DESIGN OF FLANGES

AS PER ASME SEC VIII DIVISION-1 APPENDIX -2

SL NO	DESCRIPTION	NOTATION	FORMULA	UNIT	VALUE	REMARKS
1.0	**NOTATIONS**					
Aa	No of bolts			Nos	20.00	
	Root area (ASME PCC-1 app.H)			sq in.	1.16	1.212679543
					1.16	
E	Wall thickness of Mating pipe			in	0.6260	1.023622047
F	OD of mating Pipe			in	12.750	
1.1	outside diameter of flange or, where slotted holes extend to the outside of the flange, the diameter to the bottom of the slots, in.	A		in	24.00	19.01574803
1.2	cross-sectional area of the bolts using the root diameter of the thread or least diameter of unthreaded position, if less, sq in.	Ab		sq in.	23.10	14903.196
1.3	total required cross-sectional area of bolts, taken as the greater of Am1 and Am2, sq in.	Am		sq in.	32.55	check if Ab>Am
1.4	total cross-sectional area of bolts at root of thread or section of least diameter under stress, required for the operating conditions, sq in.	Am1	=Wm1 / Sb	sq in.	32.55	
1.5	total cross-sectional area of bolts at root of thread or section of least diameter under stress, required for gasket seating, sq in.	=Am2	=Wm2 / Sa	sq in.	7.18	
1.6	inside diameter of flange, in. When B is less than 20g1 , it will be optional for the designer to substitute B1 for B in the formula for longitudinal stress SH.	B		in	12.1240	check 20g1=
1.7	B1=B + g1 , in., for loose type flanges and for integral type flanges that have calculated values h / ho and g1 / go which would indicate an f value of less than 1.0, although the minimum value of f permitted is 1.0.	B1	=B + g1	in	14.00	
1.8	B1=B + go , in., for integral type flanges when f is equal to or greater than one	B1	=B + go	in	12.12	
1.9	b=effective gasket or joint-contact-surface seating width, in. [see Note 1, 2-5(c)(1)]	b	0.33	in	0.33	check table2.5.2 bo>1/4in
1.10	bo=basic gasket seating width, in. (from Table 2-5.2)	bo		in	0.44	
1.11	C=bolt-circle diameter, in.	C		in	21.00	533.4
1.12	c=basic dimension used for the minimum sizing of welds, in., equal to tn or tx , whichever is less	c		in	0.63	
1.13						
1.14	d=factor, in.3	d				
			d = (U/V)*ho*go^2 for integral type flanges	in.3	142.65	
			d = (U/VL)*ho*go^2 for loose type flanges	in.3		
1.15	e=factor, in.^−1	e				
			e = (F/ho) for integral type flanges	in.^−1	0.22	
			e = (FL/ho) for loose type flanges	in.^−1		
1.16	F=factor for integral type flanges (from Fig. 2-7.2)	F	FUNTION OF g1/go AND h/ho		0.60	
1.17	FL=factor for loose type flanges (from Fig. 2-7.4)	FL				

