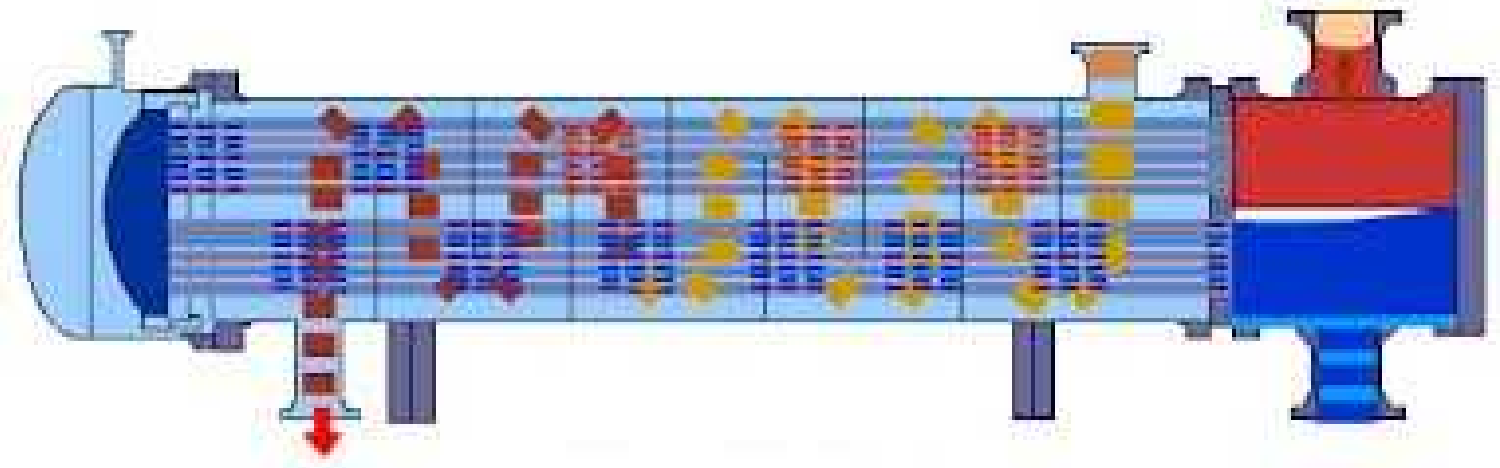
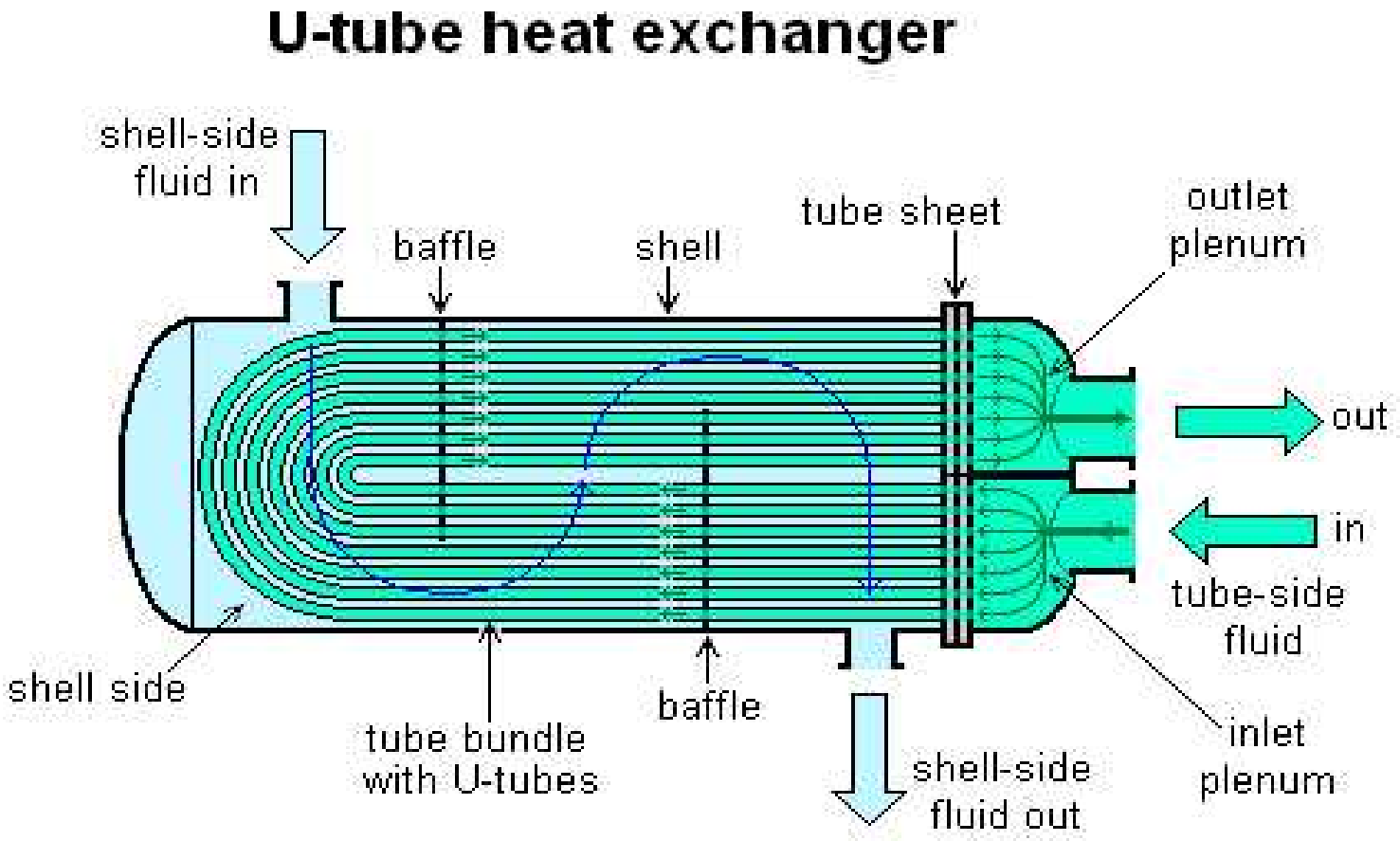
۱۳۰۷
دانشگاه صنعتی خواجه نصیر الدین طوسی
دانشکده مهندسی مکانیک

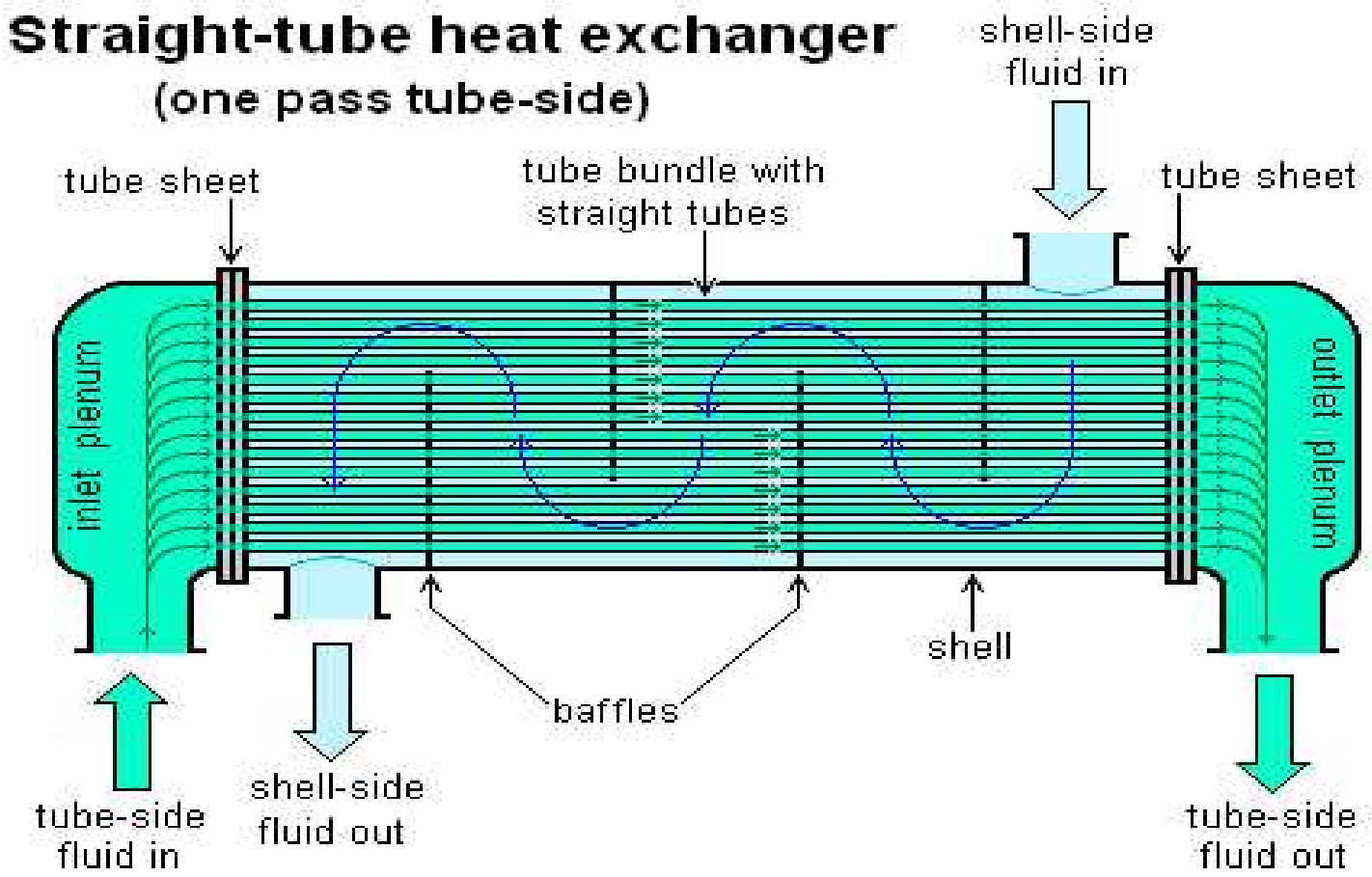
فصل دوم: مبدلهای حرارتی پوسته لوله ای Shell &Tube Heat Exchangers



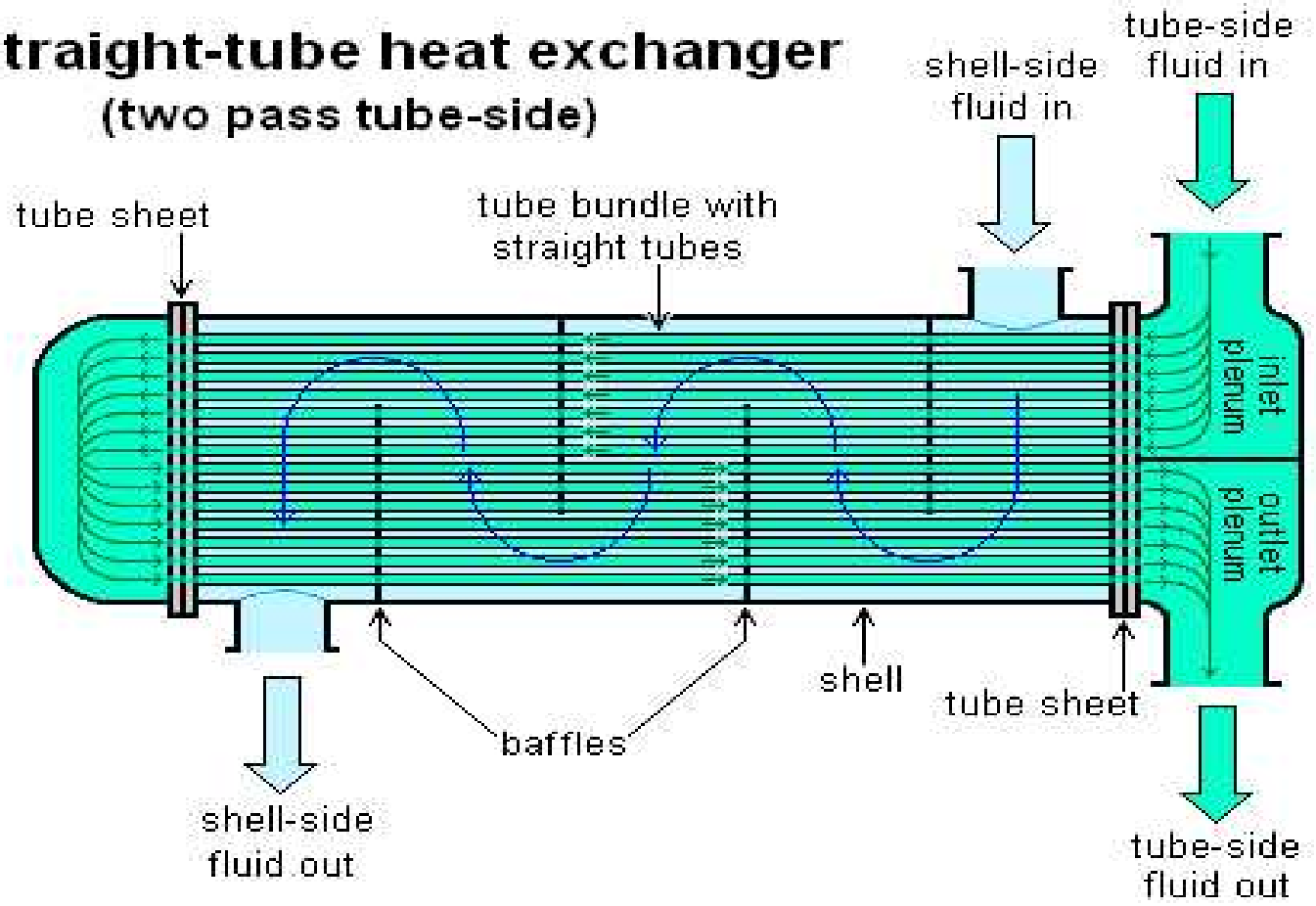
U-Tube Heat Exchanger



Straight-Tube （ 1-Pass ）



Straight-Tube （ 2-Pass ）



TEMA Heat Exchanger

Tubular Exchanger Manufacture's Association(TEMA) is the most widely used 'standard' or 'stipulated' heat exchanger 'design code'.This is a US code and is used together with ASME Section VIII(for the design of unfired pressure vessels).The TEMA code specifies the mechanical design procedure, tolerances allowed and the dimensions of the various parts of an exchanger.

TEMA Standard:

RCB-1 SCOPE AND GENERAL REQUIREMENTS

RCB-1.1 SCOPE OF STANDARDS

RCB-1.11 GENERAL

The TEMA Mechanical Standards are applicable to shell and tube heat exchangers which do not exceed any of the following criteria:

(1) inside diameters of 100 in. (2540 mm)

(2) product of nominal diameter, in. (mm) and design pressure, psi (kPa) of 100,000 (17.5×10^6)

(3) a design pressure of 3,000 psi (20684 kPa)

The intent of these parameters is to limit the maximum shell wall thickness to approximately 3 in. (76 mm), and the maximum stud diameter to approximately 4 in. (102 mm). Criteria contained in these Standards may be applied to units which exceed the above parameters.

R-1.12 DEFINITION OF TEMA CLASS "R" EXCHANGERS

The TEMA Mechanical Standards for Class "R" heat exchangers specify design and fabrication of unfired shell and tube heat exchangers for the generally severe requirements of petroleum and related processing applications.

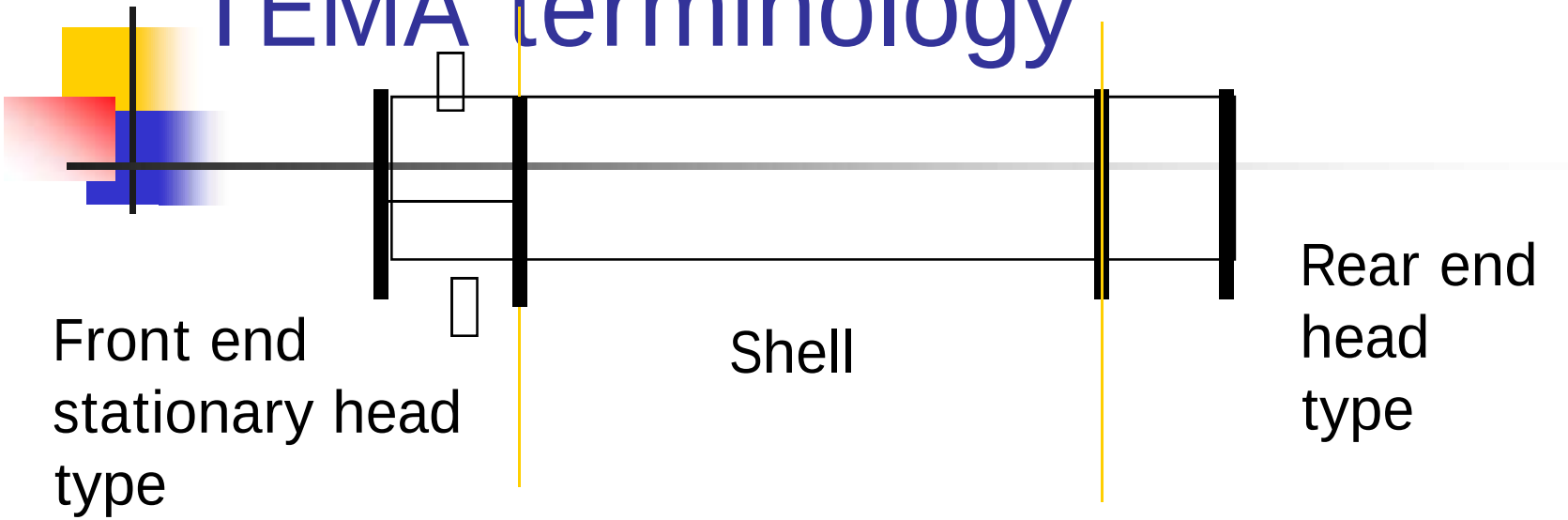
C-1.12 DEFINITION OF TEMA CLASS "C" EXCHANGERS

The TEMA Mechanical Standards for Class "C" heat exchangers specify design and fabrication of unfired shell and tube heat exchangers for the generally moderate requirements of commercial and general process applications.

B-1.12 DEFINITION OF TEMA CLASS "B" EXCHANGERS

The TEMA Mechanical Standards for Class "B" heat exchangers specify design and fabrication of unfired shell and tube heat exchangers for chemical process service.

