

ASME BPVC VIII-1 2023

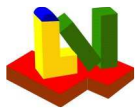
Example E4.16.1 - E4.16.2 PTB-4-2021

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Layout

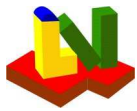
Input values:	1.234	or	1.234
Calculated values:	1.234	or	1.234
Critical values:	1.234	or	1.234
Estimated values:	1.234	or	1.234



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Example E4.16.1 - E4.16.2 PTB-4-2021

Summary

Strength Calculation Software		Program System ATLAS		Version	10.0.107
Developed by Lauterbach Verfahrenstechnik GmbH					
Certified per DIN EN ISO 9001:2008		Certificate Number 01 100 044763			



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Example E4.16.1 - E4.16.2 PTB-4-2021

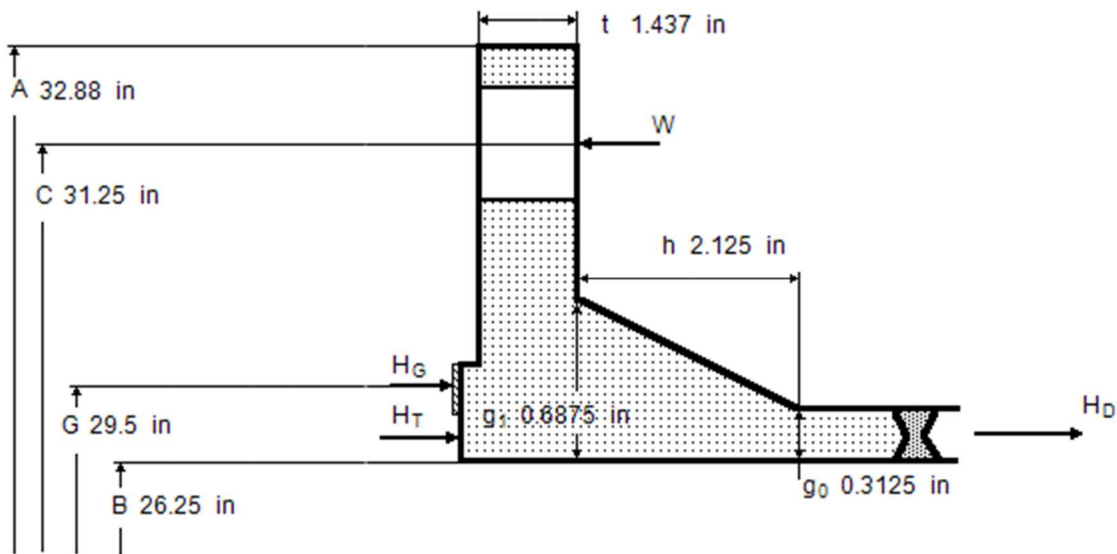
E 4.16.1 - Bolted flanges - ASME BPVC VIII Division 1 App. 2: 2023

Integral Type Flange

Design data

Design pressure	P_D	135 psi
Hydrostatic head	D_P	0 psi
Calculation pressure	P_0	135 psi
Calculation temperature	T_0	650 °F

Flange

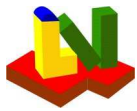


Outside diameter	A	835 mm	Inside diameter	B	26.25 in
Bolt circle diameter	C	793.8 mm	Pipe size	B_n	26.25 in
Hub length	h	2.125 in	Flange thickness	t	1.437 in
Large hub thickness	g_1	0.6875 in	Small hub thick.	g_0	0.3125 in

Thickness of semi-finished product	t_0	in
Material	K03504-SA-105--Class:-Size:	
Cast Quality Factor	f	1
Design strength operation	S_{do}	17811 psi
Design strength installation	S_{da}	20015 psi
Allowable operating stress	S_{fb}	17811 psi
Allowable installation stress	S_{fa}	20015 psi
Corrosion allowance	c_2	0 in
Modulus of elasticity at operation	E_T	2.591e+7 psi
Modulus of elasticity at test (20°C)	E_{20}	2.92e+7 psi

