



ASME BPVC VIII-1 2021

Example E4.3.7 - E4.3.8 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 E4.3.7 - E4.3.8 PTB-4-2021

E4.3.7 Large End - Cone-to-cylinder junction at large end under internal pressure - ASME BPVC VIII-1 UG-32 & Appendix-1: 2021

Cone-to-cylinder junction (wide end)

Type of reinforcing ring

(0 = no, 1 = at the cylinder, 2 = at the cone)

Without stiffener

Design pressure

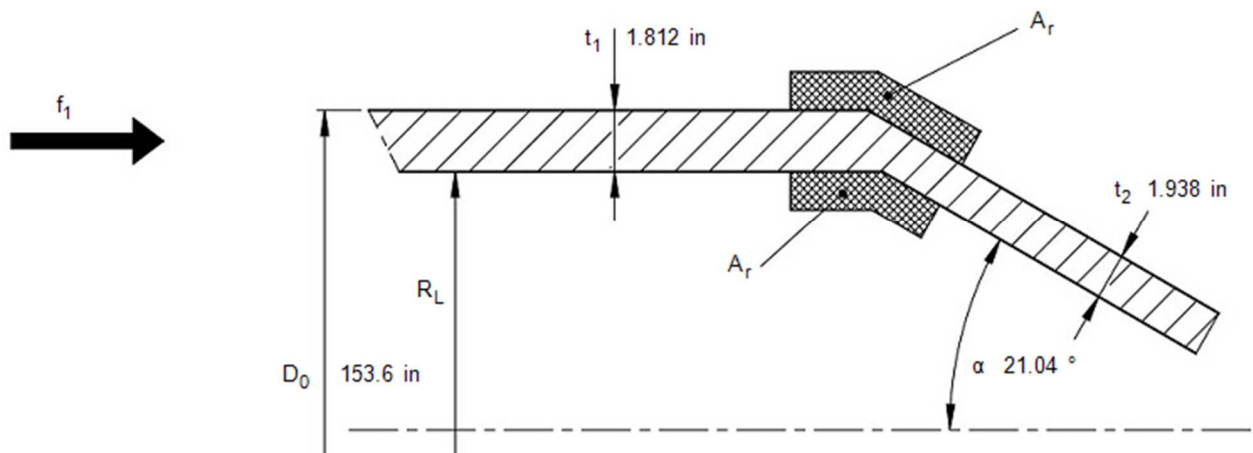
Hydrostatic head

Calculation pressure

Calculation temperature

Axial load based on circumference (for compression negative)

p_D	356 psi
D_p	0 psi
p_0	356 psi
T_0	300 °F
f_1	0 lbf/in



Cylinder

Outside diameter

Final wall thickness

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

Wall thickness allowance

Allowance (corrosion)

Thickness without allowances

Inside radius

Allowable stress

Modulus of elasticity

Weld joint efficiency (or Cast Quality Factor)

(= $D_0/2 - t_s$)

D_0	153.6 in
t_1	1.812 in
c_1	0 in
c_2	0.125 in
t_s	1.687 in
R_L	75.12 in
S_s	20015 psi
E_s	2.829e+7 psi
E_1	1

Cone

Half-apex angle ($\leq 30^\circ$)

Final wall thickness

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

Wall thickness allowance

Allowance (corrosion)

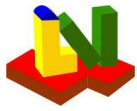
Effective thickness

Allowable stress

Modulus of elasticity

Weld joint efficiency (or Cast Quality Factor)

α	21.04 °
t_2	1.938 in
c_1	0 in
c_2	0.125 in
t_c	1.813 in
S_c	20015 psi
E_c	2.829e+7 psi
E_2	1



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Example E4.3.7 - E4.3.8 PTB-4-2021

