

Input Echo, App Y Flange Item 1, Description: brida fondo

Description of Flange Geometry (Type)	Integral Weld Neck		
Design Pressure	P	15.40	bars
Design Temperature		25.00	C
Corrosion Allowance	FCOR	0.0000	mm.
Flange Inside Diameter	B	1360.0000	mm.
Flange Outside Diameter	A	1470.0000	mm.
Flange Thickness	T	40.0000	mm.
Thickness of Hub at Small End	G0	15.0000	mm.
Thickness of Hub at Large End	G1	15.0000	mm.
Length of Hub	HL	10.0000	mm.
Flange Material		SA-240 316Ti	
Flange Material UNS Number		S31635	
Flange Allowable Stress At Temperature	SFO	137.90	N./mm ²
Flange Allowable Stress At Ambient	SFA	137.90	N./mm ²
Bolt Material		SA-574	
Bolt Allowable Stress At Temperature	SBO	233.05	N./mm ²
Bolt Allowable Stress At Ambient	SBA	233.05	N./mm ²
Diameter of Bolt Circle	C	1430.0000	mm.
Nominal Bolt Diameter	DB	24.0000	mm.
Type of Threads	TEMA Thread Series		
Number of Bolts		103	
Gasket Outside Diameter	GOD	1378.0000	mm.
Gasket Inside Diameter	GID	1368.0000	mm.
Gasket Factor, m,	M	0.0000	
Gasket Design Seating Stress	Y	0.00	N./mm ²
Elastic Modulus of Bolt Material at Des. Temp		201062681	KPa.
Elastic Modulus of Flange Material at Des. Temp		194857530	KPa.

FLANGE ANALYSIS of Identical Flange Pairs Per Appendix Y

Corroded Flange ID,	BCOR = B+2.0*FCOR	1360.000	mm.
Corroded Large Hub,	G1COR = G1-FCOR	15.000	mm.
Corroded Small Hub,	G0COR = G0-FCOR	15.000	mm.
Code R Dimension,	R = (C-B)/2.0 - G1	20.000	mm.
Gasket Contact Width,	N = (GOD-GID) / 2	5.000	mm.
Basic Gasket Width,	B0 = N / 2.0	2.500	mm.
Effective Gasket Width,	BE = B0	2.500	mm.
Gasket Reaction Diameter,	G = (GOD+GID) / 2.0	1373.000	mm.
Radial Contact Dist.,	hmax = (A - C) / 2	20.000	mm.

Basic Flange and Bolt loads:

Hydrostatic End Load due to Pressure:

$$H = 0.785 * G * G * PEQ$$

$$H = 0.7854 * 1373.0000 * 1373.0000 * 15.4000$$

$$H = 232514. \text{ Kgf}$$

Contact Load on Gasket Surfaces:

$$HP = 2 * BE * PI * G * M * P$$

$$HP = 2 * 2.5000 * 3.1416 * 1373.0000 * 0.0000 * 15.40$$

$$HP = 0. \text{ Kgf}$$

Hydrostatic End Load at Flange ID:

$$HD = 0.785 * Bcor * Bcor * P$$

$$HD = 0.785 * 1360.0000 * 1360.0000 * 15.4000$$

$$HD = 228131. \text{ Kgf}$$

Pressure Force on Flange Face:

$$HT = H - HD$$

$$HT = 232513 - 228131$$

$$HT = 4382. \text{ Kgf}$$

Operating Bolt Load:

$$WM1 = H + HP + HPP$$

$$WM1 = (232513 + 0 + 0)$$

$$WM1 = 232514. \text{ Kgf}$$

Gasket Seating Bolt Load:

$$WM2 = Y * BE * PI * G + Ypart * BEpart * GLPG + HPGY$$

$$WM2 = 0.00 * 2.5000 * 3.141 * 1373.000 + 0.00 * 0.0000 * 0.00$$

$$WM2 = 0. \text{ Kgf}$$

Required Bolt Area:

$$AM = \text{Maximum of } WM1/SBO, WM2/SBA$$

$$AM = \text{Maximum of } 232513 / 233, 0 / 233$$

$$AM = 97.8421 \text{ cm}^2$$

Bolting Information for TEMA Thread Series:

Total Area of Bolts, AB	278.432	cm ²
Minimum radial distance between hub and bolts	31.750	mm.
Minimum radial distance between bolts and edge	23.825	mm.
Minimum circumferential spacing between bolts	52.400	mm.
Actual circumferential spacing between bolts	43.610	mm.
Maximum circumferential spacing between bolts	524.450	mm.