Gasket

Gasket diameter	G	29.5 in
Basic gasket seating width	b_0	0.2031 in
Effective gasket width	b	0.2031 in
Gasket factor	m	3.75
Gasket seating load	y	7600 psi



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Example E4.16.1 - E4.16.2 PTB-4-2021

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	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} 111274 lbf
Minimum initial bolt load	Eq.(2)	W_{m2} 142982 lbf
Available cross section of bolts	A_b	13.28 in ²
Required cross section	W_{m1}/S_b	A_{m1} 4.46 in ²
Required cross section	W_{m2}/S_a	A_{m2} 5.732 in ²
Req. bolt load for gasket seating	Eq.(5)	$(A_m + A_b) \cdot S_a / 2$ W 237101 lbf
Allowable bolt load	$A_b \cdot S_a$	W_{all} 331221 lbf
Design bolt force		1

External forces and moments

	Operation	
External axial force	W_{ax}	bf
External moment	M_b	lbf·ft
Resulting external force	W	bf

Note: External forces are considered as pseudo static pressure and added to the calculation pressure!

Resulting pseudo static pressure	P'	MPa
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Moment

$M_D = H_D \cdot h_D$	=	Force	·	Lever arm	=	Result
		324826 N	·	54.77 mm	=	157458 lbf·in
$M_G = H_G \cdot h_G$	=	84732 N	·	22.23 mm	=	16667 lbf·in
$M_T = H_T \cdot h_T$	=	85412 N	·	42.86 mm	=	32403 lbf·in
Total operating moment		$M_{01} = M_D + M_G + M_T$	=			206529 lbf·in
Total gasket seating moment, Eq. (6)		$M_{02} = W \cdot (C-G)/2$	=			207464 lbf·in

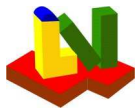
Stress

		Operation	Installation	≤ Allowable	
Longitudinal	S_H	17786 psi	17866 psi	≤ $1.5 \cdot S_f$	Eq.(8)
Ratio	S_H/S_f	0.9986	0.8926	≤ 1.5	
Allowable stress	S_f	17811 psi	20015 psi		
Radial	S_R	6157 psi	6184 psi	≤ S_f	Eq.(9)
Tangential	S_T	5548 psi	5573 psi	≤ S_f	Eq.(10)
Combination	$(S_H + S_R)/2$	= 11971 psi	12025 psi	≤ S_f	
Combination	$(S_H + S_T)/2$	= 11667 psi	11719 psi	≤ S_f	
Bolt pitch	B_S	56.67 mm	≤ 89.63 mm	= B_{Smax}	Eq.(3)

Remark

Cross-sectional area of bolts
Strength condition flange





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Example E4.16.1 - E4.16.2 PTB-4-2021

Auxiliary values

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

$$T = 1.817 \quad (\text{Fig. 2-7.1})$$

$$U = 9.623 \quad (\text{Fig. 2-7.1})$$

$$Y = 8.757 \quad (\text{Fig. 2-7.1})$$

$$Z = 4.518 \quad (\text{Fig. 2-7.1})$$

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

$$F = 0.7677 \quad (\text{Fig. 2-7.2})$$

$$V = 0.1576 \quad (\text{Fig. 2-7.3})$$

$$f = 1 \quad (\text{Fig. 2-7.6})$$

$$d = \left(\frac{U}{V} \right) \cdot h_0 \cdot g_0^2 = 279869 \text{ mm}^3$$

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

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

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

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

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

$$H_T = H - H_D = 85412 \text{ N}$$

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

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

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

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

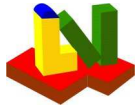
$$h_D = R + 0.5 \cdot g_1 = 54.77 \text{ mm}$$

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

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

Bolt pitch

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



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Example E4.16.1 - E4.16.2 PTB-4-2021

