Code Details - Body Flanges

Component: Front Head Flng At TS

ASME Section VIII-1 2013 App. 2 Bolted Flange With Ring Type Gaskets

Flange type: Integral tapered hub - ASME fig.2-4(6)
Flange material: SA-350 K03011 Grd LF2 Cls 2 Forgings

Int. design pressure	PI = 0.128 Kg/mm2	Design temperature	T = 250 C
Ext. design pressure	PE = 0.01 Kg/mm2	B1 = B+g1 or B+go	B1 = -
Inside corr. allow	CAI = 3 mm	Outside corr. all.	CAO = 0 mm
Stress (operating)	SFO = 13.83 Kg/mm2	Stress (atmos.)	SFA = 14.06 Kg/mm2
Outside diameter	A = 881 mm	Inside spherical rad.	L = -
Inside diameter	B = 756 mm	Hub thickness	g1 = 12.75 mm
Bolt circle diameter	C = 839 mm	Hub tks. at attach.	go = 9 mm
Mean gasket diameter	G = 794.15 mm	Weld leg/hub length	h = 30 mm
Hub to bolt circle	R = 28.75 mm	Bolt circle to OD	E = 21 mm
Flange thickness	t = 58 mm		
Overlay thickness	OL = -		

Gasket material: Grooved iron or soft metal

Gasket outside dia.	ODG = 807 mm	Gasket width	N = 13 mm
Gasket thickness	tks = 3.17 mm	Gasket factor	m = 4.000
Gasket seating stress	y = 7.04 Kg/mm2	Gasket eff. width	b = 6.42 mm
Gasket unit stress	Sg = 4.65 Kg/mm2	factor	f = 0 mm
Gasket rib length	Rib = 781 mm	Seating width	bo = 6.5 mm
Gasket rib eff width	Br = 4.76 mm	(Table 2-5.2 facing 1a/1b Col. II)	

Bolt material: SA-320 G40370 Grd L7A Bolt(<= 2 1/2)

Bolt diameter	db = 19.05 mm	No. of bolts	n = 44
Bolt root area	Area = 194.84 mm2	Sg = Ab*Sa/((Pi/4)*((do-f)**2-di**2))	
Bsmax = 2*db+6*t/(m+0.5)		Actual bolt spacing	Bs = 59.9 mm
Max bolt spacing	BsMax = 115.4 mm	Min bolt spacing	BsMin = 44.5 mm
Cf = SQRT(Bs/Bsmax)	Cf = 0.72	Cf used	Cf = 1
Stress (operating)	SB = 17.58 Kg/mm2	Stress (atmos.)	SA = 17.58 Kg/mm2

Bolting calculations:

Joint-contact compr. load	HP = 6.2832*b*G*PI*m+2*Br*m*PI*RIB	=	20222 kgf
Hydrostatic end force	H = 0.7854*G*G*PI	=	63403 kgf
Hydrostatic end force	H = 0.7854*G*G*PE	=	4953 kgf

Operating conditions:

Min. calc. bolt load	WM1 = HP+H	=	83625 kgf
Min. used bolt load	WM1 = max of 2 mating flanges	=	107141 kgf

Bolting up conditions:

Minimum bolt load	WM2 = 3.1416*b*G*Y+Br*Y*RIB	=	138949 kgf
Min. used bolt load	WM2 = max of 2 mating flanges	=	138949 kgf
Required bolt area	AM = WM2/SA or WM1/SB	=	7905.3 mm2
Available bolt area	AB = No.Bolt*Area	=	8572.9 mm2
Ratio of bolt areas	AB/AM = 1.084		
Design bolt load	W = 0.5*(AM+AB)*SA	=	144816 kgf

Minimum gasket width	NMIN = AB*SA/(6.283*y*G)	=	4.29 mm
Gasket compression stress	Gcst = AB*SA/((Pi*G*N)+(Br*RIB))	=	4.17 Kg/mm2

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Loads:                    Integral Flange Calculations
Operating conditions:
  Hydrostatic end load       HD = 0.785*B*B*PI     =   57457 kgf
  Hydrostatic end load       HDe= 0.785*B*B*PE     =    4489 kgf
  Gasket load                HG = WM1-H            =   43739 kgf
  Result. hydrostatic force  HT = H-HD             =    5945 kgf
  Result. hydrostatic force  HTe= He-HDe           =     464 kgf
Bolting up conditions:
  Gasket load                HG = W                =  144816 kgf