Flange Design Bolt Load, Gasket Seating:

$$W = SBA * (AM + AB) / 2.0$$

$$W = 233.05 * (97.8421 + 278.4317) / 2.0$$

$$W = 447091.44 \text{ Kgf}$$

Gasket Seating Force:

$$HG = WM1 - H$$

$$HG = 232513 - 232513$$

$$HG = 0.00 \text{ Kgf}$$

MOMENT ARM CALCULATIONS:

Distance to Hub Large End:

$$R = (C - BCOR) / 2 - G1COR$$

$$R = (1430.000 - 1360.000) / 2 - 15.000$$

$$R = 20.0000 \text{ mm.}$$

Distance to Gasket Load Reaction:

$$\begin{aligned} DHG &= (C - G) / 2.0 \\ DHG &= (1430.0000 - 1373.0000) / 2.0 \\ DHG &= 28.5000 \text{ mm.} \end{aligned}$$

Distance to Face Pressure Reaction:

$$\begin{aligned} DHT &= (R + G1COR + DHG) / 2.0 \\ DHT &= (20.0000 + 15.0000 + 28.5000) / 2.0 \\ DHT &= 31.7500 \text{ mm.} \end{aligned}$$

Distance to End Pressure Reaction:

$$\begin{aligned} DHD &= R + (G1COR / 2.0) \\ DHD &= 20.0000 + (15.0000 / 2.0) \\ DHD &= 27.5000 \text{ mm.} \end{aligned}$$

SUMMARY OF MOMENTS FOR INTERNAL PRESSURE:

LOADING		Force	Distance	Bolt Corr	Moment
End Pressure,	MD	228131.	27.5000	1.0000	6274. Kg-m.
Face Pressure,	MT	4382.	31.7500	1.0000	139. Kg-m.
Gasket Load,	MG	0.	28.5000	1.0000	0. Kg-m.
Gasket Seating,	MA	447091.	28.5000	1.0000	12742. Kg-m.

TOTAL MOMENT FOR OPERATION,	RMO	6413. Kg-m.
TOTAL MOMENT FOR GASKET SEATING,	RMA	12742. Kg-m.

Effective Hub Length, H0 = SQRT(BCOR*G0COR)	142.829 mm.
Hub Ratio, HRAT = HL / H0	0.070
Thickness Ratio, GRAT = (G1COR/G0COR)	1.000

Flange Factors for Integral Flange:

Factor F per 2-7.2	0.909
Factor V per 2-7.3	0.550
Factor f per 2-7.6	1.000

Factors from Figure 2-7.1	K =	1.081
T =	1.884	U = 27.294
Y =	24.838	Z = 12.883

Stress Analysis of a Class 1 Assembly

Compute the Factor: F'

$$\begin{aligned} &= g0^2 * (h0 + F * T) / V \\ &= 15.0000^2 * (142.8286 + 0.9089 * 40.0000) / 0.5501 \\ &= 4.4724 \end{aligned}$$

Factor: Js

$$\begin{aligned} &= 1/B1 * (2*hd/\beta + hc/a) + \pi*rb \\ &= 1/1375.000(2*27.500/1.0200+20.0000/1.0545)+3.14159*0.010558 \\ &= 0.0862 \end{aligned}$$

Factor: Jp

$$\begin{aligned}
&= 1/B1 * (hd/\beta + hc/a) + \pi * r_b \\
&= 1/1375.000(27.500/1.0200+20.0000/1.0545)+3.14159*0.010558 \\
&= 0.0666
\end{aligned}$$

Flange Moment due to Flange-Hub Interaction: Ms

$$\begin{aligned}
&= -(J_p * F' * M_p) / (t^3 + J_s * F') \\
&= -(0.0666 * 4.4724 * 6412.87) / (40.0000 + 0.0862 * 4.4724) \\
&= -444.9643 \text{ Kg-m.}
\end{aligned}$$

