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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

Summary

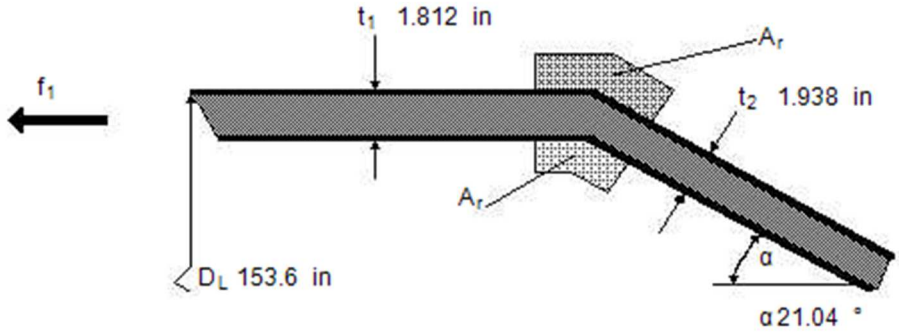
Strength Calculation Software			Program System ATLAS		Version	**8.31.2**				
Developed by Lauterbach Verfahrenstechnik GmbH										
Certified per DIN EN ISO 9001:2015			Certificate Number 01 100 044763							
				LV Soft				**ASME**		**Diff [%]**
Example E4.4.7 - Conical transition Without a knuckle (large End)										
			Required area ArL	1009,63	mm^2	1,56	in^2	1,56	in^2	**0,17%**
			Required area AeL	20735,88	mm^2	32,14	in^2	32,14	in^2	**0,00%**
	Large End/Line-of-support		Required moment of inertia Is	33871336,00	mm^4	81,38	in^4	81,85	in^4	**0,57%**
			Required moment of inertia I's	43504464,00	mm^5	104,52	in^5	105,12	in^5	**0,57%**
Example E4.4.7 - Conical transition Without a knuckle (Small End)										
			Required area ArS	715,96	mm^2	1,11	in^2	1,11	in^2	**0,08%**
			Required area AeS	6410,07	mm^2	9,94	in^2	10,11	in^2	**1,75%**
	Small End/Line-of-support		Required moment of inertia Is	6975753,50	mm^4	16,76	in^4	16,76	in^4	**0,02%**
			Required moment of inertia I's	8959684,00	mm^4	21,53	in^4	21,53	in^4	**0,02%**
Example E4.4.8 - Conical transition With a knuckle										
	Large End/Line-of-support		Required moment of inertia Is	5850143,00	mm^4	14,06	in^4	13,82	in^4	**1,70%**
			Required moment of inertia I's	7513945,00	mm^4	18,05	in^4	17,75	in^4	**1,70%**

E4.4.7 Large End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2019

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	**76.81**	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 (≤ 60°)	α	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	in²
Allowable stress	S_r	20015	psi
Modulus of elasticity	E_r	2.9e+7	psi

Results

Factor (≥ 1)	k	**1**	
Ratio	P_0/S_sE_1	**7.344e-4**	
Angle	D_{el}	**1.836**	°
Effective load	Q_L	**1062**	lbf/in
Cross sectional area	A_{rL}	**1.565**	in²
Effective area	A_{eL}	**32.14**	in²
Required cross section of reinforcement	A_{req}	**0**	in²

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

Equations

$cos(\alpha)=cos(\alpha)=cos(21.04°)=0.9333$

$tan(\alpha)=tan(\alpha)=tan(21.04°)=0.3846$

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

(1)

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

$$\frac{1\cdot 185.9\text{ N/mm}\cdot 1951\text{ mm}\cdot 0.3846}{138\text{ N/mm}^2\cdot 1}\cdot\left(1-\frac{1.014\text{ bar}\cdot 1951\text{ mm}-185.9\text{ N/mm}}{4\cdot 185.9\text{ N/mm}}\cdot\frac{1.836°}{21.04°}\right)=1010\text{ mm}^2$$

(2)

