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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

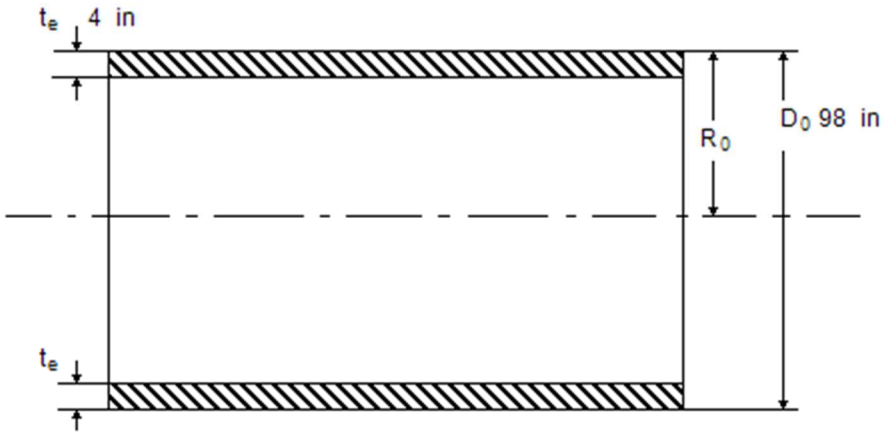
Summary

Strength Calculation Software		Program System ATLAS				Version	**8.32.1**	
Developed by Lauterbach Verfahrenstechnik GmbH								
Certified per DIN EN ISO 9001:2015		Certificate Number 01 100 044763						
		LV Soft				**ASME**		**Diff [%]**
Example E4.3.1 - Cylinder Shell								
	Required thickness tc [in]	20,62	mm	0,81	in	0,81	in	**0,00%**
	Required thickness t_{long} [in]	10,16	mm	0,40	in	0,40	in	**0,00%**
Example E4.3.2 - Conical Shell								
	Required thickness t [in]	39,92	mm	1,57	in	1,57	in	**0,11%**
Example E4.3.3 - spherical Shell								
	Required thickness t [in]	94,65	mm	3,73	in	3,73	in	**0,00%**
Example E4.3.4 - Torispherical Head							in	
	Allowable Pressure P [psi]	9,34	bar	135,42	Psi	135,30	in	**0,09%**
Example E4.3.5 - Elliptical Head								
	Allowable Pressure P [psi]	30,51	bar	442,57	Psi	442,23	in	**0,08%**

E4.3.1 - Thickness of cylindrical shells under internal pressure - ASME BPVC VIII-1 UG-27 & Appendix-1: 2019

Cylindrical shells

Design pressure	p_D	356	psi
Hydrostatic head	D_p	0	psi
Calculation pressure	P_0	**356**	psi
Calculation temperature	T_0	300	°F



Outside diameter	D_0	98	in
Design wall thickness	t_e	4	in
Wall thickness allowance	c_1	0.125	in
Allowance (corrosion)	c_2	0	in
Weld joint efficiency (or Cast Quality Factor)	E	1	
Circumferential weld joint efficiency for Eq. 2	E_c	1	

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

Allowable stress	S	20000	psi

Results

Outside radius	R_0	**49**	in
Effective thickness	t_0	**3.875**	in

Calculation as thin shell is applicable **Yes**

Required thickness	$t(R_0)$	t(R)	
thin shell acc. UG-27	**0.866**	**0.8119**	in
thick shell (not applicable)	**0.8645**	**0.8104**	in
Minimum wall thickness without condition acc. UG-16	t_{UG-27}	**20.62**	mm
Minimum wall thickness acc. UG-16	t_{UG-16}	0.05906	in
Required wall thickness for circumferential seam	t_{long}	**0.4002**	in
$t = Max\{Min[t_R;t_{R0}],t_{UG-16}\}$	t	**0.8119**	in
with allowances	$t+c_1+c_2$	**0.9369**	in

Allowable excess pressure	P	**1633**	psi
Allowable excess pressure for longitudinal stress for Eq. (2)	P_{long}	**3557**	psi
Allowable excess pressure without hydrostatic head	MAWP	**1633**	psi

Remark

For calculation of openings according to UG-37

Required thickness	t(E=1)	**0.8119**	in

Allowable unreinforced opening diameter d for welded, brazed, and flued connections acc. UG 36(c)3

d ≤ 89 mm for t ≤10 mm	or	d ≤ 3 1/2 in for t ≤3/8 in
d ≤ 60 mm for t > 10 mm	or	d ≤ 2 3/8 in for t > 3/8 in

