

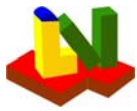
ASME BPVC VIII-1 2023
Example E4.7.1 PTB-4-2021

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Layout

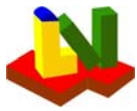
Input values:	1.234	or	1.234
Calculated values:	1.234	or	1.234
Critical values:	1.234	or	1.234
Estimated values:	1.234	or	1.234



ASME BPVC VIII-1 2023
Example E4.7.1 PTB-4-2021

Summary

Strength Calculation Software		Program System ATLAS		Version		10.0.107	
Developed by Lauterbach Verfahrenstechnik GmbH							
Certified per DIN EN ISO 9001:2008		Certificate Number 01 100 044763					
				LV Soft		ASME	
Example E4.7.1 - Thickness calculation for a type D Head						Diff [%]	
(a)		Required plate thickness t	4,25 mm	0,17 in	0,17 in	0,10%	
Step3		Required flange thickness t	50,91 mm	2,25 in	2,25 in	0,03%	
Step7		Total gasket seating moment Mo	11.976.492,00 N.mm	106.000,89 lbf.in	106168,10 lbf.in	0,16%	



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Example E4.7.1 PTB-4-2021

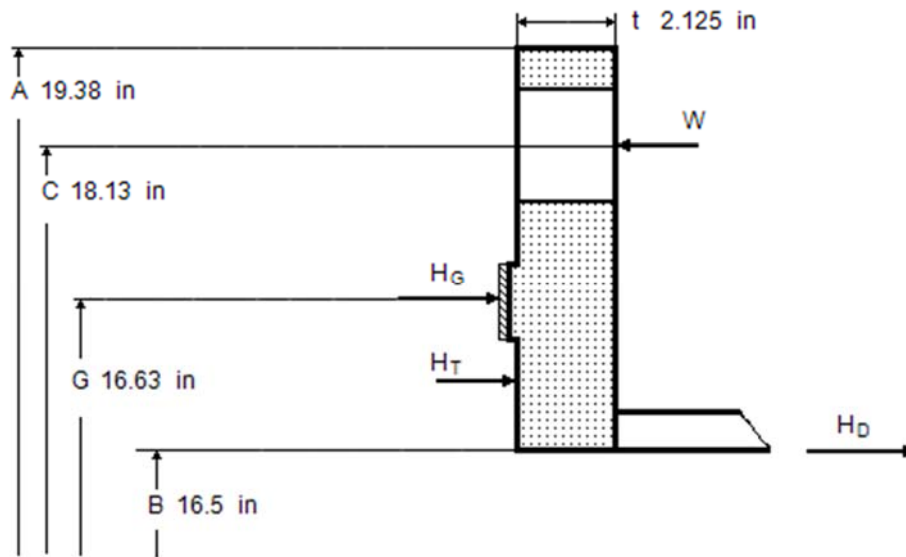
E 4.7. Step 7 - Bolted flanges - ASME BPVC VIII Division 1 App. 2: 2023

Loose Type Flange without Neck

Design data

Design pressure	P_D	213 psi
Hydrostatic head	D_P	0 psi
Calculation pressure	P_0	213 psi
Calculation temperature	T_0	400 °F

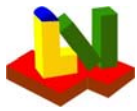
Flange



Outside diameter	A	19.38 in	Inside diameter	B	16.5 in
Bolt circle diameter	C	18.13 in	Pipe size	B_n	16.5 in
Flange thickness				t	2.125 in
Thickness of semi-finished product				t_0	mm
Material	K03504-SA-105--Class:-Size:				
Cast Quality Factor				f	1
Design strength operation				S_{do}	19989 psi
Design strength installation				S_{da}	20015 psi
Allowable operating stress				S_{fb}	19989 psi
Allowable installation stress				S_{fa}	20015 psi
Corrosion allowance				c_2	0 in
Modulus of elasticity at operation				E_T	2.766e+7 psi
Modulus of elasticity at test (20°C)				E_{20}	2.92e+7 psi

Gasket

Gasket diameter		G	16.63 in
Basic gasket seating width		b_0	3.571 mm
Effective gasket width	[Table: 2-5.2]	b	0.1406 in
Gasket factor	[Table: 2-5.1]	m	5.5
Gasket seating load	[Table: 2-5.1]	y	18000 psi



