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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

Comparison - Form for equations

Equation form

Comment
Results for example E4.3.7-8 acc. ASME and Lauterbach Verfahrenstechnik GmbH (LV)
The LV-program uses formulas for Bolted flanges acc. VIII-1, App.2.

Equations		**Value**
Conversion factor	mm2in = 0.03937	0.03937
.	N2lbf = 0.22481	0.2248
'Results Ex. E4.16.1 LV and ASME		0
Required load W acc. LV	W1 = #23(1)*N2lbf	237101
Required load W ASME	W1Asme = 237626.3	237626
Difference in %	Diff1 = (W1Asme-W1)/W1Asme*100	0.2211
'Results Ex. E4.16.2 LV and ASME		0
Required load W acc. LV	W2 = #23(2)*N2lbf	383049
Required load W ASME	W2Asme = 387702.5	387703
Difference in %	Diff2 = (W2Asme-W2)/W2Asme*100	1.2
'Maximum difference between LV and ASME		0
Dmax = Max(|Diff1|;|Diff2|)		1.2

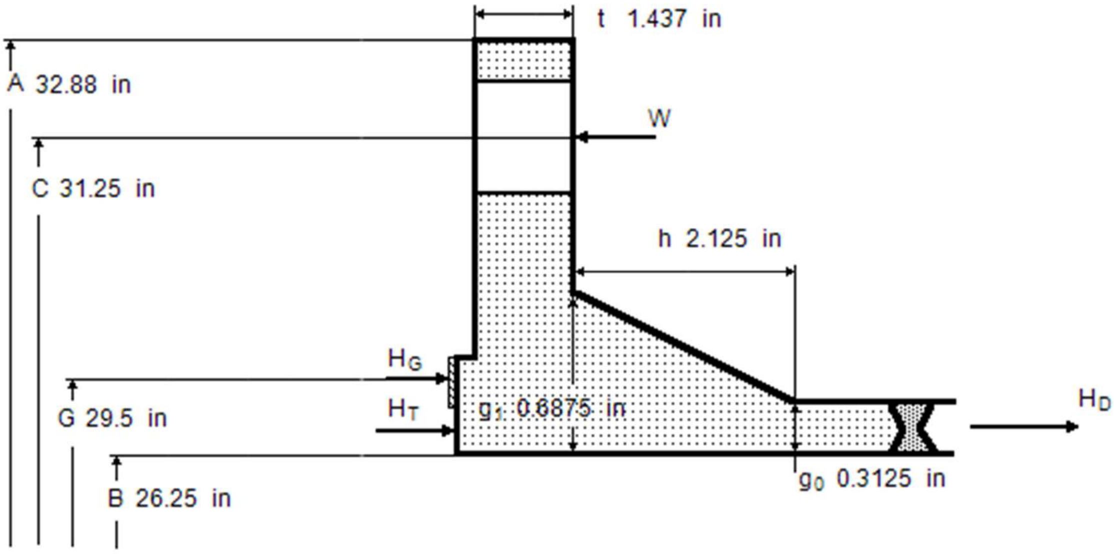
E 4.16.1 - Bolted flanges ASME BPVC VIII DIVISION 1 APP. 2, 2017 Edition

Integral Type Flange

Design data

Design pressure	P_D	**0.9308**	MPa	= p_D	9.308	bar
Hydrostatic head	D_P	**0**	MPa	= D_p	0	psi
Calculation pressure	P_0	**0.9308**	MPa	= p_0	**135**	psi
Calculation temperature				T_0	650	°F

Flange



Outside diameter	A	32.88	in	Inside diameter	B	26.25	in
Bolt circle diameter	C	31.25	in	Pipe size	B_n	**26.25**	in
Hub length	h	2.125	in	Flange thickness	t	1.437	in
Large hub thickness	g_1	0.6875	in	Small hub thick.	g_0	0.3125	in

Material K03504-SA-105--Class:-Size:

Allowable operating stress	S_{fb}	122.8	N/mm²
Allowable installation stress	S_{fa}	138	N/mm²
Corrosion allowance	c_2	0	in
Modulus of elasticity at operation	E_T	178667	MPa
Modulus of elasticity at test (20°C)	E_{20}	201000	MPa

Gasket

Gasket diameter		G	29.5	in
Effective gasket width	[Table: 2-5.2]	b	0.2031	in
Gasket factor	[Table: 2-5.1]	m	3.75	
Gasket seating load	[Table: 2-5.1]	y	52.4	N/mm²