Slope of the Flange at the ID times E (Elastic Modulus): Ethetab

$$\begin{aligned}
&= 5.46 / (\pi * t^3) * (J_s * M_s + J_p * M_p) \\
&= 5.46 / (3.14159 * 40.0000^3) * (0.0862 * -445.0 + 0.0666 * 6412.87) \\
&= 103472. \text{ KPa.}
\end{aligned}$$

Contact Force between Flanges at hc: Hc

$$\begin{aligned}
&= (M_p + M_s) / hc \\
&= (6412.87 + -444.96) / 20.0000) \\
&= 298390. \text{ Kgf}
\end{aligned}$$

Operating Bolt Load: Wm1

$$\begin{aligned}
&= H + H_g + H_c \\
&= 232513.55 + 0.00 + 298389.62 \\
&= 530903. \text{ Kgf}
\end{aligned}$$

Operating Bolt Stress: Sigtab

$$\begin{aligned}
&= Wm1 / A_b \\
&= 530903.19 / 278.4317 \\
&= 186.9930 \text{ N./mm}^2
\end{aligned}$$

Design Prestress in the Bolts: Si

$$\begin{aligned}
&= \text{Sigtab} - 1.159 * hc^2 * (M_p + M_s) / (a * t^3 * l * re * B1) \\
&= 186 - 1.159 * 20.000^2 * (5967) / (1.055 * 40.0000^3 * 102.225 * 102.225) \\
&= 184.0418 \text{ N./mm}^2
\end{aligned}$$

Radial Flange Stress at the Bolt Circle: Sr

$$\begin{aligned}
&= 6 * (M_p + M_s) / (t^2 * (\pi * C - n * D)) \\
&= 6 * (6412 + -444) / (40.0000^2 (\pi * 1430.0000 - 103 * 25.4000)) \\
&= 116.9705 \text{ N./mm}^2
\end{aligned}$$

Radial Flange Stress at the Inside Diameter: SRid

$$\begin{aligned}
&= -((2 * F * t) / (h_0 + F * t) + 6) * M_s / (\pi * B1 * t^2) \\
&= -((2 * 0.909 * 40.000) / (142.829 + 0.909 * 40.000) + 6) * -444 / (\pi * -444.964) \\
&= -3.5319 \text{ N./mm}^2
\end{aligned}$$

Tangential Flange Stress at the Inside Diameter: STid

$$\begin{aligned}
&= (t * \text{Ethetab} / B1) + ((2 * F * t * Z) / (h_0 + F * t) - 1.8) * M_s / (\pi * B1 * t^2) \\
&= (40.0000 * 103471.74 / 1375.0000) \\
&\quad + ((2 * 0.9089 * 40.0000 * 12.8831) / (142.8286 + 0.9089 * 40.0000) - 1.8) * \\
&\quad -444.96 / (\pi * 1375.000 * 40.0000^2) \\
&= 0.8460 \text{ N./mm}^2
\end{aligned}$$

Longitudinal Hub Stress: Sh

$$= (h_0 * \text{Ethetab} * f) / ((0.91 * (g1/g0)^2 * B1 * V)$$

$$= (142.8286 * 103471.7 * 0.909) / ((0.91 * (15.0000 / 15.0000)^2 * 1375.0000 * 1375.0000)$$

$$= 19.5164 \text{ N./mm}^2$$

Summary of Flange Stresses :

	Actual	Allowable
Radial Flange Stress at the Bolt Circle	116.97	137.90 N./mm ²
Tangential Flange Stress at the ID	0.85	137.90 N./mm ²
Radial Flange Stress at the ID	-3.53	137.90 N./mm ²
Longitudinal Hub Stress	19.52	206.85 N./mm ²
Average of Sh and Sr	7.99	137.90 N./mm ²
Average of Sh and St	10.18	137.90 N./mm ²
Bolt Stress	186.99	233.05 N./mm ²

Results for Required Thickness and M.A.W.P.