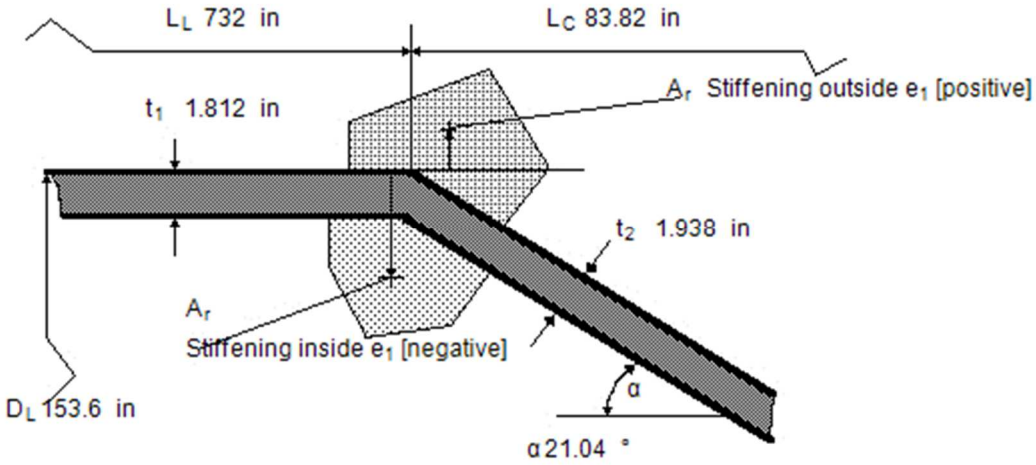
$$A_{eL}=0.55\cdot\sqrt{(D_L\cdot t_s)}\cdot\left(\frac{t_s+t_c}{\cos(\alpha)}\right)=$$

$$0.55\cdot\sqrt{(3902\text{ mm}\cdot 42.86\text{ mm})}\cdot\left(\frac{42.86\text{ mm}+46.04\text{ mm}}{0.9333}\right)=20736\text{ mm}^2$$

E4.4.7 Large End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2019

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 (≤ 60°)	α	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	in²
Moment of inertia	I_r		in^4

Results

Equivalent length	M	**393.8**	in
Effective load	F_L	**5980**	lbf/in
Reference area	A_{TL}	**693.6**	in²
Factor	B	**993.4**	psi
Factor (see material chart)	A	**6.96e-5**	
Required moment of inertia	I_s	**81.38**	in^4
Required moment of inertia	I'_s	**104.5**	in^4
Length of support	$0.55\cdot\sqrt{(D\cdot t_s)}$	**8.856**	in
Available moment of inertia	I'		in^4

Remark

Equations

$cos(\alpha)=cos(\alpha)=cos(21.04°)=0.9333$

$sin(\alpha)=sin(\alpha)=sin(21.04°)=0.359$

$tan(\alpha)=tan(\alpha)=tan(21.04°)=0.3846$

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

App. 1-8 b-3) Step 1

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

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

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 a)

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

$$18593\text{ mm}\cdot\frac{42.86\text{ mm}}{2}+2129\text{ mm}\cdot\frac{46.04\text{ mm}}{2}+0\text{ mm²}=447474\text{ mm²}$$

App. 1-8 b-3) Step 1

$$B=\frac{3}{4}\cdot\frac{F_L\cdot D_L}{A_{TL}}=\frac{3}{4}\cdot\frac{1047\text{ N/mm}\cdot 3902\text{ mm}}{447474\text{ mm²}}=6.849\text{ N/mm²}$$

App. 1-8 b-3) Step 6

$$I_s=A\cdot D_L^2\cdot\frac{A_{TL}}{14}=6.96e\text{-}5\cdot(3902\text{ mm})^2\cdot\frac{447474\text{ mm²}}{14}=3.387e+7\text{ mm^4}$$

App. 1-8 b-3) Step 6

$$I'_s=A\cdot D_L^2\cdot\frac{A_{TL}}{10.9}=6.96e\text{-}5\cdot(3902\text{ mm})^2\cdot\frac{447474\text{ mm²}}{10.9}=4.35e+7\text{ mm^4}$$