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

Eq.(3)

For

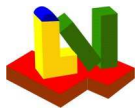
$$B_S > 2 \cdot a + t$$

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

Eq.(7)

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

Rigidity criterion: J **0.8339** ≤ 1.0



ASME BPVC VIII-1 2023 Example E4.16.1 - E4.16.2 PTB-4-2021

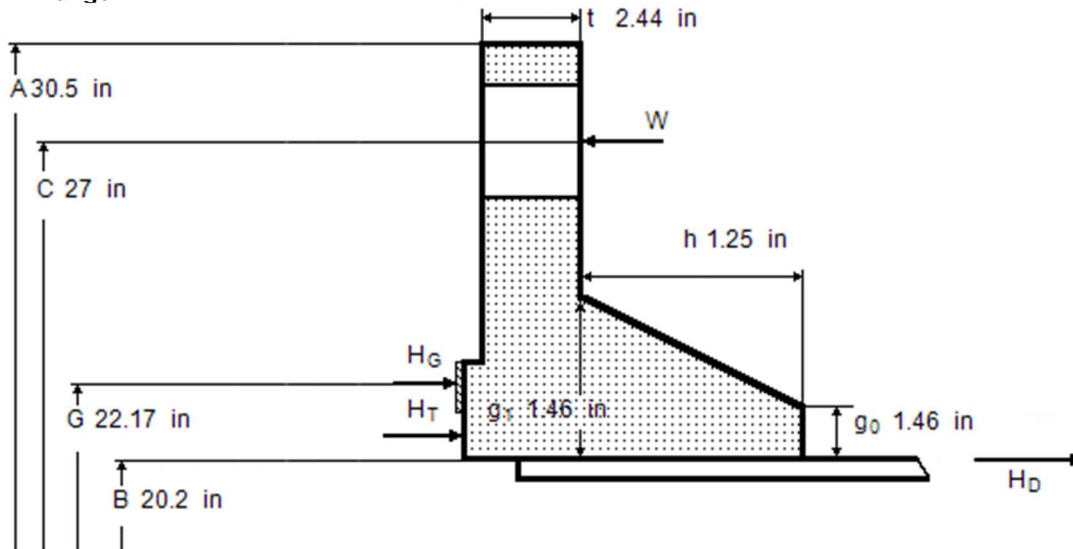
E 4.16.2 - Bolted flanges - ASME BPVC VIII Division 1 App. 2: 2023

Loose Type Flange With Full Neck

Design data

Design pressure	P_D	450 psi
Hydrostatic head	D_P	0 psi
Calculation pressure	P_0	450 psi
Calculation temperature	T_0	650 °F

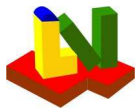
Flange



Outside diameter	A	774.7 mm	Inside diameter	B	20.2 in
Bolt circle diameter	C	685.8 mm	Pipe size	B_n	20.2 in
Hub length	h	1.25 in	Flange thickness	t	2.44 in
Large hub thickness	g_1	1.46 in	Small hub thickness	g_0	1.46 in
Thickness of semi-finished product	t_0	in			
Material K03504-SA-105--Class:-Size:					
Cast Quality Factor	f	1			
Design strength operation	S_{do}	17811 psi			
Design strength installation	S_{da}	20015 psi			
Allowable operating stress	S_{fb}	17811 psi			
Allowable installation stress	S_{fa}	20015 psi			
Corrosion allowance	c_2	0 in			
Modulus of elasticity at operation	E_T	2.591e+7 psi			
Modulus of elasticity at test (20°C)	E_{20}	2.92e+7 psi			

Gasket

Gasket diameter	G	22.17 in
Basic gasket seating width	b_0	0.5081 in
Effective gasket width	b	0.3536 in
Gasket factor	m	2
Gasket seating load	y	2500 psi



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Example E4.16.1 - E4.16.2 PTB-4-2021

