



ASME BPVC VIII-1 2021

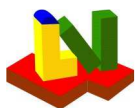
Example E4.18.8 PTB-4-2021

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Layout

Input values:	1.234	or	1.234
Calculated values:	1.234	or	1.234
Critical values:	1.234	or	1.234
Estimated values:	1.234	or	1.234



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Example E4.18.8 PTB-4-2021

Strength Calculation Software Program System ATLAS Version **10.0.92**
Developed by Lauterbach Verfahrenstechnik GmbH
Certified per DIN EN ISO 9001:2015 Certificate Number 01 100 044763

**Example 4.18.8 - Stationary Tubesheet Gasketed with Shell and Channel;
Floating Tubesheet Gasketed, Not Extending as a Flange**

Step 1

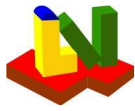
		LV Soft				ASME		Diff [%]
Basic ligament efficiency	μ	2,50E-01	2,50E-01			2,50E-01		0,00%
Effective ligament	μ^*	3,85E-01	3,85E-01			3,85E-01		0,07%
Effective depth	h_g'	5,00E+00	mm	1,97E-01	in	1,97E-01	in	0,00%
Equivalent radius	a_0	3,27E+02	mm	1,29E+01	in	1,29E+01	in	0,00%
Radial channel dimension	a_c	3,73E+02	mm	1,47E+01	in	1,47E+01	in	0,00%
Radial shell dimension	a_s	3,73E+02	mm	1,47E+01	in	1,47E+01	in	0,00%
Ratio = a_c/a_0	ρ_c	1,14E+00		1,14E+00		1,14E+00		0,07%
Ratio = a_s/a_0	ρ_s	1,14E+00		1,14E+00		1,14E+00		0,07%
Parameter	x_s	6,05E-01		6,05E-01		6,05E-01		0,05%
Parameter	x_t	7,60E-01		7,60E-01		7,60E-01		0,04%

Step 3

		LV Soft				ASME		Diff [%]
Eff. modulus of el.	E^*	7,52E+04	mm ² /N	1,09E+07	psi	1,09E+07	psi	0,04%
Ratio	E^*/E	4,04E-01		4,04E-01		4,04E-01		0,02%
Eff. Poisson's ratio	ν^*	3,08E-01		3,08E-01		3,08E-01		0,12%
Parameter: UHX-13.1	X_a	3,61E+00		3,61E+00		3,61E+00		0,01%
	Z_d	3,28E-02		3,28E-02		3,28E-02		0,13%
	Z_v	7,87E-02		7,87E-02		7,87E-02		0,05%
	Z_m	4,21E-01		4,21E-01		4,21E-01		0,07%
	Z_w	7,87E-02		7,87E-02		7,87E-02		0,05%

Step 4

		LV Soft				ASME		Diff [%]
Diameter ratio	K	1,28E+00		1,28E+00		1,28E+00		0,33%
Corfficient	F	4,28E-01		4,28E-01		4,29E-01		0,14%



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Parameter	Φ	5,60E-01	5,60E-01	5,61E-01	0,09%
	Q_1	7,82E-02	7,82E-02	7,82E-02	0,02%

Step 5

		LV Soft				ASME	Diff [%]
	ω_s	0,00E+00	mm ²	0,00E+00	in ²	0,00E+00 in ²	0,00%
	ω_s^*	1,13E+03	mm ²	1,76E+00	in ²	1,76E+00 in ²	0,01%
	ω_c	0,00E+00	mm ²	0,00E+00	in ²	0,00E+00 in ²	0,00%
	ω_c^*	1,13E+03	mm ²	1,76E+00	in ²	1,76E+00 in ²	0,01%
	γ_b			0,00E+00		0,00E+00	0,00%

Summary table for Step 6

		LV Soft				ASME		Diff [%]
Loading Case								
1	P_e	1,03E+00	Mpa	1,50E+02	psi	1,50E+02	psi	0,00%
2	P_e	1,72E+00	Mpa	2,50E+02	psi	2,50E+02	psi	0,00%
3	P_e	6,89E-01	Mpa	1,00E+02	psi	1,00E+02	psi	0,00%

Summary table for Step 7

		LV Soft				ASME		Diff [%]
Loading Case								
1	Q ₂	9,49E+02	N	2,13E+02	lbf	2,13E+02	psi	0,17%
	Q ₃	9,53E-02		9,53E-02		9,53E-02	psi	0,04%
	F _m	1,02E-01		1,02E-01		1,02E-01	psi	0,26%
	σ	1,13E+02	Mpa	1,64E+04	psi	1,64E+04	psi	0,12%
	1,5S	1,97E+02	Mpa	2,85E+04	psi	2,85E+04	psi	0,00%
2	Q ₂	1,58E+03	N	3,56E+02	lbf	3,56E+02	psi	0,12%
	Q ₃	9,53E-02		9,53E-02		9,53E-02	psi	0,04%
	F _m	1,02E-01		1,02E-01		1,02E-01	psi	0,26%
	σ	1,89E+02	Mpa	2,74E+04	psi	2,74E+04	psi	0,12%
	1,5S	1,97E+02	Mpa	2,85E+04	psi	2,85E+04	psi	0,00%
3	Q ₂	6,33E+02	N	1,42E+02	lbf	1,42E+02	psi	0,17%



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	Q₃	9,53E-02	9,53E-02	9,53E-02	psi	0,04%
	F_m	1,02E-01	1,02E-01	1,02E-01	psi	0,26%
	 σ 	7,55E+01	Mpa 1,09E+04	psi 1,09E+04	psi	0,43%
	1,5S	1,97E+02	Mpa 2,85E+04	psi 2,85E+04	psi	0,00%

Summary table for Step 8						
			LV Soft		ASME	Diff [%]
Loading Case						
1		tau	Mpa		psi	0,00%
		0,8S	Mpa	0,00E+00	psi	psi
2		tau	Mpa		psi	0,00%
		0,8S	Mpa	0,00E+00	psi	psi
3		tau	Mpa		psi	0,00%
		0,8S	Mpa	0,00E+00	psi	psi

Summary table for Step 9									
		LV Soft				ASME		Diff [%]	
Loading Case									
1	F_s	1,54E+00		1,54E+00		1,54E+00		0,02%	
	σ_{t,2}	1,77E+01	Mpa	2,56E+03	psi	2,56E+03	psi	0,01%	
	S_{t,b}	7,35E+01	Mpa	1,07E+04	psi	1,07E+04	psi	0,32%	
	S_t	9,20E+01	Mpa	1,34E+04	psi	1,34E+04	psi	0,00%	
2	F_s	1,54E+00		1,54E+00		1,54E+00		0,02%	
	-	-		-		-		-	
	σ_{t,2}	3,12E+01	Mpa	4,52E+03	psi	4,52E+03	psi	0,01%	
	S_{t,b}	7,35E+01	Mpa	1,07E+04	psi	1,07E+04	psi	0,32%	
3	S_t	9,20E+01	Mpa	1,34E+04	psi	1,34E+04	psi	0,00%	
	F_s	1,54E+00		1,54E+00		1,54E+00		0,02%	
	-	-		-		-		-	
	σ_{t,2}	1,35E+01	Mpa	1,96E+03	psi	1,96E+03	psi	0,02%	
	S_{t,b}	7,35E+01	Mpa	1,07E+04	psi	1,07E+04	psi	0,32%	
	S_t	9,20E+01	Mpa	1,34E+04	psi	1,34E+04	psi	0,00%	



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Example E4.18.8 PTB-4-2021

Stat - Floating Tubesheets - ASME BPVC VIII-1, UHX-14: 2021

Floating tubesheet according to ASME-UHX-14

Type of heat exchanger (a,b,c)

WArt a

Heat Exchanger With an Immersed Floating Head

Configuration of the tubesheet (a-f,A-D)

Type d

Stationary tubesheet gasketed with shell and channel

Type of channel (1=Cylinder, 2=Hemispherical)

1

Shell side internal operating pressure

P_s 250 psi

Tube side internal operating pressure

P_t 150 psi

Shell side internal test pressure

P_{sp} psi

Tube side internal test pressure

P_{tp} psi

Load case (1=operation, 2+3=test at 20°C, 4=other)

1

load case: operation

Calculation case acc. UHX-14.4(a): (1), (2) ... (7)

1

Tube side pressure only ($P_s=0$) without thermal expansion

Tubesheet material

Shell material (Type abc)

Tube material

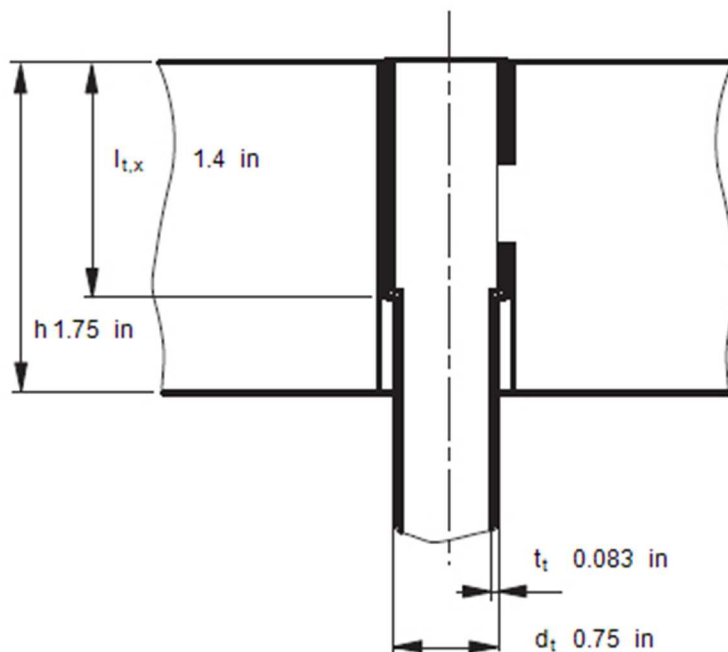
Channel material (Type aefA)



