

# ASME BPVC VIII-1 2023

## Example E4.7.1 PTB-4-2021

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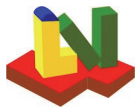
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### Layout

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



Strength Calculation Software		Program System ATLAS			Version	10.0.106				
Developed by Lauterbach Verfahrenstechnik GmbH										
Certified per DIN EN ISO 9001:2008	Certificate Number 01 100 044763									
				<b>LV Soft</b>			<b>ASME</b>		<b>Diff [%]</b>	
Example E4.7.1 - Thickness calculation for a type D Head										
	(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%			



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

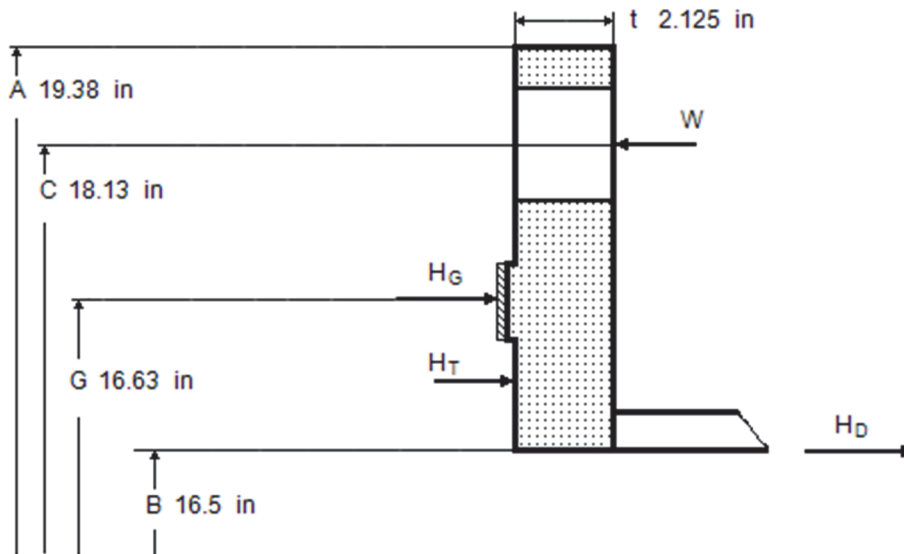
## E 4.7. Step 7 - Bolted flanges - ASME BPVC VIII Division 1 App. 2: 2023

### 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

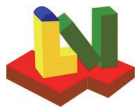
#### Flange



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	b	0.1406 in
Gasket factor	m	5.5
Gasket seating load	y	18000 psi



# ASME BPVC VIII-1 2023

## 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 $B_{SC}$	(N=No) Y	(Y/N)
Required operation bolt load	Eq.(1)	$W_{m1}$ <b>63411</b> lbf
Minimum initial bolt load	Eq.(2)	$W_{m2}$ <b>132116</b> lbf
Available cross section of bolts	$A_b$	<b>6.035</b> in <sup>2</sup>
Required cross section	$W_{m1}/S_b$	$A_{m1}$ <b>2.542</b> in <sup>2</sup>
Required cross section	$W_{m2}/S_a$	$A_{m2}$ <b>5.296</b> in <sup>2</sup>
Req. bolt load for gasket seating	Eq.(5) $(A_m + A_b) \cdot S_a / 2$	W <b>141335</b> lbf
Allowable bolt load	$A_b \cdot S_a$	$W_{all}$ <b>150555</b> 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
$M_D = H_D \cdot h_D$	= <b>45522</b> lbf	·	<b>0.8125</b> in	=	<b>3082</b> lbf·ft
$M_G = H_G \cdot h_G$	= <b>17197</b> lbf	·	<b>0.75</b> in	=	<b>1075</b> lbf·ft
$M_T = H_T \cdot h_T$	= <b>692.3</b> lbf	·	<b>0.7813</b> in	=	<b>45.07</b> lbf·ft
Total operating moment	$M_{01} = F_M \cdot (M_D + M_G + M_T)$	=			<b>4202</b> lbf·ft
Total gasket seating moment, Eq. (6)	$M_{02} = F_M \cdot W \cdot (C-G)/2$	=			<b>8833</b> 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)

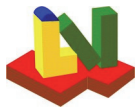
### Stress

	Operation	Installation	≤ Allowable	
Longitudinal	$S_H$ 0	0		Eq.(11)
Radial	$S_R$ 0	0		Eq.(11)
Tangential	$S_T$ <b>8234</b> psi	<b>17309</b> psi	≤ $S_f$	Eq.(11)
Allowable stress	$S_f$ <b>19989</b> psi	<b>20015</b> psi		
Bolt pitch	$B_S$ <b>2.847</b> in	≤ <b>3.625</b> 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