Equations

$$R_0 = \frac{D_0}{2} = \frac{2489\ \text{mm}}{2} = 1245\ \text{mm}$$

$$t+c1+c2 = t + c_1 + c_2 = 20.62\ \text{mm} + 3.175\ \text{mm} + 0\ \text{mm} = 23.8\ \text{mm}$$

corroded inside radius $R = R_0 - t_0 = 1245\ \text{mm} - 98.42\ \text{mm} = 1146\ \text{mm}$

1) Thin shell For

$$P_0 \le 0.385 \cdot S \cdot E \Leftrightarrow 24.55\ \text{bar} \le 53.09\ \text{N/mm}^2$$

and
with the inside radius R

$$t_e \le \frac{(R_0 - t_e)}{2} \Leftrightarrow 101.6\ \text{mm} \le 571.5\ \text{mm}$$

UG-27 (1)

$$t(R) = \frac{P_0 \cdot R}{S \cdot E - 0.6 \cdot P_0} = \frac{24.55\ \text{bar} \cdot 1146\ \text{mm}}{137.9\ \text{N/mm}^2 \cdot 1 - 0.6 \cdot 24.55\ \text{bar}} = 20.62\ \text{mm}$$

UG-27 (1)

$$P(R) = \frac{S \cdot E \cdot t_0}{R + 0.6 \cdot t_0} = \frac{137.9\ \text{N/mm}^2 \cdot 1 \cdot 98.42\ \text{mm}}{1146\ \text{mm} + 0.6 \cdot 98.42\ \text{mm}} = 11.26\ \text{MPa}$$

or with the outside radius R_0

App. 1-1 (1)

$$t(R_0) = \frac{P_0 \cdot R_0}{S \cdot E + 0.4 \cdot P_0} = \frac{24.55\ \text{bar} \cdot 1245\ \text{mm}}{137.9\ \text{N/mm}^2 \cdot 1 + 0.4 \cdot 24.55\ \text{bar}} = 22\ \text{mm}$$

App. 1-1 (1)

$$P(R_0) = \frac{S \cdot E \cdot t_0}{R_0 - 0.4 \cdot t_0} = \frac{137.9\ \text{N/mm}^2 \cdot 1 \cdot 98.42\ \text{mm}}{1245\ \text{mm} - 0.4 \cdot 98.42\ \text{mm}} = 11.26\ \text{MPa}$$

$$\text{Log}(x) = \text{Ln}(x)$$

Longitudinal Stress (Circumferential Joints)

UG-27 (2)

$$t_{long} = \frac{P_0 \cdot R}{2 \cdot S \cdot E_c + 0.4 \cdot P_0} = \frac{24.55\ \text{bar} \cdot 1146\ \text{mm}}{2 \cdot 137.9\ \text{N/mm}^2 \cdot 1 + 0.4 \cdot 24.55\ \text{bar}} = 10.16\ \text{mm}$$

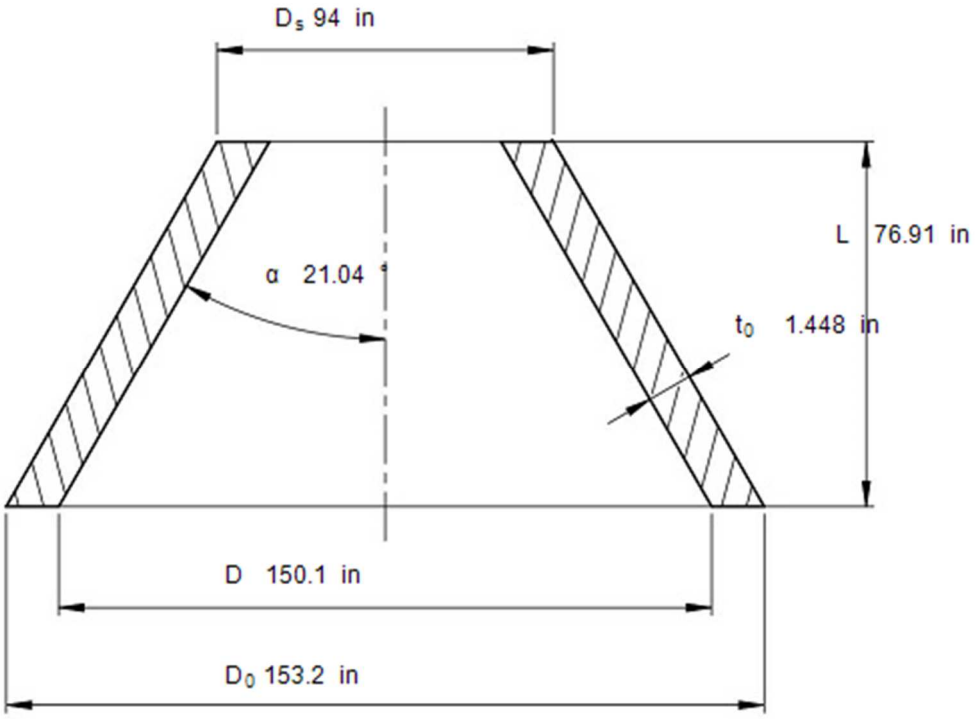
UG-27 (2)