TEMA terminology



- Letters given for the front end, shell and rear end types
- Exchanger given three letter designation
- Above is AEL
- Above letters are followed by the size of exchanger in the form of "D-L" where D is the shell diameter and L is the length of tubes

nomenclatures

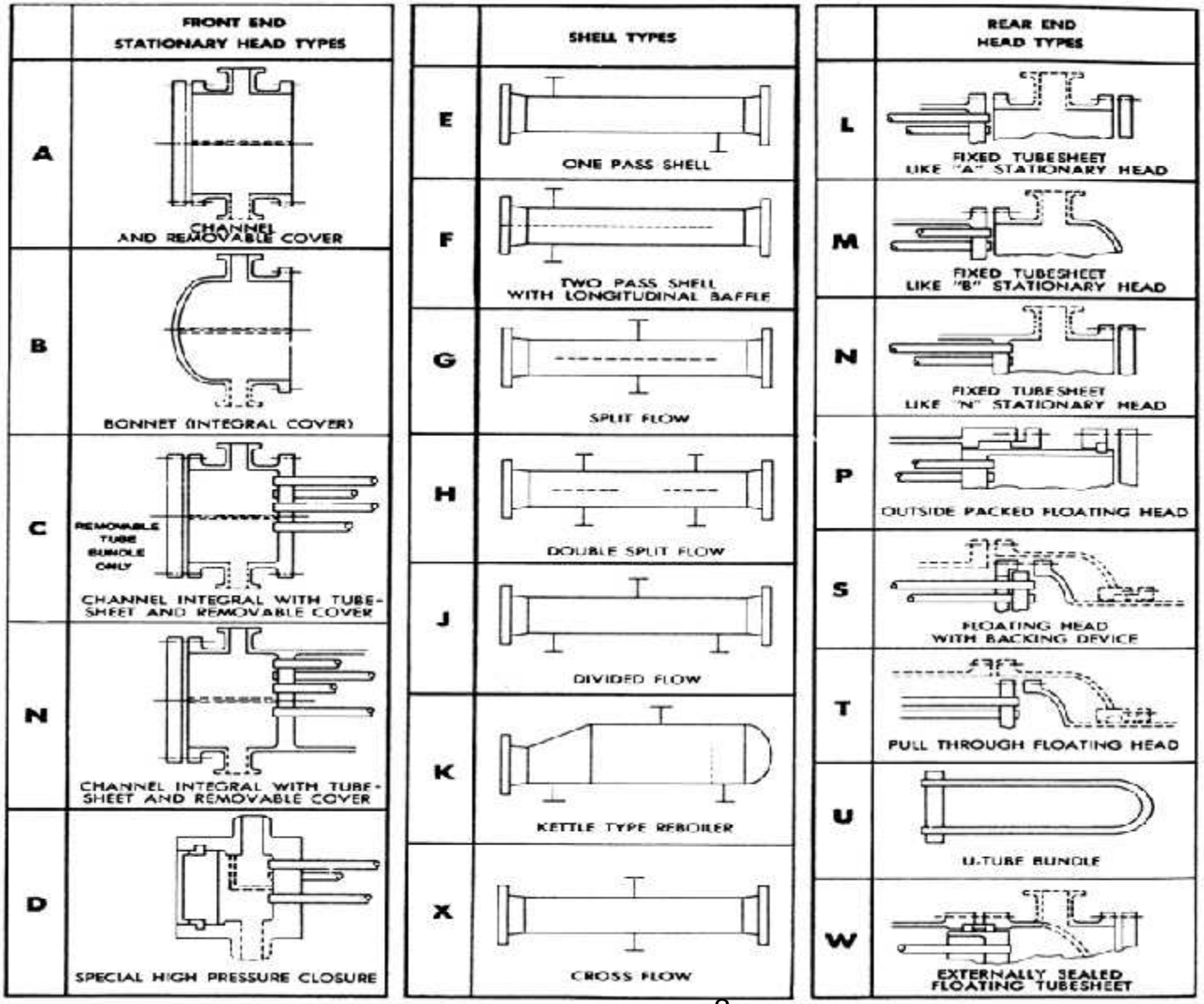


Table 2: Selection Consideration for Shell Design

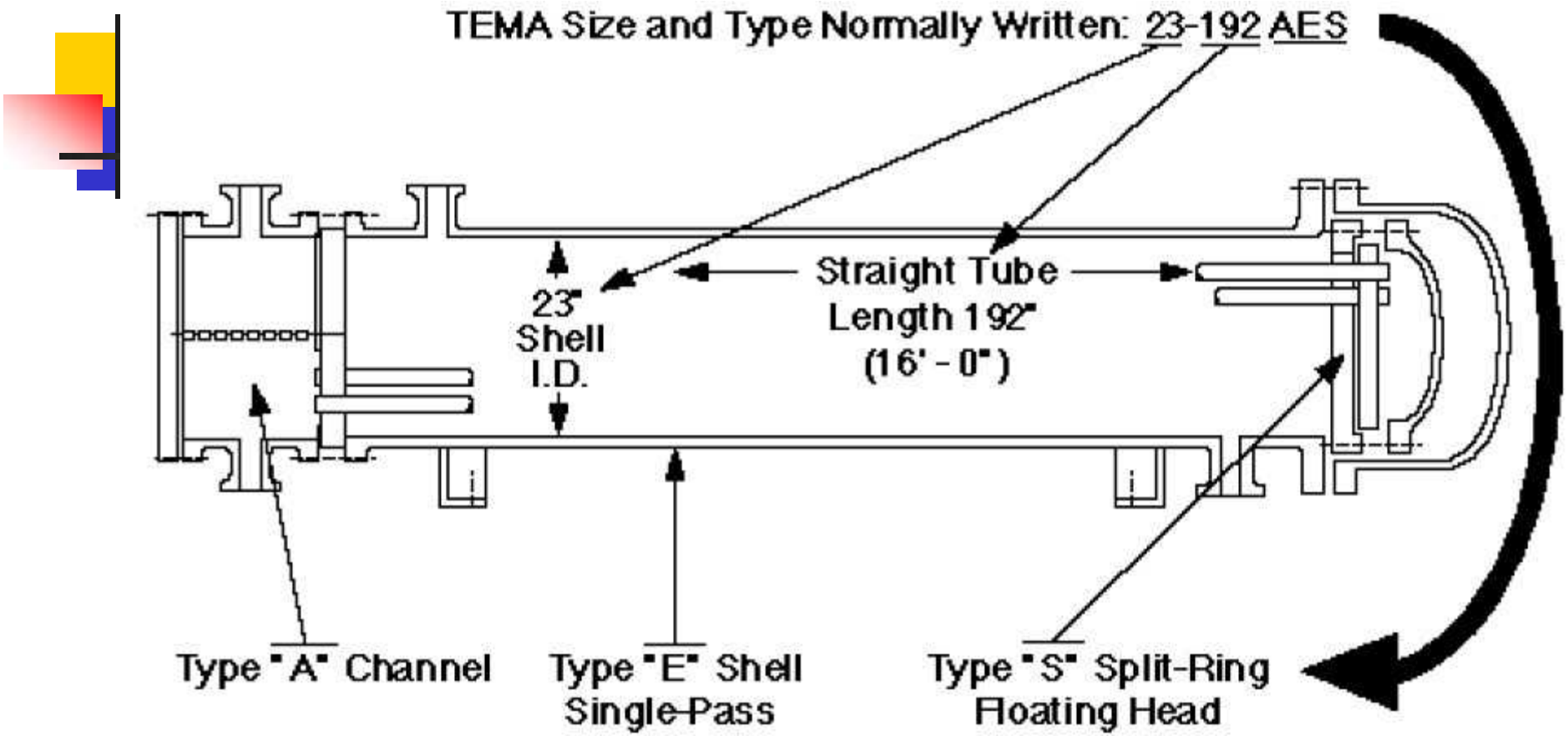
Type	Description	Selection Consideration
E	Single Pass	The most common shell design.
F	Two Pass	Two pass affords slightly better heat transfer than single pass because two passes on the shell side more closely approximates counter-current flow. In order to avoid an excessively thick longitudinal baffle, two pass should not be used with a shellside pressure drop greater than approximately 70 kPa (10 psi). Shellside temperature range should be limited to 175°C (350°F) to avoid both excessive heat leakage through the baffle and thermal stress in the baffle, the shell, and the tubesheet.
G	Split Flow	Typically used in condensing and boiling services to reduce pressure drop and to enhance heat transfer duty.
H	Double Split Flow	
J	Divided Flow Shell	
X	Cross Flow	
K	Kettle-Type Reboiler	Typically used for boiling/vaporizing services. The large shell promotes heat transfer and vapor disengagement.

Table 1:Selection Consideration for Stationary Head

Type	Description	Selection Consideration
A	Channel and Removable Cover	The most common type of head that is used in shell-and-tube heat exchangers. Used with fixed tubesheet, U-tube, and floating head exchangers. In most cases, the bundle is removable for mechanical cleaning.
B	Bonnet or Removable Channel with Integral Cover	Normally used only for low-fouling tubeside services. Used with fixed tubesheet, U-tube, and floating head exchangers. Less expensive than Type A head.
C	Channel Integral with Tubesheet and Removable Cover	Used with some types of fixed tubesheet exchangers and reboilers.
N	Channel Integral with Tubesheet, Shell, and Removable Cover	Shellside fluid must be relatively low-fouling so that chemical cleaning can be used. Not recommended for use with U-tube or floating head exchangers because of maintenance difficulties.
D	Special High Pressure Closure	Special high pressure head that is used when the tubeside design pressure exceeds approximately 10340 kPa (1500 psi).

Table 3: Selection Consideration for Rear Ends

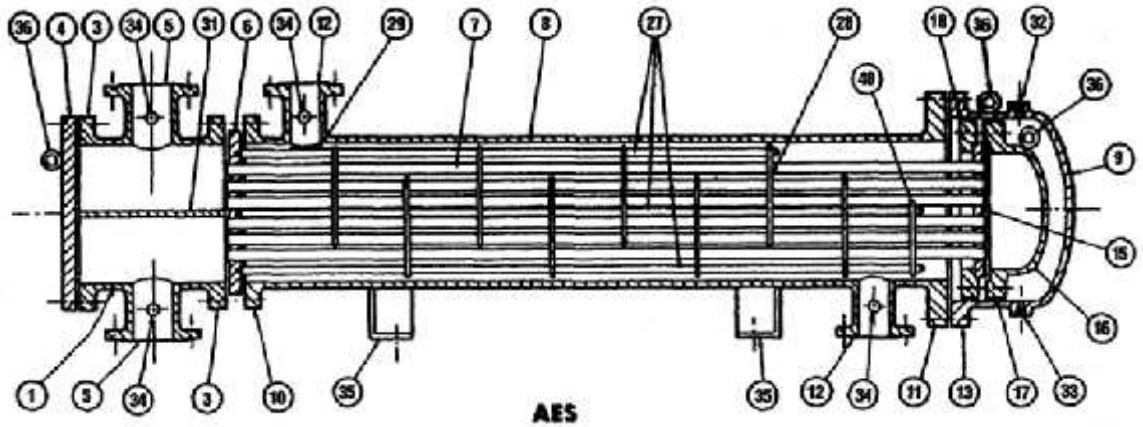
Type	Selection Consideration
L	Used with fixed tubesheet exchangers when the tubes must be cleaned mechanically.
M and N	Used, if necessary, with fixed tubesheet exchangers when the tubes can be chemically cleaned.
P	Not recommended because of the tendency of packed joints to leak. Type P heads should never be used with shellside hydrocarbons or toxic fluids.
S and T	Removable bundle designs. The floating head in an S-type exchanger has a split backing ring that reduces shell diameter requirements and that maintains high thermal efficiency. For maintenance reasons, generally Type T head is preferred, which allows the bundle to be more easily removed.
U	Used with U-tube bundle where tubeside does not need mechanical cleaning. Typically, a formed head is used on the shell, although a bonnet-type head can be used also.
W	Uses a packed joint to separate the tubeside and shellside fluids. Not recommended because of tendency of packed joints to leak.

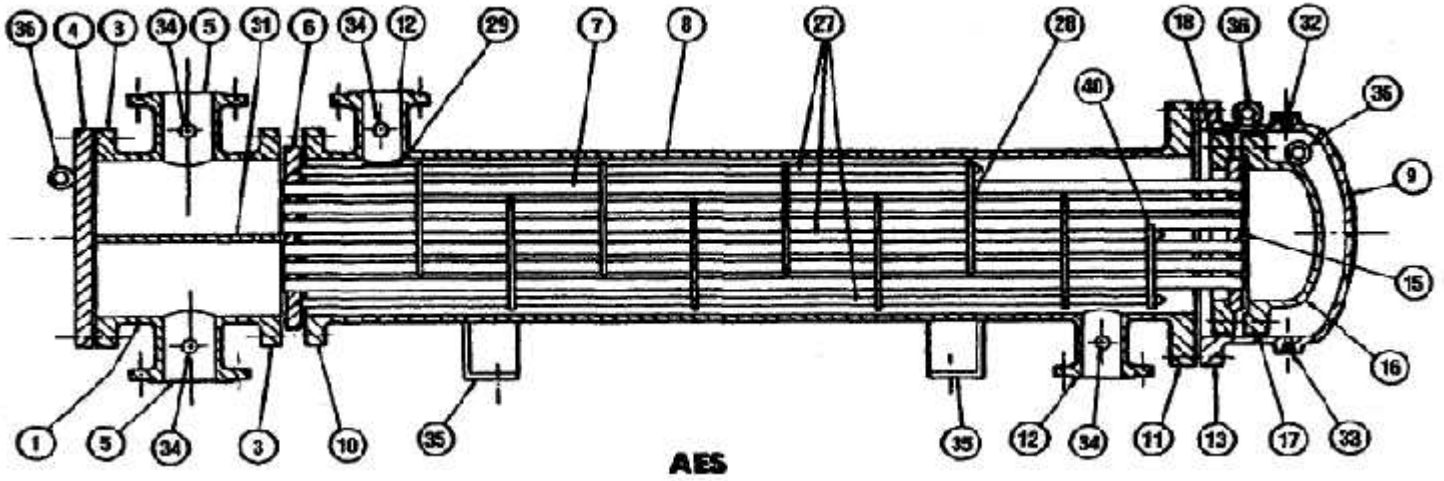

TEMA Size and Type Normally Written: 23-192 AES
23"
Shell
I.D.
Straight Tube
Length 192"
(16' - 0")
Type "A" Channel
Type "E" Shell
Single-Pass
Type "S" Split-Ring
Floating Head

Exchanger type	Fixed tubesheet	U-tube	Floating head types				
			Split backing ring	Pull through	Lantern ring	Outside packed	Bayonet tube
TEMA rear-head type	Type L,M,N	Type U	Type S	Type T	Type W	Type P	–
Does it provide for differential movement between shell and tubes?	Yes – with bellows in shell	Yes	Yes	Yes	Yes	Yes	Yes
Is tube bundle removable?	No	Yes	Yes	Yes	Yes	Yes	Yes [4]
Is replacement bundle possible?	No	Yes	Yes	Yes	Yes	Yes	Yes [4]
Can individual tubes be removed and replaced?	Yes	Outer tubes only	Yes	Yes	Yes	Yes	Yes
Method of cleaning inside	Any	Chem.	Any	Any	Any	Any	Any
Method of cleaning outside [1]	Chem.	Any	Any	Any	Any	Any	Any [4]
Number of tubeside passes	Any	Any even number	One or any even number [2]	One or any even number [2]	One or two only [3]	Any [5]	One (special)
Is double tubesheet construction permissible?	Yes	Yes	No	No	No	Yes	Yes
Are there internal gaskets?	No	No	Yes	Yes	No	No	No
Approx. diametral clearance (mm) (Shell i.d. – OTL)	11 to 18	11 to 18	35 to 50	95 to 160	15 to 35	25 to 50	11 to 18

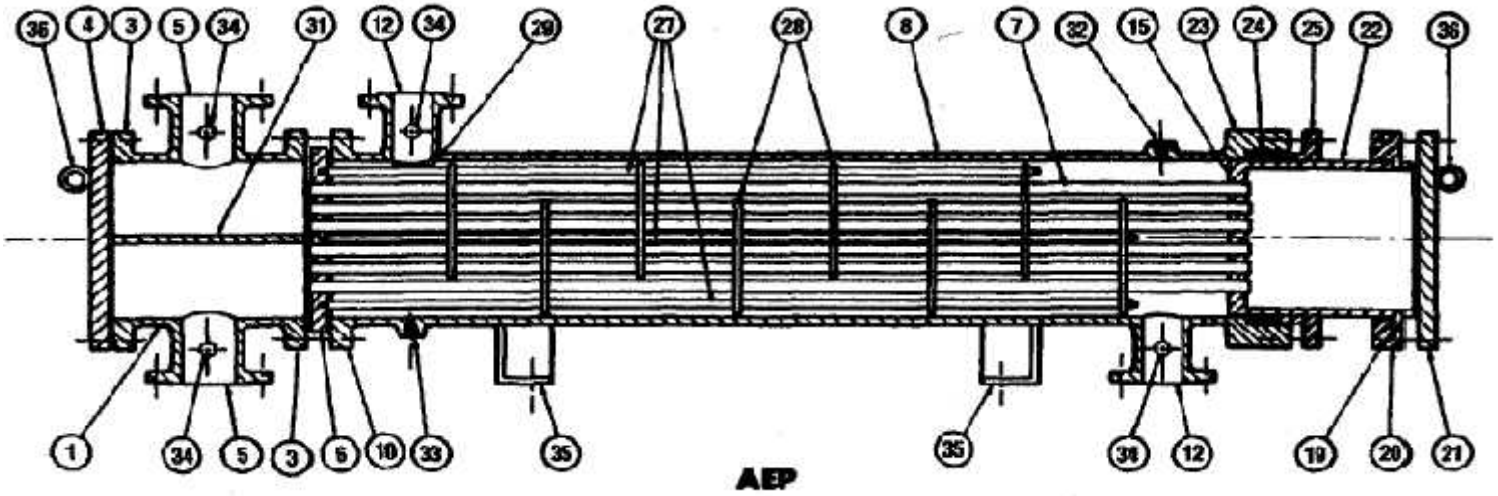
The standard nomenclature for shell and tube heat exchanger

1. Stationary Head-Channel
2. Stationary Head-Bonnet
3. Stationary Head Flange-Channel or Bonnet
4. Channel Cover
5. Stationary Head Nozzle
6. Stationary Tube sheet
7. Tubes
8. Shell
9. Shell Cover
10. Shell Flange-Stationary Head End
11. Shell Flange-Rear Head End
12. Shell Node
13. Shell Cover Flange
14. Expansion Joint
15. Floating Tube sheet
16. Floating Head Cover
17. Floating Head Cover Flange
18. Floating Head Backing Device
19. Split Shear Ring
20. Slip-on Backing Flange
21. Floating Head Cover-External
22. Floating Tube sheet Skirt
23. Packing Box
24. Packing
25. Packing Gland
26. Lantern Ring
27. Tie-rods and Spacers
28. 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
40. Floating Head Support