Minimum Required Flange Thickness	36.4794 mm.
Estimated M.A.W.P.	18.16 bars

Input Echo, App Y Flange Item 2, Description: brida virola

Description of Flange Geometry (Type)	Integral Weld Neck		
Design Pressure	P	15.40	bars
Design Temperature		25.00	C
Corrosion Allowance	FCOR	0.0000	mm.
Flange Inside Diameter	B	1360.0000	mm.
Flange Outside Diameter	A	1470.0000	mm.
Flange Thickness	T	40.0000	mm.
Thickness of Hub at Small End	G0	10.0000	mm.
Thickness of Hub at Large End	G1	10.0000	mm.
Length of Hub	HL	10.0000	mm.
Flange Material		SA-240	316Ti
Flange Material UNS Number		S31635	
Flange Allowable Stress At Temperature	SFO	137.90	N./mm ²
Flange Allowable Stress At Ambient	SFA	137.90	N./mm ²
Bolt Material		SA-574	
Bolt Allowable Stress At Temperature	SBO	233.05	N./mm ²
Bolt Allowable Stress At Ambient	SBA	233.05	N./mm ²
Diameter of Bolt Circle	C	1430.0000	mm.
Nominal Bolt Diameter	DB	24.0000	mm.
Type of Threads	TEMA Thread Series		
Number of Bolts		103	
Gasket Outside Diameter	GOD	1378.0000	mm.
Gasket Inside Diameter	GID	1368.0000	mm.
Gasket Factor, m,	M	0.0000	
Gasket Design Seating Stress	Y	0.00	N./mm ²
Elastic Modulus of Bolt Material at Des. Temp		201062681	KPa.
Elastic Modulus of Flange Material at Des. Temp		194857530	KPa.

FLANGE ANALYSIS of Identical Flange Pairs Per Appendix Y

Corroded Flange ID,	BCOR = B+2.0*FCOR	1360.000	mm.
Corroded Large Hub,	G1COR = G1-FCOR	10.000	mm.
Corroded Small Hub,	G0COR = G0-FCOR	10.000	mm.
Code R Dimension,	R = (C-B)/2.0 - G1	25.000	mm.
Gasket Contact Width,	N = (GOD-GID) / 2	5.000	mm.
Basic Gasket Width,	B0 = N / 2.0	2.500	mm.
Effective Gasket Width,	BE = B0	2.500	mm.
Gasket Reaction Diameter,	G = (GOD+GID) / 2.0	1373.000	mm.
Radial Contact Dist.,	hmax = (A - C) / 2	20.000	mm.

Basic Flange and Bolt loads:
 Hydrostatic End Load due to Pressure:

$$H = 0.785 * G * G * PEQ$$

$$H = 0.7854 * 1373.0000 * 1373.0000 * 15.4000$$

$$H = 232514. \text{ Kgf}$$

Contact Load on Gasket Surfaces:

$$HP = 2 * BE * PI * G * M * P$$

$$HP = 2 * 2.5000 * 3.1416 * 1373.0000 * 0.0000 * 15.40$$

$$HP = 0. \text{ Kgf}$$

Hydrostatic End Load at Flange ID:

$$HD = 0.785 * Bcor * Bcor * P$$

$$HD = 0.785 * 1360.0000 * 1360.0000 * 15.4000$$

$$HD = 228131. \text{ Kgf}$$

Pressure Force on Flange Face:

$$HT = H - HD$$

$$HT = 232513 - 228131$$

$$HT = 4382. \text{ Kgf}$$

Operating Bolt Load:

$$WM1 = H + HP + HPP$$

$$WM1 = (232513 + 0 + 0)$$

$$WM1 = 232514. \text{ Kgf}$$

Gasket Seating Bolt Load:

$$WM2 = Y * BE * PI * G + Ypart * BEpart * GLPG + HPGY$$

$$WM2 = 0.00 * 2.5000 * 3.141 * 1373.000 + 0.00 * 0.0000 * 0.00$$

$$WM2 = 0. \text{ Kgf}$$

Required Bolt Area:

$$AM = \text{Maximum of } WM1/SBO, WM2/SBA$$

$$AM = \text{Maximum of } 232513 / 233, 0 / 233$$

$$AM = 97.8421 \text{ cm}^2$$

Bolting Information for TEMA Thread Series:

Total Area of Bolts, AB	278.432	cm ²
Minimum radial distance between hub and bolts	31.750	mm.
Minimum radial distance between bolts and edge	23.825	mm.
Minimum circumferential spacing between bolts	52.400	mm.
Actual circumferential spacing between bolts	43.610	mm.
Maximum circumferential spacing between bolts	524.450	mm.

