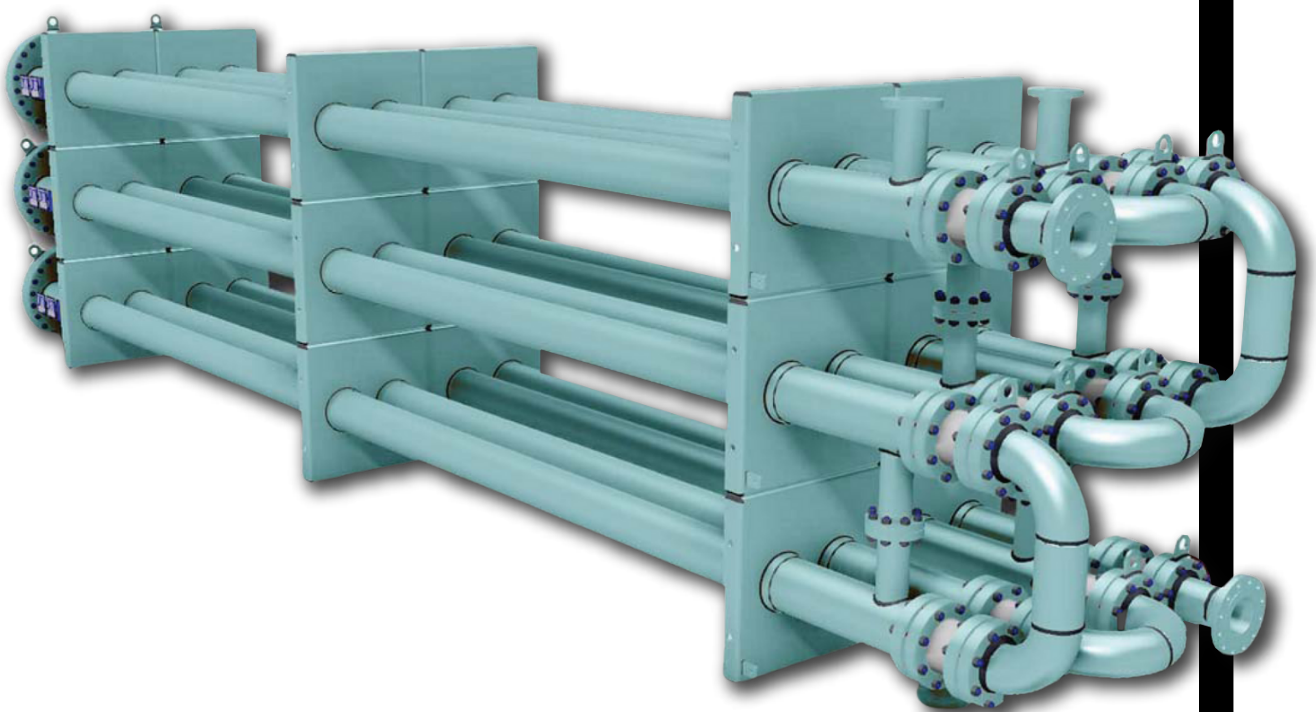
R.W. HOLLAND

STANDARD & CUSTOM HAIRPIN HEAT EXCHANGERS

Thermal Design of Hairpin Heat Exchangers

Serving the petroleum, petrochemical, chemical and power industries.

Bulletin 40



Separated Head Closure

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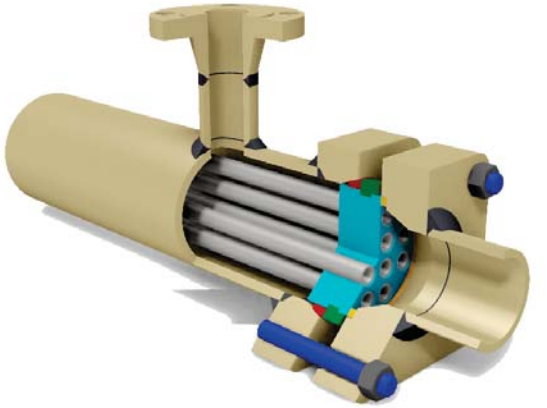
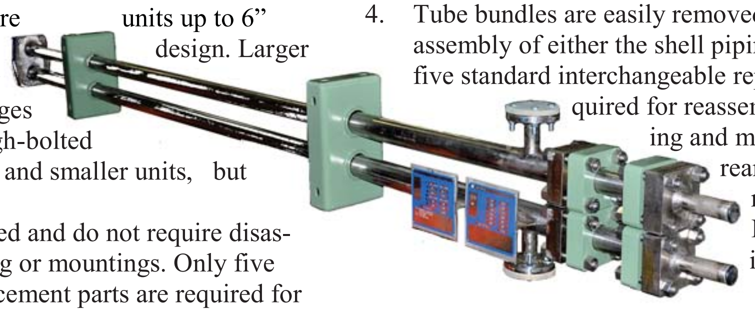
PETROFIN® Patented Closure



THE HOLLAND PETROFIN CLOSURE

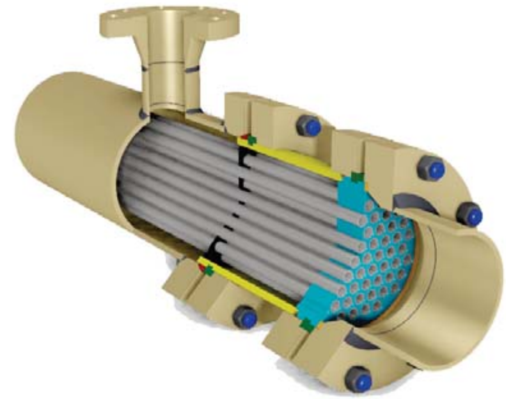
1. The Holland Petrofin closure has fewer parts, is the simplest to install and disassemble, and is the most efficient seal on the market. Only two flanges are needed to secure both shell and tube seals. No other manufacturer does this with comparable results.
2. With one expendable seal for the shell side and one expendable seal for the tube side, there is an absolute guarantee against interstream leakage.
3. There is only one reusable locking split ring which is in full view and is the simplest of all to remove and install.
4. Closures flanges on low pressure units up to 6" shell size area a square, 4 bolt design. Larger units and high pressure smaller units have circular closure flanges with additional bolting. Through-bolted closures are not standard on 6" and smaller units, but are available upon request.
5. Tube bundles are easily removed and do not require disassembly of either the shell piping or mountings. Only five standard interchangeable replacement parts are required for reassembly after routine cleaning and maintenance. These are the rear cover gasket, sealing rings, and tube gaskets. Most sizes are stocked for immediate replacement.
6. Our unique closure allows for more tubes in a given shell size resulting in more heat exchange for the same competitive price.



THE HOLLAND HAIRPIN HEAT EXCHANGER

1. All Holland hairpin heat exchangers are ASME inspected, code stamped and National board registered.
2. Multiple sections can be shipped completely assembled and ready for one inlet and outlet process piping connection.
3. Our longitudinal fintubes are produced by an electric resistance welding method, which assures high heat transfer efficiency throughout the life of the equipment.
4. Holland hairpin heat exchangers are available in a wide range of sizes to meet most process requirements. See pages 4 and 5 for the many standard design double pipe and multi-tube hairpin exchangers which are available.
5. R.W. Holland's standard designs reduce costs of engineering, thermal design, drafting, and shop fabrication. Although we offer standardized designs whenever possible, we custom engineer equipment to meet process or piping requirements. A few of our customers modifications are shown in this brochure.

