



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

### Table of contents

Table of contents .....	1
Summary .....	2
E4.4.7 Large End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021 .....	3
E4.4.7 Large End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021 .....	5
E4.4.7 Small End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021 .....	7
E4.4.7 Small End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021 .....	9
E4.4.8 Large and Small End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021 .....	11
E4.4.8 Large End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021 .....	13

### Layout

Input values:	1.234	or	1.234
Calculated values:	<b>1.234</b>	or	<b>1.234</b>
Critical values:	<b>1.234</b>	or	<b>1.234</b>
Estimated values:	<b>1.234</b>	or	<b>1.234</b>



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

### Summary

Strength Calculation Software	Program System ATLAS	Version	10.0.98						
Developed by Lauterbach Verfahrenstechnik GmbH									
Certified per DIN EN ISO 9001:2015				Certificate Number 01 100 044763					
				LV Soft		ASME		Diff [%]	
Example E4.4.7 - Conical transition Without a knuckle (large End)									
		Required area ArL		1008.88 mm <sup>2</sup>	1.56 in <sup>2</sup>	1.56 in <sup>2</sup>		0.10%	
		Required area AeL		13064.03 mm <sup>2</sup>	20.25 in <sup>2</sup>	20.38 in <sup>2</sup>		0.64%	
Large End/Line-of-support		Required moment of inertia Is		33871336.00 mm <sup>4</sup>	81.38 in <sup>4</sup>	81.85 in <sup>4</sup>		0.57%	
		Required moment of inertia I's		43504464.00 mm <sup>5</sup>	104.52 in <sup>5</sup>	105.12 in <sup>5</sup>		0.57%	
Example E4.4.7 - Conical transition Without a knuckle (Small End)									
		Required area ArS		715.96 mm <sup>2</sup>	1.11 in <sup>2</sup>	1.11 in <sup>2</sup>		0.08%	
		Required area AeS		8001.92 mm <sup>2</sup>	13.12 in <sup>2</sup>	13.12 in <sup>2</sup>		0.01%	
Small End/Line-of-support		Required moment of inertia Is		6975754.00 mm <sup>4</sup>	16.76 in <sup>4</sup>	16.76 in <sup>4</sup>		0.02%	
		Required moment of inertia I's		8959684.00 mm <sup>4</sup>	21.53 in <sup>4</sup>	21.53 in <sup>4</sup>		0.02%	
Example E4.4.8 - Conical transition With a knuckle									
Large End/Line-of-support		Required moment of inertia Is		5850143.00 mm <sup>4</sup>	14.06 in <sup>4</sup>	13.82 in <sup>4</sup>		1.70%	
		Required moment of inertia I's		7513945.00 mm <sup>4</sup>	18.05 in <sup>4</sup>	17.75 in <sup>4</sup>		1.70%	



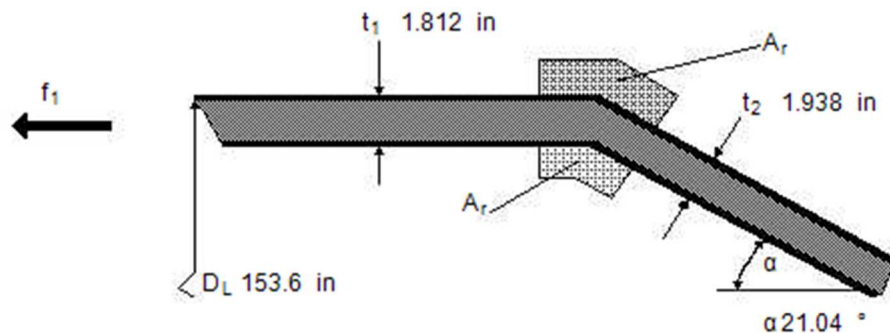
**ASME BPVC VIII-1 2021**  
Example E4.4.7 - E4.4.8 PTB-4-2021

**E4.4.7 Large End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021**

**Area at the wide end of a cone-cylinder-juncture without knuckle acc. App.1-8**

Type of stiffener                      No stiffener

External design pressure	$p_D$	14.7 psi
Hydrostatic head	$D_p$	0 psi
Calculation pressure	$p_0$	14.7 psi
Calculation temperature	$T_0$	300 °F
Axial additional load as line load (positive for tension) e.g. wind load, dead weight, traffic load, etc. but no loads resulting from internal / external pressure	$f_1$	497.1 lbf/in



**Cylinder**

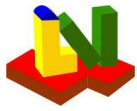
Final wall thickness	$t_1$	1.812 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0.125 in
Final thickness without allowances	$t_s$	1.687 in
Outside diameter	$D_L$	153.6 in
Tip radius $(=D_L/2)$	$R_L$	76.8 in
Required thickness without allowances (UG-28)	$t_{1r}$	0.9549 in
Required thickness with allowances (UG-28)	$t_{1r+}$	1.08 in
Joint efficiency factor	$E_1$	1
Material                      K02700-SA-516-70-Class:-Size:		
Allowable stress	$S_s$	20015 psi
Modulus of elasticity	$E_s$	2.9e+7 psi