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1.18	f = hub stress correction factor for integral flanges from Fig. 2-7.6 (When greater than one, this is the ratio of the stress in the small end of hub to the stress in the large end.) (For values below limit of figure, use f = 1.)	f	FUNTION OF g1/go AND h/ho		1.00	
1.19	G = diameter, in., at location of gasket load reaction. Except as noted in sketch (1) of Fig. 2-4, G is defined as follows (see Table 2-5.2):	G	ref ASME B16.5	in	13.84	351.5089309
			When bo <= 1/4 in., G = mean diameter of gasket contact face, in.		No	
			When bo > 1/4 in., G = outside diameter of gasket contact face less 2b, in.		Yes	
1.20	go = thickness of hub at small end, in.	go		in	0.62598425	1.023622047
1.21	g1=thickness of hub at back of flange, in.	g1	ref ASME B16.5	in	2.50000000	2.459153543
		g1/go			3.99	
1.22	H=total hydrostatic end force, lb	H	=0.785 * G^2 * P	lb	413790.24	
1.23	HD = hydrostatic end force on area inside of flange, lb	HD	=0.785 * B^2 *P	lb	317590.81	
1.24	HG = gasket load (difference between flange design bolt load and total hydrostatic end force), lb	HG	=W−H	lb	142701.82	
1.25	Hp = total joint-contact surface compression load, lb	Hp	=2 * b * 3.14 * G * m * P	lb	237193.88	
1.26	HT = difference between total hydrostatic end force and the hydrostatic end force on area inside of flange, lb	HT	= H − HD	lb	96199.43	
1.27	h = hub length, in.	h		in	3.8287402	ref truvey/b16.5 &fig2.4 6a
1.28	hD = radial distance from the bolt circle, to the circle on which HD acts, as prescribed in Table 2-6, in.	hD	=R+0.5*g1	in	3.19	
1.29	hG = radial distance from gasket load reaction to the bolt circle, in.	hG	=(C − G) /2	in	3.58	
1.30	ho = factor, in.	ho	=sqrt (B * go)	in	2.75	
		h/ho			1.39	
1.31	hT = radial distance from the bolt circle to the circle on which HT acts as prescribed in Table 2-6, in.	hT	=(R+g1+hG)/2	in	4.01	
1.32	K = ratio of outside diameter of flange to inside diameter of flange	K	= A / B		1.98	
1.33	L = factor	L	= ((te + 1) / T) + (t^3 / d)		1.13	
1.34	MD = component of moment due to HD, in.-lb	MD	= HD * hD	in-lb	1012477.01	
1.35	MG = component of moment due to HG, in.-lb	MG	= HG * hG	in-lb	510948.55	
1.36	M0 = total moment acting upon the flange, for the operating conditions or gasket seating as may apply, in.-lb (see 2-6)	MO		in-lb	1992538.10	
1.37	MT = component of moment due to HT , in.-lb	MT	= HT * hT	in-lb	385688.75	
1.38	m = gasket factor, obtain from Table 2-5.1 [see Note1, 2-5(c)(1)]	m			3.00	
1.39	N = width, in., used to determine the basic gasket seating with bo , based upon the possible contact width of the gasket (see Table 2-5.2)	N		in	0.87	
1.40	P = internal design pressure (see UG-21), psi. For flanges subject to external design pressure, see 2-11.	P		psi	2752.36	1413798.733
1.41	R = radial distance from bolt circle to point of intersection of hub and back of flange, in. For integral and hub flanges,	R	R = ((C − B) / 2) − g1	in	1.94	
1.42	Sa = allowable bolt stress at atmospheric temperature, psi (see UG-23)	Sa		psi	20000.00	137.93
1.43	Sb = allowable bolt stress at design temperature, psi (see UG-23)	Sb		psi	20000.00	137.93
1.44	Sf = allowable design stress for material of flange at design temperature (operating condition) or atmospheric temperature (gasket seating), as may apply, psi (see UG-23)	Sf		psi	20000.00	137.93

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SL NO	DESCRIPTION	NOTATION	FORMULA	UNIT	VALUE	REMARKS
1.45	Sn = allowable design stress for material of nozzle neck, vessel or pipe wall, at design temperature (operating condition) or atmospheric temperature (gasket seating), as may apply, psi (see UG- 23)	Sn		psi	20000.00	137.93
1.46	SH = calculated longitudinal stress in hub, psi	SH		psi	23205.08	
1.47	SR = calculated radial stress in flange, psi	SR		psi	28390.12	
1.48	ST = calculated tangential stress in flange, psi	ST		psi	2972.09	
1.49	T = factor involving K (from Fig. 2-7.1)	T			1.51	
1.50	t = flange thickness, in.	t		in	3.12	
1.51	tn = nominal thickness of shell or nozzle wall to which flange or lap is attached, in.	tn		in	0.63	
1.52	tx = two times the thickness g0 , when the design is calculated as an integral flange, in., or two times the thickness, in., of shell nozzle wall required for internal pressure, when the design is calculated as a loose flange, but not less than 1⁄4 in.	tx		in	1.25	
1.53	U = factor involving K (from Fig. 2-7.1)	U			3.30	
1.54	V = factor for integral type flanges (from Fig. 2-7.3)	V	FUNTION OF g1/go AND h/ho		0.025	
1.55	VL = factor for loose type flanges (from Fig. 2-7.5)	VL		lb		
1.56	W = flange design bolt load, for the operating conditions or gasket seating, as may apply, lb [see 2-5(e)]	W		lb	556,492.06	2,529,509.36
1.57	Wm1 = minimum required bolt load for the operating conditions, lb [see 2-5(c)]. For flange pairs used to contain a tubesheet for a floating head for a U-tube type of heat exchangers, or for any other similar design, Wm1 shall be the larger of the values as individually calculated for each flange, and that value shall be used for both flanges.	Wm1		lb	650,984.12	2,959,018.71
1.58	Wm2 = minimum required bolt load for gasket seating, lb [see 2-5(c)]	Wm2		lb	143,630.59	651,496.85
1.59	w = width, in., used to determine the basic gasket seating width b0 , based upon the contact width between the flange facing and the gasket (see Table 2-5.2)	w		in	0.87	325,748.42
1.60	Y = factor involving K (from Fig. 2-7.1)	Y			3.01	
1.61	y = gasket or joint-contact-surface unit seating load, psi [see Note 1, 2-5(c)] & Minimum Design Seating Stress y	y		psi	10000.00	Table 2.5.1 secVIII DIV1
1.62	Z = factor involving K (from Fig. 2-7.1)	Z			1.69	
2.0	**2-4 CIRCULAR FLANGE TYPES**					
2.1	optional type flange					
3.0	**2-5 BOLT LOADS**					
3.1	minimum required bolt load for the operating conditions	Wm1	Wm1 = H + Hp	lb	650,984.12	
			= 0.785 * G^2 * P + (2 *b * 3.14 * Gm * P)			
3.2	minimum required bolt load for gasket seating	Wm2	Wm2 = 3.14bGy	lb	143,630.59	
3.4	total cross-sectional area of bolts at root of thread or section of least diameter under stress, required for the operating conditions	Am1	Am1 = Wm1 / Sb	sq.in	32.55	