Results

Geometrical conditions
valid

Strength condition
Wall thickness acceptable

Factor			k	1
Ratio		$P_0/S_s E_1$		0.01779
Angle	(Reinforcement required if $\Delta < \alpha$)	21.04°	Δ	43.56°
Effective load			Q_L	13371 lbf/in
Required thickness cylinder (UG-27)			t	1.351 in
with allowances (t_1)	1.812 in	$\geq t_+$	t_+	1.476 in
Required thickness cone (UG-32)			t_r	1.447 in
with allowances (t_2)	1.938 in	$\geq t_r$	t_r	1.572 in
Required cross sectional area			A_{rL}	0 in ²
Available cross section			A_{eL}	8.209 in ²
Required area of reinforcement			A_r	0 in ²
Available area of reinforcement	$b_v \cdot t_v$		A_v	0 in ²
Maximum distance from the connection point of the complete reinforcing area		$\sqrt{[R_L \cdot t_s]}$		11.26 in
centroid of reinforcing area		$0.25 \cdot \sqrt{[R_L \cdot t_s]}$		2.815 in

Equations

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

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

$$Q_L = P_0 \cdot \frac{R_L}{2} + f_1 = 24.55 \text{ bar} \cdot \frac{1908 \text{ mm}}{2} + 0 \text{ N/mm} = 2342 \text{ N/mm}$$

$$A_{rL} = \frac{k \cdot Q_L \cdot R_L}{S_s \cdot E_1} \cdot \left[1 - \frac{D_{el}}{\alpha} \right] \cdot \tan(\alpha) = \frac{1 \cdot 2342 \text{ N/mm} \cdot 1908 \text{ mm}}{138 \text{ N/mm}^2 \cdot 1} \cdot \left[1 - \frac{43.56^\circ}{21.04^\circ} \right] \cdot 0.3846 = 0 \text{ mm}^2$$

$$t = \frac{P_0 \cdot R_L}{S_s \cdot E_1 - 0.6 \cdot P_0} = \frac{24.55 \text{ bar} \cdot 1908 \text{ mm}}{138 \text{ N/mm}^2 \cdot 1 - 0.6 \cdot 24.55 \text{ bar}} = 34.3 \text{ mm}$$

$$t_r = \frac{P_0 \cdot \frac{R_L}{\cos(\alpha)}}{S_c \cdot E_2 - 0.6 \cdot P_0} = \frac{24.55 \text{ bar} \cdot \frac{1908 \text{ mm}}{0.9333}}{138 \text{ N/mm}^2 \cdot 1 - 0.6 \cdot 24.55 \text{ bar}} = 36.75 \text{ mm}$$

$$A_{eL} = (t_s - t) \cdot \sqrt{R_L \cdot t_s} + (t_c - t_r) \cdot \sqrt{R_L \cdot \frac{t_c}{\cos(\alpha)}} =$$

$$(42.86 \text{ mm} - 34.3 \text{ mm}) \cdot \sqrt{1908 \text{ mm} \cdot 42.86 \text{ mm}} + (46.04 \text{ mm} - 36.75 \text{ mm}) \cdot \sqrt{1908 \text{ mm} \cdot \frac{46.04 \text{ mm}}{0.9333}} = 5296 \text{ mm}^2$$



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Example E4.3.7 - E4.3.8 PTB-4-2021

E4.3.7 Small End - Cone-to-cylinder junction at small end under internal pressure - ASME BPVC VIII-1 UG-32 & Appendix-1: 2021

Cone-to-cylinder junction (small end)

Type of reinforcing ring

(0 = no, 1 = at the cylinder, 2 = at the cone)

