DESIGN OF FLANGES

FOR

FULL FACE GASKETS

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DESIGN OF FLANGES FOR FULL FACE GASKETS

The Rules for Bolted Flanged Connections of the ASME Unfired Pressure Vessel Code cover only ring gasket types, i.e., types having the gasket entirely within the bolt holes. For flanges using full face gaskets the Rules simply recommend that they be designed in accordance with good engineering practice.

Several approaches to the problem are currently employed. Until such time as the Code actually establishes a design procedure, the following method may be used for safe construction. This method is a slight modification (see footnote) of that originally suggested by D. B. Rossheim and is recommended because it follows the framework and the terminology of the Code Rules and provides for simplicity of calculation.

To use it, the following assumptions must be made:

It is assumed that full fixation at the bolt circle is produced during bolting up, prior to the application of the internal pressure load; the inner edge of the flange in this condition is assumed unrestrained, so that the reaction of the outer gasket is determined from static equilibrium about the bolt circle as follows:

$$\text{(outside gasket reaction)} = \frac{h_G}{h'_G} \times \text{(inside gasket reaction)};$$

where the inside gasket reaction is defined as either H_{Gp} or H_{Gy} in accordance with the Code, and the outside gasket reaction is symbolized by H'_{Gp} or H'_{Gy}.

The total required bolt load then is obtained as the greater of the following two values:

$$W_P = H + H_{Gp}\left(1 + \frac{h_G}{h'_G}\right) = H + H_{Gp} + H'_{Gp};$$

$$W_y = H_{Gy}\left(1 + \frac{h_G}{h'_G}\right) = H_{Gy} + H'_{Gy}$$

Note: Mr. Rossheim's original proposal was made in 1943. The modifications included herein are primarily for the purpose of bringing it into accord with the latest code rules in so far as it is possible.

With the reactions thus determined, the flange can now be calculated like any other flange including the internal pressure load; it will be noted, however, that the sum of the inside and outside gasket moments equals zero, and accordingly the applied moment becomes:

$$M_O = M_D + M_T ;$$

There is one difference, however, as compared with regular flange design. In the case of a ring gasket, the moment remains of the same sign throughout, while in the case of a full-face gasket a moment reversal occurs. Since the moment $M_G = H_G h_G$ may be greater than the moment M_O given above, an additional check of the radial bending stress at the bolt center line will be required:

$$S'_R = \frac{6M_G}{\pi t^2 C} ;$$

In this formula the ring effect and the reduction in section caused by the bolt holes have been neglected; the latter procedure is quite defensible, since the moment at this location may be expected to be lower than calculated.

Method of Solution

Design in accordance with the Rules for Bolted Flange Connections, Par. UA-45 to UA-51 of the 1950 Edition of Section VIII, Unfired Pressure Vessels, of the ASME Boiler Code with the following modifications:

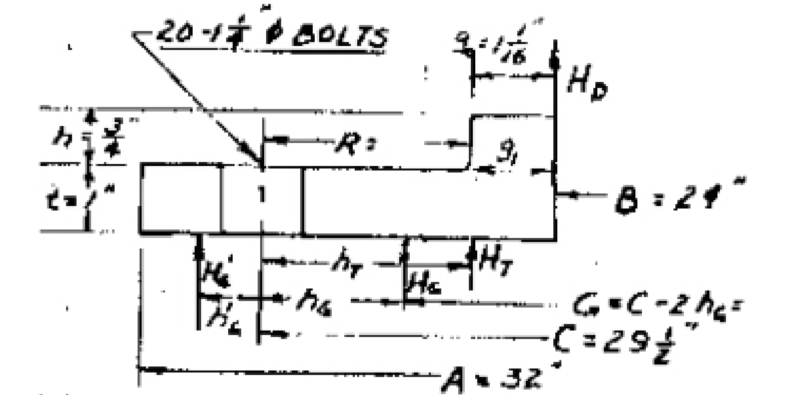
> The gasket contact area shall be divided into two parts by the bolt circle. The inner gasket reaction shall be determined as the larger of H_{Gp} and H_{Gy} as given in Par. UA-47; the outer gasket reaction shall be taken as the larger of
>
> $$\frac{h_G}{h'_G} \times H_{Gp} \quad \text{or} \quad \frac{h_G}{h'_G} \times H_{Gy}$$
>
> where: h_G and h'_G represent the moment arms of the resultant gasket reactions with respect to the bolt circle.