Separated Head Closure



THE HOLLAND SEPARATED HEAD CLOSURE

1. The Holland Separated Head Closure has separate flanges and bolting for each sealing surface.
2. With one expendable seal for the shell side, one expendable seal for the tube side, separate flanged and bolted joints for each sealing surface, this closure can handle all applications in severe service.
3. This closure is recommended for pressures above 2000 psig, cyclic services, low temperature service, extreme temperature differentials and hard to hold fluids.
4. Tube bundles are easily removed and do not require disassembly of either the shell piping or mountings. Only five standard interchangeable replacement parts are required for reassembly after routine cleaning and maintenance. These are the rear cover gasket, sealing rings and tube gaskets. Most sizes are stocked for immediate replacement.

ADVANTAGES OF THE HAIRPIN HEAT EXCHANGER

1. There are two types of hairpin heat exchangers.
   a. Double pipe section with one tube, either finned or bare, within the shell pipe.
   b. Multi-tube section with smaller tubes, either finned or bare, within the shell pipe.
2. Hairpin heat exchangers operate in true counter current flow permitting extreme temperature crossing. The full log mean temperature difference can be utilized without reducing correction factors generally necessary in shell and tube exchangers. The larger temperature difference decreases surface requirements and cost.
3. Due to their modular concept, hairpin heat exchangers are economically adaptable to service changes. Changing duties are met by merely rearranging, adding, or subtracting sections. Shell and tube exchangers frequently have to be scrapped and new exchangers ordered when duties change.
4. The hairpin exchanger is ideal for wide temperature ranges and differentials. Because of the U-tube construction, expensive expansion joints are not required. Hairpin heat exchangers are not susceptible to tube-to-tubesheet weld cracks due to thermal stress. The thermal gradient of a tubesheet on a hairpin heat exchanger is through the thickness of the tubesheet as apposed to across the tubesheet face, as in multi-pass shell & tube exchangers.
5. Hairpin deliveries are shorter than shell and tube due to the standardization of design and construction.

R. W. HOLLAND, INC. - PETROFIN®
HAIRPIN MODEL IDENTIFICATION CODE

EXAMPLE: S6B14—20—00—16ST—2B2E

- **TUBE SIZE** INCHES
- **SHELL SIZE** NOM. PIPE SIZE
- **"U" TUBE COUNT**
- **NOM. LENGTH** FEET
- **FIN COUNT/TUBE** NOT SHOWN IF BARE TUBE UNIT
- **SHELL SIDE NOZZLE** NOM. PIPE SIZE
- **TUBE SIDE NOZZLE** NOM. PIPE SIZE
- **TUBE SIDE FLANGE** NOT SHOWN IF WELD END
- **SHELL SIDE FLANGE**
- **TUBE RATING** PSI
- **SHELL RATING** PSI
- **SHELL MAT'L**
- **TUBE MAT'L**

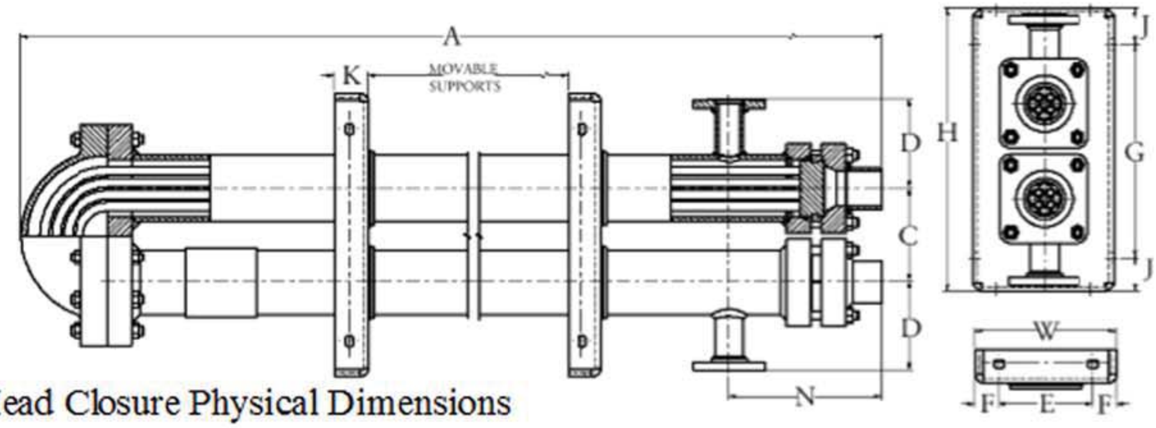
TUBE O.D.	
A	.625
B	.750
C	.84/.875
D	1.00
E	1.05
F	1.315
G	1.66
H	1.90
J	2.375
K	2.875
L	3.5
M	4.0
N	4.5
O	5.563
P	6.625
Q	8.625

CLOSURE TYPE	
	STANDARD
R	ROD-THRU
S	SEPERATED HEAD
W	WELDED

MATERIAL CODE	
0	CARBON STEEL
1	ADM. BRASS
2	STAINLESS ST'L
9	OTHER

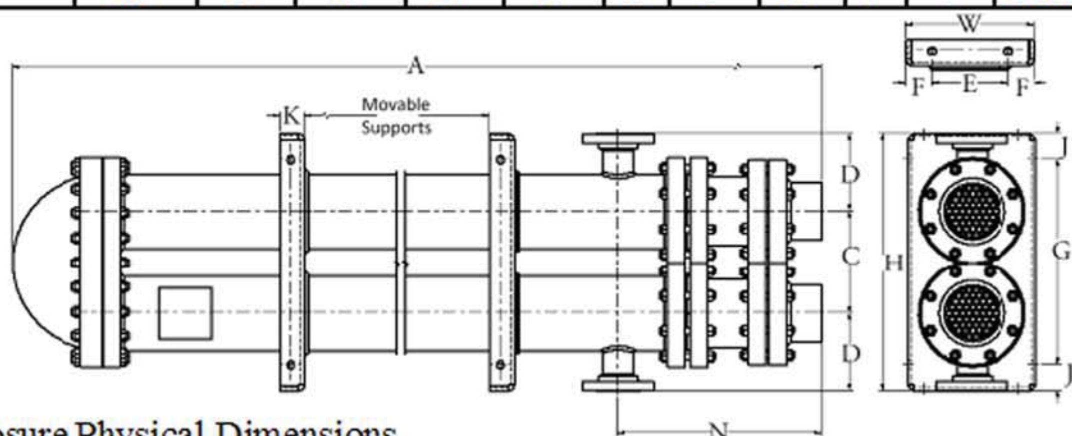
PRESSURE	
R	150
S	300
T	500
U	1200
V	OTHER