0

Without stiffener

Design pressure

p_D 356 psi

Hydrostatic head

D_p 0 psi

Calculation pressure

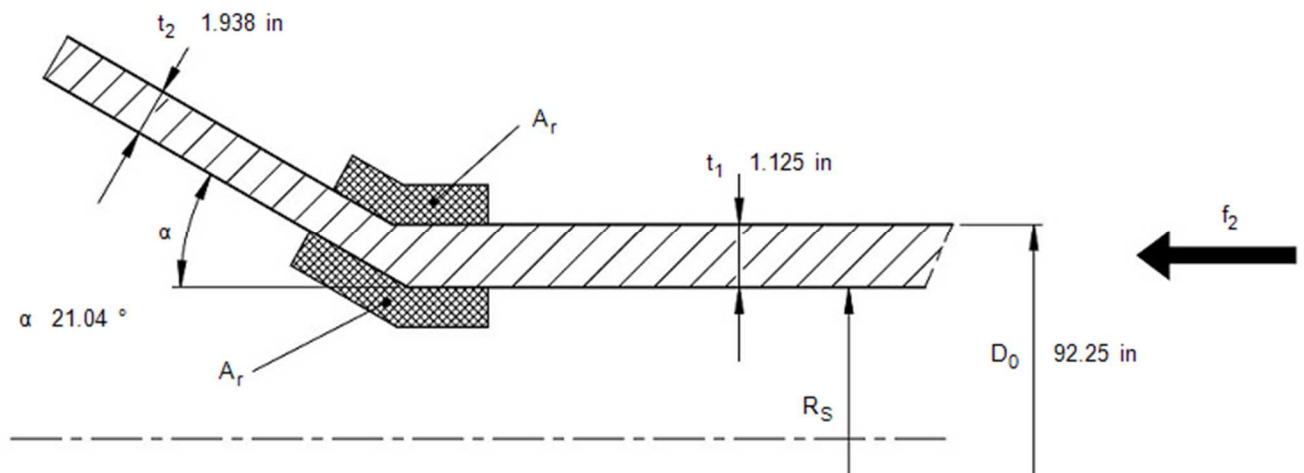
p_0 **356** psi

Calculation temperature

T_0 300 °F

Axial load based on circumference (for compression negative)

f_2 396.9 lbf/in



Cylinder

Outside diameter

D_0 92.25 in

Final wall thickness

t_1 1.125 in

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

Wall thickness allowance

c_1 0 in

Allowance (corrosion)

c_2 **0.125** in

Effective thickness

t_s **1** in

Inside radius

(= $D_0/2 - t_s$)

R_S **45.12** in

Allowable stress

S_s 20015 psi

Modulus of elasticity

E_s 2.829e+7 psi

Weld joint efficiency (or Cast Quality Factor)

E_1 1

Cone

Half-apex angle ($\leq 30^\circ$)

α 21.04 °

Final wall thickness

t_2 1.938 in

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

Wall thickness allowance

c_1 0 in

Allowance (corrosion)

c_2 **0.125** in

Thickness without allowances

t_c **1.813** in

Allowable stress

S_c 20015 psi

Modulus of elasticity

E_c 2.829e+7 psi

Weld joint efficiency (or Cast Quality Factor)

E_2 1



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Example E4.3.7 - E4.3.8 PTB-4-2021

Results

Geometrical conditions
valid

Strength condition
Wall thickness acceptable

Factor		k	1
Ratio	$P_0/S_s E_1$	Δ	0.01779
Angle		Q_S	11.87 °
Effective load			8429 lbf/in
Required thickness cylinder (UG-27)		t	0.8113 in
with allowances (t_1)	1.125 in	t_+	0.9363 in
Required thickness cone (UG-32)		t_r	0.8692 in
with allowances (t_2)	1.938 in	t_{r+}	0.9942 in
Required cross sectional area		A_{rS}	3.185 in ²
Available cross section		A_{eS}	7.876 in ²
Required area of reinforcement		A_r	0 in ²
Available area of reinforcement	$b_v \cdot t_v$	A_v	0 in ²
Maximum distance from the connection point of the complete reinforcing area	$\sqrt{[R_L \cdot t_s]}$		9.044 in
centroid of reinforcing area	$0.25 \cdot \sqrt{[R_L \cdot t_s]}$		2.261 in