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Example E4.18.8 PTB-4-2021

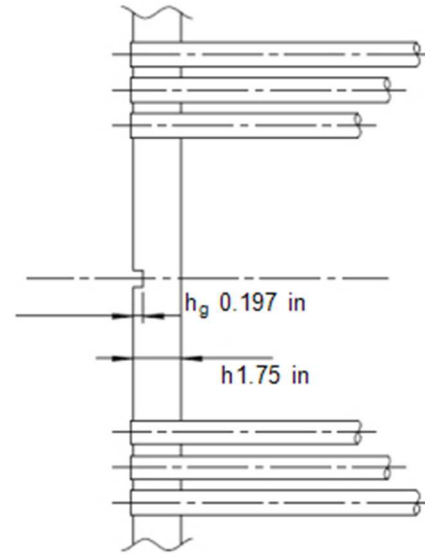
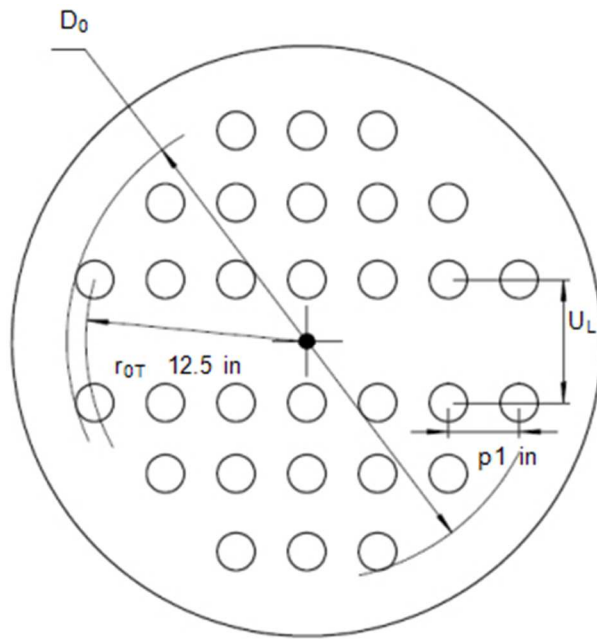
Operation	Tubesheet	Shell	Tubes	Channel
Temperature	°F	°F	°F	°F
Thickness	1.75 in	in	0.083 in	in
Outsidediameter	33.07 in	in	0.75 in	in
Poiss.-rat.	0.31	0.3	0.31	0.3
Allow. c1	0 in	in	0 in	in
Corr.all.c2	0 in	in	0 in	in
Figure				
Strength for the selected load case temperature				
Strength	psi	psi	psi	psi
Safety				
Modulus	2.7e+7 psi	psi	2.7e+7 psi	psi
of				
elasticity				
Therm.dil.	1E-6/°F	1E-6/°F	1E-6/°F	1E-6/°F
Yield str.	20550 psi	psi	20550 psi	psi
Limit	°F	°F	°F	°F
temperature				
All.stress	19000 psi	0 psi	13350 psi	0 psi
Pr.+sec.st	57000 psi	0 psi	psi	psi
Properties for testing at 20°C				
Strength	0 psi	0 psi	0 psi	0 psi
Safety				
Yield str.	psi	psi	psi	psi
Tensile str.	psi	psi	psi	psi
Additional specifications for the geometry and loading				
Tubesheet				
Tube-tubesheet joint		(1=expanded, 2=welded)		1
Tube pattern		(1=Triangle, 2=Square)		1
Number of tubes		N_t		466



Expanded length of tube in tubesheet		$l_{t,x}$	1.4 in
Expanded length ratio $l_{t,x}/h$		ρ	0.8
Radius to outermost tube hole center	UHX-11.1(a)	r_{0T}	12.5 in
Perimeter of the outermost tubes	UHX-12.2	C_p	in
Total area enclosed by C_p	UHX-12.2	A_p	in ²



ASME BPVC VIII-1 2021 Example E4.18.8 PTB-4-2021



Tube pitch (center distance)
Total untubed area $UL1 \cdot LL1 + UL2 \cdot LL2..$ UHX-11.2
Depth of tube side pass partition groove
Expanded length ratio ltx/h
Tube length between inner tubesheet faces
Unsupported tube span for buckling
Type of tube support (0.6=tubesheet-tubesheet, 0.8=tubesheet - support plate, 1=plate-plate)
Equivalent free buckling length $k \cdot l$

Flange

Bolt circle diameter (Type bcdefBC)
Number of bolts
Bolt root diameter
Total bolt area
Bolt material
Strength operation
Strength test
Safety operation
Safety test
Stress increase factor (1.5 acc. App.S)

p 1 in
 A_L 64.4 in²
 h_g 0.197 in
 ρ 0.8
 L 252.5 in
 l in
 k
 l_t 15.38 in
 C in
 n
 d_B in
 A_b 0 in²
 K_s psi
 K_{sp} psi
 S_s
 S_{sp}
 F_s 1.5

Gasket

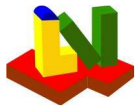
Contact outside diameter
Contact inside diameter
Theoretical seating width
Gasket factor (Table 2-5.1)
Gasket seating pressure
Diameter of gasket force
Poisson's ratio

Shell Type d,e,f

G_a in
 G_i in
 b_0 in
 m
 Y psi
 G 29.38 in
 v 0.3

Channel Type B,b,c,d

in
in
in
0 psi
29.38 in
0.3



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Example E4.18.8 PTB-4-2021

Results acc. UHX-9

	Shell	Channel
Effective seating width	b in	in
Gasket bolt-up force	W lbf	lbf
Gasket operating force	W lbf	211426 lbf
Total required bolt area	A_m in ²	in ²
Flange thickness	h_r in	in
Maximum bolt force for all calculation cases		W_{max} 211426 lbf
Bolt root area	0 in ² :	

Results acc. to UHX-14

Gasket seating force = $0.5(A_m + A_b) \cdot K_{sp}/S_{sp}$, App.2-5	W	211426 lbf
Channel thickness without allowances	t_c	in
Shell thickness without allowances	t_s	in

Step 1 acc. UHX 14.5

Basic ligament efficiency for shear	μ	0.25
Effective ligament efficiency for shear	μ^*	0.3853
Effective depth of pass partition groove	h_g'	0.197 in
Equivalent radius of outer tube limit circle	a_0	12.87 in
Radial channel dimension	a_c	14.69 in
Radial shell dimension	a_s	14.69 in
Ratio = a_c/a_0	ρ_C	1.141
Ratio = a_s/a_0	ρ_S	1.141
Parameter = $1 - N_t \cdot (0.5 \cdot d_a \text{ TUBE}/a_0)^2$	x_s	0.6047
Parameter = $1 - N_t \cdot (0.5 \cdot d_i \text{ TUBE}/a_0)^2$	x_t	0.7603

Step 2



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Example E4.18.8 PTB-4-2021

Step 3

Effective modulus of el. tubesheet (Fig.UHX-11.3)

Ratio of elasticity tubesheet

Effective Poisson's ratio tubesheet

Effective pitch

Effective tube hole diameter

Parameter for table UHX-13.1

Z_d 0.03276

Z_v 0.07874

Z_m 0.4213

Z_a 4.21

E^* 1.091e+7 psi

E^*/E 0.4039

ν^* 0.3084

p^* 1.068 in

d^* 0.6567 in

X_a 3.61

Z_w 0.07874

Step 4

Diameter ratio = A/D0

F 0.4284

Φ

0.5605

K 1.284

Q_1 0.07818

UHX-14.5.5 Step 5: Coefficients

ω_C 0 in²

ω_S 0 in²

ω_C^* 1.758 in²

ω_S^* 1.758 in²

γ_b 0

Results acc. to UHX-14.6 and step 6

T_r = 68 °F

T_s^* = 68 °F

T_c^* = 68 °F

P_s^* = 0 psi

P_c^* = 0 psi

P_e -150 psi

UHX-14.5.7 Step 7

Q_2 -213.4 lbf

Q_3 0.09534

F_m 0.1023

Strength condition for the tubesheet bending stress, case

σ = 16420 psi

$< 1.5 \cdot \sigma_B$ = 28500 psi

1 :

case 1-3

$< S_{PS}$ = 57000 psi

case 4-7

Step 8

Strength condition for the tubesheet shear stress:

τ = 0 psi $\leq \text{MIN}[0.8\sigma_B ; 0.533 S_y]$

= 10953 psi

Strength condition of step 7-8 are satisfied

Step 9, as examples UHX-20.3:2009 (old

N)

F_q 3.421

F_s 1.54

Strength condition for the tube stress with cacluation case

S_{T0} = 17.68 MN/mm²Pa $\leq \sigma_T$ = 13350 psi

1 :

for calculation case 1-3

S_{T0} $\leq 2 \cdot \sigma_T$ = 26700 psi

for calculation case 4-7

$|S_{T0}| \leq S_{tb}$ = 10665 psi

(for $S_{T0} < 0$, Buckling)

r_t 0.2376 in

F_t 64.72

C_t 161

Strength acc. UHX-14.5.9 satisfied

Step 10: Stress σ_S in the shell and σ_C in the channel

$\sigma_S = |\sigma_{Sm}| + |\sigma_{Sb}| = 0 \text{ psi} < 1.5 \cdot \sigma_{allS}, S_{PSs} \text{ or } S_{PSs1}$

$\sigma_S = |0 \text{ psi}| + |0 \text{ psi}| < 0 \text{ psi}$

$\sigma_C = |\sigma_{Cm}| + |\sigma_{Cb}| = 0 \text{ psi} < 1.5 \cdot \sigma_{allC} \text{ or } S_{PSc}$

$\sigma_C = |0 \text{ psi}| + |0 \text{ psi}| < 0 \text{ psi}$

Condition UHX-14.5.10 not required for configurations dBCD

Geometric conditions:

valid

Strength condition for linked modules (Connection activated:

Strength conditions are valid for all calculation cases

Yes):



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Stat-2 - Floating Tubesheets - ASME BPVC VIII-1, UHX-14: 2021

Floating tubesheet according to ASME-UHX-14

Type of heat exchanger (a,b,c)

WArt *a*

Heat Exchanger With an Immersed Floating Head

Configuration of the tubesheet (a-f,A-D)

Type *d*

Stationary tubesheet gasketed with shell and channel

Type of channel (1=Cylinder, 2=Hemispherical)

1

Shell side internal operating pressure

P_s 250 psi

Tube side internal operating pressure

P_t 150 psi

Shell side internal test pressure

P_{sp} psi

Tube side internal test pressure

P_{tp} psi

Load case (1=operation, 2+3=test at 20°C,
4=other)

1

load case: operation

Calculation case acc. UHX-14.4(a): (1), (2) ... (7)

2

Shell side pressure only ($P_t=0$) without thermal expansion

Tubesheet material

Shell material (Type abc)

Tube material

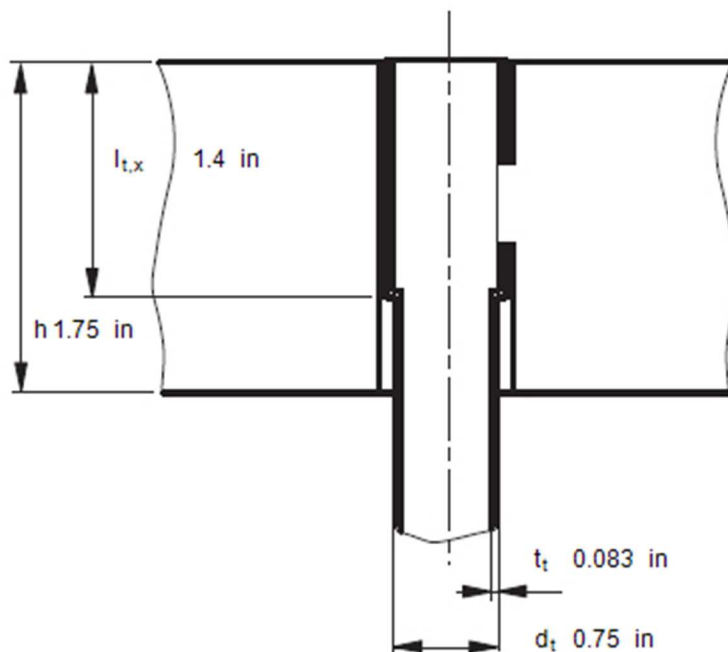
Channel material(Type aefA)