RATING/TYPE	
A	150/ANSI
B	300/ANSI
C	600/ANSI
D	900/ANSI
E	1500/ANSI
F	OTHER



Standard Head Closure Physical Dimensions

Shell Size	Overall Length Nom +A	Nozzle N	Width W	Height H	Center C	Nozzle D	Moveable Brackets E	F	G	J	K	Shell Nozzle Size	Tube Nozzle
1 ½"	NOM + 12 3/4"	11 1/2"	8"	13 ½"	4 ½"	4 ½"	5"	1 ½"	9 ½"	2"	2 ¾"	¾"-150#	¾"W.E
2"	NOM + 12 3/4"	11 1/2"	8"	13 ½"	4 ½"	4 ½"	5"	1 ½"	9 ½"	2"	2 ¾"	1"-150#	1"W.E
2 ½"	NOM + 12 3/4"	11 1/2"	8'	13 ½"	4 ½"	4 ½"	5"	1 ½"	9 ½"	2"	2 ¾"	1 ½"-150#	1 ½W.E
3"	NOM + 12 3/4"	11 3/4"	8"	13 ½"	4 ½"	4 ½"	5"	1 ½"	9 ½"	2"	2 ¾"	2"-150#	2"W.E
3 ½"	NOM + 13 5/16"	13"	10"	16"	6"	5"	7"	1 ½"	10"	3"	2 ¾"	2"-150	2"W.E
4"	NOM + 13 5/16"	13"	10"	16"	6"	5"	7"	1 ½"	10"	3"	2 ¾"	3"-150#	3"W.E
5"	NOM + 16 1/2"	13 3/4"	12"	24"	8"	8"	8"	2"	18"	3"	2 7/8"	3"-150#	3"W.E
6"	NOM + 16 1/2"	13 3/4"	12"	24"	8"	8"	8"	2"	18"	3"	2 7/8"	4"-150#	4"W.E
8"	NOM + 19 5/8"	14 3/4"	15"	30"	12"	9"	9"	3"	24"	3"	2 7/8"	6"-150#	6"W.E
10"	NOM + 23 1/4"	16 1/2"	18"	35"	15"	10"	12	3"	27"	4"	5"	As Req.	As Req.
12"	NOM + 25 3/4"	18"	20"	40"	18"	11"	14	3"	32"	4"	5"	As Req.	As Req.
14"	NOM + 26"	20"	24"	48"	24"	12"	19	3"	38"	5"	5"	As Req.	As Req.
16"	NOM + 26"	20"	24"	48"	24"	12"	19	3"	38"	5"	5"	As Req.	As Req.



Separated Closure Physical Dimensions

Shell Size	Overall Length Nom +A	Nozzle N	Width W	Height H	Center C	Nozzle D	Moveable Brackets E	F	G	J	K	Shell Nozzle Size	Tube Nozzle
1 ½"	NOM + 19 1/8"	17 7/8"	8"	13 ½"	4 ½"	4 ½"	5"	1 ½"	9 ½"	2"	2 ¾"	¾"-150#	¾"W.E
2"	NOM + 19 1/8"	17 7/8"	8"	13 ½"	4 ½"	4 ½"	5"	1 ½"	9 ½"	2"	2 ¾"	1"-150#	1"W.E
2 ½"	NOM +19 1/8"	17 7/8"	8'	13 ½"	4 ½"	4	5"	1 ½"	9 ½"	2"	2 ¾"	1 ½"-150#	1 ½W.E
3"	NOM + 19 1/8"	18 1/8"	8"	13 ½"	4 ½"	4 ½"	5"	1 ½"	9 ½"	2"	2 ¾"	2"-150#	2"W.E
3 ½"	NOM + 19	19 3/8"	10"	16"	6"	5"	7"	1 ½"	10"	3"	2 ¾"	2"-150	2"W.E
4"	NOM + 19	19 3/8"	10"	16"	6"	5"	7"	1 ½"	10"	3"	2 ¾"	3"-150#	3"W.E
5"	NOM + 25	22 3/16"	12"	24"	8"	8"	8"	2"	18"	3"	2 7/8"	3"-150#	3"W.E
6"	NOM + 25	22 3/16"	12"	24"	8"	8"	8"	2"	18"	3"	2 7/8"	4"-150#	4"W.E
8"	NOM + 28 ¼"	23 3/8"	15"	30"	12"	9"	9"	3"	24"	3"	2 7/8"	6"-150#	6"W.E
10"	NOM + 32 ¾"	26"	18"	35"	15"	10"	12	3"	27"	4"	5"	As Req.	As Req.
12"	NOM + 34 ¾"	27"	20"	40"	18"	11"	14	3"	32"	4"	5"	As Req.	As Req.
14"	NOM + 38 7/16"	32 7/16"	24"	48"	24"	12"	19	3"	38"	5"	5"	As Req.	As Req.
16"	NOM + 38 7/16"	32 7/16"	24"	48"	24"	12"	19	3"	38"	5"	5"	As Req.	As Req.

DESIGN YOUR OWN EXCHANGER

The purpose of the following article is to describe the basic heat transfer laws, and a simple method to thermally estimate hairpin heat exchangers. But first the advantages of each type should be mentioned.

1. **BARE DOUBLE PIPE & BARE MULTITUBE HAIRPIN (Table 2 & 4)**

   A. **High Pressure**:
   - Capable of carrying the maximum pressure allowed by ASME Code per given wall thickness (Up to 14600 psi with no corrosion allowance)
   - Higher pressure ratings are possible using materials with higher stress values

   B. **Low and Moderate Surface Requirement**:
   - Doublepipe (surface $\leq$ 60 ft^2)
   - Multitube (surface 60 to 1000 ft^2)

   C. **Excessive Fouling**:
   - Bare tube for processes that require frequent mechanical cleaning
   - Ease of cleaning and accessibility

   D. **Low Pressure Drop**:
   - Bare tube exchangers offer least pressure drop among most exchangers

   E. **Adopting New Application**:
   - Hairpin for process that might be modified or completely changed
   - Accommodate these changes simply by rearranging the sections.
   - One or more sections might be added or removed

   F. **Cooling Viscous Fluid on Shell Side**:
   - Bare tube good for cooling viscous fluids
   - Viscosity on fin wall is higher than bulk average viscosity, producing a lower film coefficient on fin, thus impeding heat transfer and causing excessive fouling.

   Please note that unlimited numbers of bare tube sections could be arranged in parallel and series to fit a specific application.

2. **FINNED DOUBLE PIPE & FINNED MULTITUBE (Table 3 & 5)**

   A. **High Pressure**:
   - Offers same advantages for high pressure as bare tube Hairpin

   B. **High Surface Requirements**:
   - More advantageous when shell side heat transfer coefficient is low
   - Finned Hairpin has two to five times heat transfer surface than bare tube Hairpin

   C. **Heating a Viscous Fluid on the Shell Side**:
   - High shell side viscosity results in low heat transfer coefficient, requiring more heat transfer surface
   - Holland's finned Hairpins are designed with these problems in mind

   D. **Heating and Cooling Gases**:
   - Low transfer rate of gases makes finned hairpin an attractive selection

THERMAL DESIGN PROCEDURE

Heat Transfer: The basic heat transfer law for the exchange of heat between two fluids is best described by the equation:

Eq. 1 $Q = U \times A \times \Delta T$

Q = Heat exchanged, BTU/hr
U = Overall heat transfer rate, BTU/hr-ft^2-°F
A = Effective heat transfer surface, ft^2
ΔT = Log mean temperature difference, °F

The heat load or heat exchanged may also be expressed as the product of mass flowrate, specific heat, and temperature change in each stream.

Eq. 2 $Q = m \times C_p \times (T_2 - T_1)$

Q = Heat exchanged, BTU/hr
m = Mass flow rate, lb/hr
C_p = Specific heat, BTU/lb-°F
T_1 = Inlet temperature, °F
T_2 = Outlet temperature, °F

U is the overall heat transfer rate which is the sum of the total resistance to heat transfer. *U is best described by:

Eq 3. $$\frac{1}{U} = \frac{1}{h_o} + \frac{1}{h_{io}} + R_m$$

h_o = Shellside heat transfer coef., BTU/hr-ft^2-°F
h_{io} = Tubeside heat transfer coef. Based on outside surface, BTU/hr- ft^2-°F
R_m = Tubewall metal resistance, $\frac{T}{K}$
T = Tubewall thickness, ft.
K = Thermal conductivity, BTU/hr- ft^2-°F/ft

*Table 1 shows the approximate U limits that have been calculated under different conditions. Please note that these values are based on 4 ft/sec shellside and 6 ft/sec tubeside velocity. An overall fouling factor of 0.004 and 5-10 psi pressure drop on each stream has been assumed.