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Example E4.7.1 PTB-4-2021

Bolts

Number	n	20
Root diameter	d_K	0.62 in
Nominal diameter	a	0.75 in
Material	G41400-SA-193-B7-Class:-Size:<=64	
Allowable operating stress	S_b	24946 psi
Allowable installation stress	S_a	24946 psi
Consider bolt spacing correction factor B_{SC}	2-6(7)?	(N=No) Y (Y/N)
Required operation bolt load	Eq.(1)	W_{m1} 63411 lbf
Minimum initial bolt load	Eq.(2)	W_{m2} 132116 lbf
Available cross section of bolts	A_b	6.035 in ²
Required cross section	W_{m1}/S_b	A_{m1} 2.542 in ²
Required cross section	W_{m2}/S_a	A_{m2} 5.296 in ²
Req. bolt load for gasket seating	Eq.(5) $(A_m + A_b) \cdot S_a / 2$	W 141335 lbf
Allowable bolt load	$A_b \cdot S_a$	W_{all} 150555 lbf
Design bolt force		1

External forces and moments

	Operation
External axial force	W_{ax} N
External moment	M_b N·mm
Resulting external force	W' N

Note: External forces are considered as pseudo static pressure and added to the calculation pressure!

Resulting pseudo static pressure	P'	MPa
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Moment

	Force	·	Lever arm	=	Result
$M_D = H_D \cdot h_D$	= 45522 lbf	·	0.8125 in	=	3082 lbf·ft
$M_G = H_G \cdot h_G$	= 17197 lbf	·	0.75 in	=	1075 lbf·ft
$M_T = H_T \cdot h_T$	= 692.3 lbf	·	0.7813 in	=	45.07 lbf·ft
Total operating moment	$M_{01} = F_M \cdot (M_D + M_G + M_T)$	=			4202 lbf·ft
Total gasket seating moment, Eq. (6)	$M_{02} = F_M \cdot W \cdot (C-G)/2$	=			8833 lbf·ft
Factor App.2-9 for split flange (1=full ring, 2=single split ring, 0.75=double split ring)	F_M				1 (1,2,.75)

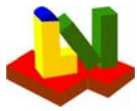
Stress

	Operation	Installation	≤ Allowable	
Longitudinal	S_H 0	0		Eq.(11)
Radial	S_R 0	0		Eq.(11)
Tangential	S_T 8234 psi	17309 psi	≤ S_f	Eq.(11)
Allowable stress	S_f 19989 psi	20015 psi		
Bolt pitch	B_S 2.847 in	≤ 3.625 in	= B_{Smax}	Eq.(3)

Remark

Cross-sectional area of bolts
Strength condition flange
Flange rigidity





ASME BPVC VIII-1 2023

Example E4.7.1 PTB-4-2021

Auxiliary values

$$K = \frac{A}{B} = 1.174$$

$$Y = 12.17$$

(Fig. 2-7.1)

$$H = 0.785 \cdot G^2 \cdot P \cdot 0.1 = 205571 \text{ N}$$

$$H_D = 0.785 \cdot B^2 \cdot P \cdot 0.1 = 202491 \text{ N}$$

$$H_P = 2 \cdot b \cdot \pi \cdot G \cdot m \cdot P \cdot 0.1 = 76496 \text{ N}$$

$$H_T = H - H_D = 3080 \text{ N}$$

$$W_{m1} = H + H_P = 282067 \text{ N}$$

Eq.(1)

$$W_{m2} = \pi \cdot b \cdot g \cdot y = 587676 \text{ N}$$

Eq.(2)

$$H_G = W_{m1} - H = 76496 \text{ N}$$

$$h_D = \frac{(C-B)}{2} = 20.64 \text{ mm}$$

$$h_G = \frac{(C-G)}{2} = 19.05 \text{ mm}$$

$$h_T = \frac{(h_D + h_G)}{2} = 19.84 \text{ mm}$$

Bolt pitch

$$B_S = \pi \cdot \frac{C}{n} = 72.32 \text{ mm}$$

Eq.(3)

$$B_{Smax} = 2 \cdot a + 6 \cdot \frac{t}{(m+0.5)} = 92.07 \text{ mm}$$

For

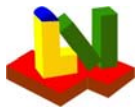
$$B_S > 2 \cdot a + t$$

Eq.(7)

$$B_{SC} = \sqrt{\frac{B_S}{(2 \cdot a + t)}} = 1$$

$$KL (=0.2 \text{ acc. Table 2-14}) = 0.2$$

$$\text{Rigidity criterion: } J = 1.289 \leq 1.0$$



ASME BPVC VIII-1 2023
Example E4.7.1 PTB-4-2021

E 4.7.1 a - Spherically dished covers (bolted heads) - ASME VIII APPENDIX 1, 1-6 2023 Edition