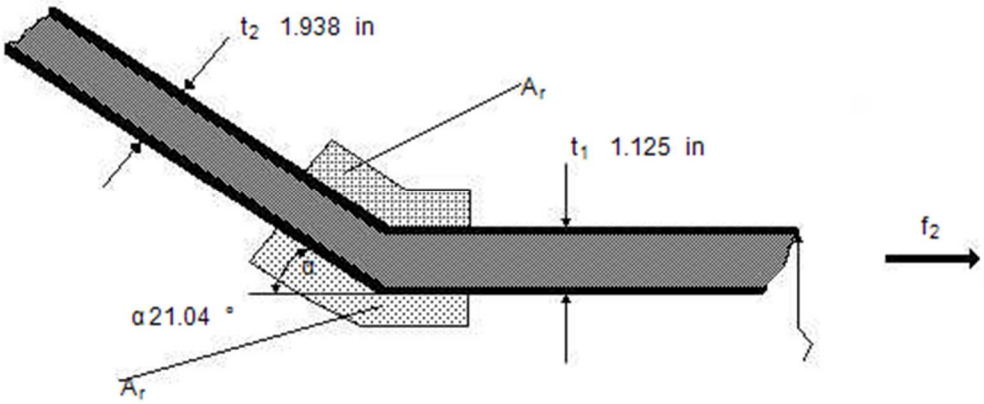
$$0.55\cdot\sqrt{(D\cdot t_s)}=0.55\cdot\sqrt{(3902\text{ mm}\cdot 42.86\text{ mm})}=224.9\text{ mm}$$

E4.4.7 Small End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2019

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 (≤ 60°)	α	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		in²
Allowable stress	S_r		psi
Modulus of elasticity	E_r		psi

Results

Factor	k	**1** ≥ 1	
Effective load	Q_S	**1252**	lbf/in
Cross sectional area	A_{rS}	**1.11**	in²
Effective area	A_{eS}	**9.936**	in²
Required cross section of the stiffener	A_{req}	**0**	in²
Remark			

Equations

$cos(\alpha) = cos(\alpha) = cos(21.04°) = 0.9333$

$tan(\alpha) = tan(\alpha) = tan(21.04°) = 0.3846$

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

(3)

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

(4)

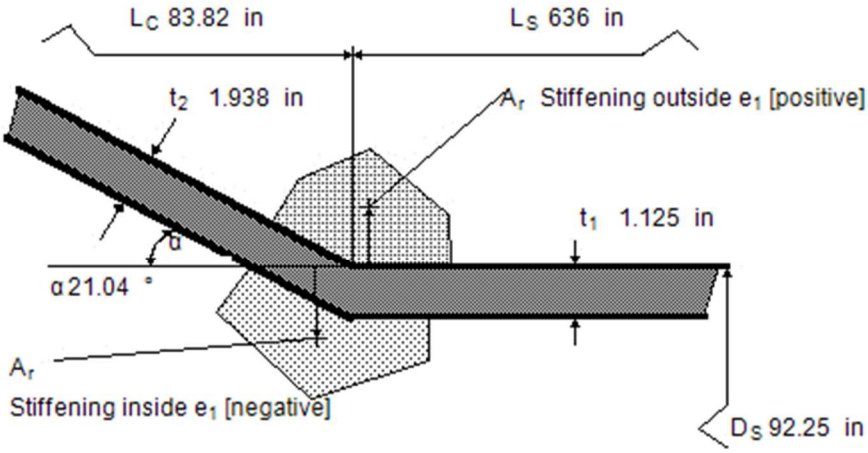
$$A_{eS} = 0.55 \cdot \sqrt{D_S \cdot t_s} \cdot \left[\frac{t_s - t + (t_c - t_r)}{\cos(\alpha)} \right] =$$

$$0.55 \cdot \sqrt{2343\ \text{mm} \cdot 25.4\ \text{mm}} \cdot \left[\frac{25.4\ \text{mm} - 17.06\ \text{mm} + (46.05\ \text{mm} - 9.242\ \text{mm})}{0.9333} \right] = 6410\ \text{mm}^2$$

E4.4.7 Small End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2019

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_{1r+}	**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_{2r+}	**0.4889**	in
Semi-apex angle (≤ 60°)	α	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	in²
Moment of inertia	I_r		in^4

Results

Equivalent length	N	**362.3**	in
Effective load	F_S	**5677**	lbf/in
Reference area	A_{TS}	**394**	in²
Factor	B	**997**	psi
Factor (see material chart)	A	**6.998e-5**	
Required moment of inertia	I_s	**16.76**	in^4
Required moment of inertia	I'_s	**21.53**	in^4
Length of support	$0.55\cdot\sqrt{(D\cdot t_s)}$	**5.283**	in
Available moment of inertia	I'		in^4
Remark			