A is the effective heat transfer surface; which is found from Table 2, 3, 4 and 5 for different types of Hairpin exchangers. To estimate surface for lengths that are not listed, simply use the following formula:

$$Surface = \frac{10' Surface}{10} x\ required\ length\ (ft)$$

Example: Using Table 3 to find the 10' surface, an 8" shell with 44 U-tubes, 3/4" OD, 23' nominal length has a surface of:

$$Surface = \frac{172.9\ ft^2}{10\ ft}\ x\ 23(ft) = 397.6\ (ft^2)$$

ΔT is the log mean temperature difference. One of the biggest advantages of Hairpin exchangers is the ability to have a true counter-current flow of streams. This allows the hottest portion of the hot stream to be in contact with the hottest portion of the cold stream at any given time. This eliminates the need for any temperature correction factor.

Example: Let's assume that fluid A enters the shellside at 300°F. Fluid B enters the tubeside at 450°F and is to be cooled down to 350°F.

Hot Fluid		Cold Fluid		Diff.
B		A		
450	High Temp	310	140	ΔT_2
350	Low Temp	300	50	ΔT_1
			90	ΔT_2-ΔT_1

Eq. 4 $\Delta T = \dfrac{\Delta T_2 - \Delta T_1}{In \frac{\Delta T_2}{\Delta T_1}}$

Using Eq. (4) $\Delta T = \dfrac{90}{In \frac{140}{50}} = \dfrac{90}{1.029} = 87.4$

Now that all the parameters of Eq. (1) have been defined, a concept called UA analysis should also be defined. Let's refer to Eq. (1):

(1) Q = U x A x ΔT

Solving for UA, UA = $\dfrac{Q}{\Delta T}$

Q is easily found by using Eq. (2), ΔT is calculated using Eq. (4) Please refer to the guidelines in the selection of bare vs. fin tube.

IF UA < 10,000
doublepipe or multitube 4" shell or under

IF 10,000 < UA < 50,000
4", 5" or 8" multi-tube shells or several doublepipe in series and/or parallel.

IF 50,000 < UA < 100,000
10" or several 6" or 8" multi-tube shells in series and/or parallel arrangements

IF 100,000 < UA < 150,000
12", 14" or 16" multitube or several 8" or 10" multi-tube shells in series and/or parallel arrangement

CHART A
APPROXIMATE FRICTION FACTOR

Reynolds Number Re	f Commercial pipe	f Commercial tubes
0.2	0.35	0.35
0.3	0.23	0.23
0.4	0.17	0.17
0.8	0.082	0.082
1.0	0.07	0.07
2.0	0.04	0.04
3.0	0.029	0.029
6.0	0.011	0.011
10.0	0.0068	0.0068
20.0	0.0056	0.0053
40.0	0.005	0.0047
100.0	0.0042	0.0038
200.0	0.0038	0.0033
400.0	0.0034	0.0029
1000.0	0.0029	0.0025
2000.0	0.0026	0.0021
10,000.0	0.002	0.002
100,000.0	0.002	0.002

Eq. 5 $$\Delta P = \frac{f\ (G`)^2 (\frac{L}{100})}{De\ \rho\phi}$$

Where ΔP is pressure drop, psi

Re' = Reynolds No. = $\frac{De\ x\ G`}{Z\ Avg}$

f = Friction Factor

G' = Mass velocity, lb/sec-ft²

Z = viscosity, cP

L = total travel path, ft

D_e = equivalent diameter, in.

ρ = density, lb/ft³

ϕ = viscosity correction factor, $\left(\frac{Z\ avg}{Z\ wall}\right)^{0.14}$

For average viscosity less than 1 cP Use a correction of 1.0

EXAMPLE OF THERMAL DESIGN

9700 lb/hr of liquid butane (specific heat of 0.579 BUT/lb-°F, viscosity of 0.14 cP and specific gravity of 0.56 at average temp.) enters the shellside at 150°F, and to be cooled at 105°F. The cooling medium is 24537 lb/hr of cooling water which enters the tubeside at 87°F and leaves at 97.3°F. Design an exchanger to fit the above application. Limit pressure drops to maximum of 10 psi on each stream.

Step 1: Check the heat load of heat exchanged

Eq. (2): $Q = m\ Cp\ (T_2 - T_1)$

Shellside Q = 9700 lb/hr x 0.579 BTU/lb-°F x (150-105)
= 252733 BTU/hr

Tubeside Q = 24537 lb/hr x 1 BTU/lb-°F x (97.3-87)
= 252731 BTU/hr

The two heat loads are almost identical.

Therefore Q = 252733 BTU/hr

Step 2: Calculate the ΔT

Using counter current flow and Eq. (4)

Hot Fluid		Cold Fluid	Temp	Diff.
150	High Temp	97.3	52.7	ΔT_2
105	Low Temp	87	18	ΔT_1
			34.7	ΔT_2 - ΔT_1

Using Eq. (4) $\Delta T = \dfrac{\Delta T_2 - \Delta T_1}{In \frac{\Delta T_2}{\Delta T_1}}$

$$\Delta T = \frac{34.7}{In \frac{52.7}{18}} = 32.3$$

Step 3: Calculate UA

Eq. (1) $Q = UA\ \Delta T$

$$UA = \frac{Q}{\Delta T} = \frac{252733\ BTU/hr}{32.3^{\circ}F} = 7824$$

The UA result is less than 10,000 which suggest the exchanger will be one or more double pipes or a 4” or smaller multitube hairpin.

Step 4: Estimate a value for overall heat transfer rate, U

From Table 1: (Since the viscosity is 0.14 cP, it is Light H.C. vs. Water in the table.)

U = 81 BTU/hr-ft^2-°F

Step 5: Estimate the surface

Eq. (1) $Q = UA\Delta T$

$$A = \frac{Q}{U\Delta T} = \frac{252733\ BTU/hr}{81 \frac{BTU}{hr\ ft^2\ ^{\circ}F}\ x\ 32.3^{\circ}F} = 96.5\ \text{ft}^2$$

Note: Since the shellside fluid is low in viscosity, it will have a high shellside heat transfer coefficient, thus making the use of bare tubes more attractive.

Now let’s check to see if the above surface is available using only one exchanger in double pipe or small multitubes (4” or smaller). The most economical lengths are 20 feet or smaller because standard tubing is always available in 42-48 feet straight lengths (About 20’ U-Tube) in warehouses. A point to remember is the fewer the number of tubes, the less expensive the unit will be (up to 20’ long).

In Table 3, a 4” unit with 12 u-tubes, ¾” OD, 0.083” wall and 20’ nominal length has 94.3 sq. ft surface which would be a suitable section. The model number is 4B12-20-00-SS.

Step 6: Pressure Drop Calculation

Pressure drop usually is one of the most important controlling factors that influence the size and cost of an exchanger. The higher the allowable pressure drop, the lower the cost. Now let’s check to see if the pressure drop remains within the specified limits in the selected exchanger.