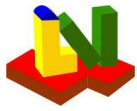
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Example E4.18.8 PTB-4-2021

Operation	Tubesheet	Shell	Tubes	Channel
Temperature	°F	°F	°F	°F
Thickness	1.75 in	in	0.083 in	in
Outsidediameter	33.07 in	in	0.75 in	in
Poiss.-rat.	0.31	0.3	0.31	0.3
Allow. c1	0 in	in	0 in	in
Corr.all.c2	0 in	in	0 in	in
Figure				
Strength for the selected load case temperature				
Strength	psi	psi	psi	psi
Safety				
Modulus	2.7e+7 psi	psi	2.7e+7 psi	psi
of				
elasticity				
Therm.dil.	1E-6/°F	1E-6/°F	1E-6/°F	1E-6/°F
Yield str.	20550 psi	psi	20550 psi	psi
Limit	°F	°F	°F	°F
temperature				
All.stress	19000 psi	0 psi	13350 psi	0 psi
Pr.+sec.st	57000 psi	0 psi	psi	psi
Properties for testing at 20°C				
Strength	0 psi	0 psi	0 psi	0 psi
Safety				
Yield str.	psi	psi	psi	psi
Tensile str.	psi	psi	psi	psi
Additional specifications for the geometry and loading				
Tubesheet				
Tube-tubesheet joint		(1=expanded, 2=welded)		1
Tube pattern		(1=Triangle, 2=Square)		1
Number of tubes		N _t		466

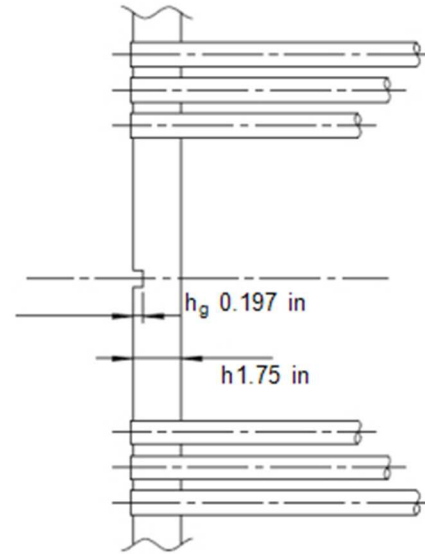
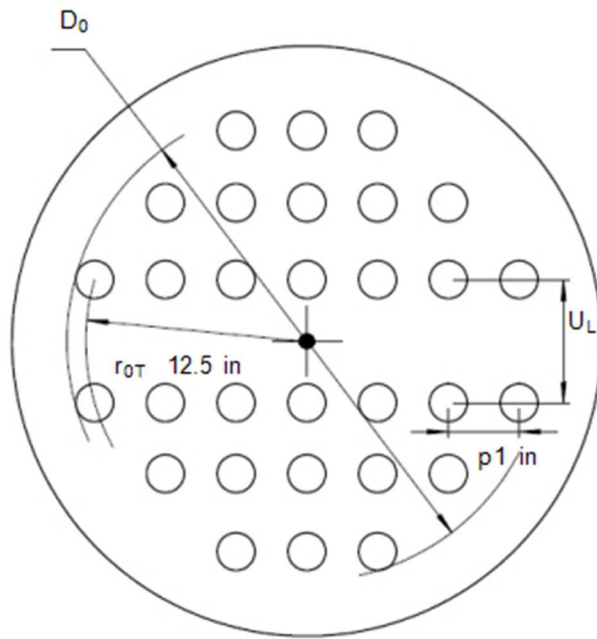


Expanded length of tube in tubesheet		$l_{t,x}$	1.4 in
Expanded length ratio $l_{t,x}/h$		ρ	0.8
Radius to outermost tube hole center	UHX-11.1(a)	r_{0T}	12.5 in
Perimeter of the outermost tubes	UHX-12.2	C_p	in
Total area enclosed by C_p	UHX-12.2	A_p	in ²



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Example E4.18.8 PTB-4-2021



Tube pitch (center distance)
 Total untubed area $UL1 \cdot LL1 + UL2 \cdot LL2..$ UHX-11.2
 Depth of tube side pass partition groove
 Expanded length ratio l_t/h
 Tube length between inner tubesheet faces
 Unsupported tube span for buckling
 Type of tube support (0.6=tubesheet-tubesheet, 0.8=tubesheet - support plate, 1=plate-plate)
 Equivalent free buckling length $k \cdot l$

Flange

Bolt circle diameter (Type bcdefBC)
 Number of bolts
 Bolt root diameter
 Total bolt area
 Bolt material
 Strength operation
 Strength test
 Safety operation
 Safety test
 Stress increase factor (1.5 acc. App.S)

p 1 in
 A_L 64.4 in²
 h_g 0.197 in
 ρ 0.8
 L 252.5 in
 l in
 k
 l_t 15.38 in
 C in
 n
 d_B in
 A_b 0 in²
 K_s psi
 K_{sp} psi
 S_s
 S_{sp}
 F_s 1.5

Gasket

Contact outside diameter
 Contact inside diameter
 Theoretical seating width
 Gasket factor (Table 2-5.1)
 Gasket seating pressure
 Diameter of gasket force
 Poisson's ratio

Shell Type d,e,f

G_a in
 G_i in
 b_o in
 m
 Y psi
 G 29.38 in
 v 0.3

Channel Type B,b,c,d

in
 in
 in
 0 psi
 29.38 in
 0.3



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Example E4.18.8 PTB-4-2021

Results acc. UHX-9

	Shell	Channel
Effective seating width	b in	in
Gasket bolt-up force	W lbf	lbf
Gasket operating force	W lbf	211426 lbf
Total required bolt area	A_m in ²	in ²
Flange thickness	h_r in	in
Maximum bolt force for all calculation cases		W_{max} 211426 lbf
Bolt root area	0 in ² :	

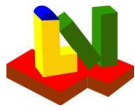
Results acc. to UHX-14

Gasket seating force = $0.5(A_m + A_b) \cdot K_{sp}/S_{sp}$, App.2-5	W	211426 lbf
Channel thickness without allowances	t_c	in
Shell thickness without allowances	t_s	in

Step 1 acc. UHX 14.5

Basic ligament efficiency for shear	μ	0.25
Effective ligament efficiency for shear	μ^*	0.3853
Effective depth of pass partition groove	h_g'	0.197 in
Equivalent radius of outer tube limit circle	a_0	12.87 in
Radial channel dimension	a_c	14.69 in
Radial shell dimension	a_s	14.69 in
Ratio = a_c/a_0	ρ_C	1.141
Ratio = a_s/a_0	ρ_S	1.141
Parameter = $1 - N_t \cdot (0.5 \cdot d_a \text{ TUBE}/a_0)^2$	x_s	0.6047
Parameter = $1 - N_t \cdot (0.5 \cdot d_i \text{ TUBE}/a_0)^2$	x_t	0.7603

Step 2



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Step 3

Effective modulus of el. tubesheet (Fig.UHX-11.3)

Ratio of elasticity tubesheet

Effective Poisson's ratio tubesheet

Effective pitch

Effective tube hole diameter

Parameter for table UHX-13.1

Z_d 0.03276

Z_v 0.07874

Z_m 0.4213

Z_a 4.21

E^* 1.091e+7 psi

E^*/E 0.4039

ν^* 0.3084

p^* 1.068 in

d^* 0.6567 in

X_a 3.61

Z_w 0.07874

Step 4

Diameter ratio = A/D0

F 0.4284

ϕ

0.5605

K 1.284

Q_1 0.07818

UHX-14.5.5 Step 5: Coefficients

ω_C 0 in²

ω_S 0 in²

ω_C^* 1.758 in²

ω_S^* 1.758 in²

ν_b 0

Results acc. to UHX-14.6 and step 6

T_r = 68 °F

T_s^* = 68 °F

T_c^* = 68 °F

P_s^* = 0 psi

P_c^* = 0 psi

P_e = 250 psi

UHX-14.5.7 Step 7

Q_2 355.6 lbf

Q_3 0.09534

F_m 0.1023

Strength condition for the tubesheet bending stress, case

σ = 27367 psi

$< 1.5 \cdot \sigma_B$ = 28500 psi

case 1-3

$< S_{PS}$ = 57000 psi

case 4-7

Step 8

Strength condition for the tubesheet shear stress:

τ = 0 psi $\leq \text{MIN}[0.8\sigma_B ; 0.533 S_y]$

= 10953 psi

Strength condition of step 7-8 are satisfied

Step 9, as examples UHX-20.3:2009 (old

N)

F_q 3.421

F_s 1.54

Strength condition for the tube stress with cacluation case

S_{T0} = -31.19 MN/mm²Pa $\leq \sigma_T$ = 13350 psi

2 : for calculation case 1-3

S_{T0} $\leq 2 \cdot \sigma_T$ = 26700 psi

for calculation case 4-7

$|S_{T0}| \leq S_{tb}$ = 10665 psi

(for $S_{T0} < 0$, Buckling)

r_t 0.2376 in

F_t 64.72

C_t 161

Buckling stability acc. UHX-14.5.9 satisfied

Step 10: Stress σ_S in the shell and σ_C in the channel

$\sigma_S = |\sigma_{Sm}| + |\sigma_{Sb}| = 0 \text{ psi} < 1.5 \cdot \sigma_{allS}, S_{PSs} \text{ or } S_{PSs1}$

$\sigma_S = |0 \text{ psi}| + |0 \text{ psi}| < 0 \text{ psi}$

$\sigma_C = |\sigma_{Cm}| + |\sigma_{Cb}| = 0 \text{ psi} < 1.5 \cdot \sigma_{allC} \text{ or } S_{PSc}$

$\sigma_C = |0 \text{ psi}| + |0 \text{ psi}| < 0 \text{ psi}$

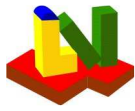
Condition UHX-14.5.10 not required for configurations dBCD

Geometric conditions:

valid

Strength condition for linked modules (Connection activated:

No):



ASME BPVC VIII-1 2021
Example E4.18.8 PTB-4-2021

Stat-3 - Floating Tubesheets - ASME BPVC VIII-1, UHX-14: 2021

Floating tubesheet according to ASME-UHX-14

Type of heat exchanger (a,b,c)