$$P_{long} = \frac{2 \cdot S \cdot E_c \cdot t_0}{R - 0.4 \cdot t_0} = \frac{2 \cdot 137.9\ \text{N/mm}^2 \cdot 1 \cdot 98.42\ \text{mm}}{1146\ \text{mm} - 0.4 \cdot 98.42\ \text{mm}} = 24.53\ \text{MPa}$$

E4.3.2 - Cone without knuckle under internal pressure - ASME BPVC VIII-1 UG-32 & Appendix-1: 2019

Conical sections without knuckle acc. to UG-32(f)

Design pressure	p_D	356	psi
Hydrostatic head	D_p	0	psi
Calculation pressure	p_0	**356**	psi
Calculation temperature	T_0	300	°F
Final wall thickness	t_e	1.573	in
Wall thickness allowance	c_1	0	in
Allowance (corrosion)	c_2	0.125	in
Effective thickness without allowances	t_0	**1.448**	in



Half-apex angle (≤ 30° without knuckle)	α	21.04	°
Outside diameter at the large end	D_0	153.2	in
Inside diameter at the large end	D	**150.1**	in
Outside diameter at the small end	D_s	94	in
Cone length	L	**76.91**	in
Weld joint efficiency (or Cast Quality Factor)	E	1	
Material			
Allowable stress	S	20000	psi

Calculation

Required thickness			t	**1.446**	in
incl. allowances	(t_e 1.573 in	≥t+)	t+	**1.571**	in
Allowable excess pressure incl. hydrost. head			P	**356.4**	psi
Allowable excess pressure without hydrostatic Head			MAWP	**356.4**	psi

Remark

Geometrical conditions
valid

Strength condition
Wall thickness acceptable

For calculation of openings according to UG-37(a) in nomenclature for t_r

Design diameter according to UG-37(a):tr(b)	D_1	in
Required thickness	t(E=1)	in

Equations according to UG-32(g)

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

$$D=D_0-2\cdot\frac{t_0}{\cos(\alpha)}=3891\text{ mm}-2\cdot\frac{36.78\text{ mm}}{0.9333}=3812\text{ mm}$$

$$t=\frac{P_0\cdot D}{2\cdot\cos(\alpha)\cdot(S\cdot E-0.6\cdot P_0)}=\frac{24.55\text{ bar}\cdot 3812\text{ mm}}{2\cdot 0.9333\cdot(137.9\text{ N/mm}^2\cdot 1-0.6\cdot 24.55\text{ bar})}=36.74\text{ mm}$$

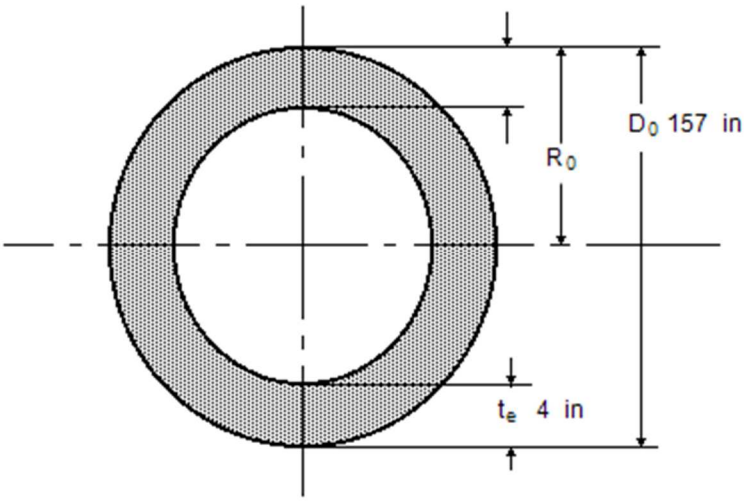
$$P=\frac{2\cdot S\cdot E\cdot t_0\cdot\cos(\alpha)}{D+1.2\cdot t_0\cdot\cos(\alpha)}=\frac{2\cdot 137.9\text{ N/mm}^2\cdot 1\cdot 36.78\text{ mm}\cdot 0.9333}{3812\text{ mm}+1.2\cdot 36.78\text{ mm}\cdot 0.9333}=2.457\text{ MPa}$$

Rem.: App.1-5(d) or (e) indicates if a reinforcement ring is required.