**Cone**

Final wall thickness	$t_2$	1.938 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0.125 in
Final thickness without allowances	$t_c$	1.813 in
Half apex angle $(\leq 60^\circ)$	$\alpha$	21.04 °
Required thickness without allowances (UG-33)	$t_{2r}$	0.3639 in
Required thickness with allowances (UG-33)	$t_{2r+}$	0.4889 in
Joint efficiency factor	$E_2$	1
Material                      K02700-SA-516-70-Class:-Size:		
Allowable stress	$S_c$	20015 psi
Modulus of elasticity	$E_c$	2.9e+7 psi

**Stiffening ring**

Material                      K02700-SA-516-70-Class:-Size:		
Actual cross section of the stiffener	$A_r$	34 in <sup>2</sup>
Allowable stress	$S_r$	20015 psi
Modulus of elasticity	$E_r$	2.9e+7 psi



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

### Results

Factor ( $\geq 1$ )

Ratio

Angle

Effective load

Cross sectional area

Effective area

Required cross section of reinforcement

Remark **Stiffening required acc. App. 1-8 (b)**

k	1
$P_0/S_s E_1$	<b>7.344e-4</b>
$D_{el}$	<b>2.818</b> °
$Q_L$	<b>1062</b> lbf/in
$A_{rL}$	<b>1.564</b> in <sup>2</sup>
$A_{eL}$	<b>20.25</b> in <sup>2</sup>
$A_{req}$	<b>0</b> in <sup>2</sup>

### Equations

$$\cos(\alpha) = \cos(\alpha) = \cos(21.04^\circ) = 0.9333$$

$$\tan(\alpha) = \tan(\alpha) = \tan(21.04^\circ) = 0.3846$$

$$Q_L = P_0 \cdot \frac{R_L}{2} + f_1 = 1.014 \text{ bar} \cdot \frac{1951 \text{ mm}}{2} + 87.06 \text{ N/mm} = 185.9 \text{ N/mm}$$

$$A_{rL} = \frac{k \cdot Q_L \cdot R_L \cdot \tan(\alpha)}{S_s \cdot E_1} \cdot \left( 1 - \frac{P_0 \cdot R_L - Q_L}{4 \cdot Q_L} \cdot \frac{D_{el}}{\alpha} \right) = \quad (1)$$

$$\frac{1 \cdot 185.9 \text{ N/mm} \cdot 1951 \text{ mm} \cdot 0.3846}{138 \text{ N/mm}^2 \cdot 1} \cdot \left( 1 - \frac{1.014 \text{ bar} \cdot 1951 \text{ mm} - 185.9 \text{ N/mm}}{4 \cdot 185.9 \text{ N/mm}} \cdot \frac{2.818^\circ}{21.04^\circ} \right) = 1009 \text{ mm}^2$$

$$A_{eL} = 0.55 \cdot \sqrt{(D_L \cdot t_s)} \cdot \left( \frac{t_s + t_c}{\cos(\alpha)} \right) = \quad (2)$$

$$0.55 \cdot \sqrt{(3902 \text{ mm} \cdot 42.86 \text{ mm})} \cdot \left( \frac{42.86 \text{ mm} + 46.04 \text{ mm}}{0.9333} \right) = 13064 \text{ mm}^2$$



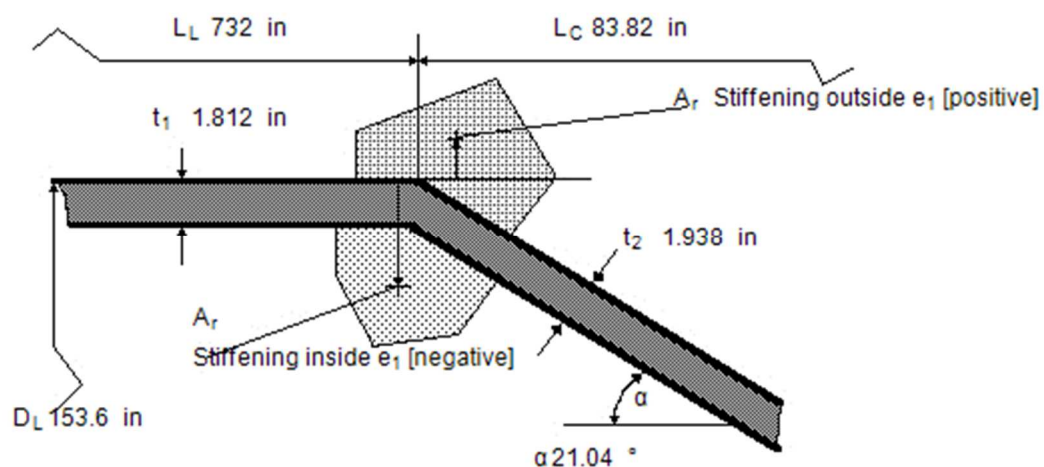
**ASME BPVC VIII-1 2021**  
Example E4.4.7 - E4.4.8 PTB-4-2021

**E4.4.7 Large End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021**

**Moment of inertia at the wide end of a cone-cylinder-juncture under external pressure acc. App. 1-8**

**(Line-of-support)**

External design pressure	$p_D$	14.7 psi
Hydrostatic head	$D_p$	0 psi
Calculation pressure	$p_0$	14.7 psi
Calculation temperature	$T_0$	300 °F
Axial additional load as line load (positive for tension) e.g. wind load, dead weight, traffic load, etc. but no loads resulting from internal / external pressure	$f_1$	497.1 lbf/in