WArt *a*

Heat Exchanger With an Immersed Floating Head

Configuration of the tubesheet (a-f,A-D)

Type *d*

Stationary tubesheet gasketed with shell and channel

Type of channel (1=Cylinder, 2=Hemispherical)

P_s 1 250 psi

Shell side internal operating pressure

P_t 150 psi

Tube side internal operating pressure

P_{sp} psi

Shell side internal test pressure

P_{tp} psi

Tube side internal test pressure

Load case (1=operation, 2+3=test at 20°C,
4=other)

1

load case: operation

Calculation case acc. UHX-14.4(a): (1), (2) ... (7)

3

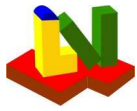
Tube and shell side pressure acting without thermal expansion

Tubesheet material

Shell material (Type abc)

Tube material

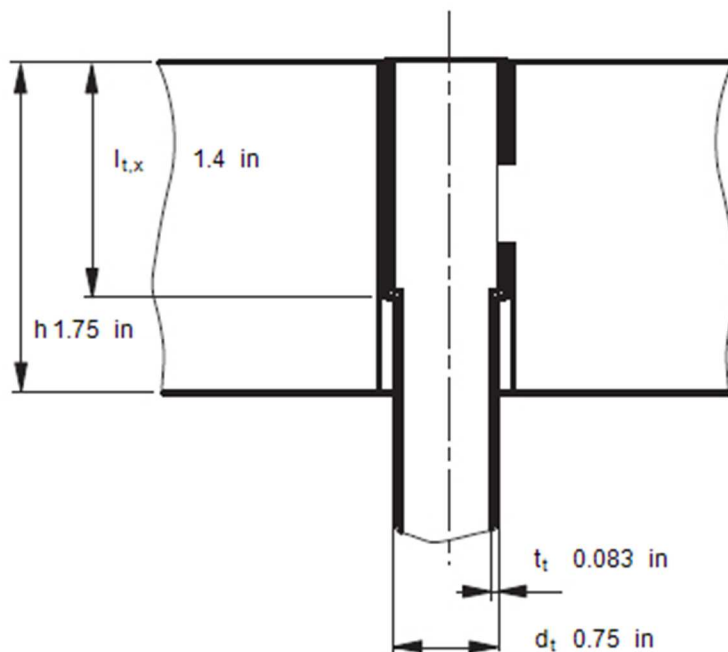
Channel material(Type aefA)



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Operation	Tubesheet	Shell	Tubes	Channel
Temperature	°F	°F	°F	°F
Thickness	1.75 in	in	0.083 in	in
Outsidediameter	33.07 in	in	0.75 in	in
Poiss.-rat.	0.31	0.3	0.31	0.3
Allow. c1	0 in	in	0 in	in
Corr.all.c2	0 in	in	0 in	in
Figure				
Strength for the selected load case temperature				
Strength	psi	psi	psi	psi
Safety				
Modulus	2.7e+7 psi	psi	2.7e+7 psi	psi
of				
elasticity				
Therm.dil.	1E-6/°F	1E-6/°F	1E-6/°F	1E-6/°F
Yield str.	20550 psi	psi	20550 psi	psi
Limit	°F	°F	°F	°F
temperature				
All.stress	19000 psi	0 psi	13350 psi	0 psi
Pr.+sec.st	57000 psi	0 psi	psi	psi
Properties for testing at 20°C				
Strength	0 psi	0 psi	0 psi	0 psi
Safety				
Yield str.	psi	psi	psi	psi
Tensile str.	psi	psi	psi	psi
Additional specifications for the geometry and loading				
Tubesheet				
Tube-tubesheet joint		(1=expanded, 2=welded)		1
Tube pattern		(1=Triangle, 2=Square)		1
Number of tubes		N _t		466

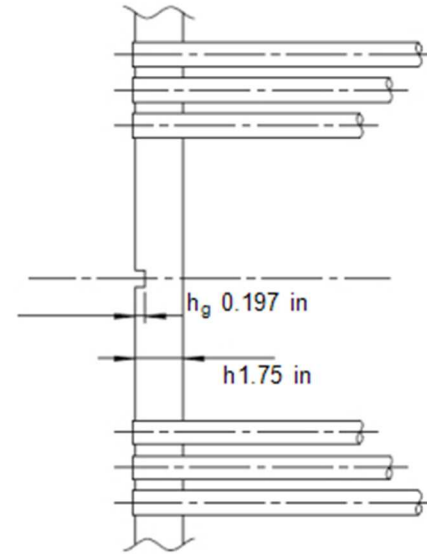
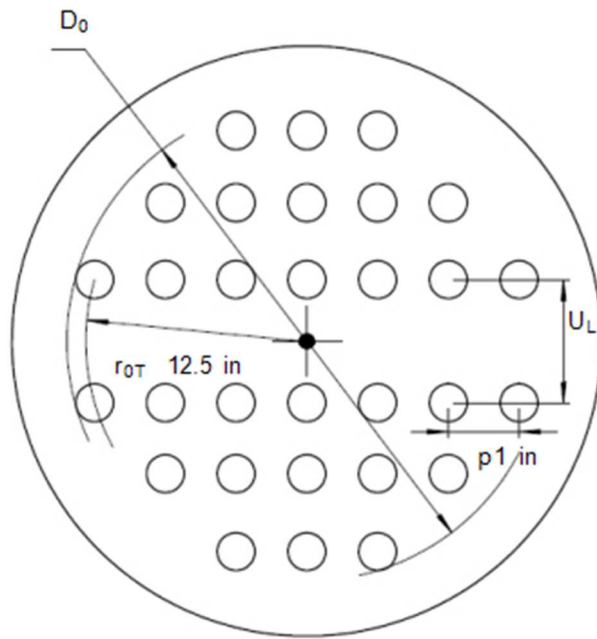


Expanded length of tube in tubesheet		$l_{t,x}$	1.4 in
Expanded length ratio $l_{t,x}/h$		ρ	0.8
Radius to outermost tube hole center	UHX-11.1(a)	r_{0T}	12.5 in
Perimeter of the outermost tubes	UHX-12.2	C_p	in
Total area enclosed by C_p	UHX-12.2	A_p	in ²



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021



Tube pitch (center distance)
 Total untubed area $UL1 \cdot LL1 + UL2 \cdot LL2..$ UHX-11.2
 Depth of tube side pass partition groove
 Expanded length ratio l_t/h
 Tube length between inner tubesheet faces
 Unsupported tube span for buckling
 Type of tube support (0.6=tubesheet-tubesheet, 0.8=tubesheet - support plate, 1=plate-plate)
 Equivalent free buckling length $k \cdot l$

Flange

Bolt circle diameter (Type bcdefBC)
 Number of bolts
 Bolt root diameter
 Total bolt area
 Bolt material
 Strength operation
 Strength test
 Safety operation
 Safety test
 Stress increase factor (1.5 acc. App.S)

p 1 in
 A_L 64.4 in²
 h_g 0.197 in
 ρ 0.8
 L 252.5 in
 l in
 k
 l_t 15.38 in
 C in
 n
 d_B in
 A_b 0 in²
 K_s psi
 K_{sp} psi
 S_s
 S_{sp}
 F_s 1.5

Gasket

Contact outside diameter
 Contact inside diameter
 Theoretical seating width
 Gasket factor (Table 2-5.1)
 Gasket seating pressure
 Diameter of gasket force
 Poisson's ratio

Shell Type d,e,f

G_a in
 G_i in
 b_o in
 m
 Y psi
 G 29.38 in
 v 0.3

Channel Type B,b,c,d

in
 in
 in
 0 psi
 29.38 in
 0.3



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Results acc. UHX-9

	Shell	Channel
Effective seating width	b in	in
Gasket bolt-up force	W lbf	lbf
Gasket operating force	W lbf	211426 lbf
Total required bolt area	A_m in ²	in ²
Flange thickness	h_r in	in
Maximum bolt force for all calculation cases		W_{max} 211426 lbf
Bolt root area	0 in ² :	

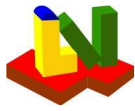
Results acc. to UHX-14

Gasket seating force = $0.5(A_m + A_b) \cdot K_{sp}/S_{sp}$, App.2-5	W	211426 lbf
Channel thickness without allowances	t_c	in
Shell thickness without allowances	t_s	in

Step 1 acc. UHX 14.5

Basic ligament efficiency for shear	μ	0.25
Effective ligament efficiency for shear	μ^*	0.3853
Effective depth of pass partition groove	h_g'	0.197 in
Equivalent radius of outer tube limit circle	a_0	12.87 in
Radial channel dimension	a_c	14.69 in
Radial shell dimension	a_s	14.69 in
Ratio = a_c/a_0	ρ_C	1.141
Ratio = a_s/a_0	ρ_S	1.141
Parameter = $1 - N_t \cdot (0.5 \cdot d_a \text{TUBE}/a_0)^2$	x_s	0.6047
Parameter = $1 - N_t \cdot (0.5 \cdot d_i \text{TUBE}/a_0)^2$	x_t	0.7603

Step 2



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Step 3

Effective modulus of el. tubesheet (Fig.UHX-11.3)

Ratio of elasticity tubesheet

Effective Poisson's ratio tubesheet

Effective pitch

Effective tube hole diameter

Parameter for table UHX-13.1

Z_d 0.03276 Z_v 0.07874 Z_m 0.4213 Z_a 4.21

E^* 1.091e+7 psi

E^*/E 0.4039

ν^* 0.3084

p^* 1.068 in

d^* 0.6567 in

X_a 3.61

Z_w 0.07874

Step 4

Diameter ratio = A/D0

F 0.4284 Φ 0.5605

K 1.284

Q_1 0.07818

UHX-14.5.5 Step 5: Coefficients

ω_C 0 in² ω_S 0 in²

ω_C^* 1.758 in²

ω_S^* 1.758 in²

ν_b 0

Results acc. to UHX-14.6 and step 6

T_r = 68 °F T_s^* = 68 °F

P_s^* = 0 psi P_c^* = 0 psi

T_c^* = 68 °F

P_e = 100 psi

UHX-14.5.7 Step 7

Q_2 142.2 lbf Q_3 0.09534

Strength condition for the tubesheet bending stress, case

σ = 10947 psi $< 1.5 \cdot \sigma_B$ = 28500 psi

$< S_{PS}$ = 57000 psi

F_m 0.1023

3 :

case 1-3

case 4-7

Step 8

Strength condition for the tubesheet shear stress:

τ = 0 psi $\leq \text{MIN}[0.8\sigma_B ; 0.533 S_y]$ = 10953 psi

Strength condition of step 7-8 are satisfied

Step 9, as examples UHX-20.3:2009 (old N)