E4.3.3 - Thickness of spherical shells under internal pressure - ASME BPVC VIII-1 UG-27 & Appendix-1: 2019

Spherical shells

Design pressure	p_D	2080	psi
Hydrostatic head	D_p	0	psi
Calculation pressure	P_0	**2080**	psi
Calculation temperature	T_0	850	°F



Outside diameter	D_0	157	in
Design wall thickness	t_e	4	in
Wall thickness allowance	c_1	0	in
Allowance (corrosion)	c_2	0	in
Weld joint efficiency (or Cast Quality Factor)	E	1	-

Material K31835-SA-542-D-Class:4a-Size:

Allowable stress	S	21000	psi

Results

Outside radius	R_0	**78.5**	in
Effective thickness	t_0	**4**	in

Calculation as thin shell is applicable **Yes**

Required thickness	$t(R_0)$	t(R)	
thin shell acc. UG-27	**3.739**	**3.726**	in
thick shell (not applicable)	**3.793**	**3.782**	in

Minimum wall thickness without condition acc. UG-16	t_{UG-27}	**94.65**	mm
Minimum wall thickness acc. UG-16	t_{UG-16}	0.05906	in
Minimum $t = Max\{Min[t_R;t_{R0}],t_{UG-16}\}$	t	**3.726**	in
with allowances	$t+c_1+c_2$	**3.726**	in
Allowable excess pressure	P	**2231**	psi
Allowable excess pressure without hydrostatic head	MAWP	**2231**	psi

Remark

For calculation of openings according to UG-37

Minimum required thickness for openings t(E=1) **3.726** in

Allowable unreinforced opening diameter d for welded, brazed, and flued connections acc. UG 36(c)3

d ≤ 89 mm for t ≤10 mm	or	d ≤ 3 1/2 in for t ≤3/8 in
d ≤ 60 mm for t > 10 mm	or	d ≤ 2 3/8 in for t > 3/8 in

Equations

$$R_0 = \frac{D_0}{2} = \frac{3988\ \text{mm}}{2} = 1994\ \text{mm}$$

$$94.65\ \text{mm} = 94.65\ \text{mm} + 0\ \text{mm} + 0\ \text{mm}$$

corroded inside radius $R = R_0 - t_0 = 1994\ \text{mm} - 101.6\ \text{mm} = 1892\ \text{mm}$

1) Thin shell For

$P_0 \le 0.665 \cdot S \cdot E \Leftrightarrow 143.4\ \text{bar} \le 97.29\ \text{N/mm}^2$

and

$t_e \le 0.356 \cdot (R_0 - t_e) \Leftrightarrow 101.6\ \text{mm} \le 673.7\ \text{mm}$

with the inside radius R

UG-27 (3)

$$t(R) = \frac{P_0 \cdot R}{2 \cdot S \cdot E - 0.2 \cdot P_0} = \frac{143.4\ \text{bar} \cdot 1892\ \text{mm}}{2 \cdot 144.8\ \text{N/mm}^2 \cdot 1 - 0.2 \cdot 143.4\ \text{bar}} = 94.65\ \text{mm}$$

UG-27 (3)

$$P(R) = \frac{2 \cdot S \cdot E \cdot t_0}{R + 0.2 \cdot t_0} = \frac{2 \cdot 144.8\ \text{N/mm}^2 \cdot 1 \cdot 101.6\ \text{mm}}{1892\ \text{mm} + 0.2 \cdot 101.6\ \text{mm}} = 15.38\ \text{MPa}$$

or with the outside radius R_0

App. 1-1 (2)

$$t(R_0) = \frac{P_0 \cdot R_0}{2 \cdot S \cdot E + 0.8 \cdot t_0} = \frac{143.4\ \text{bar} \cdot 1994\ \text{mm}}{2 \cdot 144.8\ \text{N/mm}^2 \cdot 1 + 0.8 \cdot 143.4\ \text{bar}} = 94.98\ \text{mm}$$

App. 1-1 (2)