**Cylinder**

Design wall thickness	$t_1$	1.812 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0.125 in
Final thickness without allowances	$t_s$	1.687 in
Required thickness without allowances (UG-28)	$t_{1r}$	0.9549 in
Required thickness with allowances (UG-28)	$t_{1r+}$	1.08 in
Outside diameter	$D_L$	153.6 in
Tip radius ( $=D_L/2$ )	$R_L$	76.81 in
Buckling length	$L_L$	732 in

**Cone**

Design wall thickness	$t_2$	1.938 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0.125 in
Final thickness without allowances	$t_c$	1.813 in
Required thickness without allowances (UG-33)	$t_{2r}$	0.3639 in
Required thickness with allowances (UG-33)	$t_{2r+}$	0.4889 in
Half apex angle ( $\leq 60^\circ$ )	$\alpha$	21.04 °
Buckling length	$L_C$	83.82 in

**Stiffening ring**

Material	K02700-SA-516-70-Class:-Size:	
Spec. Min. Yield	$S_y$	2.9e+7 psi
Applicable material chart	Fig	CS-2
Radial distance between the centroid of the stiffening ring and the outer surface of the cylinder	$e_1$	in
Cross sectional area	$A_r$	0 in <sup>2</sup>
Moment of inertia	$I_r$	in <sup>4</sup>



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

### Results

Equivalent length	M	393.8 in
Effective load	$F_L$	5980 lbf/in
Reference area	$A_{TL}$	693.6 in <sup>2</sup>
Factor	B	993.4 psi
Factor (see material chart)	A	6.96e-5
Required moment of inertia	$I_s$	81.38 in <sup>4</sup>
Required moment of inertia	$I'_s$	104.5 in <sup>4</sup>
Length of support	$0.55 \cdot \sqrt{(D \cdot t_s)}$	8.856 in
Available moment of inertia	$I'$	in <sup>4</sup>

Remark

### Equations

$$\cos(\alpha) = \cos(\alpha) = \cos(21.04^\circ) = 0.9333$$

$$\sin(\alpha) = \sin(\alpha) = \sin(21.04^\circ) = 0.359$$

$$\tan(\alpha) = \tan(\alpha) = \tan(21.04^\circ) = 0.3846$$

$$R_s = R_L - L_C \cdot \sin(\alpha) = 1951 \text{ mm} - 2129 \text{ mm} \cdot 0.359 = 1172 \text{ mm}$$

$$M = \frac{-R_L \cdot \tan(\alpha)}{2} + \frac{L_L}{2} + \frac{RL^2 - RS^2}{3 \cdot R_L \cdot \tan(\alpha)} =$$

$$\frac{-1951 \text{ mm} \cdot 0.3846}{2} + \frac{18593 \text{ mm}}{2} + \frac{(1951 \text{ mm})^2 - (1172 \text{ mm})^2}{3 \cdot 1951 \text{ mm} \cdot 0.3846} = 10002 \text{ mm}$$

App. 1-8 b-3) Step 1

$$F_L = P_0 \cdot M + f_1 \cdot \tan(\alpha) =$$

$$1.014 \text{ bar} \cdot 10002 \text{ mm} + 87.06 \text{ N/mm} \cdot 0.3846 = 1047 \text{ N/mm}$$

App. 1-8 b-3) Step 1

$$A_{TL} = L_L \cdot \frac{t_s}{2} + L_C \cdot \frac{t_c}{2} + A_s =$$

$$18593 \text{ mm} \cdot \frac{42.86 \text{ mm}}{2} + 2129 \text{ mm} \cdot \frac{46.04 \text{ mm}}{2} + 0 \text{ mm}^2 = 447474 \text{ mm}^2$$

App. 1-8 a)

$$B = \frac{3}{4} \cdot \frac{F_L \cdot D_L}{A_{TL}} = \frac{3}{4} \cdot \frac{1047 \text{ N/mm} \cdot 3902 \text{ mm}}{447474 \text{ mm}^2} = 6.849 \text{ N/mm}^2$$

App. 1-8 b-3) Step 1

$$I_s = A \cdot D_L^2 \cdot \frac{A_{TL}}{14} = 6.96e-5 \cdot (3902 \text{ mm})^2 \cdot \frac{447474 \text{ mm}^2}{14} = 3.387e+7 \text{ mm}^4$$

App. 1-8 b-3) Step 6

$$I'_s = A \cdot D_L^2 \cdot \frac{A_{TL}}{10.9} = 6.96e-5 \cdot (3902 \text{ mm})^2 \cdot \frac{447474 \text{ mm}^2}{10.9} = 4.35e+7 \text{ mm}^4$$

App. 1-8 b-3) Step 6

$$0.55 \cdot \sqrt{(D \cdot t_s)} = 0.55 \cdot \sqrt{(3902 \text{ mm} \cdot 42.86 \text{ mm})} = 224.9 \text{ mm}$$