Equations

$cos(\alpha)=cos(\alpha)=cos(21.04°)=0.9333$

$sin(\alpha)=sin(\alpha)=sin(21.04°)=0.359$

$tan(\alpha)=tan(\alpha)=tan(21.04°)=0.3846$

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

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

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

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

$$A_{TS}=L_S\cdot\frac{t_s}{2}+L_C\cdot\frac{t_c}{2}+A_S=16154\text{ mm}\cdot\frac{25.4\text{ mm}}{2}+2129\text{ mm}\cdot\frac{46.05\text{ mm}}{2}+0\text{ mm²}=254182\text{ mm²}$$

$$B=\frac{3}{4}\cdot\frac{F_S\cdot D_S}{AT_S}=\frac{3}{4}\cdot\frac{994.3\text{ N/mm}\cdot 2343\text{ mm}}{254182\text{ mm²}}=6.874\text{ N/mm²}$$

$$I_s=\frac{A\cdot DS^2\cdot A_{TS}}{14}=\frac{6.998\text{e-}5\cdot(2343\text{ mm})^2\cdot 254182\text{ mm²}}{14}=6975754\text{ mm^4}$$

$$I'_s=\frac{A\cdot DS^2\cdot A_{TS}}{10.9}=\frac{6.998\text{e-}5\cdot(2343\text{ mm})^2\cdot 254182\text{ mm²}}{10.9}=8959684\text{ mm^4}$$

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

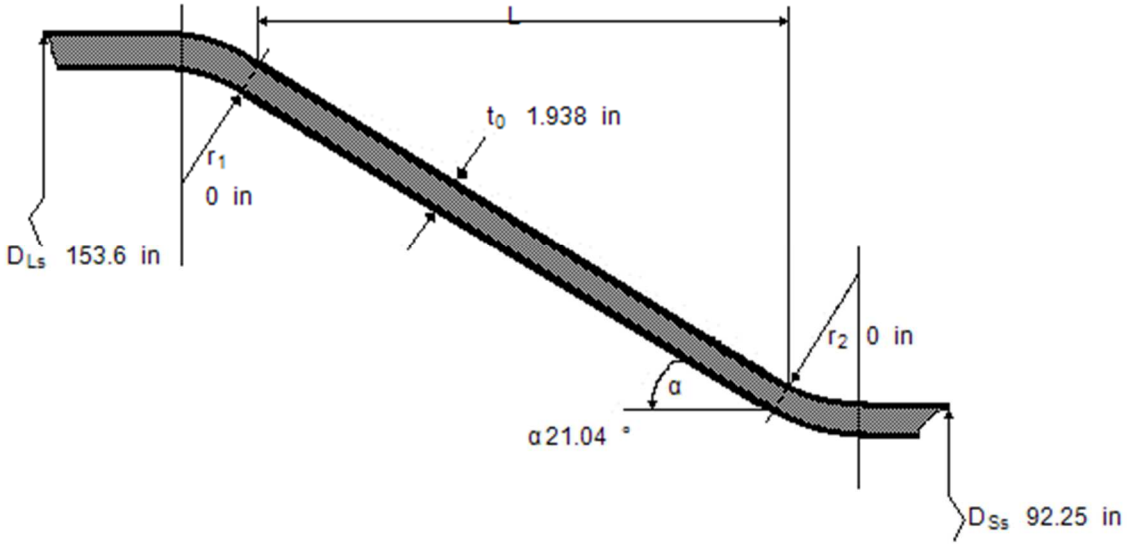
E4.4.8 Large and Small End - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2019

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 (≤ 60°)	α	21.04	°

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

Results

Effective thickness	$t_e = t \cdot \cos(\alpha)$	t_e	**1.692**	in
Axial length of the cone		L	**79.79**	in
Design length		L_e	**63.85**	in
Ratio		L_e/D_L	**0.4156**	
Ratio		D_L/t_e	**90.81**	
Factor according to fig. 5-UGO-28.0		A	**0.004054**	
Factor (see material chart)		B	**16850**	psi
Factor	$2 \cdot \text{Min}(S_0;.9 \cdot B)$	S	**31589**	psi
Allowable external pressure	(for t0)	P	***247.4***	psi
Allowable pressure without hydrostatic head		MEP	***247.4***	psi
Required thickness	(for P0)	t	***0.3664***	in
Required thickness incl. allowances		$t+c_1+c_2$	***0.4914***	in