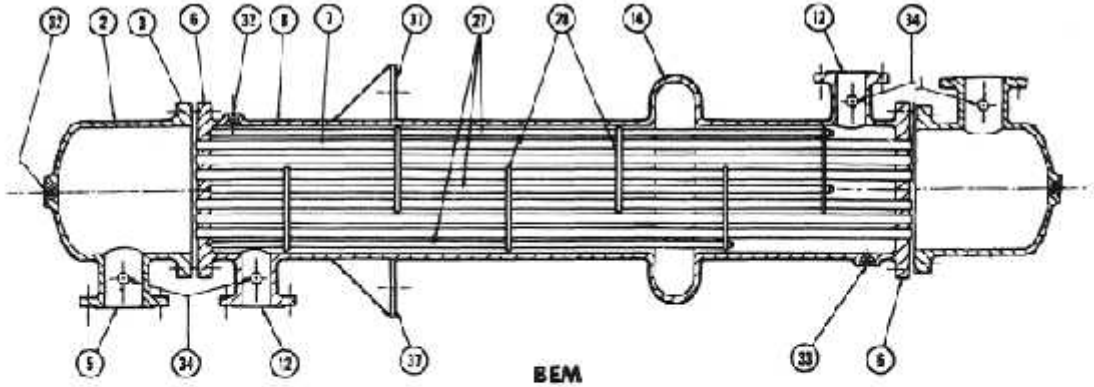


Removable cover, one pass, and floating head heat exchanger

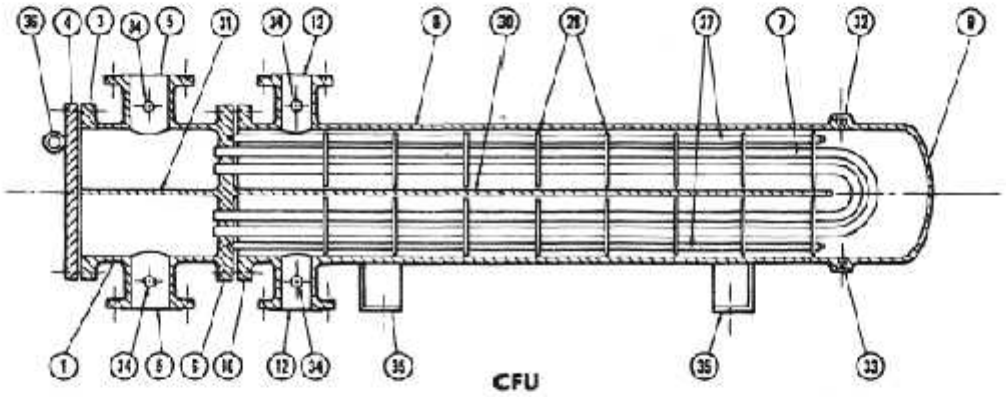


Removable cover, one pass, and outside packed floating head heat exchanger

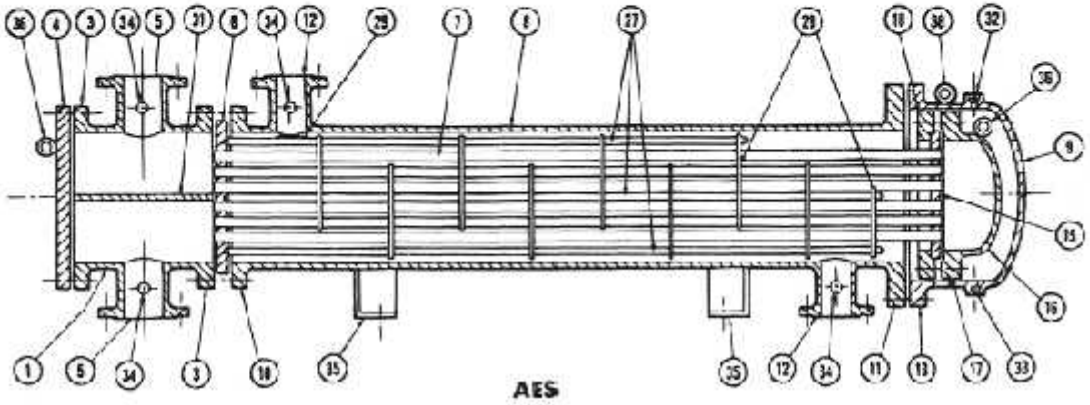
a)

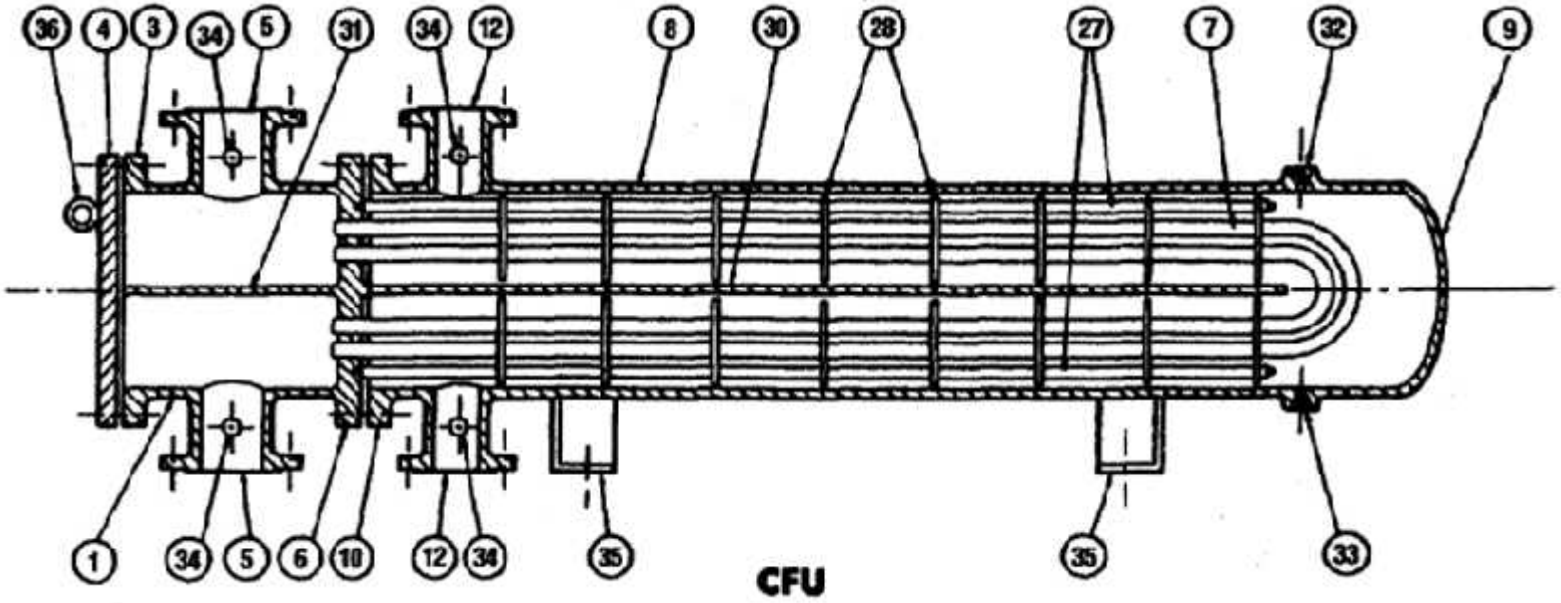


b)

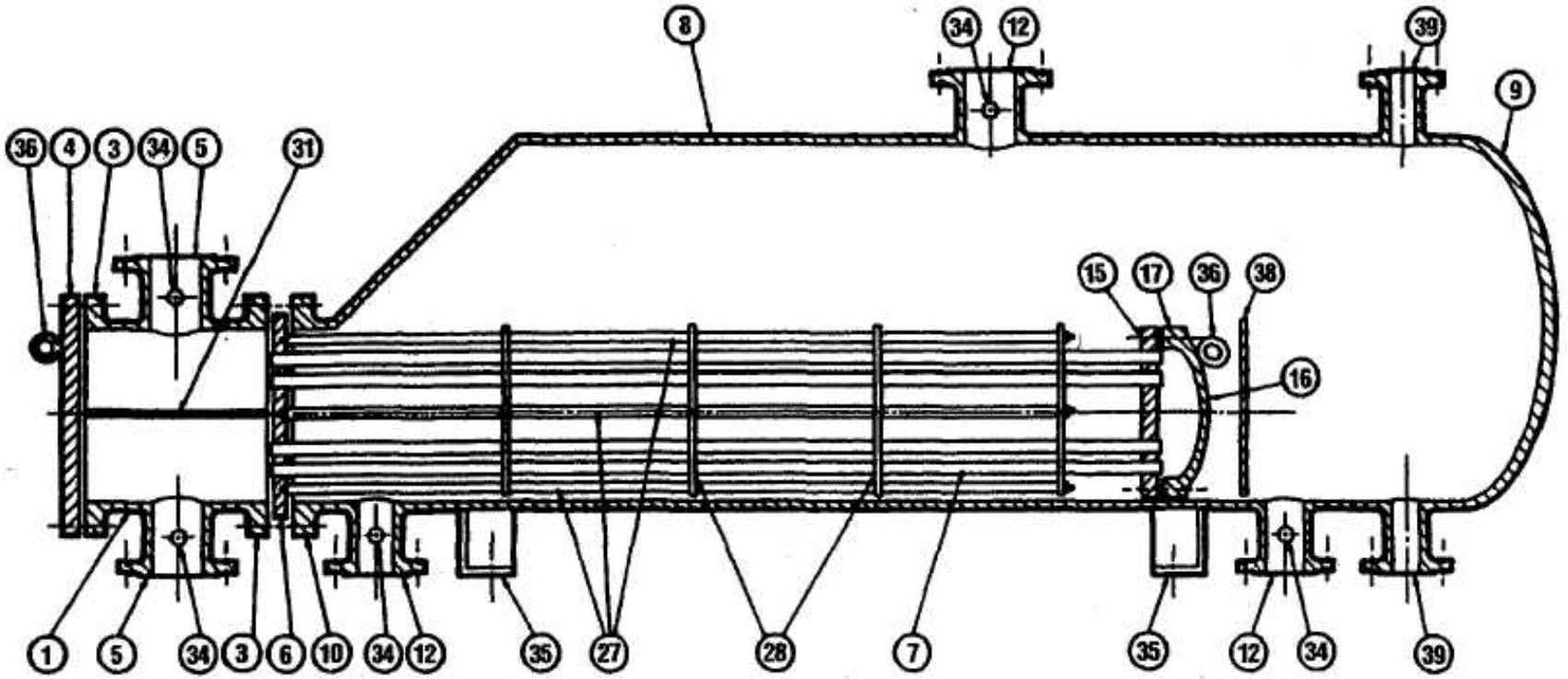


c)





Channel integral removable cover, one pass, and outside packed floating head heat exchanger



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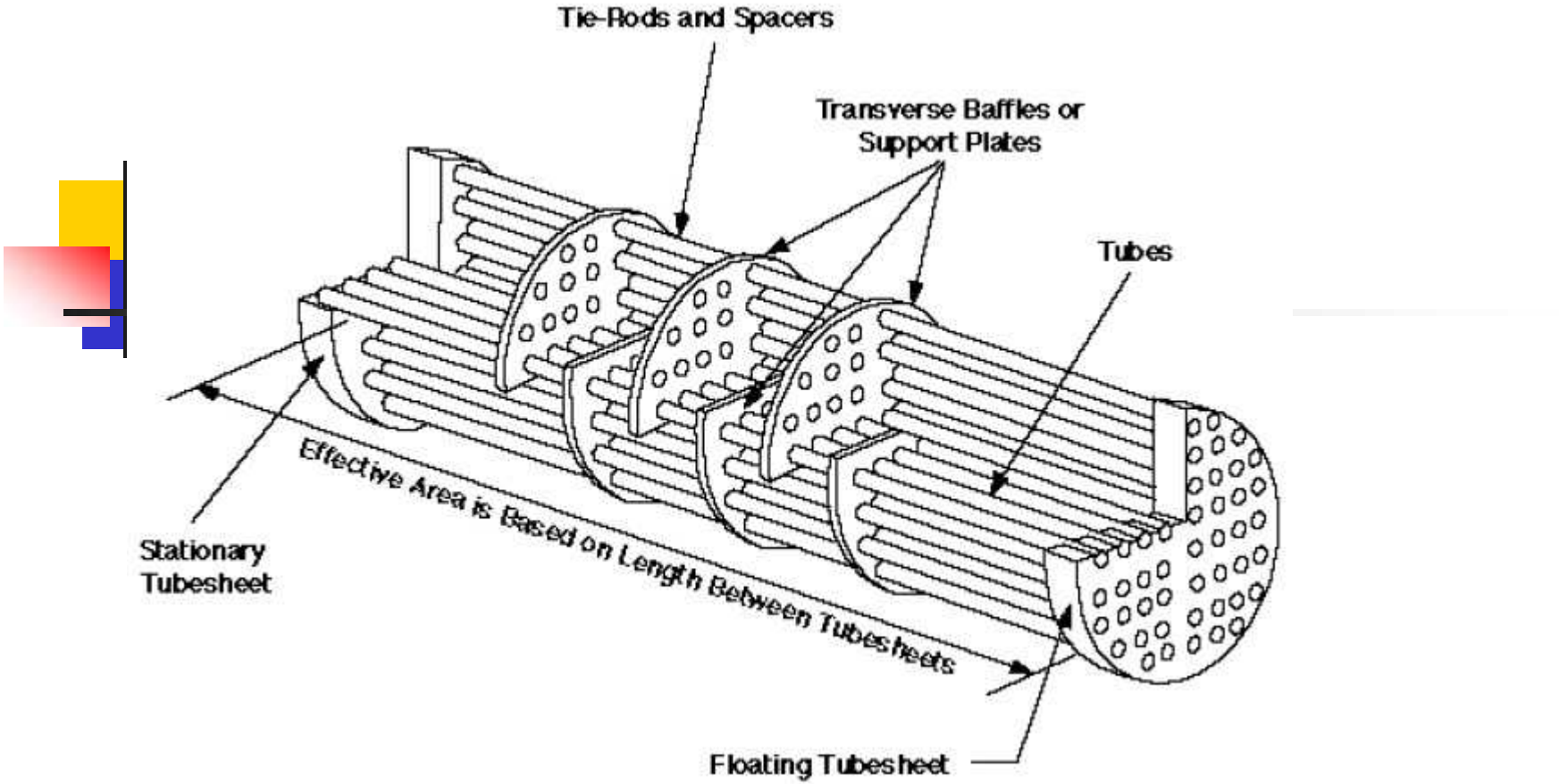
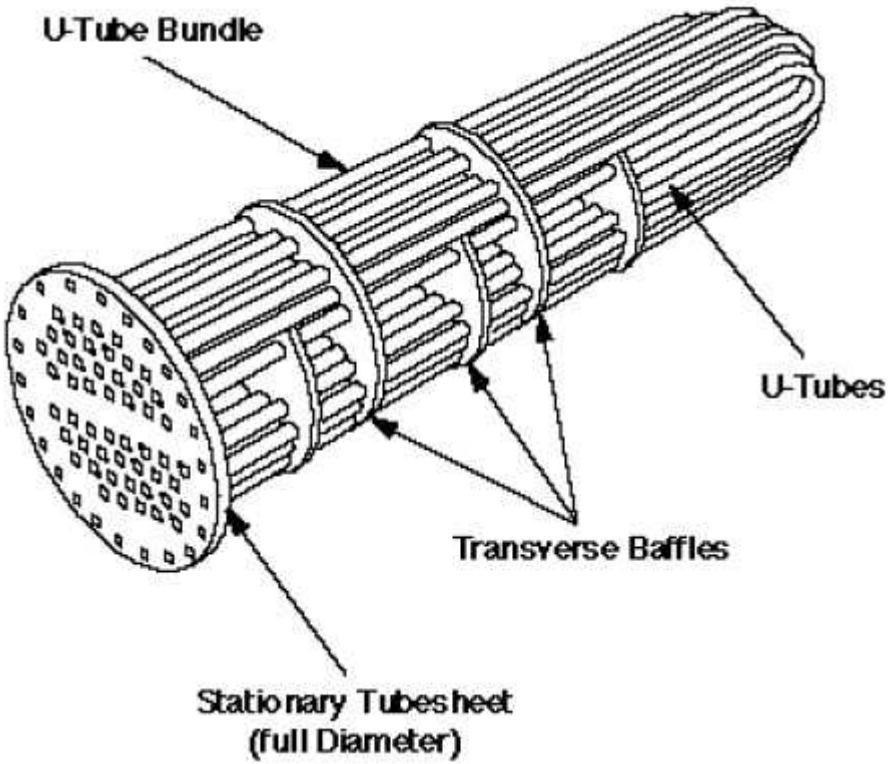
Removable kettle type reboiler with pull through floating head

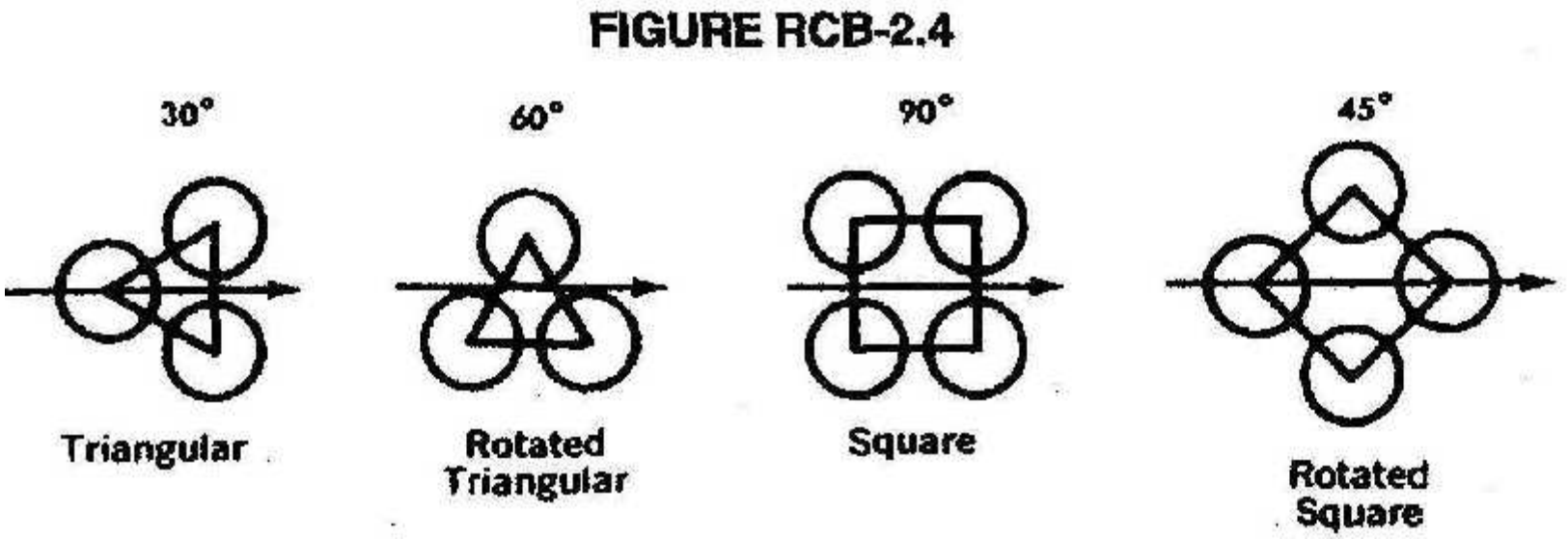

Tie-Rods and Spacers
Transverse Baffles or
Support Plates
Tubes
Effective Area is Based on Length Between Tubesheets
Stationary
Tubesheet
Floating Tubesheet


U-Tube Bundle
U-Tubes
Transverse Baffles
Stationary Tubesheet
(full Diameter)