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SL NO	DESCRIPTION	NOTATION	FORMULA	UNIT	VALUE	REMARKS
3.5	total cross-sectional area of bolts at root of thread or section of least diameter under stress, required for gasket seating	Am2	Am2 = Wm2 / Sa	sq.in	7.18	
3.6						
3.7	Flg2.7.3 for value of V	h/ho			1.39	
3.8	Flg2.7.3 for value of V	g1/go			3.99	
3.9						
3.10	flange design bolt load, for the operating conditions or gasket seating, as may apply [see 2-5(e)]	W	W = (Am + Ab) * Sa * 2	lb	556,492.06	
3.11	maximum (Wm1 , Wm2 , W)			lb	650,984.12	
3.12	flange design bolt load, for the operating conditions or gasket seating, as may apply [see 2-5(e)]	Mo	Mo = W * (C − G) / 2	lb-in	1,992,538.10	
4.0	**2.7 CALCULATION OF FLANGE STRESS**					
4.1	LONGITUDINAL HUB STRESS	SH	SH = (f * Mo) / (L * g1^2 * B)	psi	23,205.08	160.0350542
4.2	RADIAL FLANGE STRESS	SR	SR = (1.33* t*e + 1)Mo / (L*t^2 * B)	psi	28,390.12	195.7939362
4.3	Tangential flange stress	ST	ST = ((Y * Mo) / (t^2 * B))− (Z * SR)	psi	2,972.09	20.49719005
5.0	**ALLOWABLE STRESS CHECK**					
5.1	check if SH not> 1.5 Sf				OK -LONGITUDINAL HUB STRESS	
5.2	check if SR not > Sf				REDESIGN- FAILED, RADIAL FLANGE STRESS	
5.3	check if ST not > Sf				OK -TANGENTIAL FLANGE STRESS	
5.4	check if (SH + SR)/2 not > Sf				REDESIGN	
5.5	check if (SH + ST)/2 not > Sf				OK -COMB. LONG. & TANG. FLANGE STRESS	
6.0	**Bolt Torque Load**					
	Calculation as per BS EN 1591-1					
	Mt nom = KB x Fbo nom / nB				9764.76	lbin
					813.73	lbft
	where					
	KB = Pt / 2 PI() + μt x dt /(2 cos a) + μn x dn /2					
	dn = mean contact diameter under nut or bolt head					

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SL NO	DESCRIPTION	NOTATION	FORMULA	UNIT	VALUE	REMARKS
	dt					
	nB = No of Bolts					
	Calculation as per ASME PCC-1 Appendix K					
	bolt stress					
	T = K * D * F/12	eq (K-1)		ft-lb	2917.50	3955.6
	where					
	D = nominal diameter of the bolt, in				1.63	
	F = target bolt load, lb				143,630.59	
	K = nut factor (see below)				0.15	
	T = Target Torque, ft-lb					

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