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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	**8.33.8**		
Developed by Lauterbach Verfahrenstechnik GmbH										
Certified per DIN EN ISO 9001:2015			Certificate Number 01 100 044763							

				LV Soft				**ASME**		**Diff [%]**
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	**0.02%**
		Step7	Total gasket seating moment Mo	11,976,492.00	N.mm	106,000.89	lbf.in	106192.50	lbf.in	**0.18%**

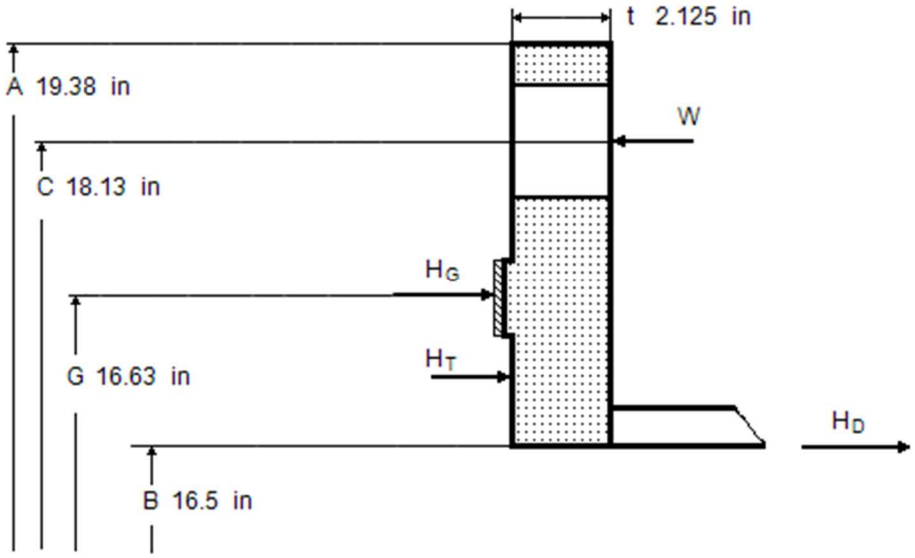
E 4.7. Step 7 - Bolted flanges - ASME BPVC VIII Division 1 App. 2: 2021

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	[Table: 2-5.2]	b	0.1406	in
Gasket factor	[Table: 2-5.1]	m	5.5	
Gasket seating load	[Table: 2-5.1]	y	18000	psi

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} 2-6(7)?		(N=No)	Y	(Y/N)

Required operation bolt load	Eq.(1)		W_{m1}	**63411**	lbf
Minimum initial bolt load	Eq.(2)		W_{m2}	**132116**	lbf
Available cross section of bolts			A_b	**6.035**	in²
Required cross section		W_{m1}/S_b	A_{m1}	**2.542**	in²
Required cross section		W_{m2}/S_a	A_{m2}	**5.296**	in²
Req. bolt load for gasket seating	Eq.(5)	$(A_m+A_b)\cdot S_a/2$	W	**141335**	lbf
Allowable bolt load		$A_b\cdot S_a$	W_{all}	**150555**	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

Moment

		Force			Lever arm			=	Result	
$M_D = H_D \cdot h_D$	=	**45522**	lbf	·	**0.8125**	in	=		**3082**	lbf·ft
$M_G = H_G \cdot h_G$	=	**17197**	lbf	·	**0.75**	in	=		**1075**	lbf·ft
$M_T = H_T \cdot h_T$	=	**692.3**	lbf	·	**0.7813**	in	=		**45.07**	lbf·ft

Total operating moment	$M_{01} = F_M \cdot (M_D + M_G + M_T)$	=	**4202**	lbf·ft
Total gasket seating moment, Eq. (6)	$M_{02} = F_M \cdot W \cdot (C-G)/2$	=	**8833**	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	**8234**	psi	**17309**	psi	≤ S_f	Eq.(11)
Allowable stress	S_f	**19989**	psi	**20015**	psi		
Bolt pitch	B_S	**2.847**	in	≤ **3.625**	in	= B_{Smax}	Eq.(3)