Model No. **4B12-20-00-SS**

Using mechanical data listed:

$$\text{Shellside} \begin{cases} \text{25NFA} = 185.6 \\ D_e = \text{equivalent diameter} = 0.725 \text{ in.} \end{cases}$$

$$\text{Tubeside} \begin{cases} \text{25NFA} = 80.3 \\ \text{ID} = 0.584 \end{cases}$$

Shellside pressure Drop

$$\text{Eq (5)}\quad \Delta P = \frac{f\,(G`)^2(\frac{L}{100})}{De\ \rho\phi}$$

$$G = \frac{Flowrate, lb/hr}{25NFA, in^2}$$

$$= \frac{9700}{185.6} = 52.26\ \frac{lb}{sec-ft^2}$$

$$Re' = \frac{De\ x\ G`}{Z} = \frac{0.0604\ ft\ x\ 52.26\frac{lb}{sec-ft^2}}{9.41*10^{-5}\frac{lb}{sec-ft^2}} = 33544$$

From Chart A, f = friction factor = 0.002

L = travel path = 20’ (1st leg) + 20’ (2nd leg) + 5’
(Return bend and inlet and outlet) = 45’

ρ = density = specific gravity x 62.4
= 0.56 x 62.4$\frac{lb}{ft^3}$ = 34.94$\frac{lb}{ft^3}$

$$\phi = \left(\frac{Z\ ave}{Z\ wall}\right)^{0.14} = 1.0 \text{ (in most L.H.C. cases)}$$

$$\Delta P = \frac{0.002\ x\left(52.25\frac{lb}{sec-ft^2}\right)^2 x\ (\frac{45}{100})}{0.725\ in\ x\ 34.94\frac{lb}{ft^3}\ x\ 1} = 0.1 \text{ psi}$$

Wrapped in the L/100 is the factor that corrects the units
ΔP = 0.1 psi calculated. The allowable is 10 psi

Tubeside pressure drop

$$G' = \frac{24537}{80.3} = 305.5\frac{lb}{sec-ft^2}$$

$$Re = \frac{0.0487\ ft\ x\ 305.5\frac{lb}{sec-ft^2}}{5.13*10^{-4}\frac{lb}{sec-ft^2}} = 29002$$

f = Friction factor from Chart A = 0.002

$$\Delta P = \frac{0.002\ x\left(305.5\frac{lb}{sec-ft^2}\right)^2 x\ (\frac{45}{100})}{0.584\ in\ x\ 62.11\frac{lb}{ft^3}\ x\ 1} = 2.32 \text{ psi}$$

ΔP = 2.32 psi calculated. The allowable is 10 psi.

Additional Information

$$\text{Velocity} = \frac{\text{mass velocity}}{\text{density}}$$

$$\text{Shellside} = \frac{52.25\frac{lb}{sec-ft^2}}{34.94\frac{lb}{ft^3}} = 1.49 \text{ ft/sec}$$

$$\text{Tubeside} = \frac{305.5\ ^{lb}/_{sec-ft^2}}{62.11\ ^{lb}/_{ft^3}} = 4.92 \text{ ft/sec}$$

NOTE: If calculated pressure drop exceeds the allowable, then the next larger exchanger(s) should be tried. A lower mass velocity (as a result of larger 25NFA) will have a lower pressure drop.

TABLE 1

APPROXIMATE OVERALL HEAT TRANSFER COEFFICIENT (1)

The estimated values are based on 4 ft/sec shellside and 6 ft/sec tubeside velocity.

HOT FLUID	COLD FLUID	OVERALL U	HOT FLUID	COLD FLUID	OVERALL U
Water	Water	100-200	Naphtha	Water	30-60
Light H.C.	Water	50-100	Steam	#2 Fuel Oil	40-70
Medium H.C.	Water	30-70	Steam	Butane (L)	50-150
Heavy H.C.	Water	5-60	Steam	Crude	10-25
Natural Gas	Water	5-35	Steam	Sulfur Slurry	50-100
Methanol	Water	100-200	Steam	Methanol	100-400
Ammonia	Water	100-200	Steam	Ammonia	100-400
Hydrogen	Water	10-60	Steam	Light Organic	100-200
Oxygen	Water	10-60	Steam	Aqueous Soln	
Air	Water	10-60		Less than 2 Cp	100-400
Glycol	Water	30-150		More than 2 Cp	75-250
Toluene	Water	20-70	Steam	Medium Organic	50-100
Sulfuric Acid	Water	20-55	Steam	Gas	5-40
Nitrogen	Water	10-60	Glycol	H.C. Vapor	5-15
Diesel Fuel	Water	50-110	Glycol	Glycol	6-40
Sour Nat’l Gas	Water	25-60	Benzene	Benzene	50-100
Lube Oil	Water	10-25	Toluene	Benzene	20-100
Carbon Dioxide	Water	15-40	Brine	Gas	20-75
Terpenes	Water	10-25	Diesel	Crude	20-60
Geraniol	Water	10-25	Oil	Fuel/Gas	20-60
Steam	#6 Fuel Oil	5-25	H.C. Vapor	Crude	5-20
Steam	Light H.C.	15-50	Ethanol	Butane	50-100
Steam	Gas	50-120	Sour Nat’l Gas	Sour Nat’l Gas	25-100
Steam	Nitrogen	50-120	Amine	Amine	20-60
Steam	50% Caustic	7-20	15% DEA	Crude	5-15
Fuel Oil	Water	10-20	Butane	Butane	30-60
Fuel Oil	Oil	6-15	Aqueous Soln	Aqueous Soln	200-450
Gasoline	Water	30-75	Heavy Organic	Heavy Organic	10-35
Asphalt	Water	10-20	Light Organic	Light Organic	30-65
Kerosene	Water	15-40	Slurry	Slurry	5-30

(1) When using finned tubes, divide the above figures by $\frac{Ao}{Ai}$ (From Tables 2,3,4,5) and use as U. (2) Light H.C. refers to fluids with 0.5 centipoise viscosity or lower. (3) Medium H.C. refers to fluids with 0.5 to 1.0 centipoise viscosity. (4) Heavy H.C. refers to fluids with above 1.0 centipoise viscosity.

TABLE 2

Bared Double Pipe Hairpin Design Data

Shell Side Sch. 40				Tube Side							
Type	25 NFA	De. In	Ao/Ai	No. U-Tubes	O.D. In	I.D. In	Wall Thk. In.	25 NFA	Surface- Ft.² - Nominal Length -		
									10'	20'	30'
1.5A1	43.2	0.985	1.24	1	0.625	0.505	0.06	5	3.3	6.5	9.8
1.5D1	31.2	0.609	1.27	1	1	0.782	0.109	12	5.2	10.5	15.7
2B1	72.8	1.316	1.28	1	0.75	0.584	0.083	6.7	3.9	7.9	11.8
2C1	68.9	1.192	1.23	1	0.875	0.709	0.083	9.9	4.6	9.2	13.7
2D1	64.2	1.066	1.27	1	1	0.782	0.109	12	5.2	10.5	15.7
2E1	62.3	1.017	1.27	1	1.05	0.824	0.113	13.3	5.5	11	16.5
2F1	49.9	0.751	1.25	1	1.315	1.049	0.133	21.6	6.9	13.8	20.7
2G1	29.7	0.407	1.2	1	1.66	1.38	0.14	37.4	8.7	17.4	26.1
2.5D1	100.0	1.468	1.27	1	1	0.782	0.109	12	5.2	10.5	15.7
2.5F1	85.6	1.153	1.25	1	1.315	1.049	0.133	21.6	6.9	13.8	20.7
2.5G1	65.5	0.808	1.2	1	1.66	1.38	0.14	37.4	8.7	17.4	26.1
2.5H1	48.7	0.568	1.18	1	1.9	1.61	0.145	50.9	10	19.9	29.9
3D1	165.0	2.066	1.27	1	1	0.782	0.109	12	5.2	10.5	15.7
3F1	150.7	1.751	1.25	1	1.315	1.049	0.133	21.6	6.9	13.8	20.7
3G1	130.6	1.407	1.2	1	1.66	1.38	0.14	37.4	8.7	17.4	26.1
3H1	113.8	1.167	1.18	1	1.9	1.61	0.145	50.9	10	19.9	29.9
3J1	74.0	0.692	1.14	1	2.375	2.067	0.154	83.8	12.4	24.9	37.3
3.5H1	176.1	1.647	1.18	1	1.9	1.61	0.145	50.9	10	19.9	29.9
3.5J1	136.3	1.172	1.14	1	2.375	2.067	0.154	83.8	12.4	24.9	37.3
3.5K1	84.8	0.672	1.16	1	2.875	2.469	0.203	119.6	15.1	30.1	45.2
4H1	247.2	2.124	1.18	1	1.9	1.61	0.145	50.9	10	19.9	29.9
4J1	207.3	1.649	1.14	1	2.375	2.067	0.154	83.8	12.4	24.9	37.3
4K1	155.8	1.15	1.16	1	2.875	2.469	0.203	119.6	15.1	30.1	45.2
4L1	77.6	0.526	1.14	1	3.5	3.068	0.216	184.7	18.3	36.7	55
5K1	337.6	2.17	1.16	1	2.875	2.469	0.203	119.6	15.1	30.1	45.2
5L1	259.4	1.546	1.14	1	3.5	3.068	0.216	184.7	18.3	36.7	55
5M1	185.8	1.046	1.12	1	4	3.548	0.226	247	21	41.9	62.9
5N1	102.4	0.547	1.11	1	4.5	4.026	0.237	318.1	23.6	47.1	70.7
6L1	481.4	2.563	1.14	1	3.5	3.068	0.216	184.7	18.3	36.7	55
6M1	407.8	2.063	1.12	1	4	3.548	0.226	247	21	41.9	62.9
6N1	324.4	1.564	1.11	1	4.5	4.026	0.237	318.1	23.6	47.1	70.7