Spherically dished covers as shown in Fig.: 1-6 (b)

Input

Flange moment from 2-6 or 2-11

Design pressure

Hydrostatic head

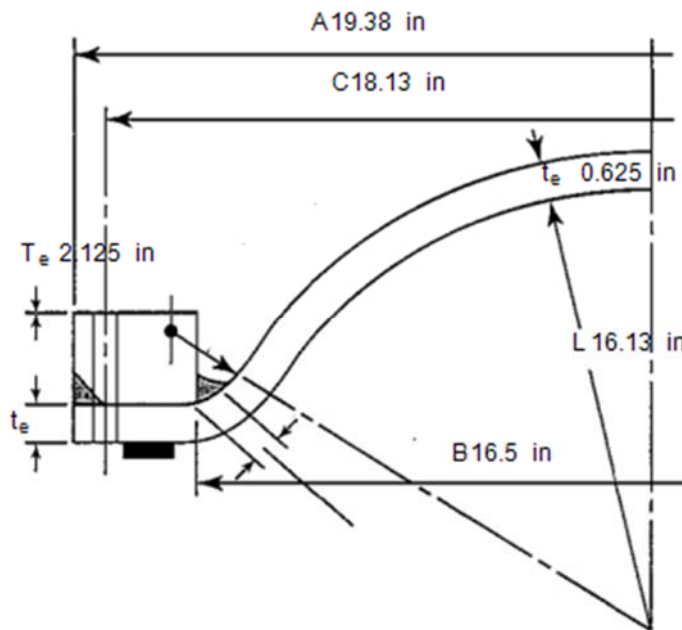
Calculation pressure

Design temperature

Gasket

Ring gasket

M_0	8849 lbf-ft
p_D	psi
D_p	psi
p_0	213 psi
T_0	400 °F



Outside diameter	A	19.38 in
Inside diameter	B	16.5 in
Bolt circle diameter	C	18.13 in
Final flange thickness	T_e	2.125 in

Crown radius	L	16.13 in
Final head thickness	t_e	0.625 in
Wall thickness allowance	c_1	0 in
Corrosion allowance	c_2	0.125 in

Material K02401-SA-515-60-Class:-Size:

Allowable stress	S	17114 psi
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Calculation

Required head thickness	t	0.1672 in	(1)
Required thickness incl. allowances	$t+c_1+c_2$	0.2922 in	
Required flange thickness (ring gasket)	$T(2)$	2.166 in	(2)
Required flange thickness (full face)	$T(3)$	1.224 in	(3)
Required flange thickness	T	2.166 in	(6)



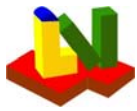
ASME BPVC VIII-1 2023
Example E4.7.1 PTB-4-2021

Equations

$$t = \frac{5 \cdot P_0 \cdot L}{6 \cdot S} = \frac{5 \cdot 1.469 \text{ N/mm}^2 \cdot 409.6 \text{ mm}}{6 \cdot 118 \text{ N/mm}^2} = 4.248 \text{ mm} \quad (1)$$

$$T = \sqrt{\frac{|M_0|}{S \cdot B} \cdot \left[\frac{A+B}{A-B} \right]} = \sqrt{\frac{|1.2e+7 \text{ Nmm}|}{118 \text{ N/mm}^2 \cdot 419.1 \text{ mm}} \cdot \left[\frac{492.1 \text{ mm} + 419.1 \text{ mm}}{492.1 \text{ mm} - 419.1 \text{ mm}} \right]} = 55.02 \text{ mm} \quad (2)$$

$$T = 0.6 \cdot \sqrt{\frac{P}{S} \cdot \left[\frac{B \cdot (A+B) \cdot (C-B)}{A-B} \right]} = 0.6 \cdot \sqrt{\frac{1.469 \text{ N/mm}^2}{118 \text{ N/mm}^2} \cdot \left[\frac{419.1 \text{ mm} \cdot (492.1 \text{ mm} + 419.1 \text{ mm}) \cdot (460.4 \text{ mm} - 419.1 \text{ mm})}{492.1 \text{ mm} - 419.1 \text{ mm}} \right]} = 31.1 \text{ mm} \quad (3)$$