Remark

Cross-sectional area of bolts	☑
Strength condition flange	☒
Flange rigidity	☒

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

$$B_S=\pi\cdot\frac{C}{n}=72.32\ \text{mm}$$

$$B_{Smax}=2\cdot a+6\cdot\frac{t}{(m+0.5)}=92.07\ \text{mm}$$ Eq.(3)

For $B_S>2\cdot a+t$

$$B_{SC}=\sqrt{\frac{B_S}{(2\cdot a+t)}}=1$$ Eq.(7)

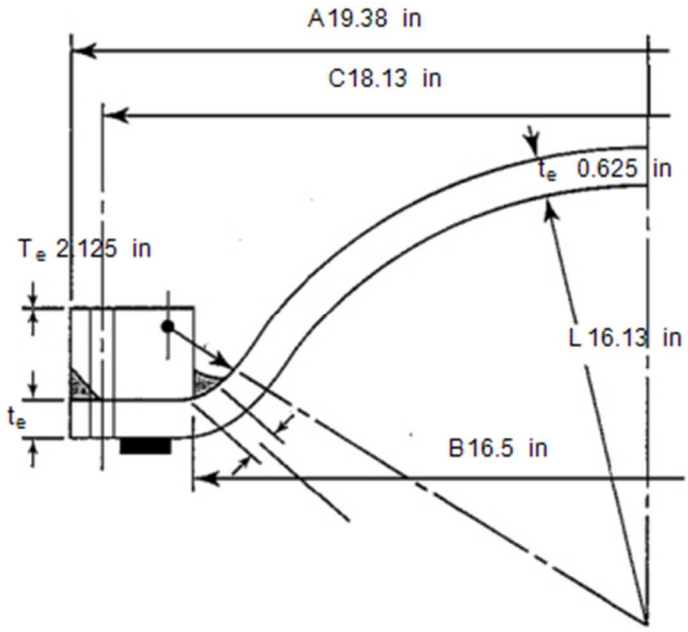
KL (=0.2 acc. Table 2-14) = **0.2**

Rigidity criterion: J **1.289** ≤ 1.0

E 4.7.1 a - Spherically dished covers (bolted heads) - ASME VIII APPENDIX 1, 1-6 2021 Edition

Spherically dished covers as shown in Fig.: 1-6 (b)
Input

Flange moment from 2-6 or 2-11	M_0	8849	lbf·ft	
Design pressure	p_D		psi	
Hydrostatic head	D_p		psi	
Calculation pressure	p_0	213	psi	
Design temperature	T_0	400	°F	
Gasket Ring gasket				



Outside diameter	A	19.38	in	
Inside diameter	B	16.5	in	
Bolt circle diameter	C	18.13	in	
Final flange thickness	T_e	2.125	in	
Crown radius	L	16.13	in	
Final head thickness	t_e	0.625	in	
Wall thickness allowance	c_1	0	in	
Corrosion allowance	c_2	0.125	in	

Material K02401-SA-515-60-Class:-Size:

Allowable stress	S	17114	psi	

Calculation

Required head thickness	t	**0.1672**	in	(1)
Required thickness incl. allowances	$t+c_1+c_2$	**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)

Equations

(1)

$$t = \frac{5 \cdot P0 \cdot L}{6 \cdot S} = \frac{5 \cdot 1.469\ \text{N/mm}^2 \cdot 409.6\ \text{mm}}{6 \cdot 118\ \text{N/mm}^2} = 4.248\ \text{mm}$$

(2)

$$T = \sqrt{\frac{|M0|}{S \cdot B} \cdot \left[\frac{A+B}{A-B}\right]} =$$

$$\sqrt{\frac{|1.2\text{e+}7\ \text{Nmm}|}{118\ \text{N/mm}^2 \cdot 419.1\ \text{mm}} \cdot \left[\frac{492.1\ \text{mm}+419.1\ \text{mm}}{492.1\ \text{mm}-419.1\ \text{mm}}\right]} = 55.02\ \text{mm}$$

(3)