TABLE 3

Finned Multi-Tube Hairpin Design Data

Shell Side Sch. 40							Tube Side							
Type	No.Fins	Fin Hgt.	25 NFA	De. In	Af/Ao	Ao/Ai	No. U-Tubes	O.D. In	I.D. In	Wall Thk In	25 NFA	Surface- Ft.² - Nominal Length -		
												10'	20'	30'
3B3	16	0.313	137	0.469	0.809	0.673	3	0.75	0.584	0.083	20.1	61.8	123.6	185.4
4B7	16	0.25	212.8	0.4	0.772	5.64	7	0.75	0.584	0.083	46.9	120.8	241.7	362.5
4C7	16	0.21	189.1	0.383	0.71	4.25	7	0.875	0.709	0.083	69.1	110.5	220.9	331.4
5D7	16	0.313	328.4	0.487	0.761	5.34	7	1	0.782	0.109	84	153.3	306.7	460
5D7	20	0.313	319.9	0.408	0.799	6.36	7	1	0.782	0.109	84	182.5	365	547.5
6B14	16	0.25	511.4	0.499	0.772	5.64	14	0.75	0.584	0.083	93.7	241.7	483.3	725
6D7	20	0.438	526.6	0.515	0.848	8.39	7	1	0.782	0.109	84	240	481.7	722.5
6D10	16	0.25	485.7	0.596	0.718	4.53	10	1	0.782	0.109	120	185.7	371.4	557.1
6D10	20	0.25	475.7	0.506	0.761	5.34	10	1	0.782	0.109	120	219	438.1	657.1
8B19	16	0.375	931.2	0.5	0.836	7.82	19	0.75	0.584	0.083	127.2	454.6	909.3	1363.9
8B31	16	0.21	784.1	0.362	0.772	5.64	31	0.75	0.584	0.083	207.5	535.1	1070.2	1605.4
8C19	16	0.313	872.6	0.522	0.784	5.72	19	0.875	0.709	0.083	187.5	403.7	807.4	1211.1
8D19	16	0.21	812.7	0.612	0.681	4.01	19	1	0.782	0.109	228.2	312.3	624.6	936.9
8D19	20	0.21	796.1	0.521	0.728	4.7	19	1	0.782	0.109	228.2	365.5	731	1096.5
10B42	16	0.25	1339.1	0.459	0.772	5.64	42	0.75	0.584	0.083	281.1	725	1450	2175
10D31	20	0.25	1207.3	0.44	0.761	5.34	31	1	0.782	0.109	372	679	1358.1	2037.1
12D44	20	0.25	1743	0.453	0.761	5.34	44	1	0.782	0.109	528.1	963.8	1927.6	2891.4
16D55	20	0.25	3212	0.667	0.761	5.35	55	1	0.782	0.109	660.4	1204.6	2409.2	3613.8