Operating conditions:
  Hydrostatic lever arm      hd = R+0.5*g1         = 35.13 mm
  Gasket load lever arm      hg = (C-G)/2.         = 22.42 mm
  Result. hydro. lever arm   ht = (R+g1+hg)/2.0    = 31.96 mm

Bolting up conditions:
  Gasket load lever arm      hg = (C-G)/2.         = 22.42 mm
Operating conditions:
  Hydrostatic moment         MD = HD*hd            =     2018 kgf*m
  Gasket moment              MG = HG*hg            =      981 kgf*m
  Result. hydro. moment      MT = HT*ht            =      190 kgf*m
  Total operating moment    MOP = MD+MG+MT         =     3189 kgf*m
                     MOPe = HDe(hd-hg)+HTe(ht-hg)  =       61 kgf*m

Bolting up conditions:
  Bolt up moment           MATM = W*hg             =     3247 kgf*m
  Effective bolt moment      MB = MATM*SFO/SFA     =     3194 kgf*m

Total moment                 MO = MOP or MB        =     3194 kgf*m

Bolt spacing correction       M = MO*Cf            =     3194 kgf*m
 (TEMA 2007 RCB-11.23) Cf= 1

Flange shape constants:
       K = A/B           = 1.1653        ho = SQ(B*G0)    = 82.4864
       T = Fig.2-7.1     = 1.8527      h/ho = h/ho        = 0.3637
       Z = Fig.2-7.1     = 6.5862         F = Fig.2-7.2   = 0.8732
       Y = Fig.2-7.1     = 12.7582        V = Fig.2-7.3   = 0.3685
       U = Fig.2-7.1     = 14.02          f = Fig.2-7.6   = 1.0
   G1/G0 = G1/Go         = 1.4167         e = F/ho        = 0.0106
       t =               = 58 mm
       d = U*ho*g0*g0/V  = 254220     Alpha = t*e+1.0     = 1.614
    Beta = 1.333*t*e+1.0 = 1.8185     Gamma = Alpha/TF    = 0.8712
   Delta = t*t*t/D       = 0.7675    Lambda = Gamma+Delta = 1.6386

Stress calculations:                                    Allowable stress:
Long. hub     SH = (f*M)/(Lambda*g1**2*B)  =15.86 Kg/mm2 1.5*SFO =21.09 Kg/mm2
Radial        SR = Beta*M/(Lambda*t**2*B)  = 1.39 Kg/mm2     SFO =13.83 Kg/mm2
Tangential   ST1 = M*Y/(t**2*B)-(Z*SR)     = 6.84 Kg/mm2     SFO =13.83 Kg/mm2
  (greater)  ST2 = (SH+SR)/2 or (SH+ST1)/2 =11.35 Kg/mm2     SFO =13.83 Kg/mm2
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Component: Front Head Flng At TS

ASME Section VIII Div.1 2013, Appendix 2, 2-14 Flange Rigidity

--- Calculations ---

Operating moment,	Mo = 3189 kgf*m	Gasket seat. moment	Ma = 3247 kgf*m
Factor VI	VI = 0.3685	Factor L	L = 1.6386
Mod. elast.design T	Ed = 19129 Kg/mm2	Mod.elast.atm. temp	Ea = 20530 Kg/mm2
Thickness g0	g0 = 9 mm	Factor h0	h0 = 82.5 mm
Factor KI	KI = 0.3	Factor KL	KL = 0.2
Corrosion allowance	ca = 3 mm	Factor K	K = 1.1653
Thickness, T	T = 58 mm		

Flange Rigidity

Loose type flanges without hubs and optional flanges designed as loose type

Gasket seating J = 109.4 * Ma / (E * T ** 3 * Ln(K) * KL) = -

Operating J = 109.4 * Mo / (E * T ** 3 * Ln(K) * KL) = -

Integral type flanges and optional type flanges designed as integral and Loose type flanges with hubs