Remark

Equations

$cos(\alpha) = cos(\alpha) = cos(21.04°) = 0.9333$

$sin(\alpha) = sin(\alpha) = sin(21.04°) = 0.359$

$tan(\alpha) = tan(\alpha) = tan(21.04°) = 0.3846$

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

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

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

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

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

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

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

1) for $D_L/t_0 \geq 10$

UG-33 f-a) Step 6

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

UG-33 f-a) Step 7

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

2) for $D_L/t_0 < 10$

UG-33 f-b) Step 2

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

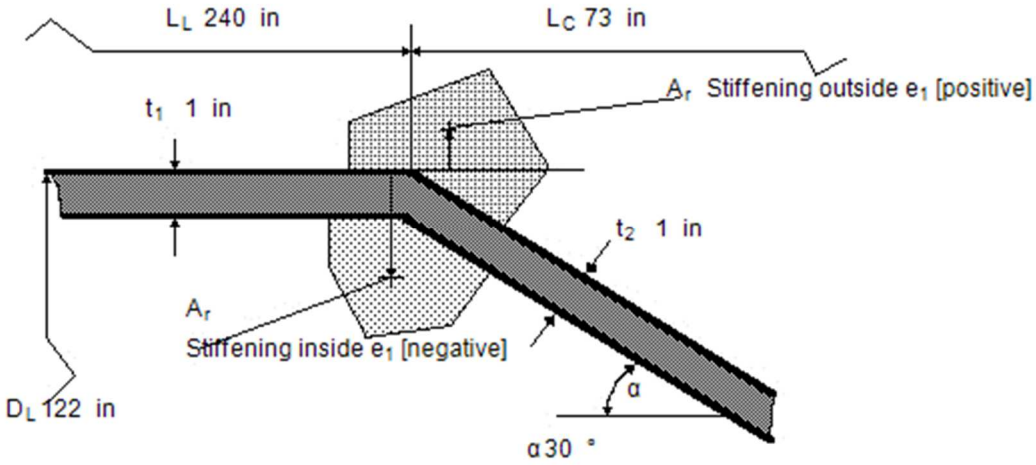
UG-33 f-b) Step 3

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

E4.4.8 Large End/Line-of-support - Formed heads pressure under external pressure - ASME BPVC VIII-1 UG-33 & Appendix-1: 2019

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 (=D_L/2)	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
Required thickness without allowances (UG-33)	t_{2r}	0.3358	in
Required thickness with allowances (UG-33)	t_{2r+}	**0.3358**	in
Half apex angle (≤ 60°)	α	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	in²
Moment of inertia	I_r	0	in^4

Results

Equivalent length	M	**134.7**	in
Effective load	F_L	**2064**	lbf/in
Reference area	A_{TL}	**156.5**	in²
Factor	B	**1207**	psi
Factor (see material chart)	A	**8.447e-5**	
Required moment of inertia	I_s	**14.06**	in^4
Required moment of inertia	I'_s	**18.05**	in^4
Length of support	$0.55\cdot\sqrt{(D\cdot t_s)}$	**6.075**	in
Available moment of inertia	I'	**18.15**	in^4

Remark **Stiffening required**

Equations

$cos(\alpha)=cos(\alpha)=cos(30°)=0.866$

$sin(\alpha)=sin(\alpha)=sin(30°)=0.5$

$tan(\alpha)=tan(\alpha)=tan(30°)=0.5774$

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

App. 1-8 b-3) Step 1

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

$$\frac{-1549\text{ mm}\cdot 0.5774}{2}+\frac{6096\text{ mm}}{2}+\frac{(1549\text{ mm})^2-(445\text{ mm})^2}{3\cdot 1549\text{ mm}\cdot 0.5774}=3421\text{ mm}$$

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 a)

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

$$6096\text{ mm}\cdot\frac{25.4\text{ mm}}{2}+1854\text{ mm}\cdot\frac{25.4\text{ mm}}{2}+0\text{ mm²}=100968\text{ mm²}$$