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

### E4.4.7 Small End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021

#### Area at the small end of a cone-cylinder-juncture without knuckle

Type of stiffener

No stiffener

External design pressure

$p_D$

14.7 psi

Hydrostatic head

$D_p$

0 psi

Calculation pressure

$p_0$

14.7 psi

Calculation temperature

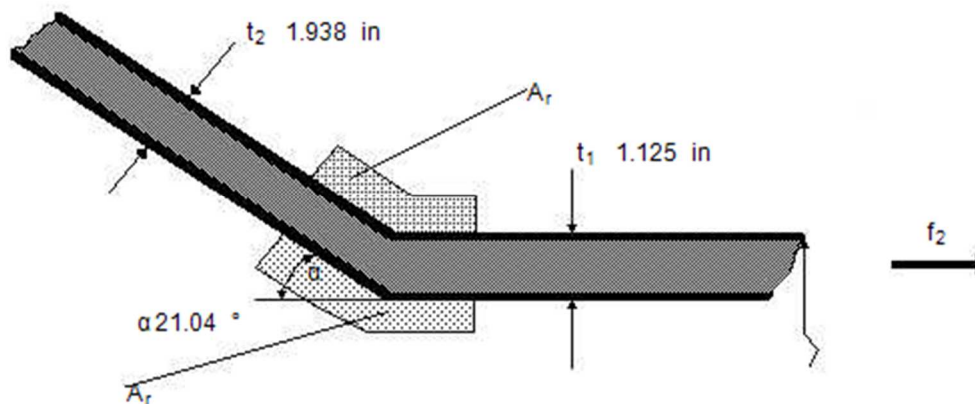
$T_0$

300 °F

Axial additional load as line load (positive for tension) e.g. wind load, dead weight, traffic load, etc. but no loads resulting from internal / external pressure

$f_2$

913 lbf/in



#### Cylinder

Final wall thickness

$t_1$

1.125 in

Wall thickness allowance

$c_1$

0 in

Allowance (corrosion)

$c_2$

0.125 in

Final thickness without allowances

$t_s$

1 in

Outside diameter

$D_S$

92.25 in

Tip radius ( $=D_S/2$ )

$R_S$

46.12 in

Required thickness without allowances (UG-28)

$t_{1r}$

0.6718 in

Required thickness with allowances (UG-28)

$t_{1r+}$

0.7968 in

Joint efficiency factor

$E_1$

1

Material K02700-SA-516-70-Class:-Size:

Allowable stress

$S_s$

20015 psi

Modulus of elasticity

$E_s$

2.9e+7 psi

#### Cone

Final wall thickness

$t_2$

1.938 in

Wall thickness allowance

$c_1$

0 in

Allowance (corrosion)

$c_2$

0.125 in

Final thickness without allowances

$t_c$

1.813 in

Semi aperture angle ( $\leq 60^\circ$ )

$\alpha$

21.04 °

Required thickness without allowances (UG-33)

$t_{2r}$

0.3639 in

Required thickness with allowances (UG-33)

$t_{2r+}$

0.4889 in

Joint efficiency factor

$E_2$

1

Material K02700-SA-516-70-Class:-Size:

Allowable stress

$S_c$

20015 psi

Modulus of elasticity

$E_c$

2.9e+7 psi

#### Stiffening ring

Material

Actual cross section of the stiffener

$A_r$

in<sup>2</sup>

Allowable stress

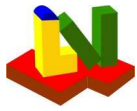
$S_r$

psi

Modulus of elasticity

$E_r$

psi



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

### Results

Factor	k	1 ≥ 1
Effective load	Q <sub>S</sub>	1252 lbf/in
Cross sectional area	A <sub>rS</sub>	1.11 in <sup>2</sup>
Effective area	A <sub>eS</sub>	12.4 in <sup>2</sup>
Required cross section of the stiffener	A <sub>req</sub>	0 in <sup>2</sup>
Remark		

### Equations

$$\cos(\alpha) = \cos(\alpha) = \cos(21.04^\circ) = 0.9333$$

$$\tan(\alpha) = \tan(\alpha) = \tan(21.04^\circ) = 0.3846$$

$$Q_S = P_0 \cdot \frac{R_S}{2} + f_2 = 1.014 \text{ bar} \cdot \frac{1172 \text{ mm}}{2} + 159.9 \text{ N/mm} = 219.3 \text{ N/mm}$$

$$A_{rS} = \frac{k \cdot Q_S \cdot R_S \cdot \tan(\alpha)}{S_s \cdot E_1} = \frac{1 \cdot 219.3 \text{ N/mm} \cdot 1172 \text{ mm} \cdot 0.3846}{138 \text{ N/mm}^2 \cdot 1} = 716 \text{ mm}^2 \quad (3)$$

$$A_{eS} = 0.55 \cdot \sqrt{D_S \cdot t_s} \cdot \left[ \frac{t_s - t + (t_c - t_r)}{\cos(\alpha)} \right] = \quad (4)$$

$$0.55 \cdot \sqrt{2343 \text{ mm} \cdot 25.4 \text{ mm}} \cdot \left[ \frac{25.4 \text{ mm} - 17.06 \text{ mm} + (46.05 \text{ mm} - 9.242 \text{ mm})}{0.9333} \right] = 8002 \text{ mm}^2$$