Bolts

Number		n	44	
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	172	N/mm²
Allowable installation stress		S_a	172	N/mm²
Consider bolt spacing correction factor B_{SC} 2-6(7)?		(N=No) Y		(Y/N)
Required operation bolt load	Eq.(1)	W_{m1}	**111274**	lbf
Minimum initial bolt load	Eq.(2)	W_{m2}	**142982**	lbf
Available cross section of bolts		A_b	**13.28**	in²
Required cross section	W_{m1}/S_b	A_{m1}	**4.46**	in²
Required cross section	W_{m2}/S_a	A_{m2}	**5.732**	in²
Req. bolt load for gasket seating	$(A_m+A_b)\cdot S_a/2$	W	**237101**	lbf (5)
Allowable bolt load	$A_b \cdot S_a$	W_{all}	**331221**	lbf
Design (gasket seating =1; max. allowable=2)			1	(1,2)

Moment

		Force		·	Lever arm		=	Result	
$M_D = H_D \cdot h_D$	=	**73024**	lbf	·	**2.156**	in	=	**13122**	lbf·ft
$M_G = H_G \cdot h_G$	=	**19049**	lbf	·	**0.875**	in	=	**1389**	lbf·ft
$M_T = H_T \cdot h_T$	=	**19202**	lbf	·	**1.688**	in	=	**2700**	lbf·ft

Total operating moment	M_{01}	= $M_D + M_G + M_T$	=	**17211**	lbf·ft
Total gasket seating moment, Eq. (6)	M_{02}	= $W \cdot (C-G)/2$	=	**17289**	lbf·ft

Stress

			Operation			Installation		≤ Allowable	
Longitudinal	S_H		**122.6**	N/mm²		**123.2**	N/mm²	≤ $1.5 \cdot S_f$	(8)
Ratio	S_H/S_f		**0.9986**			**0.8926**		≤ 1.5	
Allowable stress	S_f		122.8	N/mm²		138	N/mm²		
Radial	S_R		**42.45**	N/mm²		**42.64**	N/mm²	≤ S_f	(9)
Tangential	S_T		**38.25**	N/mm²		**38.42**	N/mm²	≤ S_f	(10)
Combination	$(S_H+S_R)/2$	=	**82.54**	N/mm²		**82.91**	N/mm²	≤ S_f	
Combination	$(S_H+S_T)/2$	=	**80.44**	N/mm²		**80.8**	N/mm²	≤ S_f	
Bolt pitch	B_S		**2.231**	in	≤	**3.529**	in	= B_{Smax}	(3)

Remark

Auxiliary values

$K=\frac{A}{B}=1.252$

$T=1.817$ (Fig. 2-7.1)

$U=9.623$ (Fig. 2-7.1)

$Y=8.757$ (Fig. 2-7.1)

$Z=4.518$ (Fig. 2-7.1)

$h_0=\sqrt{B \cdot g_0}=72.75$ mm

$F=0.7677$ (Fig. 2-7.2)

$V=0.1576$ (Fig. 2-7.3)

$f=1$ (Fig. 2-7.6)

$d=\left(\frac{U}{V}\right) \cdot h_0 \cdot g_0^2=279869$ mm³

$e=\frac{F}{h_0}=0.01055$ 1/mm

$L=\frac{(t \cdot e+1)}{T}+\frac{t^3}{d}=0.9359$

$H=0.785 \cdot G^2 \cdot P \cdot 0.1=410239$ N

$H_D=0.785 \cdot B^2 \cdot P \cdot 0.1=324826$ N

$H_P=2 \cdot b \cdot \pi \cdot G \cdot m \cdot P \cdot 0.1=84732$ N

$H_T=H-H_D=85412$ N

$W_{m1}=H+H_P=494970$ N Eq.(1)

$W_{m2}=\pi \cdot b \cdot g \cdot y=636011$ N Eq.(2)

$H_G=W_{m1}-H=84732$ N

$R=\frac{(C-B)}{2}-g_1=46.04$ mm

$h_D=R+0.5 \cdot g_1=54.77$ mm

$h_G=\frac{(C-G)}{2}=22.23$ mm

$h_T=\frac{(R+g_1+h_G)}{2}=42.86$ mm

Bolt pitch $B_S=\pi \cdot \frac{C}{n}=56.67$ mm

$$B_{Smax} = 2 \cdot a + 6 \cdot \frac{t}{(m+0.5)} = 89.63 \text{ mm} \quad (3)$$