F_q 3.421 F_s 1.54

Strength condition for the tube stress with cacluation case

S_{T0} = -13.51 MN/mm²Pa $\leq \sigma_T$ = 13350 psi

S_{T0} $\leq 2 \cdot \sigma_T$ = 26700 psi

$|S_{T0}|$ $\leq S_{tb}$ = 10665 psi

r_t 0.2376 in F_t 64.72

3 :

for calculation case 1-3

for calculation case 4-7

(for $S_{T0} < 0$, Buckling)

C_t 161

Buckling stability acc. UHX-14.5.9 satisfied

Step 10: Stress σ_S in the shell and σ_C in the channel

$\sigma_S = |\sigma_{Sm}| + |\sigma_{Sb}| = 0$ psi $< 1.5 \cdot \sigma_{allS}, S_{PSs}$ or S_{PSs1}

$\sigma_S = |0$ psi $+ 0$ psi $| < 0$ psi

$\sigma_C = |\sigma_{Cm}| + |\sigma_{Cb}| = 0$ psi $< 1.5 \cdot \sigma_{allC}$ or S_{PSc}

$\sigma_C = |0$ psi $+ 0$ psi $| < 0$ psi

Condition UHX-14.5.10 not required for configurations dBCD

Geometric conditions:

valid

Strength condition for linked modules (Connection activated:

No):



ASME BPVC VIII-1 2021
Example E4.18.8 PTB-4-2021

**Example 4.18.8 - Stationary Tubesheet Gasketed with Shell and Channel;
Floating Tubesheet Gasketed, Not Extenden as a Flange**

Step 1

		LV Soft				ASME		Diff [%]
Basic ligament	μ	2,50E-01		2,50E-01		2,50E-01		0,00%
Eff. ligament efficiency	μ^*	3,85E-01		3,85E-01		3,85E-01		0,07%
Eff. depth	h_g'	5,00E+00	mm	1,97E-01	in	1,97E-01	in	0,00%
Equivalent radius	a_0	3,27E+02	mm	1,29E+01	in	1,29E+01	in	0,00%
Radial channel dimension	a_c	3,73E+02	mm	1,47E+01	in	1,47E+01	in	0,00%
Radial shell dimension	a_s	3,73E+02	mm	1,47E+01	in	1,47E+01	in	0,00%
Ratio = a_c/a_0	ρ_c	1,03E+00		1,03E+00		1,03E+00		0,10%
Ratio = a_s/a_0	ρ_s	1,03E+00		1,03E+00		1,03E+00		0,10%
Parameter	x_s	6,05E-01		6,05E-01		6,05E-01		0,05%
Parameter	x_t	7,60E-01		7,60E-01		7,60E-01		0,04%

Step 3

		LV Soft				ASME		Diff [%]
Eff. modulus of el.	E^*	7,52E+04	mm ² /N	1,09E+07	psi	1,09E+07	psi	0,04%
Ratio of elasticity	E^*/E	4,04E-01		4,04E-01		4,04E-01		0,02%
Eff. Poisson's ratio	ν^*	3,08E-01		3,08E-01		3,08E-01		0,12%
Parameter: table 13.1	X_a	3,61E+00		3,61E+00		3,61E+00		0,01%
	Z_d	3,28E-02		3,28E-02		3,28E-02		0,13%
	Z_v	7,87E-02		7,87E-02		7,87E-02		0,05%
	Z_m	4,21E-01		4,21E-01		4,21E-01		0,07%
	Z_w	7,87E-02		7,87E-02		7,87E-02		0,05%



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Step 4

		LV Soft		ASME	Diff [%]
Diameter ratio	K	1,04E+00	1,04E+00	1,04E+00	0,41%
Corfficient	F	7,42E-02	7,42E-02	7,42E-02	0,03%
Parameter	Φ	9,70E-02	9,70E-02	9,71E-02	0,05%
	Q₁	2,05E-02	2,05E-02	2,05E-02	0,04%

Step 5

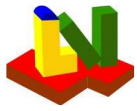
		LV Soft		ASME	Diff [%]
	ω_S	0,00E+00 mm ²	0,00E+00 in ²	0,00E+00 in ²	0,00%
	ω_S*	4,55E+01 mm ²	7,06E-02 in ²	7,06E-02 in ²	0,04%
	ω_C	0,00E+00 mm ²	0,00E+00 in ²	0,00E+00 in ²	0,00%
	ω_C*	4,55E+01 mm ²	7,06E-02 in ²	7,06E-02 in ²	0,04%
	γ_b		0,00E+00	0,00E+00	0,00%

Summary table for Step 6

		LV Soft				ASME		Diff [%]
Loading Case								
1	P _e	-1,03E+00	Mpa	-1,50E+02	psi	1,50E+02	psi	0,00%
2	P _e	1,72E+00	Mpa	2,50E+02	psi	2,50E+02	psi	0,00%
3	P _e	6,89E-01	Mpa	1,00E+02	psi	1,00E+02	psi	0,00%

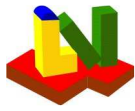
Summary table for Step 7

		LV Soft				ASME		Diff [%]
Loading Case								
1	Q ₂	-4,52E+01	N	-1,02E+01	lbf	-		0,29%
	Q ₃	2,13E-02		2,13E-02		2,13E-02	psi	0,04%
	F _m	7,51E-02		7,51E-02		7,50E-02	psi	0,13%
	σ	6,55E+01	Mpa	9,50E+03	psi	9,50E+03	psi	0,04%
	1,5S	1,97E+02	Mpa	2,85E+04	psi	2,85E+04	psi	0,00%
2	Q ₂	7,54E+01	N	1,70E+01	lbf	1,69E+01	psi	0,30%



ASME BPVC VIII-1 2021
Example E4.18.8 PTB-4-2021

	Q₃	2,13E-02		2,13E-02		2,13E-02 psi	0,04%
	F_m	7,51E-02		7,51E-02		7,51E-02 psi	0,01%
	 σ 	1,09E+02 Mpa		1,58E+04 psi		1,58E+04 psi	0,17%
	1,5S	1,97E+02 Mpa		2,85E+04 psi		2,85E+04 psi	0,00%
3	Q₂	3,02E+01 N		6,78E+00 lbf		6,78E+00 psi	0,00%
	Q₃	2,13E-02		2,13E-02		2,13E-02 psi	0,04%
	F_m	7,51E-02		7,51E-02		7,51E-02 psi	0,01%
	 σ 	4,36E+01 Mpa		6,33E+03 psi		6,33E+03 psi	0,01%
	1,5S	1,97E+02 Mpa		2,85E+04 psi		2,85E+04 psi	0,00%



ASME BPVC VIII-1 2021
Example E4.18.8 PTB-4-2021

Float - Floating Tubesheets - ASME BPVC VIII-1, UHX-14: 2021

Floating tubesheet according to ASME-UHX-14

Type of heat exchanger (a,b,c)

WArt a

Heat Exchanger With an Immersed Floating Head

Configuration of the tubesheet (a-f,A-D)

Type C

Floating tubesheet gasketed, without flange extension

Type of channel (1=Cylinder, 2=Hemispherical)

1

Shell side internal operating pressure

P_s 250 psi

Tube side internal operating pressure

P_t 150 psi

Shell side internal test pressure

P_{sp} psi

Tube side internal test pressure

P_{tp} psi

Load case (1=operation, 2+3=test at 20°C,
4=other)

1

load case: operation

Calculation case acc. UHX-14.4(a): (1), (2) ... (7)

1

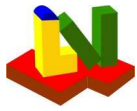
Tube side pressure only ($P_s=0$) without thermal expansion

Tubesheet material

Shell material (Type abc)

Tube material

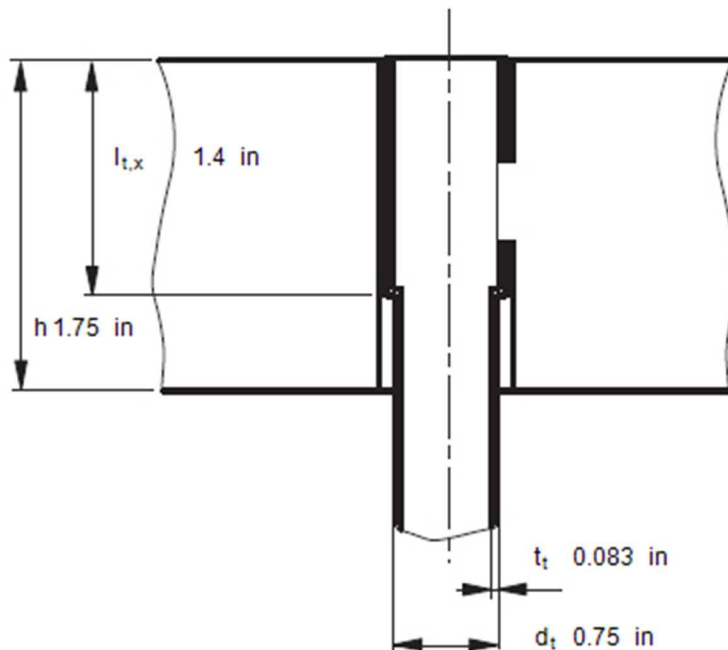
Channel material(Type aefA)



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Operation	Tubesheet	Shell	Tubes	Channel
Temperature	°F	°F	°F	°F
Thickness	1.75 in	in	0.083 in	0.3125 in
Outsidediameter	26.89 in	in	0.75 in	27.03 in
Poiss.-rat.	0.31	0.3	0.31	0.32
Allow. c1	0 in	in	0 in	0 in
Corr.all.c2	0 in	in	0 in	0 in
Figure				
Strength for the selected load case temperature				
Strength	psi	psi	psi	psi
Safety				
Modulus	2.7e+7 psi	psi	2.7e+7 psi	1.48e+7 psi
of				
elasticity				
Therm.dil.	1E-6/°F	1E-6/°F	1E-6/°F	4.8 1E-6/°F
Yield str.	20550 psi	psi	20550 psi	31600 psi
Limit	°F	°F	°F	°F
temperature				
All.stress	19000 psi	0 psi	13350 psi	11300 psi
Pr.+sec.st	57000 psi	0 psi	psi	33900 psi
Properties for testing at 20°C				
Strength	0 psi	0 psi	0 psi	0 psi
Safety				
Yield str.	psi	psi	psi	psi
Tensile str.	psi	psi	psi	psi
Additional specifications for the geometry and loading				
Tubesheet				
Tube-tubesheet joint		(1=expanded, 2=welded)		1
Tube pattern		(1=Triangle, 2=Square)		1
Number of tubes		N_t		466