Flange Design Bolt Load, Gasket Seating:

$$W = SBA * (AM + AB) / 2.0$$

$$W = 233.05 * (97.8421 + 278.4317) / 2.0$$

$$W = 447091.44 \text{ Kgf}$$

Gasket Seating Force:

$$HG = WM1 - H$$

$$HG = 232513 - 232513$$

$$HG = 0.00 \text{ Kgf}$$

MOMENT ARM CALCULATIONS:

Distance to Hub Large End:

$$R = (C - BCOR) / 2 - G1COR$$

$$R = (1430.000 - 1360.000) / 2 - 10.000$$

$$R = 25.0000 \text{ mm.}$$

Distance to Gasket Load Reaction:

$$\begin{aligned} DHG &= (C - G) / 2.0 \\ DHG &= (1430.0000 - 1373.0000) / 2.0 \\ DHG &= 28.5000 \text{ mm.} \end{aligned}$$

Distance to Face Pressure Reaction:

$$\begin{aligned} DHT &= (R + G1COR + DHG) / 2.0 \\ DHT &= (25.0000 + 10.0000 + 28.5000) / 2.0 \\ DHT &= 31.7500 \text{ mm.} \end{aligned}$$

Distance to End Pressure Reaction:

$$\begin{aligned} DHD &= R + (G1COR / 2.0) \\ DHD &= 25.0000 + (10.0000 / 2.0) \\ DHD &= 30.0000 \text{ mm.} \end{aligned}$$

SUMMARY OF MOMENTS FOR INTERNAL PRESSURE:

LOADING		Force	Distance	Bolt Corr	Moment
End Pressure,	MD	228131.	30.0000	1.0000	6844. Kg-m.
Face Pressure,	MT	4382.	31.7500	1.0000	139. Kg-m.
Gasket Load,	MG	0.	28.5000	1.0000	0. Kg-m.
Gasket Seating,	MA	447091.	28.5000	1.0000	12742. Kg-m.

TOTAL MOMENT FOR OPERATION,	RMO	6983. Kg-m.
TOTAL MOMENT FOR GASKET SEATING,	RMA	12742. Kg-m.

Effective Hub Length, H0 = SQRT(BCOR*G0COR)	116.619 mm.
Hub Ratio, HRAT = HL / H0	0.086
Thickness Ratio, GRAT = (G1COR/G0COR)	1.000

Flange Factors for Integral Flange:

Factor F per 2-7.2	0.909
Factor V per 2-7.3	0.550
Factor f per 2-7.6	1.000

Factors from Figure 2-7.1	K =	1.081
T =	1.884	U = 27.294
Y =	24.838	Z = 12.883

Stress Analysis of a Class 1 Assembly

Compute the Factor: F'

$$\begin{aligned} &= g0^2 * (h0 + F * T) / V \\ &= 10.0000^2 * (116.6190 + 0.9089 * 40.0000) / 0.5501 \\ &= 1.6970 \end{aligned}$$

Factor: Js

$$\begin{aligned} &= 1/B1 * (2*hd/\beta + hc/a) + \pi*rb \\ &= 1/1370.000(2*30.000/1.0219+20.0000/1.0584)+3.14159*0.010558 \\ &= 0.0898 \end{aligned}$$

Factor: Jp

$$\begin{aligned}
&= 1/B1 * (hd/\beta + hc/a) + \pi * r_b \\
&= 1/1370.000(30.000/1.0219+20.0000/1.0584)+3.14159*0.010558 \\
&= 0.0684
\end{aligned}$$

Flange Moment due to Flange-Hub Interaction: Ms

$$\begin{aligned}
&= -(J_p * F' * M_p) / (t^3 + J_s * F') \\
&= -(0.0684 * 1.6970 * 6983.21) / (40.0000 + 0.0898 * 1.6970) \\
&= -199.7244 \text{ Kg-m.}
\end{aligned}$$