TABLE 4

Bare Multi-Tube Hairpin Design Data

Shell Side Sch. 40				Tube Side							
Type	25 NFA	De In.	Ao / Ai	No. Tubes	O.D In.	I.D In.	Wall Thk. In.	25 NFA	Surface - Ft² -Nominal Length-		
									10’	20’	30’
2A4	53.1	0.593	1.23	4	0.625	0.505	0.06	20	13.1	26.2	39.3
2B2	61.7	0.882	1.28	2	0.75	0.584	0.083	13.4	7.9	15.7	23.6
2.5A7	65.9	0.491	1.23	7	0.625	0.505	0.06	35	22.9	45.8	68.7
2.5B4	75.4	0.703	1.28	4	0.75	0.584	0.083	26.8	15.7	31.4	47.1
3A7	131	0.896	1.23	7	0.625	0.505	0.06	35	22.9	45.8	68.7
3B7	107.4	0.658	1.28	7	0.75	0.584	0.083	46.9	27.5	55	82.5
3D3	125.8	1.056	1.27	3	1	0.782	0.109	36	15.7	31.4	47.1
3.5A12	155	0.714	1.23	12	0.625	0.505	0.06	60.1	39.3	78.6	117.9
3.5B7	169.7	0.982	1.28	7	0.75	0.584	0.083	46.9	27.5	55	82.5
3.5C7	142	0.784	1.23	7	0.875	0.709	0.083	69.1	32.1	64.1	96.2
3.5D4	168.5	1.137	1.27	4	1	0.782	0.109	48	21	41.9	62.9
4A19	172.4	0.552	1.23	19	0.625	0.505	0.06	95.1	62.2	124.4	186.6
4B7	240.8	1.322	1.28	7	0.75	0.584	0.083	46.9	27.5	55	82.5
4B12	185.6	7.25	1.28	12	0.75	0.584	0.083	80.3	47.1	94.3	141.4
4C7	231.1	1.069	1.23	7	0.875	0.709	0.083	69.1	32.1	64.1	96.2
4D7	180.7	0.834	1.27	7	1	0.782	0.109	84	36.7	73.3	110
5A31	262.2	0.547	1.23	31	0.625	0.505	0.06	155.2	101.5	203	304.5
5B12	367.4	1.332	1.28	12	0.75	0.584	0.083	80.3	47.1	94.3	141.4
5B19	290.1	0.765	1.28	19	0.75	0.584	0.083	127.2	74.6	149.3	223.9
5D9	323.2	1.172	1.27	9	1	0.782	0.109	108	47.1	94.3	141.4
6A42	399.9	0.63	1.23	42	0.625	0.505	0.06	210.2	137.5	275	412.5
6B24	456.9	0.967	1.28	24	0.75	0.584	0.083	160.6	94.3	188.6	282.9
6B31	379.6	0.659	1.28	31	0.75	0.584	0.083	207.5	121.8	243.6	365.4
6D14	447.1	1.134	1.27	14	1	0.782	0.109	168	73.3	146.7	220
8A55	828.4	0.996	1.23	55	0.625	0.505	0.06	275.3	180.1	360.1	540.2
8A73	690.4	0.656	1.23	73	0.625	0.505	0.06	365.4	239	478	717
8A85	598.4	0.499	1.23	85	0.625	0.505	0.06	425.4	278.3	556.5	834.8
8B37	841.5	1.199	1.28	37	0.75	0.584	0.083	247.6	145.4	290.7	436.1
8B42	786.4	1.014	1.28	42	0.75	0.584	0.083	281.1	165	330	495
8B44	764.3	0.949	1.28	44	0.75	0.584	0.083	294.5	172.9	345.7	518.6
8B55	642.8	0.665	1.28	55	0.75	0.584	0.083	368.1	216.1	432.1	648.2
8C37	694.8	0.877	1.23	37	0.875	0.709	0.083	365.2	169.5	339.1	508.6
8D24	778.7	1.24	1.27	24	1	0.782	0.109	288	125.7	251.4	377.1
8D31	641.6	0.838	1.27	31	1	0.782	0.109	372	162.4	324.8	487.1
10A96	1234.4	0.898	1.23	96	0.625	0.505	0.06	480.5	314.3	628.6	942.9
10A121	1042.7	0.62	1.23	121	0.625	0.505	0.06	605.6	396.1	792.3	1188.4
10B68	1219.7	1.018	1.28	68	0.75	0.584	0.083	455.1	267.1	534.3	801.4
10B85	1032	0.712	1.28	85	0.75	0.584	0.083	568.9	333.9	667.9	1001.8
10D38	1224.6	1.298	1.27	38	1	0.782	0.109	456	199	398.1	597.1
10D42	1146.1	1.122	1.27	42	1	0.782	0.109	504	220	440	660
12A151	1668.4	0.798	1.23	151	0.625	0.505	0.06	755.7	494.3	988.7	1483
12A174	1492.1	0.629	1.23	174	0.625	0.505	0.06	870.8	569.6	1139.3	1708.9
12B109	1622.7	0.881	1.28	109	0.75	0.584	0.083	729.6	428.2	865.4	1284.6
12B121	1490.2	0.738	1.28	121	0.75	0.584	0.083	809.9	475.4	950.7	1426.1
12D55	1746.6	1.327	1.27	55	1	0.782	0.109	660.1	288.1	576.2	864.3
12D64	1570	1.052	1.27	64	1	0.782	0.109	768.1	335.2	670.5	1005.7
16A208	2969.5	1.041	1.23	208	0.625	0.505	0.06	1041	681	1361.9	2042.9
16A258	2586.2	0.746	1.23	258	0.625	0.505	0.06	1291.3	844.6	1689.3	2533.9
16A301	2256.5	0.565	1.23	301	0.625	0.505	0.06	1506.5	985.4	1970.8	2956.2
16B151	2897.1	1.148	1.28	151	0.75	0.584	0.083	1017.7	593.2	1186.4	1779.6
16B199	2367.2	0.733	1.28	199	0.75	0.584	0.083	1332	781.8	1563.6	2345.4
16D85	2895.9	1.471	1.27	85	1	0.782	0.109	1020.1	445.2	890.5	1335.7
16D109	2424.9	0.994	1.27	109	1	0.782	0.109	1308.1	571	1141.9	1712.9

TABLE 5

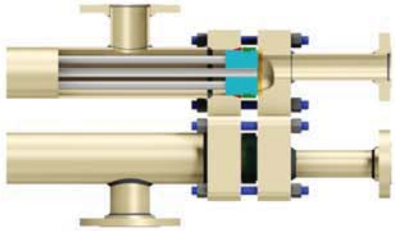
Finned Double Pipe Hairpin Design Data

Shell Side Sch. 40							Tube Side						
Type	No. Fins	Fin Height	25 NFA	De. In.	Af / Ao	Ao / Ai	No. Tubes	O.D. In.	Wall Thk. In.	25 NFA	Surface – Ft.² -Nominal Length-		
											10’	20’	30’
2B1	16	0.563	64.4	0.348	0.884	11.09	1	0.75	0.083	6.7	33.9	67.9	101.8
2D1	20	0.438	57.7	0.39	0.817	6.98	1	1	0.109	12	28.6	57.1	85.7
2F1	24	0.25	43.9	0.311	0.744	4.89	1	1.315	0.133	21.6	26.9	53.8	80.7
2.5D1	16	0.563	91.7	0.508	0.851	8.61	1	1	0.109	12	35.2	70.5	105.7
2.5F1	24	0.5	74.4	0.332	0.853	8.53	1	1.315	0.133	21.6	46.9	93.8	140.7
2.5G1	24	0.313	58.2	0.333	0.742	4.66	1	1.66	0.14	37.4	33.7	67.4	101.1
2.5G1	32	0.313	55.8	0.271	0.793	5.81	1	1.66	0.14	37.4	42	84.1	126.1
2.5H1	24	0.25	42.8	0.266	0.668	3.55	1	1.9	0.145	50.9	30	59.9	89.9
2.5H1	36	0.25	39.8	0.201	0.751	4.73	1	1.9	0.145	50.9	40	79.9	119.9
3D1	20	0.938	148	0.471	0.923	16.53	1	1	0.109	12	67.7	135.5	203.2
3H1	24	0.5	102.6	0.415	0.801	5.92	1	1.9	0.145	50.9	50	99.9	149.9
3H1	36	0.5	97	0.301	0.858	8.29	1	1.9	0.145	50.9	70	139.9	209.9
3J1	24	0.25	68.2	0.375	0.617	2.99	1	2.375	0.154	83.8	32.4	64.9	97.3
3J1	40	0.25	64	0.276	0.728	4.22	1	2.375	0.154	83.8	45.8	91.8	137.3
3.5H1	24	0.7	159.7	0.481	0.858	8.29	1	1.9	0.145	50.9	70	139.9	209.9
3.5H1	36	0.7	151.4	0.341	0.9	11.85	1	1.9	0.145	50.9	100	199.9	299.9
3.5J1	24	0.5	125.1	0.47	0.763	4.84	1	2.375	0.154	83.8	52.4	104.9	157.3
3.5J1	40	0.5	117.6	0.321	0.843	7.3	1	2.375	0.154	83.8	79.1	158.2	237.3
4H1	24	1	225.5	0.542	0.889	10.66	1	1.9	0.145	50.9	90	179.9	269.9
4H1	36	1	214.6	0.379	0.923	15.4	1	1.9	0.145	50.9	130	259.9	389.9
4J1	24	0.75	190.9	0.544	0.828	6.69	1	2.375	0.154	83.8	72.4	144.9	217.3
4J1	40	0.75	179.9	0.359	0.889	10.38	1	2.375	0.154	83.8	112.4	224.9	337.3
4K1	24	0.5	144.6	0.507	0.726	4.25	1	2.875	0.203	119.6	55.1	110.1	165.2
4K1	40	0.5	137.2	0.356	0.816	6.39	1	2.875	0.203	119.7	81.7	163.4	245.2
5K1	24	1	315.9	0.693	0.842	7.35	1	2.875	0.203	119.6	95.1	190.1	285.2
5K1	48	1	294.2	0.389	0.914	13.53	1	2.875	0.203	119.6	175.1	350.1	525.2
5L1	24	0.625	245.8	0.692	0.732	4.25	1	3.5	0.216	184.8	68.3	136.7	205
5L1	40	0.625	236.5	0.492	0.82	6.33	1	3.5	0.216	184.8	101.7	203.3	305
5L1	56	0.625	227.1	0.375	0.864	8.4	1	3.5	0.216	184.7	135	270	405
5M1	56	0.438	162.7	0.336	0.796	5.52	1	4	0.226	247	102.6	205.2	307.9
6M1	24	0.938	387.4	0.809	0.782	5.16	1	4	0.226	247	96	191.9	287.9
6M1	36	0.938	377.2	0.609	0.843	7.18	1	4	0.226	247	133.5	266.9	400.4
6M1	64	0.938	353.4	0.373	0.905	11.88	1	4	0.226	247	221	441.9	662.9
6N1	24	0.688	309.3	0.748	0.7	3.72	1	4.5	0.237	318.3	78.6	157.1	235.7