Equations

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

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

$$Q_S = P_0 \cdot \frac{RS}{2} + f_2 = 24.55 \text{ bar} \cdot \frac{1146 \text{ mm}}{2} + 69.5 \text{ N/mm} = 1476 \text{ N/mm}$$

$$A_r S = \frac{k \cdot Q_S \cdot RS}{S_s \cdot E_1} \cdot \left[1 - \frac{Del}{a} \right] \cdot \tan(\alpha) = \frac{1 \cdot 1476 \text{ N/mm} \cdot 1146 \text{ mm}}{138 \text{ N/mm}^2 \cdot 1} \cdot \left[1 - \frac{11.87^\circ}{21.04^\circ} \right] \cdot 0.3846 = 2055 \text{ mm}^2$$

$$t = \frac{P_0 \cdot RS}{S_s \cdot E_1 - 0.6 \cdot P_0} = \frac{24.55 \text{ bar} \cdot 1146 \text{ mm}}{138 \text{ N/mm}^2 \cdot 1 - 0.6 \cdot 24.55 \text{ bar}} = 20.61 \text{ mm}$$

$$t_r = \frac{P_0 \cdot \frac{RS}{(\cos(\alpha))}}{S_c \cdot E_2 - 0.6 \cdot P_0} = \frac{24.55 \text{ bar} \cdot \frac{1146 \text{ mm}}{0.9333}}{138 \text{ N/mm}^2 \cdot 1 - 0.6 \cdot 24.55 \text{ bar}} = 22.08 \text{ mm}$$

$$A_e S = 0.78 \cdot \sqrt{RS \cdot t_s} \cdot \left[(ts - t) + \frac{(tc - tr)}{\cos(\alpha)} \right] =$$

$$0.78 \cdot \sqrt{1146 \text{ mm} \cdot 25.4 \text{ mm}} \cdot \left[(25.4 \text{ mm} - 20.61 \text{ mm}) + \frac{(46.04 \text{ mm} - 22.08 \text{ mm})}{0.9333} \right] = 5082 \text{ mm}^2$$

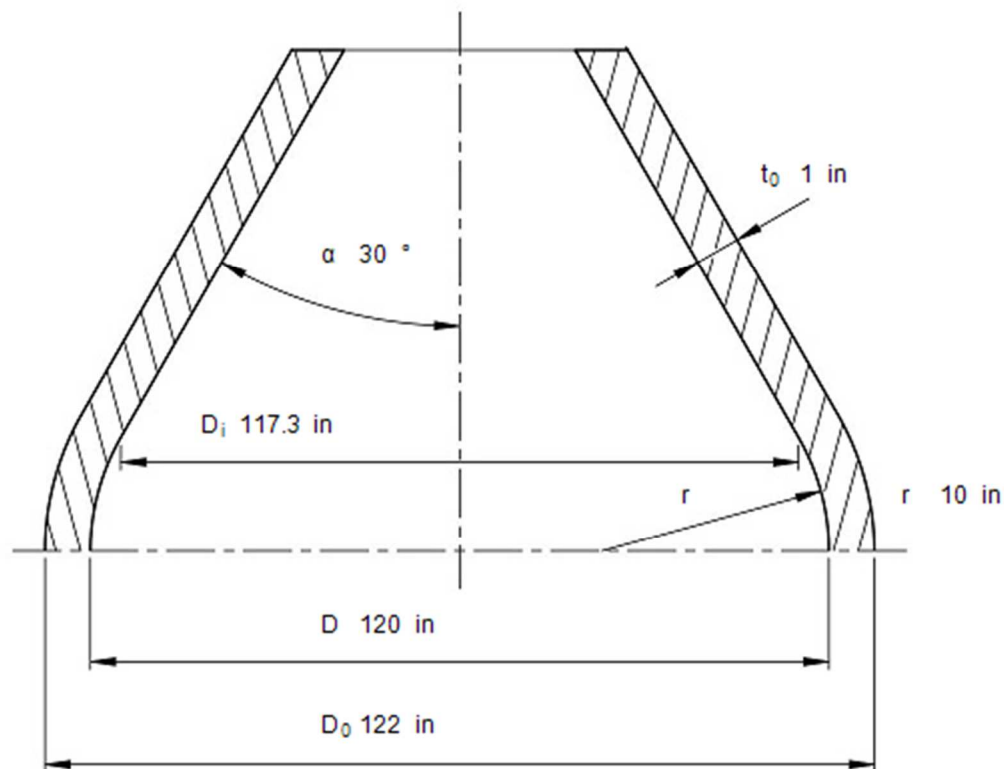


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Example E4.3.7 - E4.3.8 PTB-4-2021