Tube sizing: Birmingham Wire Gage

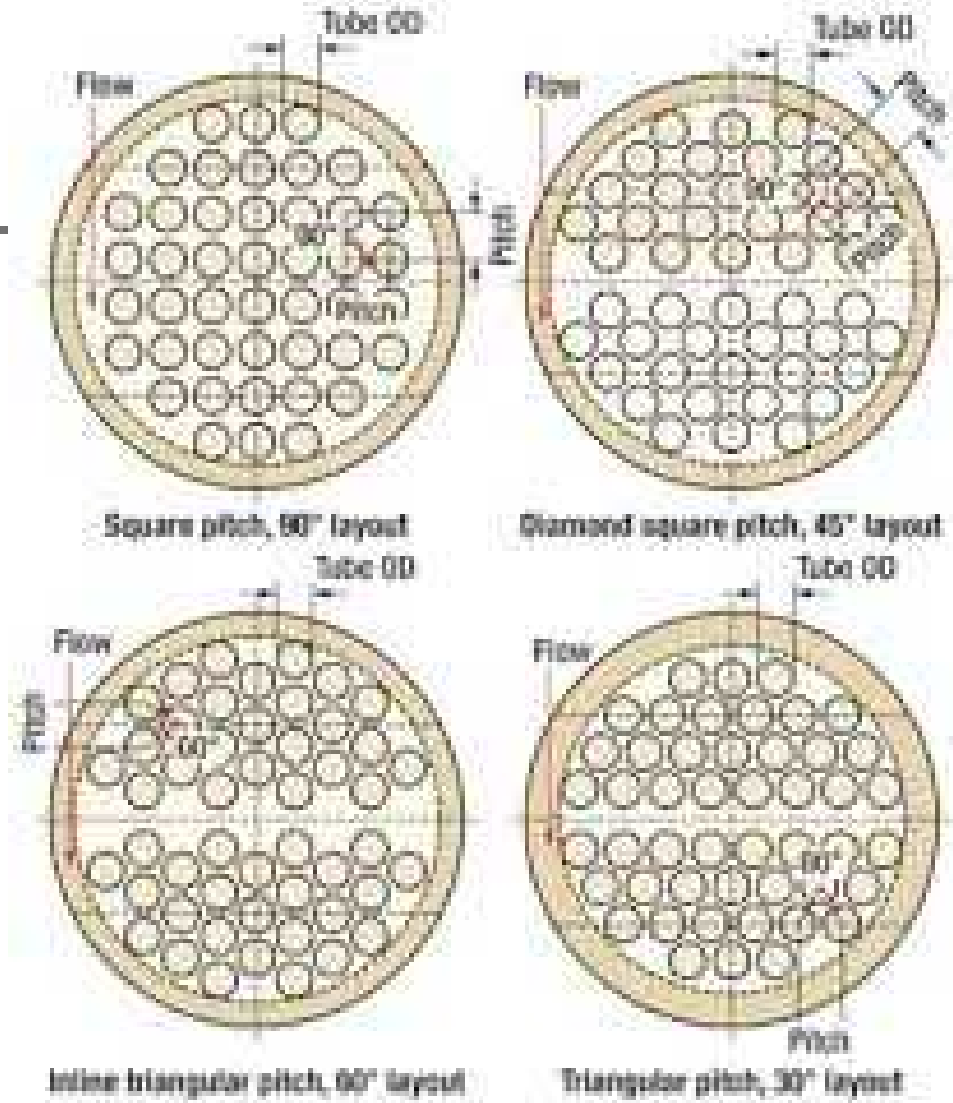
Tube O.D.	00	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch
	0.380	0.340	0.300	0.284	0.259	0.238	0.220	0.203	0.180	0.165	0.148	0.134	0.120	0.109	0.095	0.083	0.072	0.065	0.058	0.049	0.042	0.035	0.032	0.028	0.025	0.022
1/4"													0.010	0.032	0.606	0.084	0.106	0.120	0.134	0.152	0.166	0.180	0.188	0.194	0.200	0.206
3/8"									0.015	0.045	0.079	0.107	0.135	0.157	0.165	0.209	0.231	0.245	0.259	0.277	0.291	0.305	0.311	0.319	0.325	0.331
1/2"						0.024	0.060	0.094	0.140	0.170	0.204	0.232	0.260	0.282	0.310	0.334	0.356	0.370	0.384	0.402	0.416	0.430	0.438	0.444	0.450	0.456
5/8"			0.025	0.057	0.107	0.149	0.185	0.219	0.255	0.295	0.329	0.357	0.385	0.407	0.435	0.459	0.481	0.495	0.509	0.527	0.541	0.555	0.561	0.569	0.575	0.581
3/4"		0.070	0.500	0.182	0.232	0.274	0.310	0.344	0.390	0.420	0.454	0.482	0.510	0.532	0.560	0.584	0.606	0.620	0.634	0.652	0.666	0.680	0.688	0.694	0.700	0.706
7/8"	0.115	0.195	0.275	0.307	0.357	0.399	0.435	0.469	0.515	0.545	0.579	0.607	0.635	0.657	0.685	0.709	0.731	0.745	0.759	0.777	0.791	0.805	0.811	0.819	0.825	0.831
1"	0.240	0.320	0.400	0.432	0.482	0.524	0.560	0.594	0.640	0.670	0.704	0.732	0.760	0.782	0.810	0.834	0.856	0.870	0.884	0.902	0.916	0.930	0.938	0.944	0.950	0.956
1 1/8"	0.365	0.445	0.525	0.557	0.607	0.649	0.685	0.719	0.765	0.795	0.829	0.857	0.885	0.907	0.935	0.959	0.981	0.995	1.009	1.027	1.041	1.055	1.061	1.069	1.075	1.081
1 1/4"	0.490	0.570	0.650	0.682	0.732	0.774	0.810	0.844	0.890	0.920	0.954	0.982	1.010	1.032	1.060	1.084	1.106	1.120	1.134	1.152	1.166	1.180	1.188	1.194	1.200	1.206
1 1/2"	0.740	0.820	0.900	0.932	0.982	1.024	1.060	1.094	1.140	1.170	1.204	1.232	1.260	1.282	1.310	1.334	1.356	1.370	1.384	1.402	1.416	1.430	1.438	1.444	1.450	1.456
1 3/4"	0.990	1.070	1.150	1.182	1.232	1.274	1.310	1.344	1.390	1.420	1.454	1.482	1.510	1.532	1.560	1.584	1.606	1.620	1.634	1.652	1.666	1.680	1.688	1.694	1.700	1.706
2"	1.240	1.320	1.400	1.432	1.482	1.524	1.560	1.594	1.640	1.670	1.704	1.732	1.760	1.782	1.810	1.834	1.856	1.870	1.884	1.902	1.916	1.930	1.938	1.944	1.950	1.956
2 1/4"	1.490	1.570	1.650	1.682	1.732	1.774	1.810	1.844	1.890	1.920	1.954	1.982	2.010	2.032	2.060	2.084	2.106	2.120	2.134	2.152	2.166	2.180	2.188	2.194	2.200	2.206
2 1/2"	1.740	1.820	1.900	1.932	1.982	2.024	2.060	2.094	2.140	2.170	2.204	2.232	2.260	2.282	2.310	2.334	2.356	2.370	2.384	2.402	2.416	2.430	2.438	2.444	2.450	2.456
2 3/4"	1.990	2.070	2.150	2.182	2.232	2.274	2.310	2.344	2.390	2.420	2.454	2.842	2.510	2.532	2.560	2.584	2.606	2.620	2.634	2.652	2.666	2.680	2.688	2.694	2.700	2.706
3"	2.240	2.320	2.400	2.432	2.482	2.524	2.560	2.594	2.640	2.670	2.704	2.732	2.760	2.782	2.810	2.834	2.856	2.870	2.884	2.902	2.916	2.930	2.938	2.944	2.950	2.956
3 1/4"	2.490	2.570	2.650	2.682	2.732	2.774	2.810	2.844	2.890	2.920	2.954	2.982	3.010	3.032	3.060	3.084	3.105	3.120	3.134	3.151	3.166	3.180	3.188	3.194	3.200	3.206
3 1/2"	2.740	2.820	2.900	2.932	2.982	3.024	3.060	3.094	3.140	3.170	3.204	3.232	3.260	3.282	3.310	3.334	3.356	3.370	3.384	3.401	3.416	3.430	3.438	3.444	3.450	3.456
3 3/4"	2.990	3.070	3.150	3.182	3.232	3.274	3.310	3.344	3.390	3.420	3.454	3.482	3.510	3.532	3.560	3.584	3.606	3.620	3.634	3.652	3.666	3.680	3.688	3.694	3.700	3.706
4"	3.240	3.320	3.400	3.432	3.482	3.524	3.560	3.594	3.640	3.670	3.704	3.732	3.760	3.782	3.810	3.834	3.856	3.870	3.884	3.902	3.916	3.930	3.938	3.944	3.950	3.956
4 1/4"	3.490	3.570	3.650	3.682	3.732	3.774	3.810	3.844	3.890	3.920	3.954	3.962	4.010	4.032	4.060	4.084	4.106	4.120	4.134	4.152	4.166	4.180	4.188	4.194	4.200	4.206
4 1/2"	3.740	3.820	3.900	3.932	3.982	4.024	4.060	4.094	4.140	4.170	4.204	4.232	4.260	4.282	4.310	4.344	4.356	4.370	4.384	4.402	4.416	4.430	4.438	4.444	4.450	4.456
4 3/4"	3.990	4.070	4.150	4.182	4.232	4.274	4.310	4.344	4.390	4.420	4.454	4.482	4.510	4.532	4.560	4.584	4.606	4.620	4.634	4.652	4.666	4.680	4.688	4.694	4.700	4.706
5"	4.240	4.320	4.400	4.432	4.482	4.524	4.560	4.594	4.640	4.670	4.704	4.732	4.760	4.782	4.810	4.834	4.856	4.870	4.884	4.902	4.916	4.930	4.938	4.944	4.950	4.956
5 1/4"	4.490	4.570	4.650	4.682	4.732	4.774	4.810	4.844	4.890	4.920	4.954	4.982	5.010	5.032	5.060	5.084	5.105	5.120	5.134	5.152	5.166	5.180	5.188	5.194	5.200	5.206

Tube-side design



Arrangement of tubes inside the heat exchanger

Tube-side design



Arrangement of tubes inside the heat exchanger

DIMENSIONS OF WELDED AND SEAMLESS PIPE

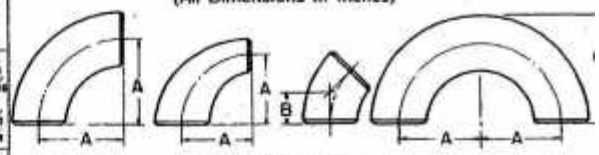
NOMINAL PIPE SIZE	OUTSIDE DIAM.	NOMINAL WALL THICKNESS FOR													
		SCHED. 5S*	SCHED. 10S*	SCHED. 10	SCHED. 20	SCHED. 30	STANDARD †	SCHED. 40	SCHED. 60	EXTRA STRONG §	SCHED. 80	SCHED. 100	SCHED. 120	SCHED. 140	SCHED. 160	XX STRONG
⅛	0.405		0.049				0.068	0.068		0.095	0.095					
¼	0.540		0.065				0.088	0.088		0.119	0.119					
⅜	0.675		0.065				0.091	0.091		0.126	0.126					
½	0.840	0.065	0.083				0.109	0.109		0.147	0.147				0.188	0.294
¾	1.050	0.065	0.083				0.113	0.113		0.154	0.154				0.219	0.308
1	1.315	0.065	0.109				0.133	0.133		0.179	0.179				0.250	0.358
1¼	1.660	0.065	0.109				0.140	0.140		0.191	0.191				0.250	0.382
1½	1.900	0.065	0.109				0.145	0.145		0.200	0.200				0.281	0.400
2	2.375	0.065	0.109				0.154	0.154		0.218	0.218				0.344	0.436
2½	2.875	0.083	0.120				0.203	0.203		0.276	0.276				0.375	0.552
3	3.5	0.083	0.120				0.216	0.216		0.300	0.300				0.438	0.600
3½	4.0	0.083	0.120				0.226	0.226		0.318	0.318					
4	4.5	0.083	0.120				0.237	0.237		0.337	0.337		0.438		0.531	0.674
5	5.563	0.109	0.134				0.258	0.258		0.375	0.375		0.500		0.625	0.750
6	6.625	0.109	0.134				0.280	0.280		0.432	0.432		0.562		0.719	0.864
8	8.625	0.109	0.148		0.250	0.277	0.322	0.322	0.406	0.500	0.500	0.594	0.719	0.812	0.906	0.875
10	10.75	0.134	0.165		0.250	0.307	0.365	0.365	0.500	0.500	0.594	0.719	0.844	1.000	1.125	1.000
12	12.75	0.156	0.180		0.250	0.330	0.375	0.406	0.562	0.500	0.688	0.844	1.000	1.125	1.312	1.000
14 O.D.	14.0	0.156	0.188	0.250	0.312	0.375	0.375	0.438	0.594	0.500	0.750	0.938	1.094	1.250	1.406	
16 O.D.	16.0	0.165	0.188	0.250	0.312	0.375	0.375	0.500	0.656	0.500	0.844	1.031	1.219	1.438	1.594	
18 O.D.	18.0	0.165	0.188	0.250	0.312	0.438	0.375	0.562	0.750	0.500	0.938	1.156	1.375	1.562	1.781	
20 O.D.	20.0	0.188	0.218	0.250	0.375	0.500	0.375	0.594	0.812	0.500	1.031	1.281	1.500	1.750	1.969	
22 O.D.	22.0	0.188	0.218	0.250	0.375	0.500	0.375		0.875	0.500	1.125	1.375	1.625	1.875	2.125	
24 O.D.	24.0	0.218	0.250	0.250	0.375	0.562	0.375	0.688	0.969	0.500	1.218	1.531	1.812	2.062	2.344	
26 O.D.	26.0			0.312	0.500		0.375			0.500						
28 O.D.	28.0			0.312	0.500	0.625	0.375			0.500						
30 O.D.	30.0	0.250	0.312	0.312	0.500	0.625	0.375			0.500						
32 O.D.	32.0			0.312	0.500	0.625	0.375	0.688		0.500						
34 O.D.	34.0			0.312	0.500	0.625	0.375	0.688		0.500						
36 O.D.	36.0			0.312	0.500	0.625	0.375	0.750		0.500						
42 O.D.	42.0						0.375			0.500						

TABLE D-2

DIMENSIONS OF WELDING FITTINGS

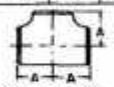
(All Dimensions in Inches)

Nom. Pipe Size	A	B	C	D	E	F	L		G
							ANSI	Short	
½	1½	⅜	1⅜	.....	.....	1	3	.....	1⅜
¾	1½	⅜	1 1⁵⁄₁₆	.....	.....	1½	3	2	1 1⁵⁄₁₆
1	1½	⅜	2⅛	1	1⅜	1½	4	2	2
1¼	1⅜	1	2¾	1¼	2¼	1½	4	2	2⅜
1½	2¼	1½	3¼	1½	2¾	1½	4	2	2⅜
2	3	1⅜	4⅜	2	3⅜	1½	6	2½	3⅝
2½	3¼	1¾	5⅜	2½	3 15⁄16	1½	6	2½	4¼
3	4½	2	6⅛	3	4¾	2	6	2½	5
3½	5¼	2¼	7¼	3½	5½	2½	6	3	5½
4	6	2½	8¼	4	6¼	2½	6	3	6⅞
5	7½	3⅛	10⅜	5	7¾	3	8	3	7⅜
6	9	3¾	12⅜	6	9⅜	3½	8	3½	8½
8	12	5	16⅜	8	12⅜	4	8	4	10⅜
10	15	6¼	20⅜	10	15⅜	5	10	5	12¾
12	18	7½	24½	12	18⅜	6	10	6	15
14	21	8¾	28	14	21	6½	12	.....	16¼
16	24	10	32	16	24	7	12	.....	18½
18	27	11¼	36	18	27	8	12	.....	21
20	30	12½	40	20	30	9	12	.....	23
24	36	15	48	24	36	10½	12	.....	27¼
30	45	18½	60	30	45	10½	...	.....	.....



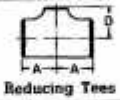
Long Radius Weld Ells

Short Radius Weld Ells | Caps | Stub Ends



Straight Tees

Nom. Pipe Size	Outlet	A	D	L
1	1	1½	.....	.....
1	¾	1½	1¼	2
1	½	1½	1½	2
1¼	1¼	1⅝	.....	.....
1¼	1	1⅝	1⅜	2
1¼	¾	1⅝	1⅜	2
1¼	½	1⅝	1⅜	2
1½	1½	2¼	.....	.....
1½	1¼	2¼	2¼	2½
1½	1	2¼	2¼	2½
1½	¾	2¼	2¼	2½
1½	½	2¼	2¼	2½
2	2	2½	.....	.....
2	1½	2½	2¾	3
2	1¼	2½	2¼	3
2	1	2½	2	3
2	¾	2½	1¾	3
2½	2½	3	.....	.....
2½	2	3	2¾	3½
2½	1½	3	2¾	3½
2½	1¼	3	2½	3½
2½	1	3	2¼	3½
3	3	3⅜	.....	.....
3	2½	3⅜	3¼	3½
3	2	3⅜	3	3½
3	1½	3⅜	2¾	3½
3	1¼	3⅜	2¾	3½
3½	3½	3¾	.....	.....
3½	3	3¾	3¾	4
3½	2½	3¾	3½	4
3½	2	3¾	3¼	4
3½	1½	3¾	3¼	4



Reducing Tees

Nom. Pipe Size	Outlet	A	D	L
4	4	4⅛	.....	.....
4	3½	4⅛	4	4
4	3	4⅛	3⅞	4
4	2½	4⅛	3¾	4
4	2	4⅛	3½	4
4	1½	4⅛	3⅜	4
5	5	4⅜	.....	.....
5	4	4⅜	4⅛	5
5	3½	4⅜	4⅛	5
5	3	4⅜	4⅛	5
5	2½	4⅜	4¼	5
5	2	4⅜	4¼	5
6	6	5⅜	.....	.....
6	5	5⅜	5⅛	5½
6	4	5⅜	5¼	5½
6	3½	5⅜	5	5½
6	3	5⅜	4⅞	5½
6	2½	5⅜	4⅞	5½
8	8	7	.....	.....
8	6	7	6⅝	6
8	5	7	6⅜	6
8	4	7	6⅛	6
8	3½	7	6	6
10	10	8½	.....	.....
10	8	8½	8	7
10	6	8½	7⅝	7
10	5	8½	7½	7
10	4	8½	7¼	7
12	12	10	.....	.....
12	10	10	9½	8
12	8	10	9	8
12	6	10	8⅝	8
12	5	10	8½	8