# ASME BPVC VIII-1 2021

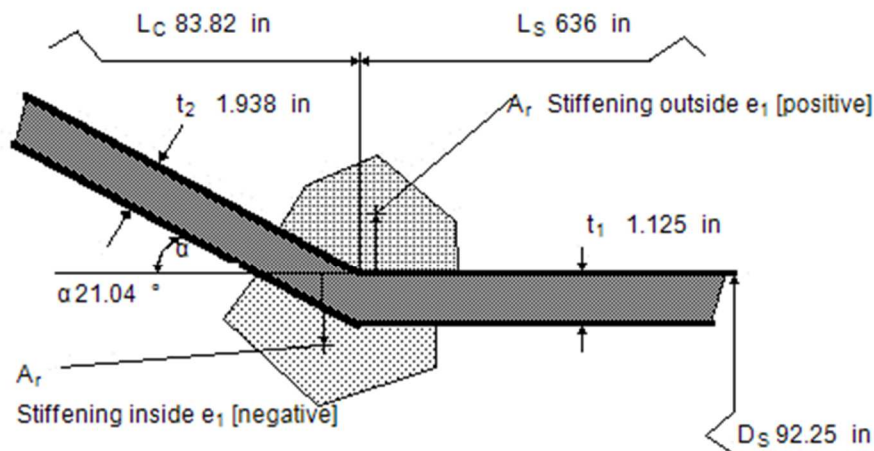
## Example E4.4.7 - E4.4.8 PTB-4-2021

### E4.4.7 Small End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021

Moment of inertia at the small end of a cone-cylinder-juncture under external pressure acc. App.1-8

(Line-of-support)

External design pressure	$p_D$	14.7 psi
Hydrostatic head	$D_p$	0 psi
Calculation pressure	$p_0$	14.7 psi
Calculation temperature	$T_0$	300 °F
Axial additional load as line load (positive for tension) e.g. wind load, dead weight, traffic load, etc. but no loads resulting from internal / external pressure	$f_2$	913 lbf/in



#### Cylinder

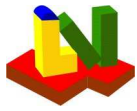
Final wall thickness	$t_1$	1.125 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0.125 in
Final thickness without allowances	$t_s$	1 in
Required thickness without allowances (UG-28)	$t_{1r}$	0.6718 in
Required thickness with allowances (UG-28)	$t_{1rt}$	0.7968 in
Outside diameter	$D_S$	92.25 in
Tip radius ( $=D_S/2$ )	$R_S$	46.12 in
Buckling length	$L_S$	636 in

#### Cone

Final wall thickness	$t_2$	1.938 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0.125 in
Final thickness without allowances	$t_c$	1.813 in
Required thickness without allowances (UG-33)	$t_{2r}$	0.3639 in
Required thickness with allowances (UG-33)	$t_{2rt}$	0.4889 in
Semi-apex angle ( $\leq 60^\circ$ )	$\alpha$	21.04 °
Buckling length	$L_C$	83.82 in

#### Stiffening ring

Material	K02700-SA-516-70-Class:-Size:	
Spec. Min. Yield	$S_y$	2.9e+7 psi
Applicable material chart	Fig	CS-2
Radial distance between the centroid of the stiffening ring and the outer surface of the cylinder	$e_1$	in
Cross sectional area	$A_r$	0 in <sup>2</sup>
Moment of inertia	$I_r$	in <sup>4</sup>



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

### Results

Equivalent length	N	362.3 in
Effective load	F <sub>S</sub>	5677 lbf/in
Reference area	A <sub>TS</sub>	394 in <sup>2</sup>
Factor	B	997 psi
Factor (see material chart)	A	6.998e-5
Required moment of inertia	I <sub>s</sub>	16.76 in <sup>4</sup>
Required moment of inertia	I' <sub>s</sub>	21.53 in <sup>4</sup>
Length of support	0.55 · √(D · t <sub>s</sub> )	5.283 in
Available moment of inertia	I'	in <sup>4</sup>
Remark		

### Equations

$$\cos(\alpha) = \cos(\alpha) = \cos(21.04^\circ) = 0.9333$$

$$\sin(\alpha) = \sin(\alpha) = \sin(21.04^\circ) = 0.359$$

$$\tan(\alpha) = \tan(\alpha) = \tan(21.04^\circ) = 0.3846$$

$$R_s = R_L - L_C \cdot \sin(\alpha) = 1952 \text{ mm} - 2129 \text{ mm} \cdot 0.359 = 1172 \text{ mm}$$

$$N = \frac{R_s \cdot \tan(\alpha)}{2} + \frac{L_s}{2} + \frac{RL^2 - RS^2}{6 \cdot R_s \cdot \tan(\alpha)} =$$

$$\frac{1172 \text{ mm} \cdot 0.3846}{2} + \frac{16154 \text{ mm}}{2} + \frac{(1952 \text{ mm})^2 - (1172 \text{ mm})^2}{6 \cdot 1172 \text{ mm} \cdot 0.3846} = 9203 \text{ mm}$$

$$994.3 \text{ N/mm} = 1.014 \text{ bar} \cdot 9203 \text{ mm} + 159.9 \text{ N/mm} \cdot 0.3846$$

$$A_{TS} = L_s \cdot \frac{t_s}{2} + L_C \cdot \frac{t_c}{2} + A_s = 16154 \text{ mm} \cdot \frac{25.4 \text{ mm}}{2} + 2129 \text{ mm} \cdot \frac{46.05 \text{ mm}}{2} + 0 \text{ mm}^2 = 254182 \text{ mm}^2$$

$$B = \frac{3}{4} \cdot \frac{F_s \cdot D_s}{A_{TS}} = \frac{3}{4} \cdot \frac{994.3 \text{ N/mm} \cdot 2343 \text{ mm}}{254182 \text{ mm}^2} = 6.874 \text{ N/mm}^2$$

$$I_s = \frac{A \cdot DS^2 \cdot A_{TS}}{14} = \frac{6.998e-5 \cdot (2343 \text{ mm})^2 \cdot 254182 \text{ mm}^2}{14} = 6975754 \text{ mm}^4$$

$$I'_s = \frac{A \cdot DS^2 \cdot A_{TS}}{10.9} = \frac{6.998e-5 \cdot (2343 \text{ mm})^2 \cdot 254182 \text{ mm}^2}{10.9} = 8959684 \text{ mm}^4$$

$$0.55 \cdot \sqrt{(D \cdot t_s)} = 0.55 \cdot \sqrt{(D \cdot 25.4 \text{ mm})} = 134.2 \text{ mm}$$