BY A. J. D. DATE .... SUBJECT EXAMPLE SHEET NO. 1 OF 1
CHKD. BY .... DATE .... MODIFIED ROSSHEIM METHOD JOB NO. ....

DESIGN OF FLANGES FOR FULL FACE GASKET

DESIGN CONDITIONS

OPERATING PRESSURE		p = 75 psi
OPERATING TEMP		300 °F
ATMOSPHERIC TEMP		100 °F
FLANGE MATERIAL		A-181, GRADE I
BOLTING MATERIAL		A-307, GRADE B
ALLOWABLE BOLT STRESS	OPER. TEMP	S_{op} = 7000 psi
	ATM. TEMP	S_{ATM} = 7000 psi
ALLOWABLE FLANGE STRESS	OPER. TEMP	S_{FO} = 15,000 psi
	ATM. TEMP	S_{FA} = 15,000 psi



ALL DIMENSIONS SHOWN IN CORRODED CONDITION

GASKET AND BOLTING CALCULATIONS

GASKET & FACING DETAILS	24" x 32" x $\frac{1}{8}$ - 75 DUROMETER RUBBER - ON FLAT FACE	FROM SHEET B: y = 200, m = 1.00	$b = (C-B)/4 = 1.375$"
GASKET LEVER ARMS	$h_G = \frac{(C-B)(2B+C)}{6(B+C)} = 1.325$"	$h_G' = \frac{(A-C)(2A+C)}{6(C+A)} = 0.633$"	$G = C - 2h_G = 26.850$"
GASKET REACTIONS	$H_{GY} = b\pi GY = 23,200$	$H_{GY}' = \frac{h_G}{h_G'} H_{GY} = 48,500$	
	$H_{GP} = 2b\pi Gmp = 17,400$	$H_{GP}' = \frac{h_G}{h_G'} H_{GP} = 36,400$	
BOLT LOADS	$H = \frac{G^2\pi p}{4} = 42,300$	$H_D = \frac{B^2\pi p}{4} = 33,900$	$H_T = H - H_D = 8,400$
	$W_P = H + H_{GP} + H_{GP}' = 96,100$	$W_Y = H_{GY} + H_{GY}' = 71,700$	W_m = GREATER OF W_P & W_Y = 96,100
	$W_a = 20 \times .429 \times 7,000 = 130,100$ (MUST BE GREATER THAN W_m)	$W = \frac{W_m + W_a}{2} = 113,050$	

FLANGE MOMENTS

LEVER ARMS	$h_D = R + g_1 = 2.75$"	$h_T = .5(R + g_1 + h_G) = 2.037$"	$M = \frac{M_o}{B} = 4,600$
MOMENTS	$M_o = M_D + M_T = H_D h_D + H_T h_T = 110,300$		

SHAPE CONSTANTS

K = A/B = 1.333		$h_o = \sqrt{Bg_o} = 5.04$		t (ASSUMED)	1.00
FROM FIG I OR FIG Ia	T = 1.78	$h/h_o = 0.149$		$\alpha = te + 1$	1.992
	Z = 3.57	FROM FIG. III	$F_L = 5.00$	$\beta = \frac{4}{3}te + 1$	2.324
	Y = 6.91		$V_L = 40.00$	$\gamma = \alpha/T$	1.120
	U = 7.59	$e = F_L/h_o = 0.992$		$\delta = t^3/d$	0.927
g_1/g_o = 1.00		$d = \frac{U}{V_L} h_o g_o^2 = 1.08$		$\lambda = \gamma + \delta$	2.047

STRESS CALCULATIONS

ALLOWABLE		
1.5 S_{FO}	LONGITUDINAL HUB STRESS, $S_H = M/\lambda g_1^2$	2,000
S_{FO}	RADIAL FLANGE STRESS, $S_R = \beta M/\lambda t^2$	5,200
S_{FO}	TANGENTIAL FLANGE STRESS, $S_T = (MY/t^2) - ZS_R$	13,200
S_{FO}	GREATER OF $.5(S_H + S_R)$ OR $.5(S_H + S_T)$	7,600