For $B_S > 2 \cdot a + t$

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

KI (=0.3 acc. Table 2-14) = **0.3**

J = 52.14·V·[M_{01} or M_{02}]/L/[E or E_{20C}]/(g_0-c_2)²/K_L/h_0
= 52.14 · **0.1576** · [**2.333e+7** or **2.344e+7**]/ **0.9359**

/[178667 or 201000]/(7.938 0)²/ **0.3**/ **72.75**

Rigidity criterion: J **0.8339** ≤ 1.0

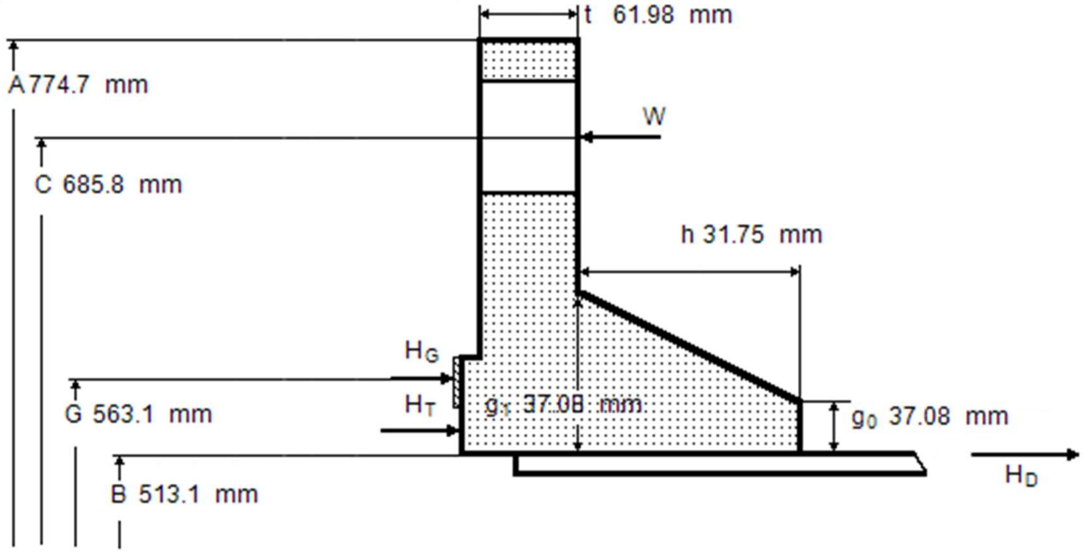
E 4.16.2 - Bolted flanges ASME BPVC VIII DIVISION 1 APP. 2, 2017 Edition

Loose Type Flange With Full Neck

Design data

Design pressure	P_D	31.03 bar	$= p_D$	31.03	bar
Hydrostatic head	D_P	0 bar	$= D_p$	0	bar
Calculation pressure	P_0	31.03 bar	$= p_0$	31.03	bar
Calculation temperature			T_0	343.3	°C

Flange



Outside diameter	A	774.7 mm	Inside diameter	B	513.1	mm
Bolt circle diameter	C	685.8 mm	Pipe size	B_n	513.1	mm
Hub length	h	31.75 mm	Flange thickness	t	61.98	mm
Large hub thickness	g_1	37.08 mm	Small hub thickness	g_0	37.08	mm

Material K03504-SA-105--Class:-Size:

Allowable operating stress	S_{fb}	122.8	N/mm²
Allowable installation stress	S_{fa}	138	N/mm²
Corrosion allowance	c_2	0	mm
Modulus of elasticity at operation	E_T	178667	N/mm²
Modulus of elasticity at test (20°C)	E_{20}	201000	N/mm²

Gasket

Gasket diameter		G	563.1	mm
Effective gasket width	[Table: 2-5.2]	b	8.981	mm
Gasket factor	[Table: 2-5.1]	m	2	
Gasket seating load	[Table: 2-5.1]	y	17.24	N/mm²