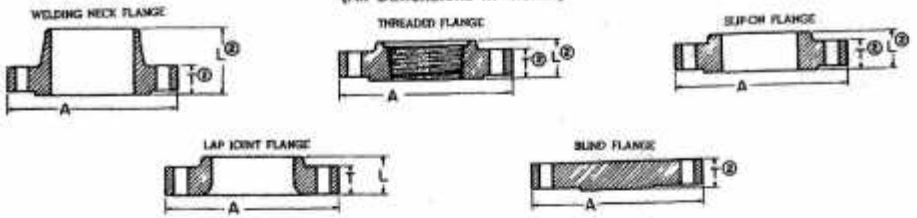
Con. & Ecc. Reducers

Nom. Pipe Size	Outlet	A	D	L
14	14	11	.....	.....
14	12	11	10¾	13
14	10	11	10¼	13
14	8	11	9¾	13
14	6	11	9⅜	13
16	16	12	.....	.....
16	14	12	12	14
16	12	12	11⅝	14
16	10	12	11⅛	14
16	8	12	10¾	14
16	6	12	10⅜	14
18	18	13½	.....	.....
18	16	13½	13	15
18	14	13½	13	15
18	12	13½	12⅝	15
18	10	13½	12⅛	15
18	8	13½	11¾	15
20	20	15	.....	.....
20	18	15	14½	20
20	16	15	14	20
20	14	15	14	20
20	12	15	13⅝	20
20	10	15	13¼	20
20	8	15	12¾	20
24	24	17	.....	.....
24	20	17	17	20
24	18	17	16½	20
24	16	17	16	20
24	14	17	16	20
24	12	17	15⅝	20
24	10	17	15⅛	20

TABLE D-3

DIMENSIONS OF ASME STANDARD FLANGES

(All Dimensions in Inches)



150 LB. FLANGES

Nom. Pipe Size	A	T[2]	L[2] Weld Neck	L[2] Thrd. Slip on	L[2] Lap Joint	Bolt Circle	No. and Sizes of Holes
½	3½	7/16	1 3/16	5/8	5/8	2 3/8	4-5/8
¾	3 7/8	½	2 1/16	5/8	5/8	2 3/4	4-5/8
1	4¼	9/16	2 7/16	11/16	11/16	3 1/8	4-5/8
1¼	4 5/8	5/8	2 13/16	13/16	13/16	3½	4-5/8
1½	5	11/16	2 15/16	7/8	7/8	3 7/8	4-5/8
2	6	¾	2½	1	1	4¾	4-¾
2½	7	7/8	2 3/4	1 1/16	1 1/16	5½	4-¾
3	7½	15/16	2 3/4	1 5/16	1 5/16	6	4-¾
3½	8½	15/16	2 15/16	1½	1¼	7	8-¾
4	9	15/16	3	1 5/8	1 5/8	7½	8-¾
5	10	15/16	3½	1 3/4	1 3/4	8½	8-¾
6	11	1	3½	1 5/8	1 5/8	9½	8-¾
8	13½	1 1/16	4	1½	1¾	11¾	8-¾
10	16	1 1/8	4	1 15/16	1 15/16	14¼	12-1
12	19	1¼	4½	2 3/16	2 3/16	17	12-1
14	21	1 3/8	5	2¼	3½	18¾	12-1 1/8
16	23½	1 7/16	5	2½	3 5/8	21¼	16-1 1/8
18	25	1 9/16	5½	2 11/16	3 13/16	22¾	16-1¼
20	27½	1 11/16	5 13/16	2¾	4 1/16	25	20-1¼
24	32	1 7/8	6	3¼	4 3/8	29½	20-1 3/8

300 LB. FLANGES

A	T[2]	L[2] Weld Neck	L[2] Thrd. Slip on	L[2] Lap Joint	Bolt Circle	No. and Size of Holes	Nom. Pipe Size
3¾	9/16	2 1/16	3/8	3/8	2 5/8	4-5/8	½
4 5/8	5/8	2 1/4	1	1	3 1/4	4-¾	¾
4 7/8	11/16	2 5/16	1 1/16	1 1/16	3½	4-¾	1
5 1/4	¾	2 5/8	1 1/16	1 1/16	3 7/8	4-¾	1¼
6 1/8	13/16	2 11/16	1 3/16	1 3/16	4½	4-¾	1½
6½	⅞	2¾	1 5/16	1 5/16	5	8-¾	2
7½	1	3	1½	1½	5 7/8	8-¾	2½
8¼	1 1/16	3 1/16	1 11/16	1 11/16	6 5/8	8-⅞	3
9	1 3/16	3 3/16	1 13/16	1 13/16	7¼	8-⅞	3½
10	1¼	3 3/8	1 7/8	1 7/8	7 7/8	8-⅞	4
11	1 3/8	3 3/8	2	2	9¼	8-⅞	5
12½	1 7/16	3 5/8	2 1/16	2 1/16	10 5/8	12-⅞	6
15	1 5/8	4 3/8	2 5/16	2 5/16	13	12-1	8
17½	1 7/8	4 5/8	2 5/8	3 1/16	15¼	16-1 1/8	10
20½	2	5 1/8	2 7/8	4	17¾	16-1½	12
23	2 1/8	5 5/8	3	4 1/16	20¼	20-1½	14
25½	2¼	5¾	3 1/4	4 5/16	22½	20-1 5/8	16
28	2 3/8	6¼	3½	5 1/16	24¾	24-1 5/8	18
30½	2½	6 3/8	3 5/8	5½	27	24-1¾	20
36	2¾	6 5/8	4¼	6	32	24-1¾	24

400 LB. FLANGES

Nom. Pipe Size	A	T[2]	L[2] Weld Neck	L[2] Thrd. Slip on	L[2] Lap Joint	Bolt Circle	No. and Size of Holes
½	3¾	9/16	2 1/16	3/8	3/8	2 5/8	4-5/8
¾	4 5/8	5/8	2 1/4	1	1	3 1/4	4-¾
1	4 7/8	11/16	2 5/16	1 1/16	1 1/16	3½	4-¾
1¼	5¼	13/16	2 5/8	1 1/16	1 1/16	3 7/8	4-¾
1½	6 1/8	¾	2¾	1 1/4	1 1/4	4½	4-⅞
2	6½	1	2 7/8	1 5/16	1 5/16	5	8-¾
2½	7½	1 1/16	3 1/4	1 7/16	1 7/16	5 7/8	8-⅞
3	8¼	1 1/4	3 1/4	1 11/16	1 11/16	6 5/8	8-⅞
3½	9	1 3/8	3 3/8	1 15/16	1 15/16	7¼	8-1
4	10	1 3/8	3½	2	2	7 7/8	8-1
5	11	1 1/2	4	2 1/16	2 1/16	9¼	8-1
6	12½	1 5/8	4 5/16	2 1/4	2 1/4	10⅝	12-1
8	15	1 7/8	4 3/8	2 11/16	2 11/16	13	12-1 1/8
10	17½	2 1/8	4 7/8	2 7/8	4	15¼	16-1 1/4
12	20½	2 1/4	5 3/8	3 1/8	4 1/4	17¾	16-1 3/8
14	23	2 3/8	5 7/8	3 5/16	4 3/8	20¼	20-1 3/8
16	25½	2 1/2	6	3 11/16	5	22½	20-1½
18	28	2 5/8	6 1/2	3 7/8	5 3/8	24¾	24-1½
20	30½	2 3/4	6 3/4	4	5 3/8	27	24-1 5/8
24	36	3	6 7/8	4 1/2	6 1/4	32	24-1⅞

600 LB. FLANGES

A	T[2]	L[2] Weld Neck	L[2] Thrd. Slip on	L[2] Lap Joint	Bolt Circle	No. and Size of Holes	Nom. Pipe Size
3¾	9/16	2 1/16	3/8	3/8	2 5/8	4-5/8	½
4 5/8	5/8	2 1/4	1	1	3 1/4	4-¾	¾
4 7/8	11/16	2 5/16	1 1/16	1 1/16	3½	4-¾	1
5 1/4	13/16	2 5/8	1 1/16	1 1/16	3 7/8	4-¾	1¼
6 1/8	⅞	2 3/4	1 1/4	1 1/4	4½	4-⅞	1½
6½	1	2 7/8	1 5/16	1 5/16	5	8-¾	2
7½	1 1/16	3 1/16	1 7/16	1 7/16	5 7/8	8-⅞	2½
8¼	1 1/4	3 1/4	1 11/16	1 11/16	6 5/8	8-⅞	3
9	1 3/8	3 3/8	1 15/16	1 15/16	7¼	8-1	3½
10¾	1½	4	2 1/16	2 1/16	8½	8-1	4
13	1 3/4	4½	2 3/8	2 3/8	10½	8-1 1/8	5
14	1 7/8	4 5/8	2 5/8	2 5/8	11½	12 1 1/8	6
16½	2 3/8	5 1/4	3	3	13¾	12-1¼	8
20	2 1/2	6	3 3/8	4 1/16	17	16-1 3/8	10
22	2 3/4	6 1/8	3 3/8	4 1/8	19¼	20-1 3/8	12
23¾	2 3/4	6½	3 11/16	5	20¾	20-1½	14
27	3	7	4 1/4	5½	23¾	20-1 5/8	16
29¼	3 1/4	7 1/4	4 3/8	6	25¾	20-1¾	18
32	3½	7½	5	6½	28½	24-1¾	20
37	4	8	5½	7¼	33	24-2	24

TABLE D-3 (continued)
DIMENSIONS OF ASME STANDARD FLANGES

900 LB. FLANGES

Nom. Pipe Size	A	T	L② Weld Neck	L② Thrd. Slip on	L② Lap Joint	Bolt Circle	No. and Size of Holes
½	4¾	⅞	2⅜	1¼	1¼	3¼	4-⅞
¾	5⅛	1	2¾	1⅜	1⅜	3½	4-⅞
1	5⅞	1⅛	2⅞	1⅜	1⅜	4	4-1
1¼	6¼	1⅛	2⅞	1⅜	1⅜	4⅜	4-1
1½	7	1¼	3¼	1¾	1¾	4⅞	4-1⅛
2	8½	1½	4	2¼	2¼	6½	8-1
2½	9⅜	1⅜	4⅛	2½	2½	7½	8-1⅛
3	9½	1½	4	2⅛	2⅛	7½	8-1
3½	.....	.....	.....	.....	.....	.....	.....
4	11½	1¾	4½	2¾	2¾	9¼	8-1¾
5	13¾	2	5	3⅛	3⅛	11	8-1¾
6	15	2⅜	5½	3⅜	3⅜	12½	12-1¼
8	18½	2½	6⅜	4	4½	15½	12-1½
10	21½	2¾	7¼	4¼	5	18½	16-1½
12	24	3⅛	7⅞	4⅝	5⅝	21	20-1½
14	25¼	3⅜	8⅜	5⅛	6⅛	22	20-1⅝
16	27¾	3½	8½	5¼	6½	24¼	20-1¾
18	31	4	9	6	7½	27	20-2
20	33¾	4¼	9¾	6¼	8¼	29½	20-2¼
24	41	5½	11½	8	10½	35½	20-2⅝

1500 LB. FLANGES

A	T①	L② Weld Neck	L② Thrd. Slip on	L② Lap Joint	Bolt Circle	No. and Size of Holes	Nom. Pipe Size
4¾	⅞	2⅜	1¼	1¼	3¼	4-⅞	½
5⅛	1	2¾	1⅜	1⅜	3½	4-⅞	¾
5⅞	1⅛	2⅞	1⅜	1⅜	4	4-1	1
6¼	1¼	2⅞	1⅝	1⅜	4⅜	4-1	1¼
7	1¼	3¼	1¾	1¾	4⅞	4-1⅛	1½
8½	1½	4	2¼	2¼	6½	8-1	2
9⅜	1⅝	4⅛	2½	2½	7½	8-1⅛	2½
10½	1⅞	4⅝	2⅞	2⅞	8	8-1¼	3
.....	.....	.....	.....	.....	.....	.....	3½
12¼	2¼	4⅞	3¼	3¼	9½	8-1⅜	4
14¾	2⅜	6⅛	4⅛	4⅛	11½	8 1⅝	5
15½	3¼	6¾	4¼	4¼	12½	12-1½	6
19	3⅝	8¼	5⅝	5⅝	15½	12-1¾	8
23	4¼	10	6¼	7	19	12-2	10
26½	4⅞	11¼	7⅛	8⅛	22½	16-2¼	12
29½	5¼	11¾	.....	9½	25	16-2⅜	14
32½	5⅝	12¼	.....	10¼	27¾	16-2⅝	16
36	6⅛	12⅞	.....	10⅞	30½	16-2¾	18
38¾	7	14	.....	11½	32¾	16-3⅛	20
46	8	16	.....	13	39	16-3¾	24

2500 LB. FLANGES

Nom. Pipe Size	A	T①	L② Weld Neck	L② Thrd.	L② Lap Joint	Bolt Circle	No. and Size of Holes
½	5¼	1¾	2⅞	1⅝	1⅝	3½	4- ⅞
¾	5½	1¾	3⅛	1⅝	1⅝	3¾	4- ⅞
1	6¼	1⅞	3½	1⅞	1⅞	4¼	4-1
1¼	7¼	1½	3¾	2⅛	2⅛	5⅛	4-1⅛
1½	8	1¾	4¾	2⅜	2⅜	5½	4-1¼
2	9½	2	5	2¾	2¾	6¾	8-1⅛
2½	10½	2¼	5⅝	3⅛	3⅛	7¾	8-1¼
3	12	2⅝	6⅜	3⅝	3⅝	9	8-1⅜
4	14	3	7½	4¼	4¼	10¾	8-1⅝
5	16½	3⅝	9	5¼	5¼	12¾	8-1⅞
6	19	4¼	10⅜	6	6	14½	8-2⅛
8	21¾	5	12½	7	7	17¼	12-2¼
10	26½	6½	16½	9	9	21¼	12-2⅝
12	30	7¼	18¼	10	10	24¾	12-2⅞

① Bore to match schedule of attached pipe.

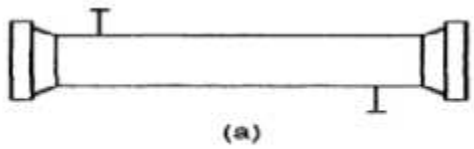
② Includes 1/16" raised face in 150 pound and 300 pound standard. Does *not* include raised face in 400, 600, 900, 1500 and 2500 pound standard.

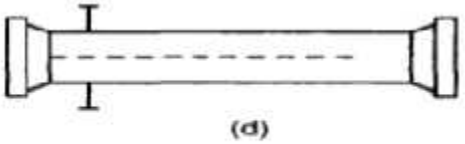
③ Inside pipe diameters are also provided by this table.

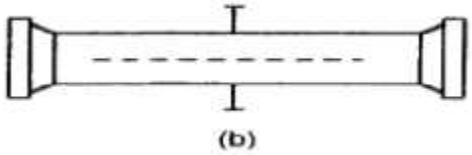
WELDING NECK FLANGE BORES③③

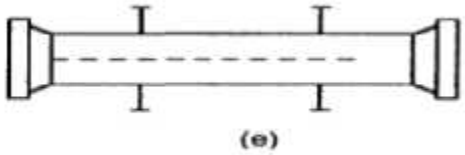
Nom. Pipe Size	Outside Diameter	Sched. 10	Sched. 20	Sched. 30	Standard Wall	Sched. 40	Sched. 60	Extra Strong	Sched. 80	Sched. 100	Sched. 120	Sched. 140	Sched. 160	Double Extra Strong	Nom. Pipe Size
½	0.840	....	....	....	0.622	0.622	....	0.546	0.546	....	....	....	0.466	0.252	½
¾	1.050	....	....	....	0.824	0.824	....	0.742	0.742	....	....	....	0.614	0.434	¾
1	1.315	....	....	....	1.049	1.049	....	0.957	0.957	....	....	....	0.815	0.599	1
1¼	1.660	....	....	....	1.380	1.380	....	1.278	1.278	....	....	....	1.160	0.896	1¼
1½	1.900	....	....	....	1.610	1.610	....	1.500	1.500	....	....	....	1.338	1.100	1½
2	2.375	....	....	....	2.067	2.067	....	1.939	1.939	....	....	....	1.689	1.503	2
2½	2.875	....	....	....	2.468	2.469	....	2.323	2.323	....	....	....	2.125	1.771	2½
3	3.500	....	....	....	3.068	3.068	....	2.900	2.900	....	....	....	2.624	2.300	3
3½	4.000	....	....	....	3.548	3.548	....	3.364	3.364	....	....	....	....	....	3½
4	4.500	....	....	....	4.026	4.026	....	3.826	3.826	....	3.624	....	3.438	3.152	4
5	5.563	....	....	....	5.047	5.047	....	4.813	4.813	....	4.563	....	4.313	4.063	5
6	6.625	....	....	....	6.065	6.065	....	5.761	5.761	....	5.501	....	5.189	4.897	6
8	8.625	....	8.125	8.071	7.981	7.981	7.813	7.625	7.625	7.439	7.189	7.001	6.813	6.875	8
10	10.750	....	10.250	10.136	10.020	10.020	9.750	9.750	9.564	9.314	9.064	8.750	8.500	....	10
12	12.750	....	12.250	12.090	12.000	11.938	11.626	11.750	11.376	11.064	10.750	10.500	10.126	....	12
14	14.000	13.500	13.375	13.250	13.250	13.124	12.814	13.000	12.500	12.126	11.814	11.500	11.188	....	14
16	16.000	15.500	15.375	15.250	15.250	15.000	14.688	15.000	14.314	13.938	13.564	13.124	12.814	....	16
18	18.000	17.500	17.375	17.124	17.250	16.876	16.500	17.000	16.126	15.688	15.250	14.876	14.438	....	18
20	20.000	19.500	19.250	19.000	19.250	18.814	18.376	19.000	17.938	17.438	17.000	16.500	16.064	....	20
24	24.000	23.500	23.250	22.876	23.250	22.626	22.064	23.000	21.564	20.938	20.376	19.876	19.314	....	24
30	30.000	29.376	29.000	28.750	29.250	....	....	29.000	....	....	....	....	....	....	30

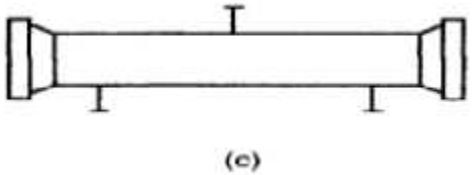
Shell-side design

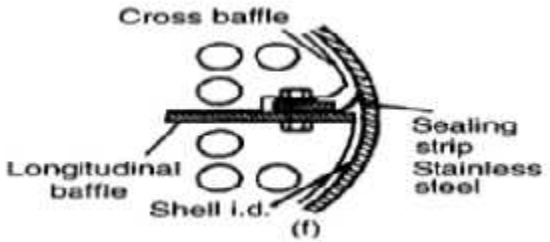












types of shell passes

(a)one-pass shell for E-type,
(b)split flow of G-type,
(c)divided flow of J-type,
(d)two-pass shell with longitudinal baffle of F-type
(e)double split flow of H-type.

Shell-side design

1- Shell thickness is calculated based on ASME code Section VIII Div. 1 or 2
2-Minimum shell thickness for different diameters and material of constructions Was given in TEMA standard.