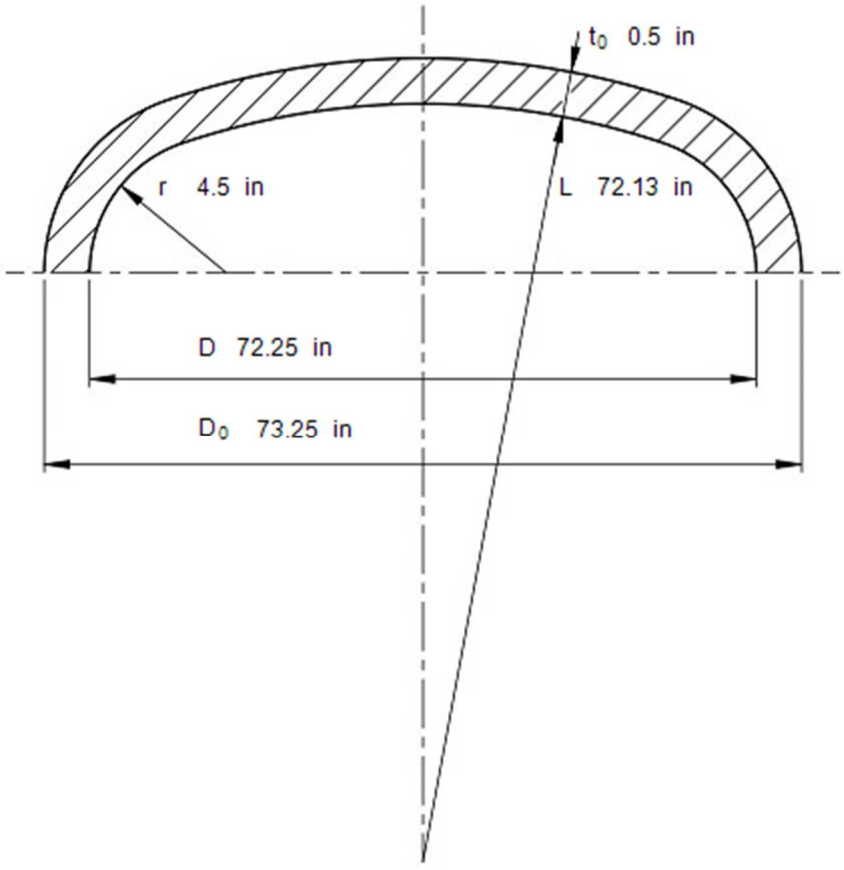
$$P(R_0) = \frac{2 \cdot S \cdot E \cdot t_0}{R_0 - 0.8 \cdot t_0} = \frac{2 \cdot 144.8\ \text{N/mm}^2 \cdot 1 \cdot 101.6\ \text{mm}}{1994\ \text{mm} - 0.8 \cdot 101.6\ \text{mm}} = 15.38\ \text{MPa}$$

$\text{Log}(x) = \text{Ln}(x)$

E4.3.4 - Torispherical heads (Kloepper, Korbbogen, Semi-spherical) under internal pressure - ASME BPVC VIII-1 UG-32 & Appendix-1: 2019

Type of head

(1=Kloepper-, 2=Korbbogen-, 3=Torispherical, 4=Hemispherical, 5=Elliptical 2:1)			3
Torispherical			
Design pressure		p_D	136 psi
Hydrostatic head		D_p	0 psi
Calculation pressure		p_0	**136** psi
Calculation temperature		T_0	650 °F
Final wall thickness		t_e	0.625 in
Wall thickness allowance		c_1	0 in
Allowance (corrosion)		c_2	0.125 in
Effective thickness without allowances		t_0	**0.5** in



Outside diameter of cylindrical shell		D_0	73.25 in
Inside diameter of cylindrical shell	(= D_0-2t_0)	D	**72.25** in
Outside crown radius		L_0	72.63 in
Outside crown radius with allowances		L_1	**1848** mm
Inside crown radius	(= L_0-t_0)	L	**72.13** in
Knuckle radius		r	4.5 in
Weld joint efficiency (or Cast Quality Factor)		E	1

Material data

Material K11789-SA-387-11-Class:1-Size:

Elasticity modulus	E_T	2.66e+7	psi
Elastic limit	S_y	26948	psi
Reduce allowable*) stress for R_{m20} > 485 MPa?		Yes	(Yes/No)
Tensile strength at 20°C	R_{m20}	60190	psi
Allowable stress			
at working temperature acc. ASME-table	S_T	17114	psi
at 20°C	S_{20}	17100	psi
acc. UG-32(d) or endnote 90	S	**17114**	psi

*) According to App. 1-4(c,d), the allowable stress must be reduced to 138 * S_T /S_{20} (=20 ksi*...) for R_{m20} > 485 MPa (70 ksi).