App. 1-8 b-3) Step 1

$$B=\frac{3}{4}\cdot\frac{F_L\cdot D_L}{A_{TL}}=\frac{3}{4}\cdot\frac{361.4\text{ N/mm}\cdot 3099\text{ mm}}{100968\text{ mm²}}=8.32\text{ N/mm²}$$

App. 1-8 b-3) Step 6

$$I_s=A\cdot D_L^2\cdot\frac{A_{TL}}{14}=8.447\text{e-}5\cdot(3099\text{ mm})^2\cdot\frac{100968\text{ mm²}}{14}=5850143\text{ mm^4}$$

App. 1-8 b-3) Step 6

$$I'_s=A\cdot D_L^2\cdot\frac{A_{TL}}{10.9}=8.447\text{e-}5\cdot(3099\text{ mm})^2\cdot\frac{100968\text{ mm²}}{10.9}=7513945\text{ mm^4}$$

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

Appendix: Material documentation

Section 5: Zylinder/E4.4.7 Large End
Section 5: Kegel/E4.4.7 Large End
Section 5: Versteifung/E4.4.7 Large End
Section 4: Verstärkung/E4.4.7 Large End/Line-of-support
Section 2: Zylinder/E4.4.7 Small End
Section 2: Kegel/E4.4.7 Small End
Section 7: Verstärkung/E4.4.7 Small End/Line-of-support
Section 1: Boden/E4.4.8 Large and Small End
Section 10: Verstärkung/E4.4.8 Large End/Line-of-support

Material specification:		
Material code: K02700-SA-516-70-Class:-Size:	Regulation: ASME II.D Table 1A:2017	Spec. No.: SA-516
Short name: Carbon steel	Product: Plate	
Delivery condition:		

Design conditions and dimensions:	
Temperature [°C]: 148.89	Thickness [mm]: 46.04
Pressure [bar]: 1.01	Outside diameter [mm]: 3902.08

Material values for test and design conditions:		
	Test condition	Operating condition
Nominal design strength [N/mm²]:	138	138
Safety factor:	1	1
Allowable stress [N/mm²]:	138	138
Modulus of elasticity [kN/mm²]:	202.4	195.1

Notes:
G10: General Requirements
Upon prolonged exposure to temperatures above 425°C, the carbide phase of carbon steel may be converted to graphite. See Nonmandatory Appendix A, A–201 and A–202.
S1: Size Requirements
For Section I applications, stress values at temperatures of 450°C and above are permissible but, except for tubular products 75 mm O.D. or less enclosed within the boiler setting, use of these materials at these temperatures is not current practice.
T2: Time-Dependent Properties
Allowable stresses for temperatures of 400°C and above are values obtained from time–dependent properties.

Strength values at 20°C		
R_{eH}	density	Tensile strength
.	.	$R_{m,\ min}$
N/mm²	kg/dm³	N/mm²
260	7.85	485

Strength values as a function of temperature										
T	°C	40	100	150	250	325	375	425	475	525
K	N/mm²	138	138	138	138	132	123	83.8	51	21.3

Young's modulus-values in dependence of the temperature															
T	°C	-200	-125	-75	25	100	150	200	250	300	350	400	450	500	550
E	kN/mm²	216	212	209	202	198	195	192	189	185	179	171	162	151	137

Mean coefficient of thermal expansion-values in dependence of the temperature										
T	°C	20	100	200	300	400	500	600	700	800
α_m	1e-6/K	11.5	12.1	12.7	13.3	13.8	14.4	14.8	15.1	15.4

Differential coefficient of thermal expansion-values in dependence of the temperature										
T	°C	20	100	200	300	400	500	600	700	800
α_{diff}	1e-6/K	11.5	12.7	13.8	14.9	15.9	16.7	17.0	17.1	17.7

Design conditions and dimensions:	
Temperature [°C]: 148.89	Thickness [mm]: 49.21
Pressure [bar]: 1.01	Outside diameter [mm]: 3902.08

Design conditions and dimensions:	
Temperature [°C]: 148.89	Thickness [mm]: 49.23
Pressure [bar]: 1.01	Outside diameter [mm]: 2343.15