TABLE R-3.13
MINIMUM SHELL THICKNESS
Dimensions in Inches (mm)

Nominal Shell Diameter		Minimum Thickness					
		Carbon Steel				Alloy *	
		Pipe	Plate				
6	(152)	SCH. 40	-			1/8	(3.2)
8-12	(203-305)	SCH. 30	-			1/8	(3.2)
13-29	(330-737)	SCH. STD	3/8	(9.5)		3/16	(4.8)
30-39	(762-991)	-	7/16	(11.1)		1/4	(6.4)
40-60	(1016-1524)	-	1/2	(12.7)		5/16	(7.9)
61-80	(1549-2032)	-	1/2	(12.7)		5/16	(7.9)
81-100	(2057-2540)	-	1/2	(12.7)		3/8	(9.5)

TABLE CB-3.13
MINIMUM SHELL THICKNESS
Dimensions in Inches (mm)

Nominal Shell Diameter		Minimum Thickness					
		Carbon Steel				Alloy *	
		Pipe	Plate				
6	(152)	SCH. 40	-			1/8	(3.2)
8-12	(203-205)	SCH. 30	-			1/8	(3.2)
13-23	(330-584)	SCH. 20	5/16	(7.9)		1/8	(3.2)
24-29	(610-737)	-	5/16	(7.9)		3/16	(4.8)
30-39	(762-991)	-	3/8	(9.5)		1/4	(6.4)
40-60	(1016-1524)	-	7/16	(11.1)		1/4	(6.4)
61-80	(1549-2032)	-	1/2	(12.7)		5/16	(7.9)
81-100	(2057-2540)	-	1/2	(12.7)		3/8	(9.5)

*Schedule 5S is permissible for 6 inch (152 mm) and 8 inch (203 mm) shell diameters.

Baffle types:
1) Segmental Baffles

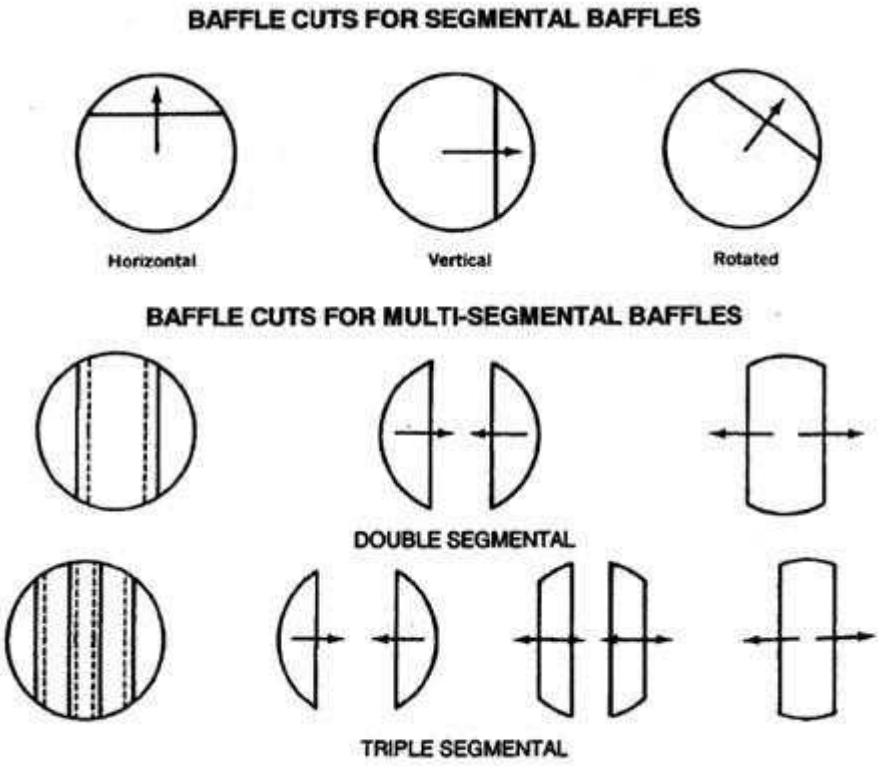
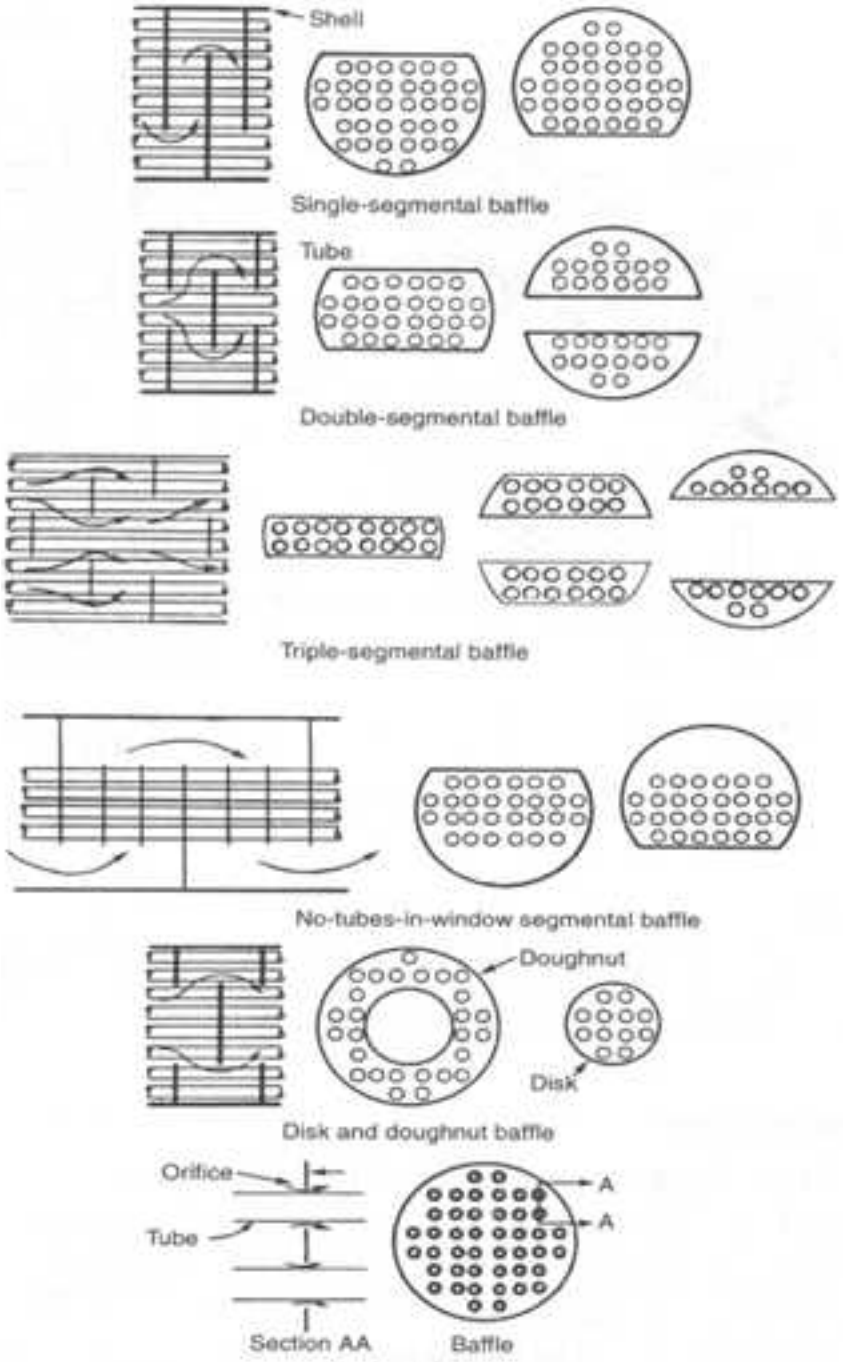
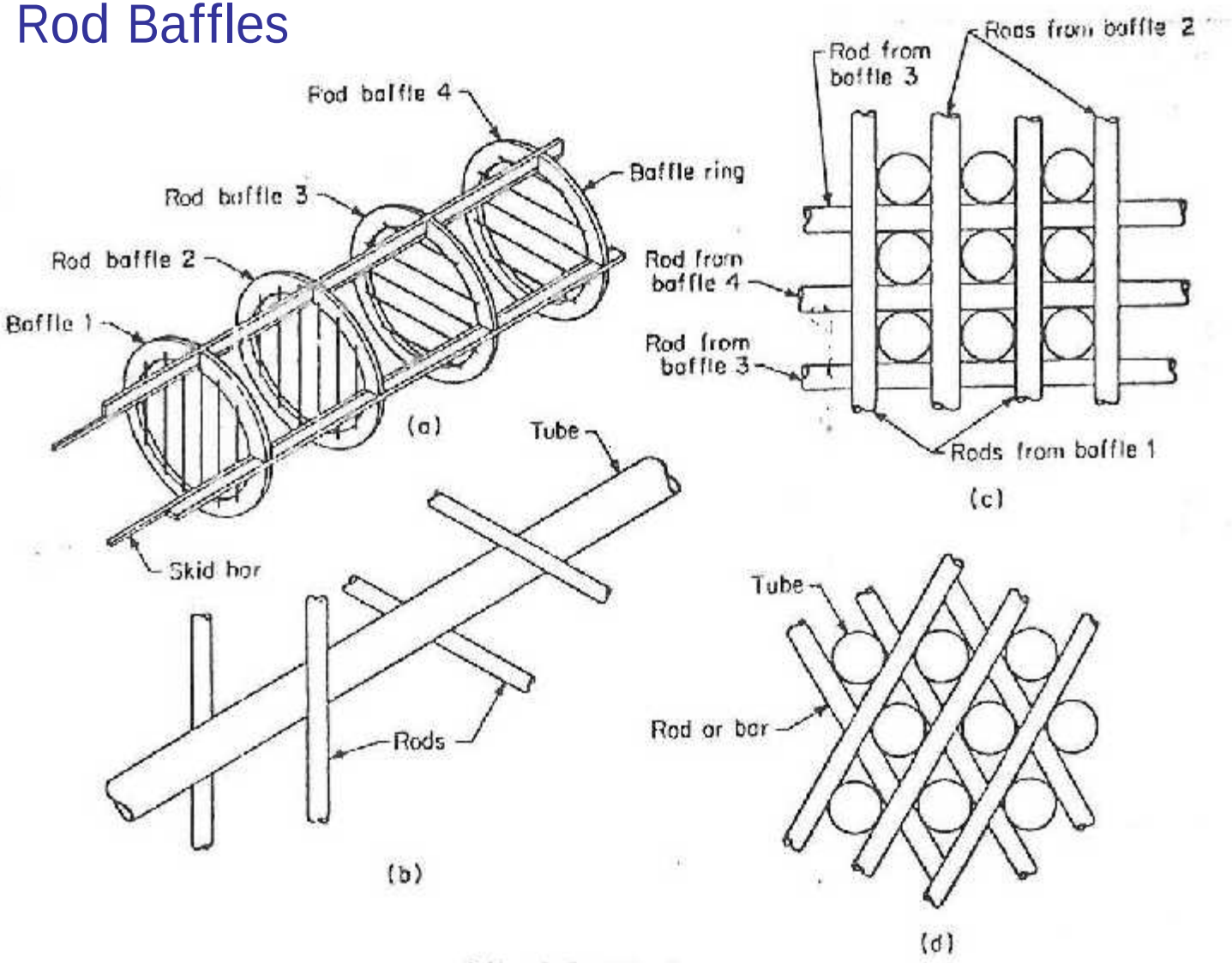


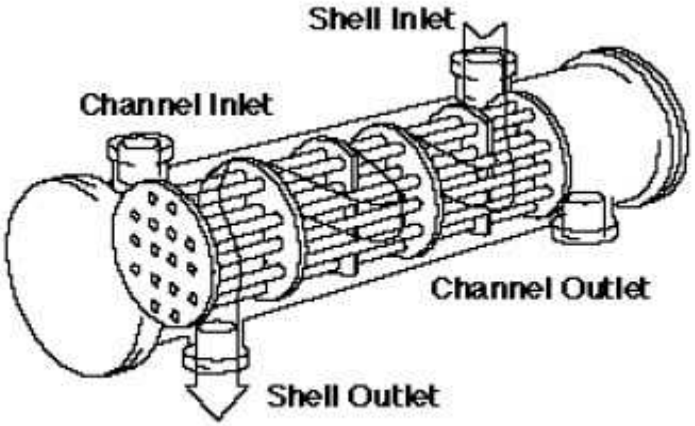
Fig. 9: Baffle cuts



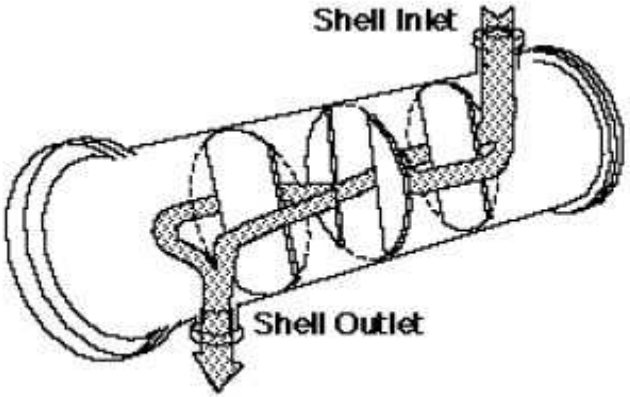
Baffle types:
2) Rod Baffles



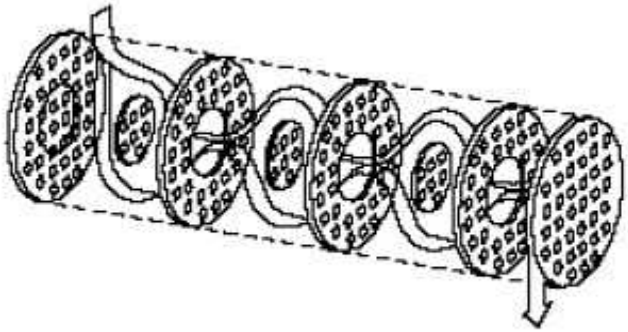
Baffle types:
3) Longitudinal vs. segmental Baffles



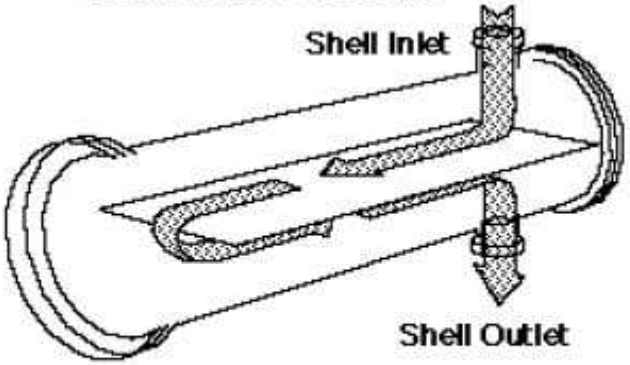
SINGLE SEGMENTAL
TRANSVERSE BAFFLES



DOUBLE SEGMENTAL
TRANSVERSE BAFFLES



DOUGHNUT AND DISC TYPE BAFFLES



LONGITUDINAL BAFFLE

Baffle thickness

TABLE R-4.41

BAFFLE OR SUPPORT PLATE THICKNESS

Dimensions in Inches (mm)

Nominal Shell ID		Plate Thickness									
		Unsupported tube length between central baffles. End spaces between tubesheets and baffles are not a consideration.									
		24 (610) and Under		Over 24 (610) to 36 (914) Inclusive		Over 36 (914) to 48 (1219) Inclusive		Over 48 (1219) to 60 (1524) Inclusive		Over 60 (1524)	
6-14	(152-356)	1/8	(3.2)	3/16	(4.8)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)
15-28	(381-711)	3/16	(4.8)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)	1/2	(12.7)
29-38	(737-965)	1/4	(6.4)	5/16	(7.5)	3/8	(9.5)	1/2	(12.7)	5/8	(15.9)
39-60	(991-1524)	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)	5/8	(15.9)	5/8	(15.9)
61-100	(1549-2540)	3/8	(9.5)	1/2	(12.7)	5/8	(15.9)	3/4	(19.1)	3/4	(19.1)

Baffle thickness (cont.)

TABLE CB-4.41

BAFFLE OR SUPPORT PLATE THICKNESS
Dimensions in Inches (mm)

Nominal Shell ID		Plate Thickness									
		Unsupported tube length between central baffles. End spaces between tubesheets and baffles are not a consideration.									
		12 (305) and Under		Over 12 (305) to 24 (610) Inclusive		Over 24 (610) to 36 (914) Inclusive		Over 36 (914) to 48 (1219) Inclusive		Over 48 (1219) to 60 (1524) Inclusive		Over 60 (1524)	
6-14	(152-356)	1/16	(1.6)	1/8	(3.2)	3/16	(4.8)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)
15-28	(381-711)	1/8	(3.2)	3/16	(4.8)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)	1/2	(12.7)
29-38	(737-965)	3/16	(4.8)	1/4	(6.4)	5/16	(7.5)	3/8	(9.5)	1/2	(12.7)	5/8	(15.9)
39-60	(991-1524)	1/4	(6.4)	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)	5/8	(15.9)	5/8	(15.9)
61-100	(1549-2540)	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)	5/8	(12.7)	3/4	(19.1)	3/4	(19.1)

R-4.42 LONGITUDINAL BAFFLES

R-4.421 LONGITUDINAL BAFFLES WITH LEAF SEALS

Longitudinal baffles with leaf (or other type) seals shall not be less than 1/4" (6.4 mm) nominal metal thickness.