Calculation

Ratio	L/r	**16.03**	
Factor	M	**1.751**	
Required thickness without allowance	t	**0.5021**	in
incl. allowances (t_e 0.625 in ≥t+)	t+	**0.6271**	in
Allowable excess pressure incl. hydrost. head	P	**135.4**	psi
Allowable excess pressure without hydrostatic Head	MAWP	**135.4**	psi

Geometrical conditions
valid

Strength condition
Final wall thickness 15,875 < 15,9296 = required thickness

Required thickness for openings acc. to UG-37(a) in nomenclature for t_r

Using UG-32 with E=1	t(E=1)	**0.5021**	in
acc. section (a) in the crown region	t_1(E=1)	**0.2868**	in

Allowable unreinforced opening diameter d for welded, brazed, and flued connections acc. UG 36(c)3

d ≤ 89 mm (3.5 in.) for t ≤10 mm (3/8 in.)
d ≤ 60 mm (2 3/8 in.) for t > 10 mm (3/8 in.)

Remark

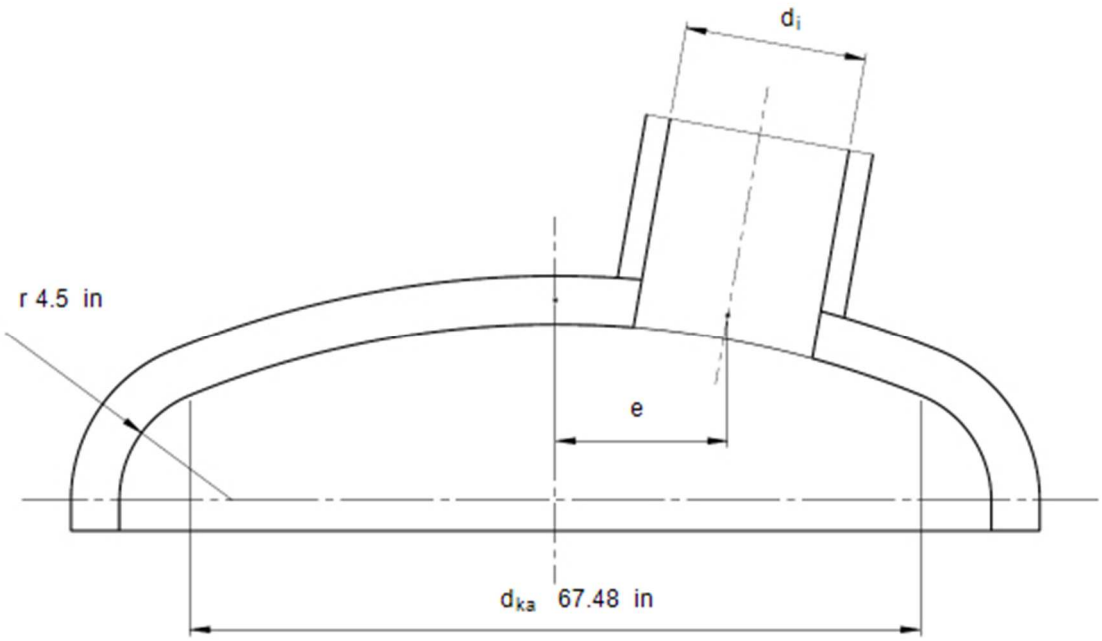
Equations

$$t = \frac{P_0 \cdot L \cdot M}{2 \cdot S \cdot E - 0.2 \cdot P_0} = \frac{9.377\ \text{bar} \cdot 1832\ \text{mm} \cdot 1.751}{2 \cdot 118\ \text{N/mm}^2 \cdot 1 - 0.2 \cdot 9.377\ \text{bar}} = 12.75\ \text{mm}$$

$$P = \frac{2 \cdot S \cdot E \cdot t_0}{L \cdot M + 0.2 \cdot t_0} = \frac{2 \cdot 118\ \text{N/mm}^2 \cdot 1 \cdot 12.7\ \text{mm}}{1832\ \text{mm} \cdot 1.751 + 0.2 \cdot 12.7\ \text{mm}} = 0.9337\ \text{MPa}$$