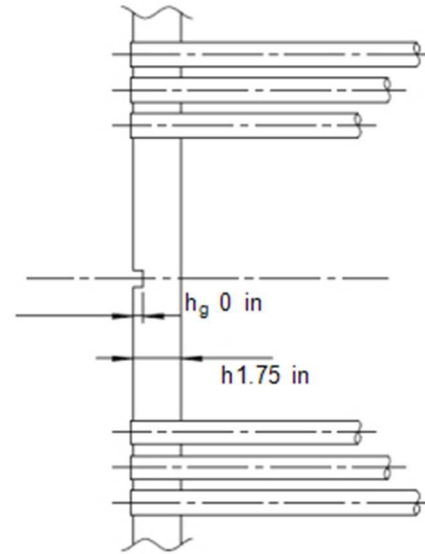
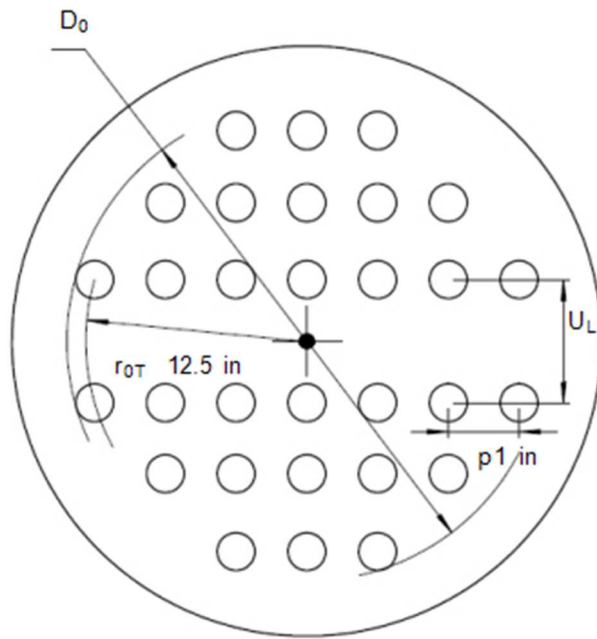


Expanded length of tube in tubesheet		$l_{t,x}$	1.4 in
Expanded length ratio $l_{t,x}/h$		ρ	0.8
Radius to outermost tube hole center	UHX-11.1(a)	r_{0T}	12.5 in
Perimeter of the outermost tubes	UHX-12.2	C_p	in
Total area enclosed by C_p	UHX-12.2	A_p	in ²



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021



Tube pitch (center distance)
 Total untubed area $UL1 \cdot LL1 + UL2 \cdot LL2..$ UHX-11.2
 Depth of tube side pass partition groove
 Expanded length ratio lt_x/h
 Tube length between inner tubesheet faces
 Unsupported tube span for buckling
 Type of tube support (0.6=tubesheet-tubesheet, 0.8=tubesheet - support plate, 1=plate-plate)
 Equivalent free buckling length $k \cdot l$

Flange

Mean contact diameter tubesheet-flange (Type cfC)
 Bolt circle diameter (Type bcdefBC)
 Number of bolts
 Bolt root diameter
 Total bolt area
 Bolt material
 Strength operation
 Strength test
 Safety operation
 Safety test
 Stress increase factor (1.5 acc. App.S)

p 1 in
 A_L 64.4 in²
 h_g 0 in
 ρ 0.8
 L 252.5 in
 l in
 k
 l_t 15.38 in
 G_1 26.5 in
 C 27.99 in
 n
 d_B in
 A_b 0 in²
 K_s psi
 K_{sp} psi
 S_s
 S_{sp}
 F_s 1.5

Gasket

Contact outside diameter
 Contact inside diameter
 Theoretical seating width
 Gasket factor (Table 2-5.1)
 Gasket seating pressure
 Diameter of gasket force
 Poisson's ratio

Shell Type d,e,f

G_a in
 G_i in
 b_0 in
 m
 Y psi
 G in
 v 0.3

Channel Type B,b,c,d

in
 in
 in
 0 psi
 26.5 in
 0.32



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Results acc. UHX-9

	Shell	Channel
Effective seating width	b in	in
Gasket bolt-up force	W lbf	lbf
Gasket operating force	W lbf	26225 lbf
Total required bolt area	A_m in ²	0 in ²
Flange thickness	h_r in	0 in
Maximum bolt force for all calculation cases		W_{max} 0 lbf
Bolt root area	0 in ² : sufficient	

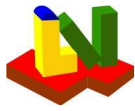
Results acc. to UHX-14

Gasket seating force = $0.5(A_m + A_b) \cdot K_{sp}/S_{sp}$, App.2-5	W	26225 lbf
Channel thickness without allowances	t_c	0.3125 in
Shell thickness without allowances	t_s	in

Step 1 acc. UHX 14.5

Basic ligament efficiency for shear	μ	0.25
Effective ligament efficiency for shear	μ^*	0.3853
Effective depth of pass partition groove	h_g'	0 in
Equivalent radius of outer tube limit circle	a_0	12.87 in
Radial channel dimension	a_c	13.25 in
Radial shell dimension	a_s	13.25 in
Ratio = a_c/a_0	ρ_C	1.029
Ratio = a_s/a_0	ρ_S	1.029
Parameter = $1 - N_t \cdot (0.5 \cdot d_a \text{ TUBE}/a_0)^2$	x_s	0.6047
Parameter = $1 - N_t \cdot (0.5 \cdot d_i \text{ TUBE}/a_0)^2$	x_t	0.7603

Step 2



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Step 3

Effective modulus of el. tubesheet (Fig.UHX-11.3)

Ratio of elasticity tubesheet

Effective Poisson's ratio tubesheet

Effective pitch

Effective tube hole diameter

Parameter for table UHX-13.1

$Z_d = 0.03276$ $Z_v = 0.07874$ $Z_m = 0.4213$ $Z_a = 4.21$

$E^* = 1.091e+7$ psi

$E^*/E = 0.4039$

$\nu^* = 0.3084$

$p^* = 1.068$ in

$d^* = 0.6567$ in

$X_a = 3.61$

$Z_w = 0.07874$

Step 4

Diameter ratio = A/D0

$F = 0.07417$ $\Phi = 0.09705$

$K = 1.044$

$Q_1 = 0.02049$

UHX-14.5.5 Step 5: Coefficients

$\omega_S = 0$ in² $\omega_C^* = 0.07057$ in²

$\omega_S^* = 0.07057$ in²

$\omega_C = 0$ in²

$\nu_b = 0$

Results acc. to UHX-14.6 and step 6

$T_r = 68$ °F $T_s^* = 68$ °F

$T_c^* = 68$ °F

$P_s^* = 0$ psi $P_c^* = 0$ psi

$P_e = -150$ psi

UHX-14.5.7 Step 7

$Q_2 = -10.17$ lbf $Q_3 = 0.02131$

$F_m = 0.0751$

Strength condition for the tubesheet bending stress, case

$\sigma = 9496$ psi $< 1.5 \cdot \sigma_B = 28500$ psi

case 1-3

$< S_{PS} = 57000$ psi

case 4-7

Step 8

Strength condition for the tubesheet shear stress:

$\tau = 0$ psi $\leq \text{MIN}[0.8\sigma_B ; 0.533 S_y] = 10953$ psi

Strength condition of step 7-8 are satisfied

Step 9, as examples UHX-20.3:2009 (old N)

$F_q = 2.925$ $F_s = 1.787$

Strength condition for the tube stress with cacluation case

$S_{T0} = 14.39$ MN/mm²Pa $\leq \sigma_T = 13350$ psi

1 :

$S_{T0} \leq 2 \cdot \sigma_T = 26700$ psi

for calculation case 1-3

$|S_{T0}| \leq S_{tb} = 9188$ psi

for calculation case 4-7

$r_t = 0.2376$ in $F_t = 64.72$

(for $S_{T0} < 0$, Buckling)

$C_t = 161$

Condition UHX-14.5.9 not required for configuration ABCD

Step 10: Stress σ_S in the shell and σ_C in the channel

$\sigma_S = |\sigma_{Sm}| + |\sigma_{Sb}| = 0$ psi $< 1.5 \cdot \sigma_{allS}, S_{PSs}$ or S_{PSs1}

$\sigma_S = 0$ psi $+ 0$ psi < 0 psi

$\sigma_C = |\sigma_{Cm}| + |\sigma_{Cb}| = 0$ psi $< 1.5 \cdot \sigma_{allC}$ or S_{PSc}

$\sigma_C = 0$ psi $+ 0$ psi < 16950 psi

Condition UHX-14.5.10 not required for configurations dBCD

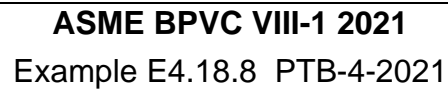
Geometric conditions:

valid

Strength condition for linked modules (Connection activated:

Yes):

Strength conditions are valid for all calculation cases

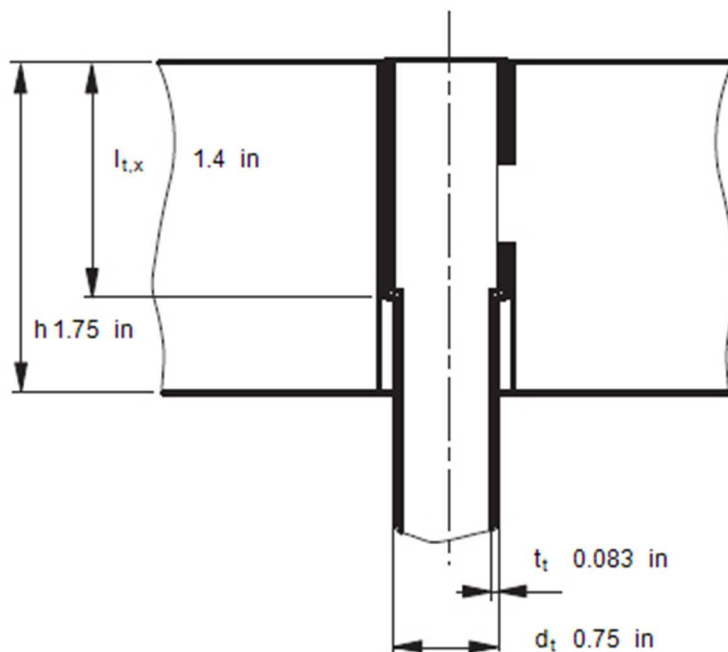




ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Operation	Tubesheet	Shell	Tubes	Channel
Temperature	°F	°F	°F	°F
Thickness	1.75 in	in	0.083 in	0.3125 in
Outsidediameter	26.89 in	in	0.75 in	27.03 in
Poiss.-rat.	0.31	0.3	0.31	0.32
Allow. c1	0 in	in	0 in	0 in
Corr.all.c2	0 in	in	0 in	0 in
Figure				
Strength for the selected load case temperature				
Strength	psi	psi	psi	psi
Safety				
Modulus of elasticity	2.7e+7 psi	psi	2.7e+7 psi	1.48e+7 psi
Therm.dil.	1E-6/°F	1E-6/°F	1E-6/°F	4.8 1E-6/°F
Yield str.	20550 psi	psi	20550 psi	31600 psi
Limit temperature	°F	°F	°F	°F
All.stress	19000 psi	0 psi	13350 psi	11300 psi
Pr.+sec.st	57000 psi	0 psi	psi	33900 psi
Properties for testing at 20°C				
Strength	0 psi	0 psi	0 psi	0 psi
Safety				
Yield str.	psi	psi	psi	psi
Tensile str.	psi	psi	psi	psi
Additional specifications for the geometry and loading				
Tubesheet				
Tube-tubesheet joint		(1=expanded, 2=welded)		1
Tube pattern		(1=Triangle, 2=Square)		1
Number of tubes		N_t		466