**ASME BPVC VIII-1 2021**  
Example E4.4.7 - E4.4.8 PTB-4-2021

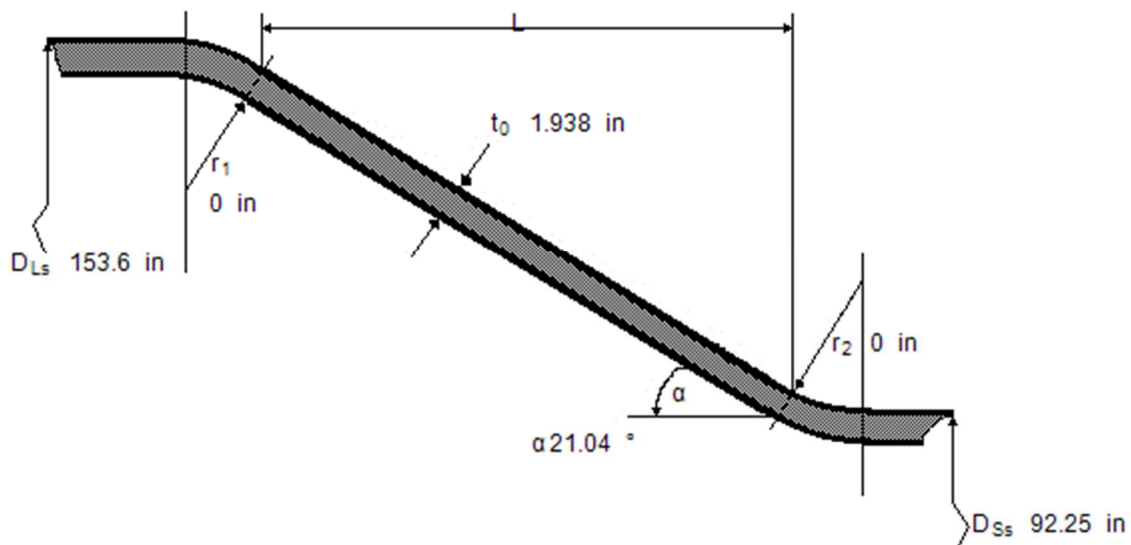
**E4.4.8 Large and Small End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021**

**Conical shells under external pressure acc. UG-33(f)**

External design pressure	$p_D$	14.7 psi
Hydrostatic head	$D_p$	0 psi
Calculation pressure	$p_0$	14.7 psi
Calculation temperature	$T_0$	300 °F

Material K02700-SA-516-70-Class:-Size:

Spec. Min. Yield	$S_y$	37710 psi
Allowable stress	$S_0$	20015 psi
Applicable material chart	Fig	CS-2
Modulus of elasticity	$E$	2.9e+7 psi

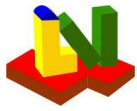


Cone wall thickness with allowances	$t_0$	1.938 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0.125 in
Cone wall thickness without allowances	$t$	1.813 in

Is a cylinder connected, which does not act as line of support?

	N	(Y/N)
Outside diameter (wide end)	$D_{Ls}$	153.6 in
Knuckle radius (wide end)	$r_1$	0 in
Outside diameter (small end)	$D_{Ss}$	92.25 in
Knuckle radius (small end)	$r_2$	0 in
Half apex angle ( $\leq 60^\circ$ )	$\alpha$	21.04 °

**Proof for cross-section area according to App. 1-8 required for cone-connection without knuckle**



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

### Results

Effective thickness	$t_e = t \cdot \cos(\alpha)$	$t_e$	<b>1.692</b> in
Axial length of the cone		$L$	<b>79.79</b> in
Design length		$L_e$	<b>63.85</b> in
Ratio		$L_e/D_L$	<b>0.4156</b>
Ratio		$D_L/t_e$	<b>90.81</b>
Factor according to fig. 5-UGO-28.0		$A$	<b>0.004054</b>
Factor (see material chart)		$B$	<b>16850</b> psi
Factor	$2 \cdot \text{Min}(S_0, 0.9 \cdot B)$	$S$	<b>31589</b> psi
Allowable external pressure (for $t_0$ )		$P$	<b>247.4</b> psi
Allowable pressure without hydrostatic head		MEP	<b>247.4</b> psi
Required thickness (for $P_0$ )		$t$	<b>0.3664</b> in
Required thickness incl. allowances		$t+c_1+c_2$	<b>0.4914</b> in