For openings in the crown region with

Opening diameter	d_i		in
Distance between opening center and head center	e		in



Available reinforcement width acc. UG37

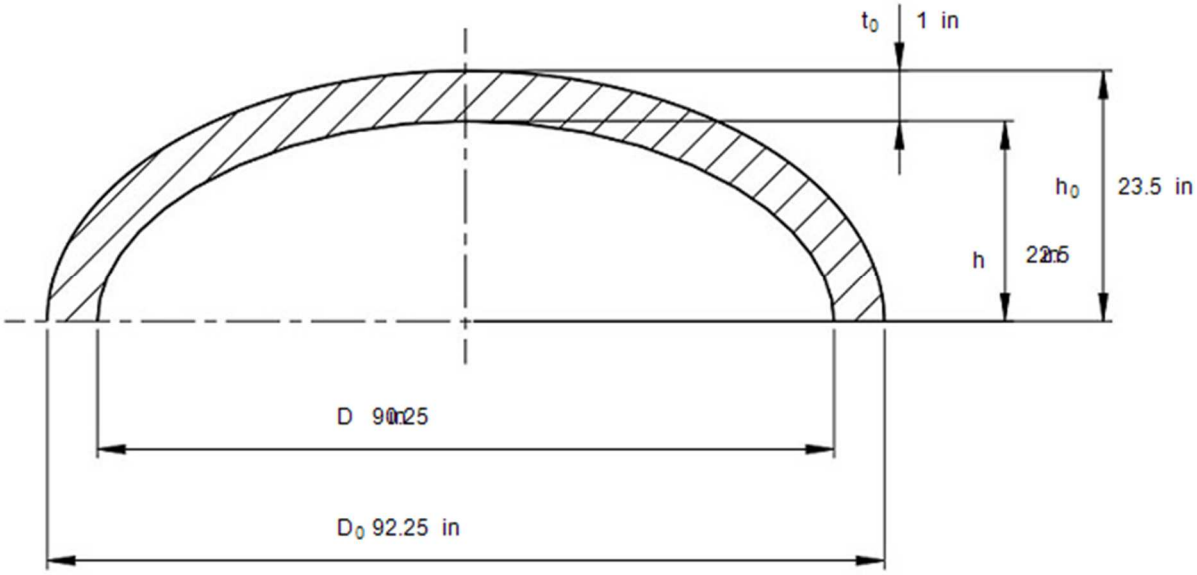
Available reinforcement width of the crown	b'		in
Diameter of the crown region	d_{ka}	**67.48**	in
Angle of the knuckle region		**62.24**	°
Arc length of the knuckle region	b''	**5.567**	in

$d_{ka} = (2 \cdot L + t_e) \cdot (D/2 - r)/(L - r)$
$\varphi = \arccos((D/2 - r)/(L - r))$
$b' = (d_{ka} - d_i)/2 - e$
$b'' = (r + t_e) \cdot \varphi$

E4.3.5 - Elliptical heads under internal pressure - ASME BPVC VIII-1 UG-32 & Appendix-1: 2019

Ellipsoidal heads acc. UG-32(c) and Appendix 1-4(f)

Design pressure	p_D	442.2	psi
Hydrostatic head	D_p	0	psi
Calculation pressure	p_0	**442.2**	psi
Calculation temperature	T_0	300	°F
Final wall thickness	t_e	1.125	in
Wall thickness allowance	c_1	0	in
Allowance (corrosion)	c_2	0.125	in
Effective thickness without allowances	t_0	**1**	in



Outside diameter of cylindrical shell		D_0	**92.25**	in
Inside diameter of cylindrical shell	(= D_0-2t_0)	D	90.25	in
Outer height of head		h_0	**23.5**	in
Inside depth of head	(minor semi-axis= h_0-t_0)	h	**22.5**	in
Weld joint efficiency (or Cast Quality Factor)		E	1	

Material data

Material	K02700-SA-516-70-Class:-Size:		
Elasticity modulus	E_T	2.829e+7	psi
Elastic limit	S_y	33668	psi
Reduce allowable*) stress for R_{m20} > 485 MPa?		Yes	(Yes/No)
Tensile strength at 20°C	R_{m20}	70343	psi
Allowable stress			
at working temperature acc. ASME-table	S_T	20015	psi
at 20°C	S_{20}	20000	psi
acc. UG-32(c) or App. 1-4(c)	S	**20015**	psi

*) According to App. 1-4(c,d), the allowable stress must be reduced to 138 * S_T /S_{20} (=20 ksi*...) for R_{m20} > 485 MPa (70 ksi).