R-4.422 WELDED-IN LONGITUDINAL BAFFLES

The thickness of longitudinal baffles that are welded to the shell cylinder shall not be less than the thicker of ¼" (6.4mm) or the thickness calculated using the following formula:

$$t = b\sqrt{\frac{qB}{1.5S}}$$

where

t = Minimum baffle plate thickness, in. (mm)

B = Table value as shown in Table RCB-9.132 (linear interpolation may be used)

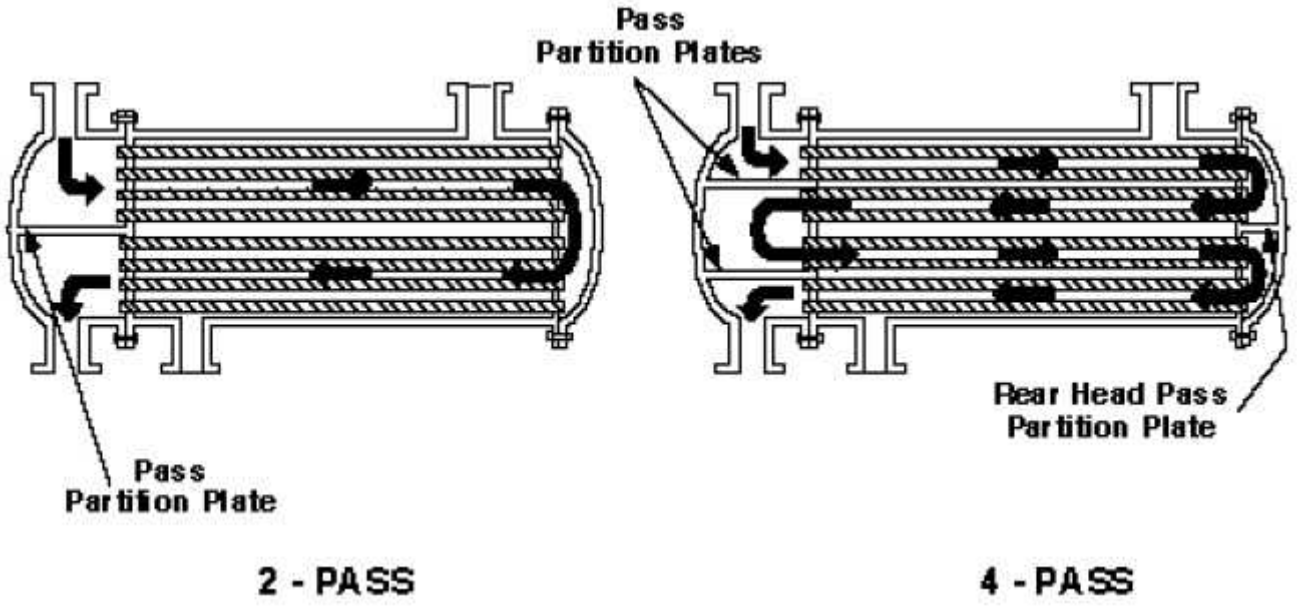
q = Maximum pressure drop across baffle, psi (kPA)

S = Code allowable stress in tension, at design temperature, psi (kPa)

b = Plate dimension. See Table RCB-9.132, in. (mm)

a = Plate dimension. See Table RCB-9.132, in. (mm)

Pass Partition Plate



Baffle clearances

TABLE R-4.41

BAFFLE OR SUPPORT PLATE THICKNESS

Dimensions in Inches (mm)

Nominal Shell ID		Plate Thickness									
		Unsupported tube length between central baffles. End spaces between tubesheets and baffles are not a consideration.									
		24 (610) and Under		Over 24 (610) to 36 (914) Inclusive		Over 36 (914) to 48 (1219) Inclusive		Over 48 (1219) to 60 (1524) Inclusive		Over 60 (1524)	
6-14	(152-356)	1/8	(3.2)	3/16	(4.8)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)
15-28	(381-711)	3/16	(4.8)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)	1/2	(12.7)
29-38	(737-965)	1/4	(6.4)	5/16	(7.5)	3/8	(9.5)	1/2	(12.7)	5/8	(15.9)
39-60	(991-1524)	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)	5/8	(15.9)	5/8	(15.9)
61-100	(1549-2540)	3/8	(9.5)	1/2	(12.7)	5/8	(15.9)	3/4	(19.1)	3/4	(19.1)

RCB-4.2 TUBE HOLES

Where the maximum unsupported tube length is 36 in. (914 mm) or less, or for tubes larger in diameter than 1-1/4 in. (31.8 mm) OD, standard tube holes are to be 1/32 inch (0.8 mm) over the OD of the tubes. Where the unsupported tube length exceeds 36 in. (914 mm) for tubes 1-1/4 in. (31.8 mm) diameter and smaller, standard tube holes are to be 1/64 inch (0.4 mm) over the OD of the tubes. For pulsating conditions, tube holes may be smaller than standard. Any burrs shall be removed and the tube holes given a workmanlike finish. Baffle holes will have an over-tolerance of 0.010 inch (0.3 mm) except that 4% of the holes are allowed an over-tolerance of 0.015 inch (0.4 mm).

Baffle Spacing

RCB-4.5 SPACING OF BAFFLES AND SUPPORT PLATES

RCB-4.51 MINIMUM SPACING

Segmental baffles normally should not be spaced closer than 1/5 of the shell ID or 2 in. (51 mm), whichever is greater. However, special design considerations may dictate a closer spacing.

RCB-4.52 MAXIMUM SPACING

Tube support plates shall be so spaced that the unsupported tube span does not exceed the value indicated in Table RCB-4.52 for the tube material used.

TABLE RCB-4.52

MAXIMUM UNSUPPORTED STRAIGHT TUBE SPANS
Dimensions in Inches (mm)

Tube OD	Tube Materials and Temperature Limits ° F (° C)	
	Carbon Steel & High Alloy Steel, 750 (399) Low Alloy Steel, 850 (454) Nickel-Copper, 600 (316) Nickel, 850 (454) Nickel-Chromium-Iron, 1000 (538)	Aluminum & Aluminum Alloys, Copper & Copper Alloys, Titanium Alloys At Code Maximum Allowable Temperature
1/4 (6.4)	26 (660)	22 (559)
3/8 (9.5)	35 (889)	30 (762)
1/2 (12.7)	44 (1118)	38 (965)
5/8 (15.9)	52 (1321)	45 (1143)
3/4 (19.1)	60 (1524)	52 (1321)
7/8 (22.2)	69 (1753)	60 (1524)
1 (25.4)	74 (1880)	64 (1626)
1-1/4 (31.8)	88 (2235)	76 (1930)
1-1/2 (38.1)	100 (2540)	87 (2210)
2 (50.8)	125 (3175)	110 (2794)
2-1/2 (63.5)	125 (3175)	110 (2794)
3 (76.2)	125 (3175)	110 (2794)

Notes:

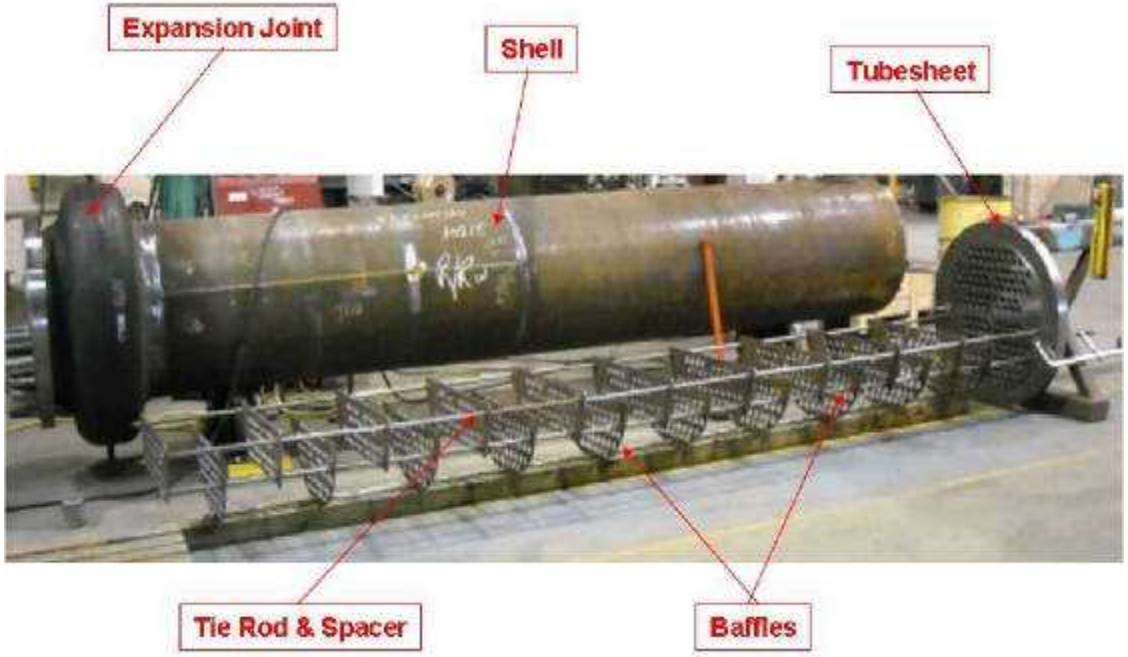
(1) Above the metal temperature limits shown, maximum spans shall be reduced in direct proportion to the fourth root of the ratio of elastic modulus at design temperature to elastic modulus at tabulated limit temperature.

(2) In the case of circumferentially finned tubes, the tube OD shall be the diameter at the root of the fins and the corresponding tabulated or interpolated span shall be reduced in direct proportion to the fourth root of the ratio of the weight per unit length of the tube, if stripped of fins to that of the actual finned tube.

(3) The maximum unsupported tube spans in Table RCB-4.52 do not consider potential flow induced vibration problems. Refer to Section 6 for vibration criteria.

Tie rods and spacers

Tie rods and spacers (Cont.)



Tie rods and spacers (sizes)

TABLE R-4.71

TIE ROD STANDARDS
Dimensions in Inches (mm)

Nominal Shell Diameter		Tie Rod Diameter		Minimum Number of Tie Rods
6 - 15	(152-381)	3/8	(9.5)	4
16 – 27	(406-686)	3/8	(9.5)	6
28 – 33	(711-838)	1/2	(12.7)	6
34 – 48	(864-1219)	1/2	(12.7)	8
49 – 60	(1245-1524)	1/2	(12.7)	10
61 – 100	(1549-2540)	5/8	(15.9)	12

CB-4.71 NUMBER AND SIZE OF TIE RODS

Table CB-4.71 shows suggested tie rod count and diameter for various sizes of heat exchangers. Other combinations of tie rod number and diameter with equivalent metal area are permissible; however, no fewer than four tie rods, and no diameter less than 3/8" (9.5 mm) shall be used above 15 inch (381) nominal shell diameter. Any baffle segment requires a minimum of three points of support.

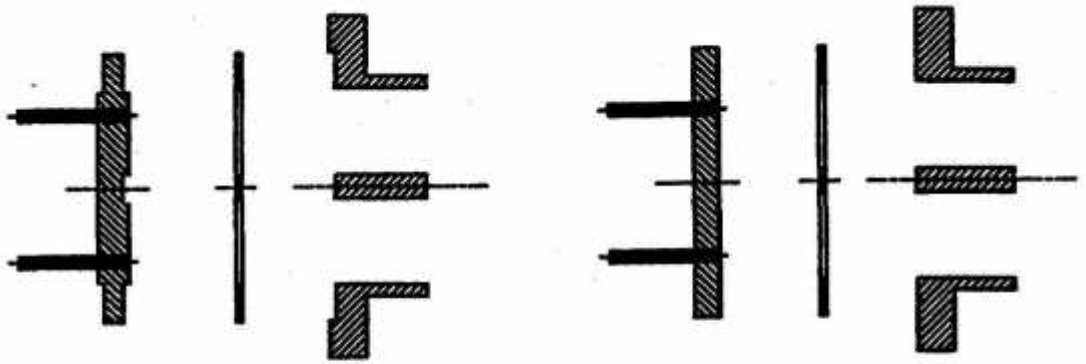
TABLE CB-4.71

TIE ROD STANDARDS
Dimensions in Inches (mm)

Nominal Shell Diameter		Tie Rod Diameter		Minimum Number of Tie Rods
6 – 15	(152-381)	1/4	(6.4)	4
16 – 27	(406-686)	3/8	(9.5)	6
28 – 33	(711-838)	1/2	(12.7)	6
34 – 48	(864-1219)	1/2	(12.7)	8
49 – 60	(1245-1524)	1/2	(12.7)	10
61 – 100	(1549-2540)	5/8	(15.9)	12

Gaskets:

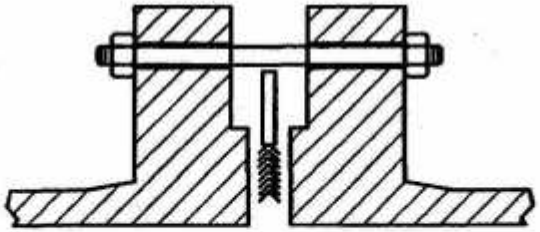
FIGURE RCB-6.5



Confined Gasket

Unconfined Gasket

For dimensions and tolerances, see Figure F-3.



Confined Gasket

SPIRAL WOUND GASKET WITH OUTER METAL RING

Tubesheet

***RCB-7 TUBESHEETS**

RCB-7.1 TUBESHEET THICKNESS

R-7.11 MINIMUM TUBESHEET THICKNESS WITH EXPANDED TUBE JOINTS

In no case shall the total thickness minus corrosion allowance, in the areas into which tubes are to be expanded, of any tubesheet be less than the outside diameter of tubes. In no case shall the total tubesheet thickness, including corrosion allowance, be less than 3/4" (19.1 mm).

C-7.11 MINIMUM TUBESHEET THICKNESS WITH EXPANDED TUBE JOINTS

In no case shall the total thickness minus corrosion allowance, in the areas into which tubes are to be expanded, of any tubesheet be less than three-fourths of the tube outside diameter for tubes of 1" (25.4 mm) OD and smaller, 7/8" (22.2 mm) for 1 1/4" (31.8 mm) OD, 1" (25.4mm) for 1 1/2" (38.1 mm) OD, or 1 1/4" (31.8 mm) for 2" (50.8 mm) OD.

B-7.11 MINIMUM TUBESHEET THICKNESS WITH EXPANDED TUBE JOINTS

In no case shall the total thickness minus corrosion allowance, in the areas into which tubes are to be expanded, of any tubesheet be less than three-fourths of the tube outside diameter for tubes of 1" (25.4 mm) OD and smaller, 7/8" (22.2 mm) for 1 1/4" (31.8 mm)OD, 1" (25.4) for 1 1/2" (38.1 mm) OD, or 1 1/4" (31.8 mm) for 2" (50.8 mm) OD. In no case shall the total tubesheet thickness, including corrosion allowance, be less than 3/4" (19.1 mm).

Actual Tubesheet thickness should be calculated using ASME code Section VIII and/or TEMA calculation procedures (Paragraph A.13)

Tubesheet (cont.)

RCB-7.12 DOUBLE TUBESHEETS

Double tubesheets may be used where the operating conditions indicate their desirability. The diversity of construction types makes it impractical to specify design rules for all cases. Paragraphs RCB-7.124, RCB-7.125, and RCB-7.126 provide the design rules for determining the thickness of double tubesheets for some of the most commonly used construction types.

RCB-7.121 MINIMUM THICKNESS

Neither component of a double tubesheet shall have a thickness less than that required by Paragraph A.131.

RCB-7.122 VENTS AND DRAINS

Double tubesheets of the edge welded type shall be provided with vent and drain connections at the high and low points of the enclosed space.

RCB-7.123 SPECIAL PRECAUTIONS

When double tubesheets are used, special attention shall be given to the ability of the tubes to withstand, without damage, the mechanical and thermal loads imposed on them by the construction.

RCB-7.124 INTEGRAL DOUBLE TUBESHEETS

The tubesheets are connected in a manner which distributes axial load and radial thermal expansion loads between tubesheets by means of an interconnecting element capable of preventing individual radial growth of tubesheets. It is assumed that the element is rigid enough to mutually transfer all thermal and mechanical radial loads between the tubesheets. Additionally, it is understood that the tubes are rigid enough to mutually transfer all mechanically and thermal axial loads between the tubesheets.

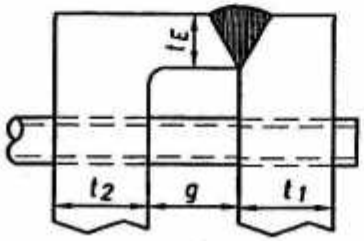


FIGURE RCB-7.124

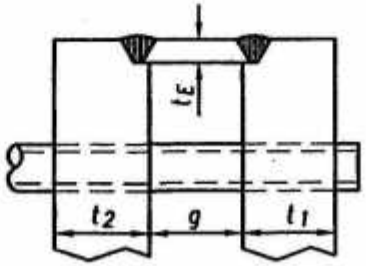


FIGURE RCB-7.125

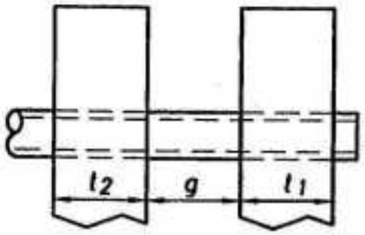


FIGURE RCB-7.126

Tubesheet (cont.): Tube hole tolerances

TABLE RCB-7.21M

TUBE HOLE DIAMETERS AND TOLERANCES
(All Dimensions in mm)

Nominal Tube OD	Nominal Tube Hole Diameter and Under Tolerance				Over Tolerance; 96% of tube holes must meet value in column (c). Remainder may not exceed value in column (d)	
	Standard Fit (a)		Special Close Fit (b)			
	Nominal Diameter	Under Tolerance	Nominal Diameter	Under Tolerance	(c)	(d)
6.4	6.58	0.10	6.53	0.05	0.05	0.18
9.5	9.75	0.10	9.70	0.05	0.05	0.18
12.7	12.95	0.10	12.90	0.05	0.05	0.20
15.9	16.13	0.10	16.08	0.05	0.05	0.25
19.1	19.30	0.10	19.25	0.05	0.05	0.25
22.2	22.48	0.10	22.43	0.05	0.05	0.25
25.4	25.70	0.10	25.65	0.05	0.05	0.25
31.8	32.11	0.15	32.03	0.08	0.08	0.25
38.1	38.56	0.18	38.46	0.08	0.08	0.25
50.8	51.36	0.18	51.26	0.08	0.08	0.25
63.5	64.20	0.25	64.07	0.10	0.10	0.25
76.2	77.04	0.30	76.89	0.11	0.10	0.25

Tubesheet (cont.): Tube hole ligament

TABLE RCB-7.22M

TABLE OF TUBESHEET LIGAMENTS AND RECOMMENDED HEAVIEST TUBE GAGES

(All Dimensions in mm)

Tube Dia d_o	Tube Pitch p	p/d_o	$p - d_o$	Heaviest Recommended Tube Gage BWG	Tube Hole Dia. Std. Fit	Nominal Ligament Width	Minimum Std. Ligaments (96% of ligaments must equal or exceed values tabulated below) Tubesheet Thickness								Minimum Permissible Ligament Width
							25.4	38.1	50.8	63.5	76.2	101.6	127.0	152.4	
6.4	7.94	1.25	1.59	22	6.579	1.372	0.635	0.635	0.635	0.635	-	-	-	-	0.635
	9.53	1.50	3.18	20		2.946	2.108	1.956	1.778	1.626	-	-	-	-	1.524
9.5	11.51	1.21	1.98	20	9.754	1.753	1.041	0.914	0.813	0.711	0.610	-	-	-	0.762
	12.70	1.33	3.18	18		2.946	2.210	2.108	2.007	1.905	1.778	1.575	-	-	1.524
	13.49	1.42	3.97	18		3.734	3.023	2.896	2.794	2.692	2.591	2.362	2.159	1.930	1.905
12.7	15.88	1.25	3.18	18	12.954	2.921	2.261	2.159	2.083	2.007	1.930	1.753	1.600	-	1.524
	16.67	1.31	3.97	16		3.708	3.048	2.972	2.870	2.794	2.718	2.565	2.388	2.235	1.905
	17.46	1.38	4.76	16		4.521	3.835	3.759	3.683	3.607	3.505	3.353	3.200	3.023	2.286
15.9	19.05	1.20	3.18	16	16.129	2.921	2.032	1.956	1.905	1.829	1.778	1.651	1.499	1.372	1.524
	19.84	1.25	3.97	15		3.708	2.819	2.769	2.692	2.616	2.565	2.438	2.311	2.184	1.905
	20.64	1.30	4.76	14		4.521	3.607	3.556	3.480	3.429	3.353	3.226	3.099	2.972	2.286
	22.23	1.40	6.35	14		6.096	5.207	5.131	5.080	5.004	4.953	4.801	4.674	4.547	3.048
19.1	23.81	1.25	4.76	13	19.304	4.521	3.632	3.581	3.531	3.480	3.429	3.302	3.200	3.099	2.286
	25.40	1.33	6.35	12		6.096	5.232	5.182	5.105	5.055	5.004	4.902	4.801	4.674	3.048
	26.99	1.42	7.94	12		7.696	6.807	6.756	6.706	6.655	6.604	6.477	6.375	6.274	3.810
	28.58	1.50	9.53	12		9.271	8.407	8.357	8.280	8.230	8.179	8.077	7.976	7.849	4.699
22.2	27.78	1.25	5.56	12	22.479	5.309	4.445	4.394	4.343	4.318	4.267	4.166	4.064	3.988	2.667
	28.58	1.29	6.35	12		6.096	5.232	5.207	5.156	5.105	5.055	4.953	4.877	4.775	3.048
	30.16	1.36	7.94	10		7.696	6.833	6.782	6.731	6.680	6.655	6.553	6.452	6.375	3.810
	31.75	1.43	9.53	10		9.271	8.407	8.382	8.331	8.280	8.230	8.128	8.052	7.950	4.699
25.4	31.75	1.25	6.35	10	25.705	6.045	5.207	5.156	5.131	5.080	5.029	4.953	4.877	4.801	3.048
	33.34	1.31	7.94	9		7.645	6.782	6.756	6.706	6.680	6.629	6.553	6.477	6.375	3.810
	34.93	1.38	9.53	9		9.220	8.382	8.331	8.306	8.255	8.204	8.128	8.052	7.976	4.699
31.8	39.69	1.25	7.94	9	32.106	7.595	6.756	6.731	6.680	6.655	6.629	6.553	6.502	6.426	3.810
38.1	47.63	1.25	9.53	8	38.557	9.068	8.255	8.230	8.204	8.179	8.153	8.077	8.026	7.976	4.572
50.8	63.50	1.25	12.70	6	51.359	12.141	-	11.328	11.303	11.278	11.252	11.227	11.176	11.125	6.350
63.5	79.38	1.25	15.88	6	64.211	15.164	-	14.35	14.34	14.32	14.304	14.27	14.24	14.21	7.62
76.2	95.25	1.25	19.05	6	77.038	18.212	-	17.41	17.4	17.38	17.369	17.34	17.31	17.29	8.89

Notes: The above table of minimum standard ligaments is based on a ligament tolerance not exceeding the sum of twice the drill drift tolerance plus 0.51mm for tubes less than 15.9mm OD and 0.76mm for tubes 15.9mm OD and larger.
Drill drift tolerance = 0.041 (thickness of tubesheet in tube diameters), mm

* For tubesheet thicknesses greater than 152.4mm, it is permissible to determine minimum standard ligaments according to the note above.