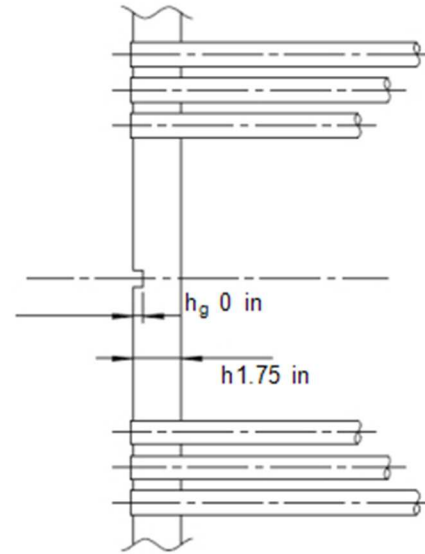
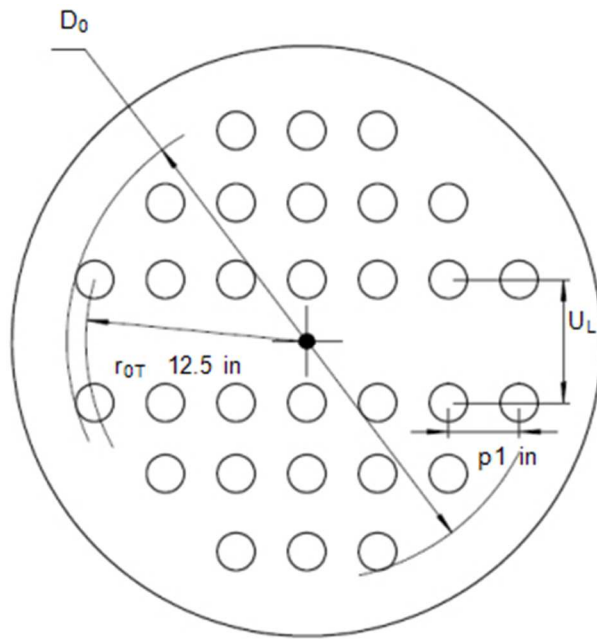


Expanded length of tube in tubesheet		$l_{t,x}$	1.4 in
Expanded length ratio $l_{t,x}/h$		ρ	0.8
Radius to outermost tube hole center	UHX-11.1(a)	r_{0T}	12.5 in
Perimeter of the outermost tubes	UHX-12.2	C_p	in
Total area enclosed by C_p	UHX-12.2	A_p	in ²



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021



Tube pitch (center distance)
 Total untubed area $UL1 \cdot LL1 + UL2 \cdot LL2..$ UHX-11.2
 Depth of tube side pass partition groove
 Expanded length ratio ltx/h
 Tube length between inner tubesheet faces
 Unsupported tube span for buckling
 Type of tube support (0.6=tubesheet-tubesheet, 0.8=tubesheet - support plate, 1=plate-plate)
 Equivalent free buckling length $k \cdot l$

Flange

Mean contact diameter tubesheet-flange (Type cfC)
 Bolt circle diameter (Type bcdefBC)
 Number of bolts
 Bolt root diameter
 Total bolt area
 Bolt material
 Strength operation
 Strength test
 Safety operation
 Safety test
 Stress increase factor (1.5 acc. App.S)

p 1 in
 A_L 64.4 in²
 h_g 0 in
 ρ 0.8
 L 252.5 in
 l in
 k
 l_t 15.38 in
 G_1 26.5 in
 C 27.99 in
 n
 d_B in
 A_b 0 in²
 K_s psi
 K_{sp} psi
 S_s
 S_{sp}
 F_s 1.5

Gasket

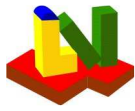
Contact outside diameter
 Contact inside diameter
 Theoretical seating width
 Gasket factor (Table 2-5.1)
 Gasket seating pressure
 Diameter of gasket force
 Poisson's ratio

Shell Type d,e,f

G_a in
 G_i in
 b_0 in
 m
 Y psi
 G in
 v 0.3

Channel Type B,b,c,d

in
 in
 in
 0 psi
 26.5 in
 0.32



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Results acc. UHX-9

	Shell	Channel
Effective seating width	b in	in
Gasket bolt-up force	W lbf	lbf
Gasket operating force	W lbf	26225 lbf
Total required bolt area	A_m in ²	0 in ²
Flange thickness	h_r in	0 in
Maximum bolt force for all calculation cases		W_{max} 0 lbf
Bolt root area	0 in ² : sufficient	

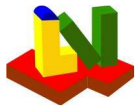
Results acc. to UHX-14

Gasket seating force = $0.5(A_m + A_b) \cdot K_{sp}/S_{sp}$, App.2-5	W	26225 lbf
Channel thickness without allowances	t_c	0.3125 in
Shell thickness without allowances	t_s	in

Step 1 acc. UHX 14.5

Basic ligament efficiency for shear	μ	0.25
Effective ligament efficiency for shear	μ^*	0.3853
Effective depth of pass partition groove	h_g'	0 in
Equivalent radius of outer tube limit circle	a_0	12.87 in
Radial channel dimension	a_c	13.25 in
Radial shell dimension	a_s	13.25 in
Ratio = a_c/a_0	ρ_C	1.029
Ratio = a_s/a_0	ρ_S	1.029
Parameter = $1 - N_t \cdot (0.5 \cdot d_a \text{TUBE}/a_0)^2$	x_s	0.6047
Parameter = $1 - N_t \cdot (0.5 \cdot d_i \text{TUBE}/a_0)^2$	x_t	0.7603

Step 2



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Step 3

Effective modulus of el. tubesheet (Fig.UHX-11.3)

Ratio of elasticity tubesheet

Effective Poisson's ratio tubesheet

Effective pitch

Effective tube hole diameter

Parameter for table UHX-13.1

$Z_d = 0.03276$ $Z_v = 0.07874$ $Z_m = 0.4213$ $Z_a = 4.21$

$E^* = 1.091e+7$ psi

$E^*/E = 0.4039$

$\nu^* = 0.3084$

$p^* = 1.068$ in

$d^* = 0.6567$ in

$X_a = 3.61$

$Z_w = 0.07874$

Step 4

Diameter ratio = A/D0

$F = 0.07417$ $\Phi = 0.09705$

$K = 1.044$

$Q_1 = 0.02049$

UHX-14.5.5 Step 5: Coefficients

$\omega_C = 0$ in² $\omega_S = 0$ in²

$\omega_C^* = 0.07057$ in² $\omega_S^* = 0.07057$ in²

$\omega_S^* = 0.07057$ in²

$\nu_b = 0$

Results acc. to UHX-14.6 and step 6

$T_r = 68$ °F $T_s^* = 68$ °F

$P_s^* = 0$ psi $P_c^* = 0$ psi

$T_c^* = 68$ °F

$P_e = 250$ psi

UHX-14.5.7 Step 7

$Q_2 = 16.95$ lbf $Q_3 = 0.02131$

Strength condition for the tubesheet bending stress, case

$\sigma = 15826$ psi $< 1.5 \cdot \sigma_B = 28500$ psi

$< S_{PS} = 57000$ psi

$F_m = 0.0751$

2 :

case 1-3

case 4-7

Step 8

Strength condition for the tubesheet shear stress:

$\tau = 0$ psi $\leq \text{MIN}[0.8\sigma_B ; 0.533 S_y] = 10953$ psi

Strength condition of step 7-8 are satisfied

Step 9, as examples UHX-20.3:2009 (old N)

$F_q = 2.925$ $F_s = 1.787$

Strength condition for the tube stress with cacluation case

$S_{T0} = -25.7$ MN/mm²Pa $\leq \sigma_T = 13350$ psi

$S_{T0} \leq 2 \cdot \sigma_T = 26700$ psi

$|S_{T0}| \leq S_{tb} = 9188$ psi

$r_t = 0.2376$ in $F_t = 64.72$

2 :

for calculation case 1-3

for calculation case 4-7

(for $S_{T0} < 0$, Buckling)

$C_t = 161$

Condition UHX-14.5.9 not required for configuration ABCD

Step 10: Stress σ_S in the shell and σ_C in the channel

$\sigma_S = |\sigma_{Sm}| + |\sigma_{Sb}| = 0$ psi $< 1.5 \cdot \sigma_{allS}, S_{PSs}$ or S_{PSs1}

$\sigma_S = 0$ psi $+ 0$ psi < 0 psi

$\sigma_C = |\sigma_{Cm}| + |\sigma_{Cb}| = 0$ psi $< 1.5 \cdot \sigma_{allC}$ or S_{PSc}

$\sigma_C = 0$ psi $+ 0$ psi < 16950 psi

Condition UHX-14.5.10 not required for configurations dBCD

Geometric conditions:

valid

Strength condition for linked modules (Connection activated:

No):



ASME BPVC VIII-1 2021
Example E4.18.8 PTB-4-2021

Float-3 - Floating Tubesheets - ASME BPVC VIII-1, UHX-14: 2021

Floating tubesheet according to ASME-UHX-14

Type of heat exchanger (a,b,c)

WArt a

Heat Exchanger With an Immersed Floating Head

Configuration of the tubesheet (a-f,A-D)

Type C

Floating tubesheet gasketed, without flange extension

Type of channel (1=Cylinder, 2=Hemispherical)

1

Shell side internal operating pressure

P_s 250 psi

Tube side internal operating pressure

P_t 150 psi

Shell side internal test pressure

P_{sp} psi

Tube side internal test pressure

P_{tp} psi

Load case (1=operation, 2+3=test at 20°C,
4=other)

1

load case: operation

Calculation case acc. UHX-14.4(a): (1), (2) ... (7)

3

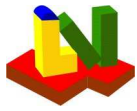
Tube and shell side pressure acting without thermal expansion

Tubesheet material

Shell material (Type abc)