Remark

### Equations

$$\cos(\alpha) = \cos(\alpha) = \cos(21.04^\circ) = 0.9333$$

$$\sin(\alpha) = \sin(\alpha) = \sin(21.04^\circ) = 0.359$$

$$\tan(\alpha) = \tan(\alpha) = \tan(21.04^\circ) = 0.3846$$

$$D_L = D_{Ls} - r_1 \cdot (1 - \cos(\alpha)) = 3902 \text{ mm} - 0 \text{ mm} \cdot (1 - 0.9333) = 3902 \text{ mm}$$

$$D_S = D_{Ss} + r_2 \cdot (1 - \cos(\alpha)) = 2343 \text{ mm} + 0 \text{ mm} \cdot (1 - 0.9333) = 2343 \text{ mm}$$

$$L = \frac{(D_L - D_S)}{2} \cdot \tan(\alpha) = \frac{(3902 \text{ mm} - 2343 \text{ mm})}{2} \cdot 0.3846 = 2027 \text{ mm}$$

$$L_1 = r_1 \cdot \sin(\alpha) = 0 \text{ mm} \cdot 0.359 = 0 \text{ mm}$$

$$L_2 = r_2 \cdot \left( \frac{D_{Ss}}{D_{Ls}} \right) \cdot \sin(\alpha) = 0 \text{ mm} \cdot 0.6005 \cdot 0.359 = 0 \text{ mm}$$

$$L_3 = \frac{L}{2} \cdot \frac{(D_L + D_S)}{D_{Ls}} = \frac{2027 \text{ mm}}{2} \cdot \frac{(3902 \text{ mm} + 2343 \text{ mm})}{3902 \text{ mm}} = 1622 \text{ mm}$$

$$L_e = L_1 + L_2 + L_3 = 0 \text{ mm} + 0 \text{ mm} + 1622 \text{ mm} = 1622 \text{ mm}$$

1) for  $D_L/t_0 \geq 10$

$$Pa(B) = \frac{4 \cdot B}{3 \cdot \left( \frac{D_L}{t_0} \right)} = \frac{4 \cdot 116.2 \text{ N/mm}^2}{3 \cdot 90.81} = 1.706 \text{ N/mm}^2$$

UG-33 f-a) Step 6

$$Pa(E) = \frac{2 \cdot A \cdot E}{3 \cdot \left( \frac{D_L}{t_0} \right)} = \frac{2 \cdot 0.004054 \cdot 199948 \text{ N/mm}^2}{3 \cdot 90.81} = 5.951 \text{ N/mm}^2$$

UG-33 f-a) Step 7

2) for  $D_L/t_0 < 10$



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

$$P_{a1} = \left[ \frac{2.167}{\frac{D_L}{t_0}} - 0.0833 \right] \cdot B = \left[ \frac{2.167}{90.81} - 0.0833 \right] \cdot 116.2 \text{ N/mm}^2 = -6.905 \text{ N/mm}^2$$

UG-33 f-b) Step 2

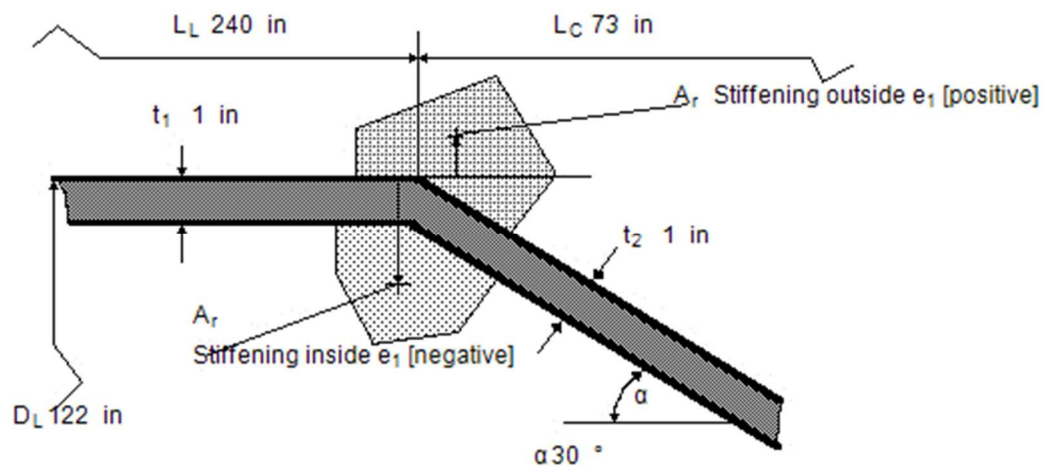
$$P_{a2} = \frac{2 \cdot S}{\frac{D_L}{t_0}} \cdot \left[ 1 - \frac{2 \cdot S}{\frac{D_L}{t_0}} \right] = \frac{2 \cdot 217.8 \text{ N/mm}^2}{90.81} \cdot \left[ 1 - \frac{2 \cdot 217.8 \text{ N/mm}^2}{90.81} \right] = 4.744 \text{ N/mm}^2$$

UG-33 f-b) Step 3

## E4.4.8 Large End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2021

### Moment of inertia at the wide end of a cone-cylinder-juncture under external pressure acc. App. 1-8 (Line-of-support)

External design pressure	$p_D$	14.7 psi
Hydrostatic head	$D_p$	0 psi
Calculation pressure	$p_0$	14.7 psi
Calculation temperature	$T_0$	300 °F
Axial additional load as line load (positive for tension) e.g. wind load, dead weight, traffic load, etc. but no loads resulting from internal / external pressure	$f_1$	145 lbf/in