E4.3.8 - Cone with knuckle under internal pressure - ASME BPVC VIII-1 UG-32 & Appendix-1: 2021

Toriconical sections

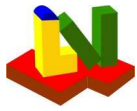
Design pressure	p_D	285.4 psi
Hydrostatic head	D_p	0 psi
Calculation pressure	p_0	285.4 psi
Calculation temperature	T_0	300 °F
Final wall thickness	t_e	1 in
Wall thickness allowance	c_1	0 in
Allowance (corrosion)	c_2	0 in
Effective thickness without allowances	t_0	1 in



Outside diameter of cylindrical shell	D_0	122 in
Inside diameter of cylindrical shell (= $D_0 - 2t_0$)	D	120 in
Semi-apex angle	α	30 °
Knuckle radius ($\geq 0.06 \cdot D_0$, $\geq 3 \cdot t_0$)	r	10 in
Weld joint efficiency (or Cast Quality Factor)	E	1

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

Allowable stress S **20015** psi



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Example E4.3.7 - E4.3.8 PTB-4-2021

Calculation

Largest inside diameter of cone	D_i	117.3 in
Equivalent radius	L	67.74 in
Ratio	L/r	6.774
Factor	M	1.401
Required knuckle thickness	t	0.6773 in
Allowable inside pressure of knuckle	P	421 psi
Calculation diameter of cone	D_1	117.3 in
Required cone thickness at D_1	t_1	0.9741 in
Allowable inside pressure of cone	P_1	292.9 psi
Remark		
Required thickness incl. allowances	$t+C_1+C_2$	$t+$ 0.9741 in
Allowable excess pressure	$\text{Min}(P, P_1)$	P_m 292.9 psi
Allowable excess pressure without hydr. Head		MAWP 292.9 psi

Geometrical conditions
valid

Strength condition
Wall thickness acceptable

Equations knuckle

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

$$D_i = D - 2 \cdot r \cdot (1 - \cos(\alpha)) = 3048 \text{ mm} - 2 \cdot 254 \text{ mm} \cdot (1 - 0.866) = 2980 \text{ mm}$$

$$L = \frac{D_i}{2 \cdot \cos(\alpha)} = \frac{2980 \text{ mm}}{2 \cdot 0.866} = 1720 \text{ mm}$$

$$t = \frac{P_0 \cdot L \cdot M}{2 \cdot S \cdot E - 0.2 \cdot P_0} = \frac{19.68 \text{ bar} \cdot 1720 \text{ mm} \cdot 1.401}{2 \cdot 138 \text{ N/mm}^2 \cdot 1 - 0.2 \cdot 19.68 \text{ bar}} = 17.2 \text{ mm}$$

$$P = \frac{2 \cdot S \cdot E \cdot t_0}{L \cdot M + 0.2 \cdot t_0} = \frac{2 \cdot 138 \text{ N/mm}^2 \cdot 1 \cdot 25.4 \text{ mm}}{1720 \text{ mm} \cdot 1.401 + 0.2 \cdot 25.4 \text{ mm}} = 2.903 \text{ MPa}$$

Equations cone

$$t_1 = \frac{P_0 \cdot D_1}{2 \cdot \cos(\alpha) \cdot (S \cdot E - 0.6 \cdot P_0)} = \frac{19.68 \text{ bar} \cdot 2980 \text{ mm}}{2 \cdot 0.866 \cdot (138 \text{ N/mm}^2 \cdot 1 - 0.6 \cdot 19.68 \text{ bar})} = 24.74 \text{ mm}$$

$$P = \frac{2 \cdot S \cdot E \cdot t_0 \cdot \cos(\alpha)}{D_1 + 1.2 \cdot t_0 \cdot \cos(\alpha)} = \frac{2 \cdot 138 \text{ N/mm}^2 \cdot 1 \cdot 25.4 \text{ mm} \cdot 0.866}{2980 \text{ mm} + 1.2 \cdot 25.4 \text{ mm} \cdot 0.866} = 2.019 \text{ MPa}$$