Tube material

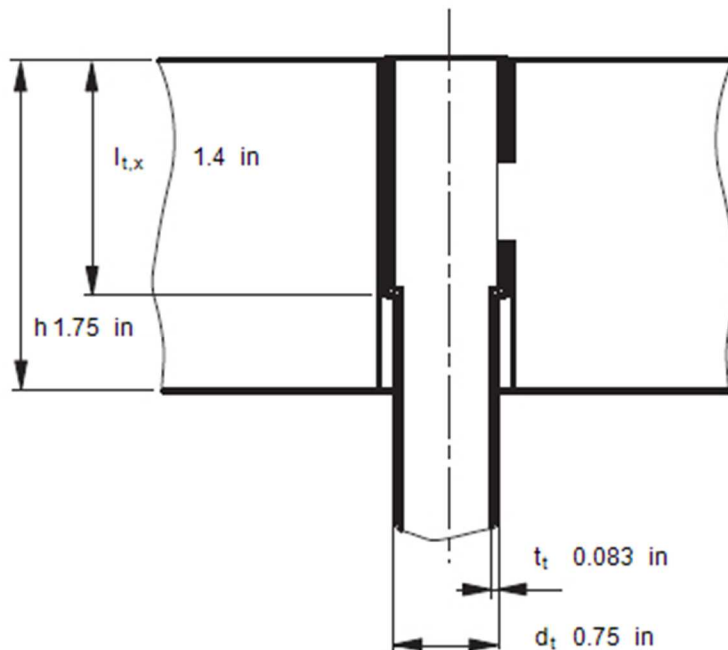
Channel material(Type aefA)



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Operation	Tubesheet	Shell	Tubes	Channel
Temperature	°F	°F	°F	°F
Thickness	1.75 in	in	0.083 in	0.3125 in
Outsidediameter	26.89 in	in	0.75 in	27.03 in
Poiss.-rat.	0.31	0.3	0.31	0.32
Allow. c1	0 in	in	0 in	0 in
Corr.all.c2	0 in	in	0 in	0 in
Figure				
Strength for the selected load case temperature				
Strength	psi	psi	psi	psi
Safety				
Modulus	2.7e+7 psi	psi	2.7e+7 psi	1.48e+7 psi
of				
elasticity				
Therm.dil.	1E-6/°F	1E-6/°F	1E-6/°F	4.8 1E-6/°F
Yield str.	20550 psi	psi	20550 psi	31600 psi
Limit	°F	°F	°F	°F
temperature				
All.stress	19000 psi	0 psi	13350 psi	11300 psi
Pr.+sec.st	57000 psi	0 psi	psi	33900 psi
Properties for testing at 20°C				
Strength	0 psi	0 psi	0 psi	0 psi
Safety				
Yield str.	psi	psi	psi	psi
Tensile str.	psi	psi	psi	psi
Additional specifications for the geometry and loading				
Tubesheet				
Tube-tubesheet joint		(1=expanded, 2=welded)		1
Tube pattern		(1=Triangle, 2=Square)		1
Number of tubes		N _t		466

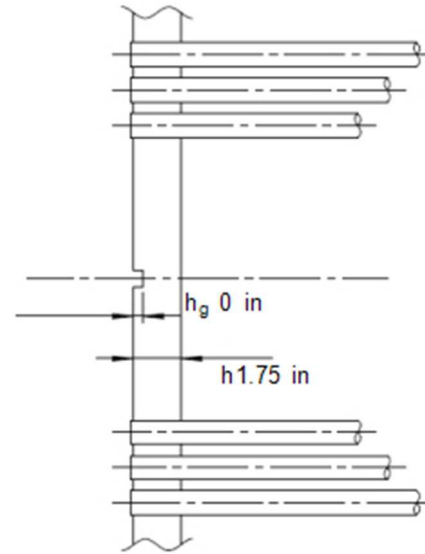
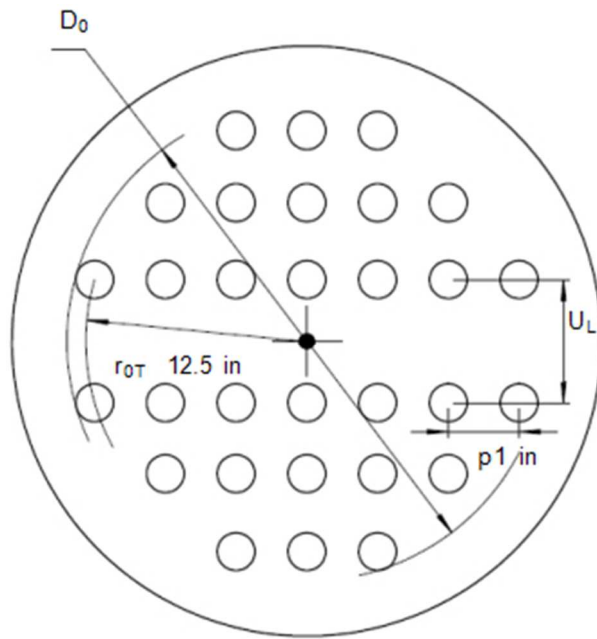


Expanded length of tube in tubesheet		$l_{t,x}$	1.4 in
Expanded length ratio $l_{t,x}/h$		ρ	0.8
Radius to outermost tube hole center	UHX-11.1(a)	r_{0T}	12.5 in
Perimeter of the outermost tubes	UHX-12.2	C_p	in
Total area enclosed by C_p	UHX-12.2	A_p	in ²



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021



Tube pitch (center distance)
 Total untubed area $UL1 \cdot LL1 + UL2 \cdot LL2..$ UHX-11.2
 Depth of tube side pass partition groove
 Expanded length ratio ltx/h
 Tube length between inner tubesheet faces
 Unsupported tube span for buckling
 Type of tube support (0.6=tubesheet-tubesheet, 0.8=tubesheet - support plate, 1=plate-plate)
 Equivalent free buckling length $k \cdot l$

Flange

Mean contact diameter tubesheet-flange (Type cfC)
 Bolt circle diameter (Type bcdefBC)
 Number of bolts
 Bolt root diameter
 Total bolt area
 Bolt material
 Strength operation
 Strength test
 Safety operation
 Safety test
 Stress increase factor (1.5 acc. App.S)

p 1 in
 A_L 64.4 in²
 h_g 0 in
 ρ 0.8
 L 252.5 in
 l in
 k
 l_t 15.38 in
 G_1 26.5 in
 C 27.99 in
 n
 d_B in
 A_b 0 in²
 K_s psi
 K_{sp} psi
 S_s
 S_{sp}
 F_s 1.5

Gasket

Contact outside diameter
 Contact inside diameter
 Theoretical seating width
 Gasket factor (Table 2-5.1)
 Gasket seating pressure
 Diameter of gasket force
 Poisson's ratio

Shell Type d,e,f

G_a in
 G_i in
 b_0 in
 m
 Y psi
 G in
 v 0.3

Channel Type B,b,c,d

in
 in
 in
 0 psi
 26.5 in
 0.32



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Results acc. UHX-9

	Shell	Channel
Effective seating width	b in	in
Gasket bolt-up force	W lbf	lbf
Gasket operating force	W lbf	26225 lbf
Total required bolt area	A_m in ²	0 in ²
Flange thickness	h_r in	0 in
Maximum bolt force for all calculation cases		W_{max} 0 lbf
Bolt root area	0 in ² : sufficient	

Results acc. to UHX-14

Gasket seating force = $0.5(A_m + A_b) \cdot K_{sp}/S_{sp}$, App.2-5	W	26225 lbf
Channel thickness without allowances	t_c	0.3125 in
Shell thickness without allowances	t_s	in

Step 1 acc. UHX 14.5

Basic ligament efficiency for shear	μ	0.25
Effective ligament efficiency for shear	μ^*	0.3853
Effective depth of pass partition groove	h_g'	0 in
Equivalent radius of outer tube limit circle	a_0	12.87 in
Radial channel dimension	a_c	13.25 in
Radial shell dimension	a_s	13.25 in
Ratio = a_c/a_0	ρ_C	1.029
Ratio = a_s/a_0	ρ_S	1.029
Parameter = $1 - N_t \cdot (0.5 \cdot d_a \text{TUBE}/a_0)^2$	x_s	0.6047
Parameter = $1 - N_t \cdot (0.5 \cdot d_i \text{TUBE}/a_0)^2$	x_t	0.7603

Step 2



ASME BPVC VIII-1 2021

Example E4.18.8 PTB-4-2021

Step 3

Effective modulus of el. tubesheet (Fig.UHX-11.3)

Ratio of elasticity tubesheet

Effective Poisson's ratio tubesheet

Effective pitch

Effective tube hole diameter

Parameter for table UHX-13.1

Z_d **0.03276** Z_v **0.07874** Z_m **0.4213** Z_a **4.21**

E^* **1.091e+7** psi

E^*/E **0.4039**

ν^* **0.3084**

p^* **1.068** in

d^* **0.6567** in

X_a **3.61**

Z_w **0.07874**

Step 4

Diameter ratio = $A/D0$

F **0.07417** Φ **0.09705**

K **1.044**

Q_1 **0.02049**

UHX-14.5.5 Step 5: Coefficients

ω_C **0** in² ω_S **0** in²

ω_C^* **0.07057** in² ω_S^* **0.07057** in²

ω_S^* **0.07057** in²

ν_b **0**

Results acc. to UHX-14.6 and step 6

$T_r =$ **68** °F $T_s^* =$ **68** °F

$P_s^* =$ **0** psi $P_c^* =$ **0** psi

T_c^* **68** °F

P_e **100** psi

UHX-14.5.7 Step 7

Q_2 **6.78** lbf Q_3 **0.02131**

Strength condition for the tubesheet bending stress, case

$\sigma =$ **6330** psi $< 1.5 \cdot \sigma_B =$ **28500** psi

$< S_{PS} =$ **57000** psi

F_m **0.0751**

3 :

case 1-3

case 4-7

Step 8

Strength condition for the tubesheet shear stress:

$\tau =$ **0** psi $\leq \text{MIN}[0.8\sigma_B ; 0.533 S_y]$ **= 10953** psi

Strength condition of step 7-8 are satisfied

Step 9, as examples UHX-20.3:2009 (old N)

F_q **2.925** F_s **1.787**

Strength condition for the tube stress with cacluation case

$S_{T0} =$ **-11.32** MN/mm²Pa $\leq \sigma_T =$ **13350** psi

$S_{T0} \leq 2 \cdot \sigma_T =$ **26700** psi

$|S_{T0}| \leq S_{tb} =$ **9188** psi

r_t **0.2376** in F_t **64.72**

3 :

for calculation case 1-3

for calculation case 4-7

(for $S_{T0} < 0$, Buckling)

C_t **161**

Condition UHX-14.5.9 not required for configuration ABCD

Step 10: Stress σ_S in the shell and σ_C in the channel

$\sigma_S = |\sigma_{Sm}| + |\sigma_{Sb}| =$ **0** psi $< 1.5 \cdot \sigma_{allS}, S_{PSs}$ or S_{PSs1}

$\sigma_S =$ **0** psi $+$ **0** psi $<$ **0** psi

$\sigma_C = |\sigma_{Cm}| + |\sigma_{Cb}| =$ **0** psi $< 1.5 \cdot \sigma_{allC}$ or S_{PSc}

$\sigma_C =$ **0** psi $+$ **0** psi $<$ **16950** psi

Condition UHX-14.5.10 not required for configurations dBCD

Geometric conditions:

valid

Strength condition for linked modules (Connection activated:

No):