Bolts

Number	n	24
Root diameter	d_K	1.08 in
Nominal diameter	a	1.25 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)?	
Required operation bolt load	Eq.(1)	W_{m1} 217897 lbf
Minimum initial bolt load	Eq.(2)	W_{m2} 61533 lbf
Available cross section of bolts	A_b	21.97 in ²
Required cross section	A_{m1}	8.735 in ²
Required cross section	A_{m2}	2.467 in ²
Req. bolt load for gasket seating	Eq.(5) $(A_m + A_b) \cdot S_a / 2$	W 383049 lbf
Allowable bolt load	$A_b \cdot S_a$	W_{all} 548201 lbf
Design bolt force		1

External forces and moments

External axial force	W_{ax}	lbf
External moment	M_b	Lbf.ft
Resulting external force	W'	lbf

Operation

Note: External forces are considered as pseudo static pressure and added to the calculation pressure!

Resulting pseudo static pressure	P'	MPa
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Moment

	Force	·	Lever arm	=	Result
$M_D = H_D \cdot h_D$	= 641171 N	·	86.36 mm	=	490082 lbf·in
$M_G = H_G \cdot h_G$	= 197073 N	·	61.37 mm	=	107043 lbf·in
$M_T = H_T \cdot h_T$	= 131005 N	·	73.86 mm	=	85646 lbf·in
Total operating moment	$M_{01} = M_D + M_G + M_T$	=		=	682770 lbf·in
Total gasket seating moment, Eq. (6)	$M_{02} = W \cdot (C-G)/2$	=		=	925485 lbf·in

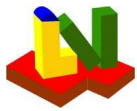
Stress

		Operation	Installation	≤ Allowable	
Longitudinal	S_H	3864 psi	5238 psi	≤ 1.5 · S_f	Eq.(8)
Ratio	S_H/S_f	0.217	0.2617	≤ 1.5	
Allowable stress	S_f	17811 psi	20015 psi		
Radial	S_R	4080 psi	5530 psi	≤ S_f	Eq.(9)
Tangential	S_T	17278 psi	23420 psi	≤ S_f	Eq.(10)
Combination	$(S_H + S_R)/2$	= 3972 psi	5384 psi	≤ S_f	
Combination	$(S_H + S_T)/2$	= 10571 psi	14329 psi	≤ S_f	
Bolt pitch	B_S	89.77 mm	≤ 212.2 mm	= B_{Smax}	Eq.(3)

Remark

Cross-sectional area of bolts
Strength condition flange
Flange rigidity





ASME BPVC VIII-1 2023

Example E4.16.1 - E4.16.2 PTB-4-2021

Auxiliary values

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

$$T = 1.706 \quad (\text{Fig. 2-7.1})$$

$$U = 5.368 \quad (\text{Fig. 2-7.1})$$

$$Y = 4.885 \quad (\text{Fig. 2-7.1})$$

$$Z = 2.563 \quad (\text{Fig. 2-7.1})$$

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

$$F = 3.261 \quad (\text{Fig. 2-7.4})$$

$$V = 11.37 \quad (\text{Fig. 2-7.5})$$

$$f = 1$$

$$d = \left(\frac{U}{V} \right) \cdot h_0 \cdot g_0^2 = 89541 \text{ mm}^3$$

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

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

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

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

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

$$H_T = H - H_D = 131005 \text{ N}$$

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

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

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

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

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

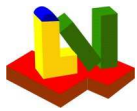
$$h_T = \frac{(h_D + h_G)}{2} = 73.86 \text{ mm}$$

Bolt pitch

$$B_s = \pi \cdot \frac{C}{n} = 89.77 \text{ mm}$$

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

Eq.(3)



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Example E4.16.1 - E4.16.2 PTB-4-2021

For

$$B_s > 2 \cdot a + t$$

Eq.(7)

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

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

Rigidity criterion: J **1.979** ≤ 1.0