### Cylinder

Design wall thickness	$t_1$	1 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0 in
Final thickness without allowances	$t_s$	1 in
Required thickness without allowances (UG-28)	$t_{1r}$	0.5205 in
Required thickness with allowances (UG-28)	$t_{1r+}$	0.5205 in
Outside diameter	$D_L$	122 in
Tip radius	$R_L$	61 in
Buckling length	$L_L$	240 in

### Cone

Design wall thickness	$t_2$	1 in
Wall thickness allowance	$c_1$	0 in
Allowance (corrosion)	$c_2$	0 in
Final thickness without allowances	$t_c$	1 in



# ASME BPVC VIII-1 2021

## Example E4.4.7 - E4.4.8 PTB-4-2021

Required thickness without allowances (UG-33)	$t_{2r}$	0.3358 in
Required thickness with allowances (UG-33)	$t_{2r+}$	<b>0.3358</b> in
Half apex angle ( $\leq 60^\circ$ )	$\alpha$	30 °
Buckling length	$L_C$	73 in

### Stiffening ring

Material	K02700-SA-516-70-Class:-Size:	
Spec. Min. Yield	$S_y$	2.9e+7 psi
Applicable material chart	Fig	CS-2
Radial distance between the centroid of the stiffening ring and the outer surface of the cylinder	$e_1$	0 in
Cross sectional area	$A_r$	0 in <sup>2</sup>
Moment of inertia	$I_r$	0 in <sup>4</sup>

### Results

Equivalent length	$M$	<b>134.7</b> in
Effective load	$F_L$	<b>2064</b> lbf/in
Reference area	$A_{TL}$	<b>156.5</b> in <sup>2</sup>
Factor	$B$	<b>1207</b> psi
Factor (see material chart)	$A$	<b>8.447e-5</b>
Required moment of inertia	$I_s$	<b>14.06</b> in <sup>4</sup>
Required moment of inertia	$I'_s$	<b>18.05</b> in <sup>4</sup>
Length of support	$0.55 \cdot \sqrt{(D \cdot t_s)}$	<b>6.075</b> in
Available moment of inertia	$I'$	<b>18.15</b> in <sup>4</sup>

Remark **Stiffening required**

### Equations

$$\cos(\alpha) = \cos(\alpha) = \cos(30^\circ) = 0.866$$

$$\sin(\alpha) = \sin(\alpha) = \sin(30^\circ) = 0.5$$

$$\tan(\alpha) = \tan(\alpha) = \tan(30^\circ) = 0.5774$$

$$R_s = R_L - L_C \cdot \sin(\alpha) = 1549 \text{ mm} - 1854 \text{ mm} \cdot 0.5 = 445 \text{ mm}$$

$$M = \frac{-R_L \cdot \tan(\alpha)}{2} + \frac{L_L}{2} + \frac{RL^2 - RS^2}{3 \cdot R_L \cdot \tan(\alpha)} = \frac{-1549 \text{ mm} \cdot 0.5774}{2} + \frac{6096 \text{ mm}}{2} + \frac{(1549 \text{ mm})^2 - (445 \text{ mm})^2}{3 \cdot 1549 \text{ mm} \cdot 0.5774} = 3421 \text{ mm}$$

App. 1-8 b-3) Step 1

$$F_L = P_0 \cdot M + f_1 \cdot \tan(\alpha) = 1.014 \text{ bar} \cdot 3421 \text{ mm} + 25.39 \text{ N/mm} \cdot 0.5774 = 361.4 \text{ N/mm}$$

App. 1-8 b-3) Step 1

$$A_{TL} = L_L \cdot \frac{t_s}{2} + L_C \cdot \frac{t_c}{2} + A_s = 6096 \text{ mm} \cdot \frac{25.4 \text{ mm}}{2} + 1854 \text{ mm} \cdot \frac{25.4 \text{ mm}}{2} + 0 \text{ mm}^2 = 100968 \text{ mm}^2$$

App. 1-8 a)

$$B = \frac{3}{4} \cdot \frac{F_L \cdot D_L}{A_{TL}} = \frac{3}{4} \cdot \frac{361.4 \text{ N/mm} \cdot 3099 \text{ mm}}{100968 \text{ mm}^2} = 8.32 \text{ N/mm}^2$$

App. 1-8 b-3) Step 1

$$I_s = A \cdot D_L^2 \cdot \frac{A_{TL}}{14} = 8.447e-5 \cdot (3099 \text{ mm})^2 \cdot \frac{100968 \text{ mm}^2}{14} = 5850143 \text{ mm}^4$$

App. 1-8 b-3) Step 6



**ASME BPVC VIII-1 2021**  
Example E4.4.7 - E4.4.8 PTB-4-2021

App. 1-8 b-3) Step 6

$$I'_s = A \cdot D_L^2 \cdot \frac{A_{TL}}{10.9} = 8.447 \text{e-}5 \cdot (3099 \text{ mm})^2 \cdot \frac{100968 \text{ mm}^2}{10.9} = 7513945 \text{ mm}^4$$

$$0.55 \cdot \sqrt{(D \cdot t_s)} = 0.55 \cdot \sqrt{(3099 \text{ mm} \cdot 25.4 \text{ mm})} = 154.3 \text{ mm}$$