Bolts

Number		n	24	
Root diameter		d_K	27.43 mm	
Nominal diameter		a	31.75 mm	
Material G41400-SA-193-B7-Class:-Size:<=64				
Allowable operating stress		S_b	172 N/mm²	
Allowable installation stress		S_a	172 N/mm²	
Consider bolt spacing correction factor B_{SC} 2-6(7)?		(N=No) Y	(Y/N)	
Required operation bolt load	Eq.(1)	W_{m1}	**969249** N	
Minimum initial bolt load	Eq.(2)	W_{m2}	**273712** N	
Available cross section of bolts		A_b	**14177** mm²	
Required cross section	W_{m1}/S_b	A_{m1}	**5635** mm²	
Required cross section	W_{m2}/S_a	A_{m2}	**1591** mm²	
Req. bolt load for gasket seating	$(A_m+A_b)\cdot S_a/2$	W	**1703879** N	(5)
Allowable bolt load	$A_b\cdot S_a$	W_{all}	**2438509** N	
Design (gasket seating =1; max. allowable=2)			1 (1,2)	

Moment

	Force	·	Lever arm	=	Result
$M_D = H_D \cdot h_D$ =	**641171** N	·	**86.36** mm	=	**5.537e+7** N·mm
$M_G = H_G \cdot h_G$ =	**197073** N	·	**61.37** mm	=	**1.209e+7** N·mm
$M_T = H_T \cdot h_T$ =	**131005** N	·	**73.86** mm	=	**9676610** N·mm

Total operating moment	M_{01} =	$M_D + M_G + M_T$	=	**7.714e+7** N·mm
Total gasket seating moment, Eq. (6)	M_{02} =	$W \cdot (C\text{-}G)/2$	=	**1.046e+8** N·mm

Stress

		Operation		Installation	≤ Allowable	
Longitudinal	S_H	**26.64** N/mm²		**36.12** N/mm²	≤ $1.5\cdot S_f$	(8)
Ratio	S_H/S_f	**0.217**		**0.2617**	≤ 1.5	
Allowable stress	S_f	122.8 N/mm²		138 N/mm²		
Radial	S_R	**28.13** N/mm²		**38.13** N/mm²	≤ S_f	(9)
Tangential	S_T	**17278** psi		**161.5** N/mm²	≤ S_f	(10)
Combination	$(S_H+S_R)/2$ =	**27.39** N/mm²		**37.12** N/mm²	≤ S_f	
Combination	$(S_H+S_T)/2$ =	**72.89** N/mm²		**98.8** N/mm²	≤ S_f	
Bolt pitch	B_S	**89.77** mm	≤	**212.2** mm	= B_{Smax}	(3)

Remark

Auxiliary values

$K=\frac{A}{B}=1.51$

$T=1.706$ (Fig. 2-7.1)

$U=5.368$ (Fig. 2-7.1)

$Y=4.885$ (Fig. 2-7.1)

$Z=2.563$ (Fig. 2-7.1)

$h_0=\sqrt{B \cdot g_0}=137.9$ mm

$F=3.261$ (Fig. 2-7.4)

$V=11.37$ (Fig. 2-7.5)

$f=1$

$d=\left(\frac{U}{V}\right) \cdot h_0 \cdot g_0^2=89541$ mm³

$e=\frac{F}{h_0}=0.02364$ 1/mm

$L=\frac{(t \cdot e+1)}{T}+\frac{t^3}{d}=4.103$

$H=0.785 \cdot G^2 \cdot P \cdot 0.1=772176$ N

$H_D=0.785 \cdot B^2 \cdot P \cdot 0.1=641171$ N

$H_P=2 \cdot b \cdot \pi \cdot G \cdot m \cdot P \cdot 0.1=197073$ N

$H_T=H-H_D=131005$ N

$W_{m1}=H+H_P=969249$ N Eq.(1)

$W_{m2}=\pi \cdot b \cdot g \cdot y=273712$ N Eq.(2)

$H_G=W_{m1}-H=197073$ N

$h_D=\frac{(C-B)}{2}=86.36$ mm

$h_G=\frac{(C-G)}{2}=61.37$ mm

$h_T=\frac{(h_D+h_G)}{2}=73.86$ mm

Bolt pitch $B_S=\pi \cdot \frac{C}{n}=89.77$ mm

$B_{Smax}=2 \cdot a+6 \cdot \frac{t}{(m+0.5)}=212.2$ mm (3)

For $B_S > 2 \cdot a + t$

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

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

$J = 52.14 \cdot V \cdot [M_{01}$ or $M_{02}]/L/[E$ or $E_{20C}]/(g_0 - c_2)^2/K_L/h_0$
= 52.14 · **11.37** · [**7.714e+7** or **1.046e+8**]/ **4.103** /

/[178667 or 201000]/(37.08 0)²/ **0.2** / **137.9**

Rigidity criterion: J **1.982** ≤ 1.0

Appendix: Material documentation

Section 2: Flansch/AFL
Section 3: Flansch/AFL

Material specification:

Regulation: ASMET1A:2017Spec. No.: SA-105 Product: Forgings
Material code: K03504-SA-105--Class:-Size: Short name: Carbon steel

Design conditions and dimensions:

Temperature [°C]: 343,3333 Pressure [bar]: 9,31
Thickness [mm]: 2 Outside diameter [mm]: 0

Material values for test and design conditions:

	Test condition	Operating condition
Nominal design strength [N/mm²]:	138,00	122,80
Safety factor:	1,00	1,00
Allowable stress [N/mm²]:	138,00	122,80
Modulus of elasticity [kN/mm²]:	201	178,6667

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.