Gasket seating J = 52.14 * Ma * VI/ (L*E*G0**2 * ho * KI) = 0.9253

Operating J = 52.14 * Mo * VI/ (L*E*G0**2 * ho * KI) = 0.9751

ASME appendix 2 calculation of hub thickness 'go' as a cylinder

Design pressure	P = 0.128 Kg/mm2	Allowable stress	S = 13.83 Kg/mm2
Outside radius	OR = -	Inside radius	IR = 378 mm
Joint efficiency	E = 0.85	Corr.Allow or OL	c = 3 mm
		Material tolerance	tol = 0 mm

Min hub thk / small end = P*IR / (S*E - 0.6*P)+c+Tol UG-27(c)(1)
= 7.14 mm

Hub thk / small end = 12 mm

New thickness 'go	= 12 mm	New thickness 'g1'	= 15.75 mm
Corroded thickness 'go'	= 9 mm	Corroded thk 'g1'	= 12.75 mm

Code Details - MAWP/MDMT/Test P/Static P

Maximum Allowable Working Pressures
* = Shell Side MAWP + = Tube Side MAWP

Component	Side	--Design conditions-- Temp C	Stress kg/mm2	MAWP kg/cm2	---- New and cold --- Temp C	Stress kg/mm2	MAWP kg/cm2
Shell Cylinder	S	220	14.06	28.06	21.1	14.06	37.53
Front Head Cylinder	T	250	14.06	28.06	21.1	14.06	37.53
Front Head Cover	T	250	14.06	33.4	21.1	14.06	44.5
Shell Cover	S	220	14.06	33.4	21.1	14.06	44.5
Front Tubesheet	S	250	13.83	18.35	21.1	14.06	22.72*
Front Tubesheet	T	250	13.83	18.35			2.72+
Front Head Flng At TS	T	250	13.83	16.62			23.03
Front Shell Flng	S	220	13.98	16.97*	21.1	14.06	24
Tubes	T	250	9.42	225.13	21.1	9.42	225.13
Nozzle N1	T	250	12.02	13.95+	21.1	12.02	24.97
Nozzle N2	T	250	13.83	515.58	21.1	14.06	661.18
Nozzle N3A	S	220	12.02	22.02	21.1	12.02	33.09
Nozzle N3B	S	220	12.02	22.02	21.1	12.02	33.09
Nozzle N4A	S	220	12.02	22.02	21.1	12.02	33.09
Nozzle N4B	S	220	12.02	22.02	21.1	12.02	33.09
Nozzle Flng N1	T	250	13.83	42.92	21.1	14.06	52.03
Nozzle Flng N2	T	250	13.83	42.92	21.1	14.06	52.03
Nozzle Flng N3A	S	220	13.98	44.05	21.1	14.06	52.03
Nozzle Flng N3B	S	220	13.98	44.05	21.1	14.06	52.03
Nozzle Flng N4A	S	220	13.98	44.05	21.1	14.06	52.03
Nozzle Flng N4B	S	220	13.98	44.05	21.1	14.06	52.03
Nozzle Reinforcement N1	T	250	-	17.28	21.1	-	22.95
Nozzle Reinforcement N2	T	250	-	33.31	21.1	-	44.16
Nozzle Reinforcement N3A	S	220	-	18.63	21.1	-	24.65
Nozzle Reinforcement N3B	S	220	-	18.63	21.1	-	24.65
Nozzle Reinforcement N4A	S	220	-	18.63	21.1	-	24.65
Nozzle Reinforcement N4B	S	220	-	18.63	21.1	-	24.65
Front Hd Bolting At TS	T	250	17.58	23.06			3.06
Front Hd Bolting At TS	S	250	17.58	23.35			3.35
Nozzle Flng Bolting N1	T	250	17.58	42.92			2.03
Nozzle Flng Bolting N2	T	250	17.58	42.92			2.03
Nozzle Flng Bolting N3A	S	220	17.58	44.05	21.1	17.58	52.03
Nozzle Flng Bolting N3B	S	220	17.58	44.05	21.1	17.58	52.03
Nozzle Flng Bolting N4A	S	220	17.58	44.05	21.1	17.58	52.03
Nozzle Flng Bolting N4B	S	220	17.58	44.05	21.1	17.58	52.03

Flange MAWP

Bolting for the same flange MAWP