Tubesheet (cont.): tube to tubesheet joint

***RCB-7.23 TUBE HOLE FINISH**

The inside edges of tube holes in tubesheets shall be free of burrs to prevent cutting of the tubes. Internal surfaces shall be given a workmanlike finish.

RB-7.24 TUBE HOLE GROOVING

Tube holes for expanded joints for tubes 5/8" (15.9mm) OD and larger shall be machined with annular ring groove(s) for additional longitudinal load resistance. For strength welded tube to tubesheet joints, ring grooves are not required.

(1) For roller expanded tube joints, when tubesheet thickness exceeds 1" (25.4mm) at least two grooves shall be used, each approximately 1/8" (3.2mm) wide by 1/64" (0.4mm) deep. Tubesheets with thickness less than or equal to 1" (25.4mm) may be provided with one groove.

(2) For hydraulic or explosive expanded tube joints, when tubesheet thickness exceeds 3" (76mm), at least two grooves shall be used. Minimum groove width shall be calculated as $w = 1.56\sqrt{Rt}$ where R = mean tube radius and t = tube wall thickness, except groove width need not exceed 1/2" (12.7mm). Groove depth to be 1/64" (0.4mm). Tubesheets with thickness less than or equal to 3" (76mm) may be provided with one groove.

When integrally clad or applied tubesheet facings are used, all grooves should be in the base material unless otherwise specified by the purchaser. Other groove configurations may be used based on the exchanger manufacturer's experience or the recommendations of the expansion equipment manufacturer.

Tubesheet (cont.): tube to tubesheet joint

C-7.24 TUBE HOLE GROOVING

For design pressures over 300 psi (2068 kPa) and/or temperatures in excess of 350 °F (177 °C), the tube holes for expanded joints for tubes 5/8" (15.9mm) OD and larger shall be machined with annular ring groove(s) for additional longitudinal load resistance. For strength welded tube to tubesheet joints, ring grooves are not required.

(1) For roller expanded tube joints, when tubesheet thickness exceeds 1" (25.4mm), at least two grooves shall be used, each approximately 1/8" (3.2mm) wide by 1/64" (0.4mm) deep. Tubesheets with thickness less than or equal to 1" (25.4mm) may be provided with one groove.

(2) For hydraulic or explosive expanded tube joints, when tubesheet thickness exceeds 3" (76mm), at least two grooves shall be used. Minimum groove width shall be calculated as $w = 1.56\sqrt{Rt}$ where R = mean tube radius and t = tube wall thickness, except groove width need not exceed 1/2" (12.7mm). Groove depth to be 1/64" (0.4mm). Tubesheets with thickness less than or equal to 3" (76mm) may be provided with one groove.

When integrally clad or applied tubesheet facings are used, all grooves should be in the base material unless otherwise specified by the purchaser. Other groove configurations may be used based on the exchanger manufacturer's experience or the recommendations of the expansion equipment manufacturer.

Tubesheet (cont.): tube to tubesheet joint

***RCB-7.3 TUBE-TO-TUBESHEET JOINTS**

RCB-7.31 EXPANDED TUBE-TO-TUBESHEET JOINTS

Expanded tube-to-tubesheet joints are standard.

RB-7.311 LENGTH OF EXPANSION

Tubes shall be expanded into the tubesheet for a length no less than 2" (50.8 mm) or the tubesheet thickness minus 1/8" (3.2 mm), whichever is smaller. In no case shall the expanded portion extend beyond the shell side face of the tubesheet. When specified by the purchaser, tubes may be expanded for the full thickness of the tubesheet.

C-7.311 LENGTH OF EXPANSION

Tubes shall be expanded into the tubesheet for a length no less than two tube diameters, 2" (50.8 mm), or the tubesheet thickness minus 1/8" (3.2mm), whichever is smaller. In no case shall the expanded portion extend beyond the shell side face of the tubesheet. When specified by the purchaser, tubes may be expanded for the full thickness of the tubesheet.

RCB-7.312 CONTOUR OF THE EXPANDED TUBE

The expanding procedure shall be such as to provide substantially uniform expansion throughout the expanded portion of the tube, without a sharp transition to the unexpanded portion.

RCB-7.313 TUBE PROJECTION

Tubes shall be flush with or extend by no more than one half of a tube diameter beyond the face of each tubesheet, except that tubes shall be flush with the top tubesheet in vertical exchangers to facilitate drainage unless otherwise specified by the purchaser.

RCB-7.32 WELDED TUBE-TO-TUBESHEET JOINTS

When both tubes and tubesheets, or tubesheet facing, are of suitable materials, the tube joints may be welded.

RCB-7.321 SEAL WELDED JOINTS

When welded tube joints are used for additional leak tightness only, and tube loads are carried by the expanded joint, the tube joints shall be subject to the rules of Paragraphs RCB-7.2 through RCB-7.31.

Tubesheet (cont.): tube to tubesheet joint

RCB-7.322 STRENGTH WELDED JOINTS

When welded tube joints are used to carry the longitudinal tube loads, consideration may be given to modification of the requirements of Paragraphs RCB-7.2 through RCB-7.31. Minimum tubesheet thicknesses shown in Paragraphs R-7.11, C-7.11 and B-7.11 do not apply.

RCB-7.323 FABRICATION AND TESTING PROCEDURES

Welding procedures and testing techniques for either seal welded or strength welded tube joints shall be by agreement between the manufacturer and the purchaser.

RCB-7.33 EXPLOSIVE BONDED TUBE-TO-TUBESHEET JOINTS

Explosive bonding and/or explosive expanding may be used to attach tubes to the tubesheets where appropriate. Consideration should be given to modifying the relevant parameters (e.g., tube-to-tubesheet hole clearances and ligament widths) to obtain an effective joint.

R-7.4 TUBESHEET PASS PARTITION GROOVES

Tubesheets shall be provided with approximately 3/16" (4.8mm) deep grooves for pass partition gaskets.

CB-7.4 TUBESHEET PASS PARTITION GROOVES

For design pressures over 300 psi (2068 kPa), tubesheets shall be provided with pass partition grooves approximately 3/16" (4.8 mm) deep, or other suitable means for retaining the gaskets in place.

RCB-7.5 TUBESHEET PULLING EYES

In exchangers with removable tube bundles having a nominal diameter exceeding 12" (305 mm) and/or a tube length exceeding 96" (2438 mm), the stationary tubesheet shall be provided with two tapped holes in its face for pulling eyes. These holes shall be protected in service by plugs of compatible material. Provision for means of pulling may have to be modified or waived for special construction, such as clad tubesheets or manufacturer's standard, by agreement between the manufacturer and the purchaser.

RB-7.6 CLAD AND FACED TUBESHEETS

The nominal cladding thickness at the tube side face of a tubesheet shall not be less than 5/16" (7.8 mm) when tubes are expanded only, and 1/8" (3.2 mm) when tubes are welded to the tubesheet. The nominal cladding thickness on the shell side face shall not be less than 3/8" (9.5 mm). Clad surfaces, other than in the area into which tubes are expanded, shall have at least 1/8" (3.2 mm) nominal thickness of cladding.

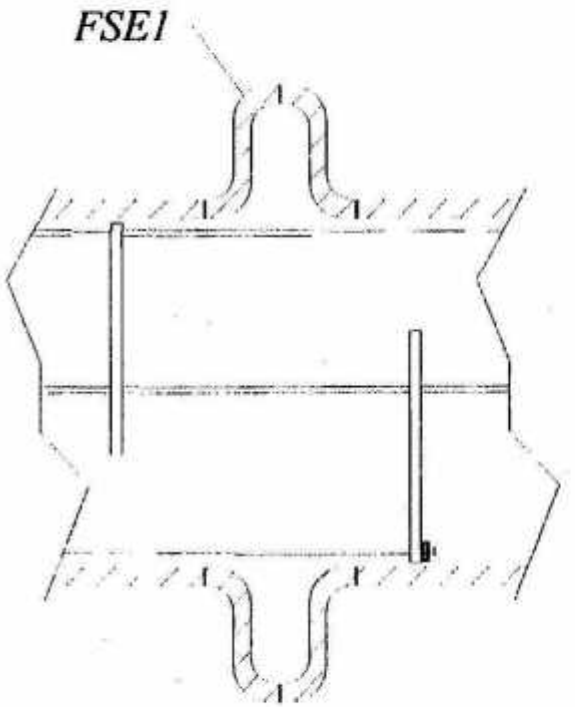
C-7.6 CLAD AND FACED TUBESHEETS

The nominal cladding thickness at the tube side face of a tubesheet shall not be less than 3/16" (4.8 mm) when tubes are expanded only, and 1/8" (3.2 mm) when tubes are welded to the tubesheet. The nominal cladding thickness on the shell side face shall not be less than 3/8" (9.5 mm). Clad surfaces, other than in the area into which tubes are expanded, shall have at least 1/8" (3.2 mm) nominal thickness of cladding.

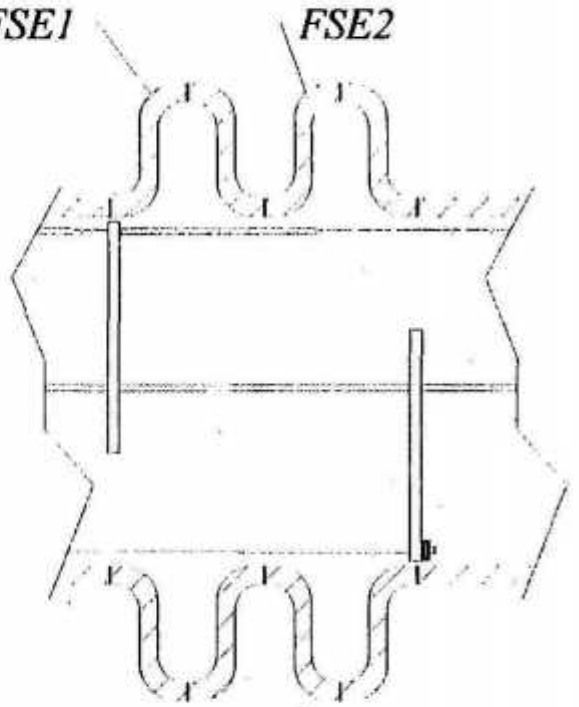
Flexible joint (expansion joint)

(4) above.

FIGURE RCB-8.51



ONE FLEXIBLE ELEMENT



TWO FLEXIBLE ELEMENTS

CB-9 CHANNELS, COVERS, AND BONNETS

RCB-9.1 CHANNELS AND BONNETS

R-9.11 MINIMUM THICKNESS OF CHANNELS AND BONNETS

Channel and bonnet thickness is determined by the Code design formulae, plus corrosion allowance, but in no case shall the nominal thickness of channels and bonnets be less than the minimum shell thicknesses shown in Table R-3.13. The nominal total thickness for clad channels and bonnets shall be the same as for carbon steel channels.

CB-9.11 MINIMUM THICKNESS OF CHANNELS AND BONNETS

Channel and bonnet thickness is determined by the Code design formulae, plus corrosion allowance, but in no case shall the nominal thickness of channels and bonnets be less than the minimum shell thicknesses shown in Table CB-3.13. The nominal total thickness for clad channels and bonnets shall be the same as for carbon steel channels.

RCB-9.12 MINIMUM INSIDE DEPTH

For multipass channels and bonnets the inside depth shall be such that the minimum cross-over area for flow between successive tube passes is at least equal to 1.3 times the flow area through the tubes of one pass. When an axial nozzle is used, the depth at the nozzle centerline shall be a minimum of one-third the inside diameter of the nozzle.

RCB-9.13 PASS PARTITION PLATES

RCB-9.131 MINIMUM THICKNESS

The thickness of pass partitions shall not be less than the greater of that shown in Table RCB-9.131 or calculated in Paragraph RCB-9.132. Pass partition plates may be tapered to gasket width at the contact surface.

TABLE RCB-9.131

NOMINAL PASS PARTITION PLATE THICKNESS
Dimensions are in Inches (mm)

Nominal Size	Carbon Steel	Alloy Material
Less than 24 (610)	3/8 (9.5)	1/4 (6.4)
24 to 60 (610-1524)	1/2 (12.7)	3/8 (9.5)
61 to 100 (1549-2540)	5/8 (15.9)	1/2 (12.7)

FIGURE G-5.2M HEAT EXCHANGER SPECIFICATION SHEET

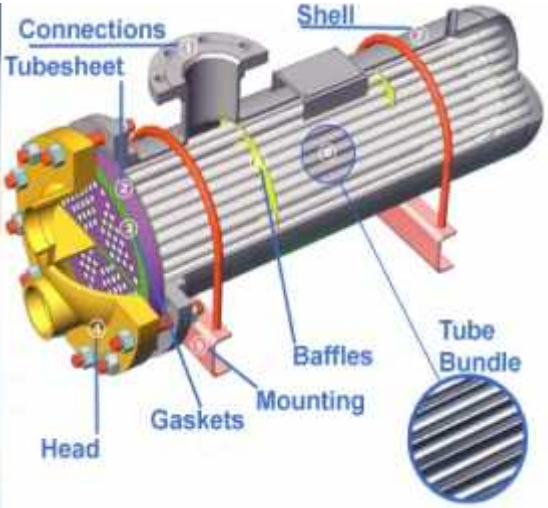
1						Job No.			
2	Customer					Reference No.			
3	Address					Proposal No.			
4	Plant Location					Date	Rev.		
5	Service of Unit					Item No.			
6	Size	Type	(Hor/Vert)			Connected in	Parallel	Series	
7	Surf/Unit (Gross/Eff.)		Sq m; Shells/Unit			Surf/Shell (Gross/Eff.)		sq m	
8	**PERFORMANCE OF ONE UNIT**								
9	Fluid Allocation			Shell Side		Tube Side			
10	Fluid Name								
11	Fluid Quantity Total		kg/Hr						
12	Vapor (In/Out)								
13	Liquid								
14	Steam								
15	Water								
16	Noncondensable								
17	Temperature (In/Out)		°C						
18	Specific Gravity								
19	Viscosity, Liquid		cP						
20	Molecular Weight, Vapor								
21	Molecular Weight, Noncondensable								
22	Specific Heat		J/kg °C						
23	Thermal Conductivity		W/m °C						
24	Latent Heat		J/kg @ °C						
25	Inlet Pressure		kPa(abs.)						
26	Velocity		m/sec						
27	Pressure Drop, Allow. /Calc.		kPa	/		/			
28	Fouling Resistance (Min.)		Sq m °C / W						
29	Heat Exchanged			W / MTD (Corrected)					°C
30	Transfer Rate, Service			Clean					W/Sq m °C
31	**CONSTRUCTION OF ONE SHELL**					Sketch (Bundle/Nozzle Orientation)			
32				Shell Side	Tube Side				
33	Design / Test Pressure		kPag	/	/				
34	Design Temp. Max/Min		°C	/	/				
35	No. Passes per Shell								
36	Corrosion Allowance		mm						
37	Connections	In							
38	Size &	Out							
39	Rating	Intermediate							
40	Tube No.	OD	mm;Thk (Min/Avg)		mm;Length	mm;Pitch	mm	◁ 30 △ 60 ▭ 90 ◇ 45	
41	Tube Type					Material			
42	Shell	ID	OD	mm		Shell Cover		(Integ.)	(Remov.)
43	Channel or Bonnet					Channel Cover			
44	Tubesheet-Stationary					Tubesheet-Floating			
45	Floating Head Cover					Impingement Protection			
46	Baffles-Cross		Type			%Cut (Diam/Area)	Spacing: c/c	Inlet	mm
47	Baffles-Long					Seal Type			
48	Supports-Tube		U-Bend			Type			
49	Bypass Seal Arrangement					Tube-to-Tubesheet Joint			
50	Expansion Joint					Type			
51	pV^2-Inlet Nozzle		Bundle Entrance			Bundle Exit			
52	Gaskets-Shell Side					Tube Side			
53	Floating Head								
54	Code Requirements					TEMA Class			
55	Weight / Shell		Filled with Water			Bundle			kg
56	Remarks								
57									
58									
59									
60									
61									

General design consideration

Factor	Tube-side	Shell-side
Corrosion	More corrosive fluid	Less corrosive fluids
Fouling	Fluids with high fouling and scaling	Low fouling and scaling
Fluid temperature	High temperature	Low temperature
Operating pressure	Fluids with high pressure	Fluids with low pressure
Viscosity	Less viscous fluid	More viscous fluid
Stream flow rate	High flow rate	Low flow rate

باشلر

سوال؟


Connections
Tubesheet
Shell
Baffles
Tube
Bundle
Mounting
Gaskets
Head