Slope of the Flange at the ID times E (Elastic Modulus): Ethetab

$$\begin{aligned}
&= 5.46/(\pi * t^3) * (J_s * M_s + J_p * M_p) \\
&= 5.46/(3.14159 * 40.0000^3) * (0.0898 * -199.7 + 0.0684 * 6983.21) \\
&= 122402. \text{ KPa.}
\end{aligned}$$

Contact Force between Flanges at hc: Hc

$$\begin{aligned}
&= (M_p + M_s) / hc \\
&= (6983.21 + -199.72) / 20.0000) \\
&= 339168. \text{ Kgf}
\end{aligned}$$

Operating Bolt Load: Wm1

$$\begin{aligned}
&= H + H_g + H_c \\
&= 232513.55 + 0.00 + 339167.84 \\
&= 571681. \text{ Kgf}
\end{aligned}$$

Operating Bolt Stress: Sigtab

$$\begin{aligned}
&= Wm1 / A_b \\
&= 571681.38 / 278.4317 \\
&= 201.3557 \text{ N./mm}^2
\end{aligned}$$

Design Prestress in the Bolts: Si

$$\begin{aligned}
&= \text{Sigtab} - 1.159 * hc^2 * (M_p + M_s) / (a * t^3 * l * re * B1) \\
&= 201 - 1.159 * 20.000^2 * (6783) / (1.058 * 40.0000^3 * 102.225 * 102.225) \\
&= 198.0013 \text{ N./mm}^2
\end{aligned}$$

Radial Flange Stress at the Bolt Circle: Sr

$$\begin{aligned}
&= 6 * (M_p + M_s) / (t^2 * (\pi * C - n * D)) \\
&= 6 * (6983 + -199) / (40.0000^2 (\pi * 1430.0000 - 103 * 25.4000)) \\
&= 132.9558 \text{ N./mm}^2
\end{aligned}$$

Radial Flange Stress at the Inside Diameter: SRid

$$\begin{aligned}
&= -((2 * F * t) / (h_0 + F * t) + 6) * M_s / (\pi * B1 * t^2) \\
&= -((2 * 0.909 * 40.000) / (116.619 + 0.909 * 40.000) + 6) * -199 / (\pi * -199.724) \\
&= -1.5713 \text{ N./mm}^2
\end{aligned}$$

Tangential Flange Stress at the Inside Diameter: STid

$$\begin{aligned}
&= (t * \text{Ethetab} / B1) + ((2 * F * t * Z) / (h_0 + F * t) - 1.8) * M_s / (\pi * B1 * t^2) \\
&= (40.0000 * 122402.39 / 1370.0000) \\
&\quad + ((2 * 0.9089 * 40.0000 * 12.8831) / (116.6190 + 0.9089 * 40.0000) - 1.8) * \\
&\quad -199.72 / (\pi * 1370.000 * 40.0000^2) \\
&= 2.3443 \text{ N./mm}^2
\end{aligned}$$

Longitudinal Hub Stress: Sh

$$= (h_0 * \text{Ethetab} * f) / ((0.91 * (g1/g0)^2 * B1 * V)$$

$$= (116.6190 \times 122402.4 \times 0.909) / ((0.91 \times (10.0000 / 10.0000)^2 \times 1370.0000 \times 1370.0000)$$

$$= 18.9193 \text{ N./mm}^2$$

Summary of Flange Stresses :

	Actual	Allowable
Radial Flange Stress at the Bolt Circle	132.96	137.90 N./mm ²
Tangential Flange Stress at the ID	2.34	137.90 N./mm ²
Radial Flange Stress at the ID	-1.57	137.90 N./mm ²
Longitudinal Hub Stress	18.92	206.85 N./mm ²
Average of Sh and Sr	8.67	137.90 N./mm ²
Average of Sh and St	10.63	137.90 N./mm ²
Bolt Stress	201.36	233.05 N./mm ²

Results for Required Thickness and M.A.W.P.

Minimum Required Flange Thickness	39.2476 mm.
Estimated M.A.W.P.	15.97 bars

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Appendix Y Results For : brida fondo

Minimum Required Flange Thickness

36.4794 mm.

Estimated M.A.W.P.

18.16 bars

Appendix Y Results For : brida virola

Minimum Required Flange Thickness

39.2476 mm.

Estimated M.A.W.P.

15.97 bars

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