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Example E4.7.1 PTB-4-2021

E.4.7.1 c.Step3 - Spherically dished covers (bolted heads) - ASME VIII APPENDIX 1, 1-6 2023 Edition

Spherically dished covers as shown in Fig.: 1-6 (b)

Input

Flange moment from 2-6 or 2-11

Design pressure

Hydrostatic head

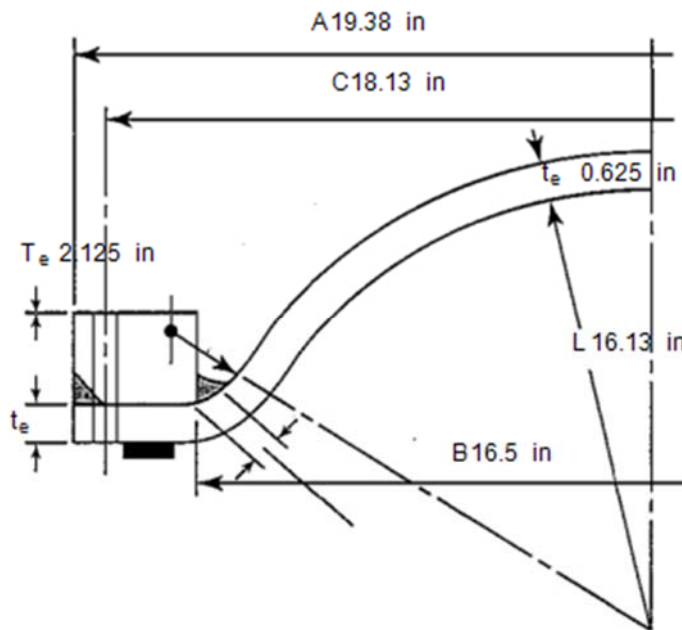
Calculation pressure

Design temperature

Gasket

Ring gasket

M_0	8849 lbf-ft
p_D	psi
D_p	psi
p_0	213 psi
T_0	400 °F



Outside diameter	A	19.38 in
Inside diameter	B	16.5 in
Bolt circle diameter	C	18.13 in
Final flange thickness	T_e	2.125 in

Crown radius	L	16.13 in
Final head thickness	t_e	0.625 in
Wall thickness allowance	c_1	0 in
Corrosion allowance	c_2	0.125 in

Material K03504-SA-105--Class:-Size:

Allowable stress	S	19989 psi
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Calculation

Required head thickness	t	0.1432 in	(1)
Required thickness incl. allowances	$t+c_1+c_2$	0.2682 in	
Required flange thickness (ring gasket)	$T(2)$	2.004 in	(2)
Required flange thickness (full face)	$T(3)$	1.133 in	(3)
Required flange thickness	T	2.004 in	(6)



ASME BPVC VIII-1 2023

Example E4.7.1 PTB-4-2021

Equations

$$t = \frac{5 \cdot P_0 \cdot L}{6 \cdot S} = \frac{5 \cdot 1.469 \text{ N/mm}^2 \cdot 409.6 \text{ mm}}{6 \cdot 137.8 \text{ N/mm}^2} = 3.637 \text{ mm} \quad (1)$$

$$T = \sqrt{\frac{|M_0|}{S \cdot B} \cdot \left[\frac{A+B}{A-B} \right]} = \sqrt{\frac{|1.2e+7 \text{ Nmm}|}{137.8 \text{ N/mm}^2 \cdot 419.1 \text{ mm}} \cdot \left[\frac{492.1 \text{ mm} + 419.1 \text{ mm}}{492.1 \text{ mm} - 419.1 \text{ mm}} \right]} = 50.91 \text{ mm} \quad (2)$$

$$T = 0.6 \cdot \sqrt{\frac{P}{S} \cdot \left[\frac{B \cdot (A+B) \cdot (C-B)}{A-B} \right]} = 0.6 \cdot \sqrt{\frac{1.469 \text{ N/mm}^2}{137.8 \text{ N/mm}^2} \cdot \left[\frac{419.1 \text{ mm} \cdot (492.1 \text{ mm} + 419.1 \text{ mm}) \cdot (460.4 \text{ mm} - 419.1 \text{ mm})}{492.1 \text{ mm} - 419.1 \text{ mm}} \right]} = 28.78 \text{ mm} \quad (3)$$