--
Creep rupture strength for 100000 h [MPa]:

Tensile strength and yield stress at ambient temperature:

Diam./ Thick. <= mm	Tensile str. Rm min MPa	Rm max MPa	ReH MPa	Rupture elong. längs %	Rupture elong quer %

K-values as function of the temperature

Diam./ Thickn. <= mm	50°C MPa	100°C MPa	150°C MPa	200°C MPa	250°C MPa	300°C MPa	350°C MPa	400°C MPa
		138	138	138	136	129	122	101

K-values as function of the temperature

Diam./ Thickn. <= mm	450°C MPa	500°C MPa	550°C MPa	600°C MPa	650°C MPa	700°C MPa	800°C MPa
	67.0	33.6	12.9				

Modulus of elasticity in dependence of the temperature:

Static modulus of elasticity in [kN/mm²] at the temperature of

-75	-200	-125	25	100	150	200	250	300	350	400	450	500	550	600
207	215	211	201	197	194	191	188	183	178	170	161	149	136	121

Coefficient of linear expansion:

Thermal coefficient of expansion between 20°C and

Density (20 °C) kg/dm³	100°C 10E-6/K	200°C 10E-6/K	300°C 10E-6/K	400°C 10E-6/K	500°C 10E-6/K	600°C 10E-6/K	700°C 10E-6/K	800°C 10E-6/K	Heat cond. W/Km	Heat capac. J/kgK
7,85	12,1	12,7	13,3	13,8	14,4	-	-	-		

—

Section 2: Schraube/AFL
Section 3: Schraube/AFL

Material specification:

Regulation: ASMET3:2010Spec. No.: SA-193 Product: Bolting
Material code: G41400-SA-193-B7-Class:-Size:<=64 Short name: 1Cr-0.2Mo

Design conditions and dimensions:

Temperature [°C]: 343,3333 Pressure [bar]: 9,30798
Thickness [mm]: 2 Outside diameter [mm]: 0

Material values for test and design conditions:

	Test condition	Operating condition
Nominal design strength [N/mm²]:	172,00	172,00
Safety factor:	1,00	1,00
Allowable stress [N/mm²]:	172,00	172,00
Modulus of elasticity [kN/mm²]:	204	183,4

Notes:

--
Creep rupture strength for 100000 h [MPa]:

Tensile strength and yield stress at ambient temperature:

Diam./ Thick. <= mm	Tensile str. Rm min MPa	Rm max MPa	ReH MPa	Rupture elong. längs %	Rupture elong quer %

K-values as function of the temperature

Diam./ Thickn. <= mm		50°C MPa	100°C MPa	150°C MPa	200°C MPa	250°C MPa	300°C MPa	350°C MPa	400°C MPa
		172	172	172	172	172	172	162	

K-values as function of the temperature

Diam./ Thickn. <= mm	450°C MPa	500°C MPa	550°C MPa	600°C MPa	650°C MPa	700°C MPa	800°C MPa
	118	68.8	18.9				

Modulus of elasticity in dependence of the temperature:

Static modulus of elasticity in [kN/mm²] at the temperature of

650	-75	-200	-125	25	100	150	200	250	300	350	400	450	500	550
150	210	218	213	204	200	197	193	190	186	183	179	174	169	164

Static modulus of elasticity in [kN/mm²] at the temperature of

600	700			
157	142			

Coefficient of linear expansion:

Thermal coefficient of expansion between 20°C and

Density (20 °C) kg/dm³	100°C 10E-6/K	200°C 10E-6/K	300°C 10E-6/K	400°C 10E-6/K	500°C 10E-6/K	600°C 10E-6/K	700°C 10E-6/K	800°C 10E-6/K	Heat cond. W/Km	Heat capac. J/kgK
7,85	12,1	12,7	13,3	13,8	14,4	-	-	-		