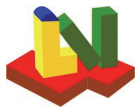
$$B_S > 2 \cdot a + t$$

Eq.(7)

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

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

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



**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

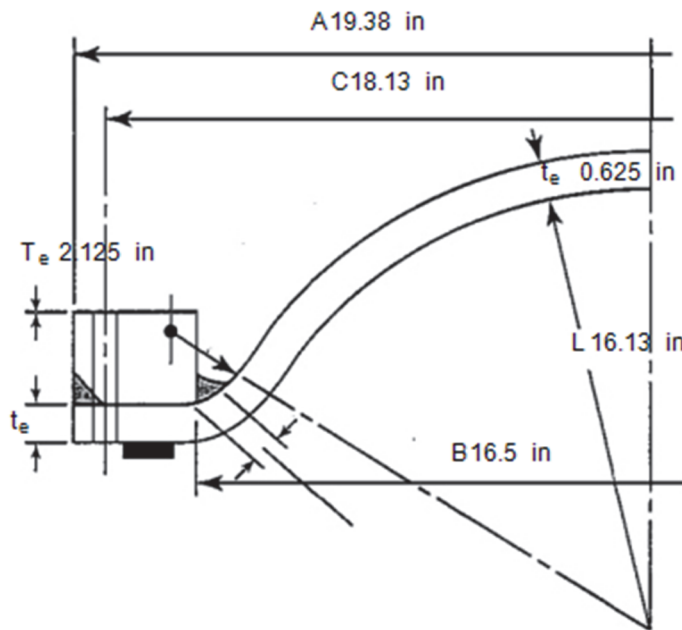
Calculation pressure

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 <sub>e</sub>	2.125 in

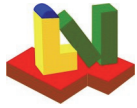
Crown radius	L	16.13 in
Final head thickness	t <sub>e</sub>	0.625 in
Wall thickness allowance	c <sub>1</sub>	0 in
Corrosion allowance	c <sub>2</sub>	0.125 in

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 <sub>1</sub> +c <sub>2</sub>	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

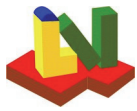
## Example E4.7.1 PTB-4-2021

### Equations

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

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

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



**ASME BPVC VIII-1 2023**  
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

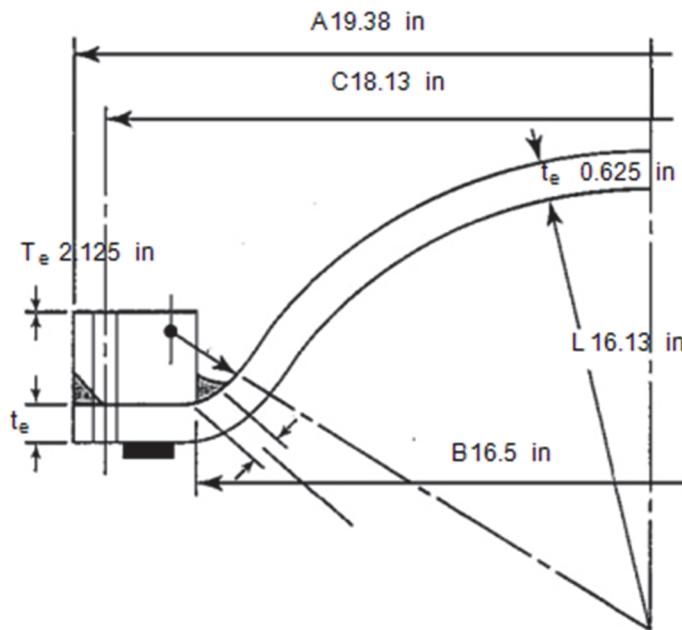
Calculation pressure

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 <sub>e</sub>	2.125 in

Crown radius	L	16.13 in
Final head thickness	t <sub>e</sub>	0.625 in
Wall thickness allowance	c <sub>1</sub>	0 in
Corrosion allowance	c <sub>2</sub>	0.125 in

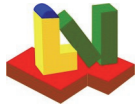
Material K03504-SA-105--Class:-Size:

Allowable stress	S	19989 psi
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**Calculation**

Required head thickness	t	0.1432 in	(1)
Required thickness incl. allowances	t+c <sub>1</sub> +c <sub>2</sub>	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

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

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

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