Results

Ratio	D/2h	2	
Factor	K	**1**	
Factor K1 acc. Table UG-37	K_1	**0.9**	
Required thickness	t	**0.9992**	in
incl. allowances (t_e 1.125 in ≥t+)	t+	**1.124**	in
Allowable excess pressure incl. hydrostatic Head	P	**442.6**	psi
Allowable excess pressure without hydrostatic Head	MAWP	**442.6**	psi

Required thickness for openings acc. to UG-37(a) in nomenclature for t_r

Using UG-32 with E=1		t(E=1)	**0.9992**	in
Section (c) in the centre circle (< 0.8·D)		t_1(E=1)	**0.8993**	in
Equivalent spherical outside diameter	$2\cdot(K_1\cdot D+t_E)$	D_s	**164.7**	in

Geometrical conditions

valid

Strength

Wall thickness acceptable

Allowable unreinforced opening diameter d for welded, brazed, and flued connections acc. UG 36(c)3

d ≤ 89 mm (3.5 in.) for t ≤10 mm (3/8 in.)
d ≤ 60 mm (2 3/8 in.) for t > 10 mm (3/8 in.)

Remark

Equations according to UG-32

$$t=\frac{P_0\cdot D\cdot K}{2\cdot S\cdot E-0.2\cdot P_0}=\frac{30.49\ \text{bar}\cdot 2292\ \text{mm}\cdot 1}{2\cdot 138\ \text{N/mm}^2\cdot 1-0.2\cdot 30.49\ \text{bar}}=25.38\ \text{mm}$$

$$P=\frac{2\cdot S\cdot E\cdot t_0}{K\cdot D+0.2\cdot t_0}=\frac{2\cdot 138\ \text{N/mm}^2\cdot 1\cdot 25.4\ \text{mm}}{1\cdot 2292\ \text{mm}+0.2\cdot 25.4\ \text{mm}}=3.051\ \text{MPa}$$

Appendix: Material documentation

Section 1: SCHALE/E4.3.1
Section 9: Boden/E4.3.5

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]: 101.6
Pressure [bar]: 24.55	Outside diameter [mm]: 2489.2

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]: 28.58
Pressure [bar]:	Outside diameter [mm]: 2343.15

Section 8: Schale/E4.3.3

Material specification:		
Material code: K31835-SA-542-D-Class:4a-Size:	Regulation: ASME II.D Table 1A:2017	Spec. No.: SA-542
Short name: 2.25Cr-1Mo-V	Product: Plate	
Delivery condition:		

Design conditions and dimensions:	
Temperature [°C]: 454.44	Thickness [mm]: 101.6
Pressure [bar]: 143.41	Outside diameter [mm]: 3987.8

Material values for test and design conditions:		
	Test condition	Operating condition
Nominal design strength [N/mm²]:	168	144.29
Safety factor:	1	1
Allowable stress [N/mm²]:	168	144.3
Modulus of elasticity [kN/mm²]:	200	149.5

Strength values at 20°C	
R_{eH}	Tensile strength
.	$R_{m,\ min}$
N/mm²	N/mm²
415	585

Strength values as a function of temperature									
T	°C	40	100	150	250	325	375	425	475
K	N/mm²	168	168	168	168	162	157	149	141

Young's modulus-values in dependence of the temperature							
T	°C	20	150	260	370	425	480
E	kN/mm²	200	200	186	169	157	143

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

Section 5: Boden/E4.3.4

Material specification:		
Material code: K11789-SA-387-11-Class:1-Size:	Regulation: ASME II.D Table 1A:2017	Spec. No.: SA-387
Short name: 1.25Cr-0.5Mo-Si	Product: Plate	
Delivery condition:		

Design conditions and dimensions:	
Temperature [°C]: 343.33	Thickness [mm]: 15.88
Pressure [bar]:	Outside diameter [mm]: 1860.55

Material values for test and design conditions:		
	Test condition	Operating condition
Nominal design strength [N/mm²]:	118	118
Safety factor:	1	1
Allowable stress [N/mm²]:	118	118
Modulus of elasticity [kN/mm²]:	204.3	183.4

Notes:
S4: Size Requirements
For Section I applications, stress values at temperatures of 625°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.
T4: Time-Dependent Properties
Allowable stresses for temperatures of 480°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
240	7.85	415

Strength values as a function of temperature												
T	°C	40	100	150	250	325	375	425	475	525	575	625
K	N/mm²	118	118	118	118	118	118	116	101	51.7	25.2	12.4

Young's modulus-values in dependence of the temperature															
T	°C	25	100	150	200	250	300	350	400	450	500	550	600	650	700
E	kN/mm²	204	200	197	193	190	186	183	179	174	169	164	157	150	142

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