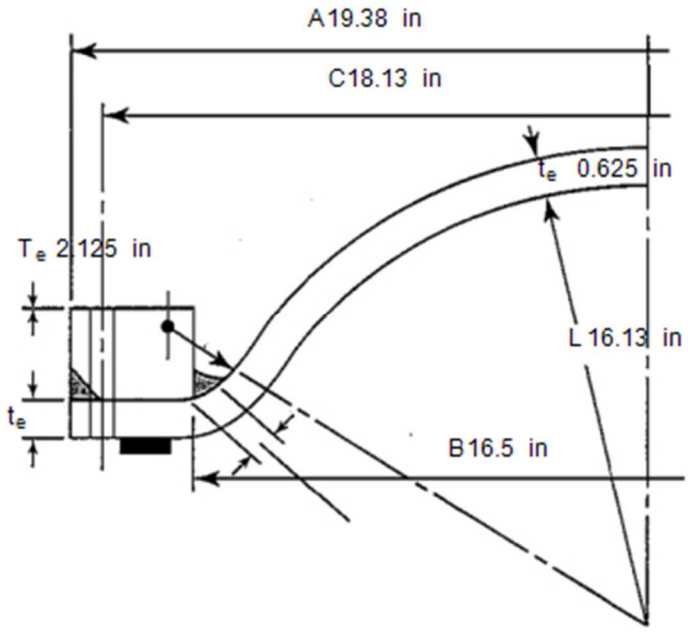
$$T = 0.6 \cdot \sqrt{\frac{P}{S} \cdot \left[\frac{B \cdot (A+B) \cdot (C-B)}{A-B}\right]} =$$

$$0.6 \cdot \sqrt{\frac{1.469\ \text{N/mm}^2}{118\ \text{N/mm}^2} \cdot \left[\frac{419.1\ \text{mm} \cdot (492.1\ \text{mm}+419.1\ \text{mm}) \cdot (460.4\ \text{mm}-419.1\ \text{mm})}{492.1\ \text{mm}-419.1\ \text{mm}}\right]} = 31.1\ \text{mm}$$

E.4.7.1 c.Step3 - Spherically dished covers (bolted heads) - ASME VIII APPENDIX 1, 1-6 2021 Edition

Spherically dished covers as shown in Fig.: 1-6 (b)
Input

Flange moment from 2-6 or 2-11	M_0	8849	lbf·ft	
Design pressure	p_D		psi	
Hydrostatic head	D_p		psi	
Calculation pressure	p_0	213	psi	
Design temperature	T_0	400	°F	
Gasket Ring gasket				



Outside diameter	A	19.38	in	
Inside diameter	B	16.5	in	
Bolt circle diameter	C	18.13	in	
Final flange thickness	T_e	2.125	in	
Crown radius	L	16.13	in	
Final head thickness	t_e	0.625	in	
Wall thickness allowance	c_1	0	in	
Corrosion allowance	c_2	0.125	in	
Material K03504-SA-105--Class:-Size:				
Allowable stress	S	19989	psi	

Calculation

Required head thickness	t	**0.1432**	in	(1)
Required thickness incl. allowances	$t+c_1+c_2$	**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)

Equations

(1)

$$t = \frac{5 \cdot P0 \cdot L}{6 \cdot S} = \frac{5 \cdot 1.469\ \text{N/mm}^2 \cdot 409.6\ \text{mm}}{6 \cdot 137.8\ \text{N/mm}^2} = 3.637\ \text{mm}$$

(2)

$$T = \sqrt{\frac{|M0|}{S \cdot B} \cdot \left[\frac{A+B}{A-B}\right]} =$$

$$\sqrt{\frac{|1.2\text{e+}7\ \text{Nmm}|}{137.8\ \text{N/mm}^2 \cdot 419.1\ \text{mm}} \cdot \left[\frac{492.1\ \text{mm} + 419.1\ \text{mm}}{492.1\ \text{mm} - 419.1\ \text{mm}}\right]} = 50.91\ \text{mm}$$

(3)

$$T = 0.6 \cdot \sqrt{\frac{P}{S} \cdot \left[\frac{B \cdot (A+B) \cdot (C-B)}{A-B}\right]} =$$

$$0.6 \cdot \sqrt{\frac{1.469\ \text{N/mm}^2}{137.8\ \text{N/mm}^2} \cdot \left[\frac{419.1\ \text{mm} \cdot (492.1\ \text{mm} + 419.1\ \text{mm}) \cdot (460.4\ \text{mm} - 419.1\ \text{mm})}{492.1\ \text{mm} - 419.1\ \text{mm}}\right]} = 28.78\ \text{mm}$$