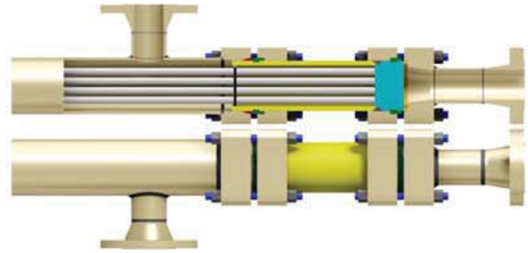
Surface and weights are based on 20 ft. nominal tube length *Refer to Model Indentification Code

R.W HOLLAND OFFERS FLEXIBILITY TO MEET CUSTOMER APPLICATIONS AND SPECIFICATIONS

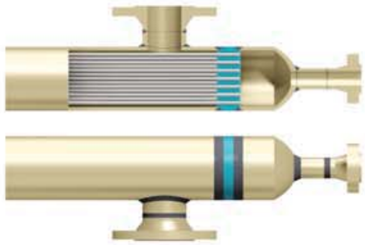
TUBE END CLOSURES



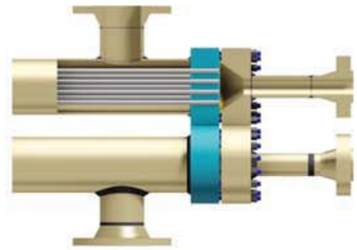
Holland standard closure. Tube nozzles can be offset for venting and draining. ANSI flange connections.



Holland separated head closure. Separate flanges and bolting for each gasket surface.

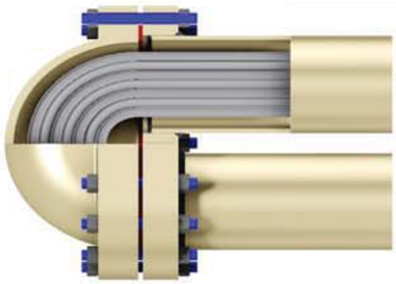


Fixed tubesheet design, non-removable channel.

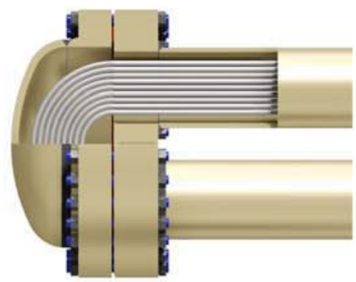


Fixed tubesheet design with removable channel for tube inspection.

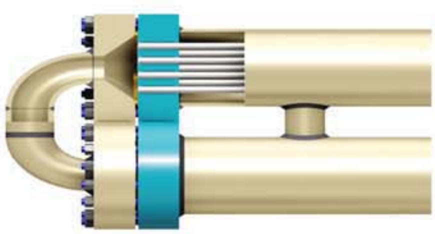
RETURN END CLOSURES



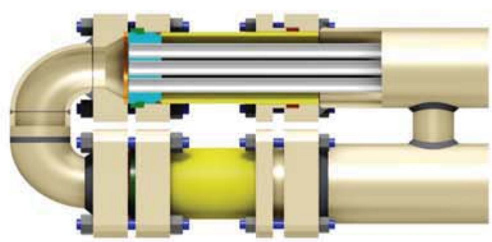
Holland standard closure. When casting is removed, tube returns are completely exposed.



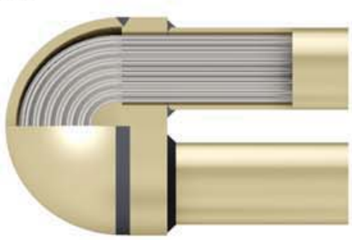
Fabricated closure for high pressure and alloy design where standard closure is not adequate.



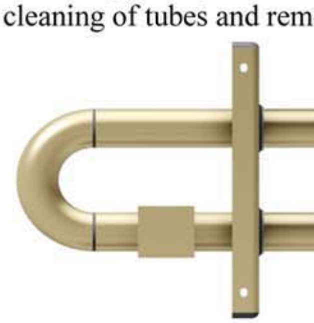
Rod thru design with fixed tubesheets allows straight thru cleaning of tubes. Expansion joints furnished when required.



Rod thru design with packed joint which allows straight thru cleaning of tubes and removing bundle.



Welded closure for all welded design units using elliptical or hemispherical heads.



Welded closure for all welded design using a 180 degree return.

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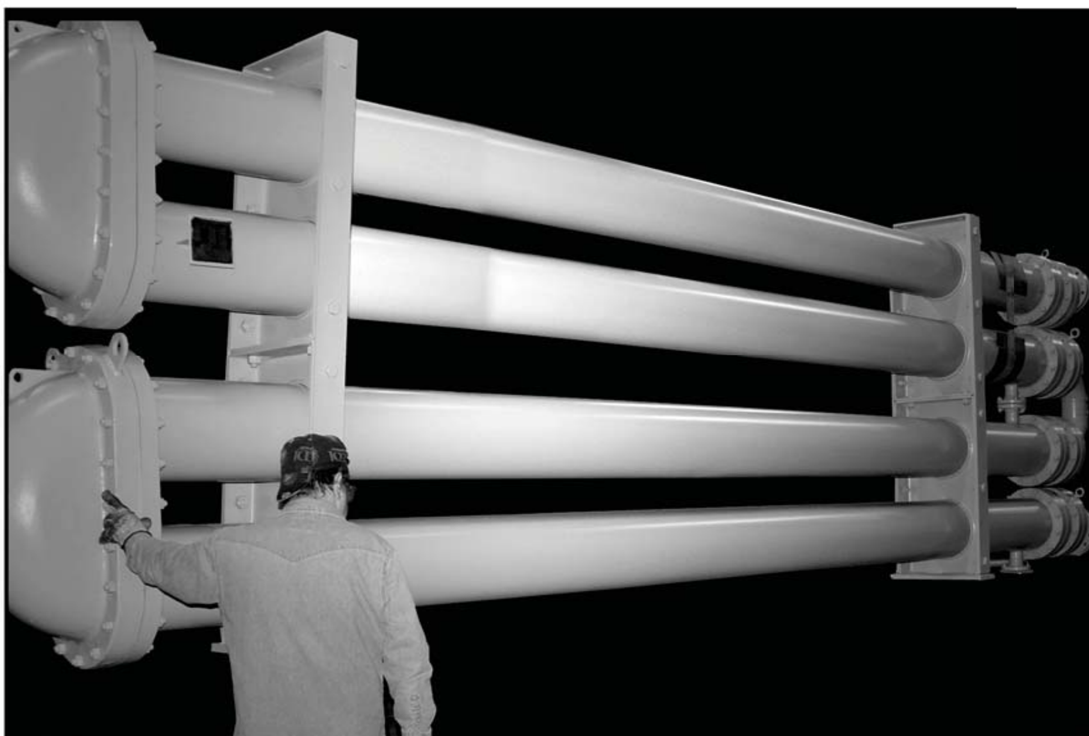
Bulletin 40



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