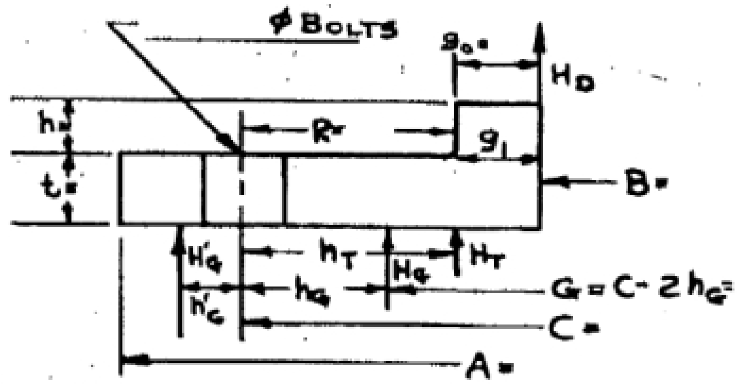
CHECK OF RADIAL BENDING STRESS AT BOLT CENTERLINE

REVERSE MOMENT	$M_G = H_G h_G = (W - H) / \left[\frac{1}{h_G} + \frac{1}{h_G'}\right] = 30,300$	
ALLOWABLE = S_{FO}	RADIAL STRESS AT BOLT ℄, $S_R = \frac{6 M_G}{t^2 \pi C}$	1,960

DESIGN OF FLANGES FOR FULL FACE GASKET

DESIGN CONDITIONS

OPERATING PRESSURE		p=
OPERATING TEMP.		
ATMOSPHERIC TEMP.		
FLANGE MATERIAL		
BOLTING MATERIAL		
ALLOWABLE BOLT STRESS	OPER. TEMP.	S_{OP}=
	ATM. TEMP.	S_{ATM}=
ALLOWABLE FLANGE STRESS	OPER. TEMP.	S_{FO}=
	ATM. TEMP.	S_{FA}=



ALL DIMENSIONS SHOWN IN CORRODED CONDITION

GASKET AND BOLTING CALCULATIONS

GASKET & FACING DETAILS		FROM SHEET B: y = ; m =	$b = (C-B)/4$ =
GASKET LEVER ARMS	$h_G = \frac{(C-B)(2B+C)}{6(B+C)}$ =	$h'_G = \frac{(A-C)(2A+C)}{6(C+A)}$ =	$G = C - 2h_G$ =
GASKET REACTIONS	$H_{GY} = b\pi G y$ =	$H'_{GY} = \frac{h_G}{h'_G} H_{GY}$ =	
	$H_{GP} = 2b\pi G m p$ =	$H'_{GP} = \frac{h_G}{h'_G} H_{GP}$ =	
BOLT LOADS	$H = \frac{G^2 \pi P}{4}$ =	$H_D = \frac{B^2 \pi P}{4}$ =	$H_T = H - H_D$ =
	$W_P = H + H_{GP} + H'_{GP}$ =	$W_Y = H_{GY} + H'_{GY}$ =	W_m = GREATER OF W_P OR W_Y =
	W_a = (MUST BE GREATER THAN W_m)	$W = \frac{W_m + W_a}{2}$ =	

FLANGE MOMENTS

LEVER ARMS	$h_D = R + g_1$ =	$h_T = .5(R + g_1 + h_G)$ =	$M = \frac{M_o}{B}$ =
MOMENTS	$M_o = M_D + M_T = H_D h_D + H_T h_T$ =		

SHAPE CONSTANTS

$K = A/B$ =		$h_o = \sqrt{Bg_o}$ =		t (ASSUMED)				
FROM FIG. I OR FIG. Ia	T =	h/h_o =		$\alpha = te + 1$				
	Z =	FROM FIG. III	F_L =	$\beta = \frac{4}{3}te_1 + 1$				
	Y =		V_L =	$\gamma = \alpha/T$				
	U =	$e = F_L/h_o$ =		$\delta = t^3/d$				
g_1/g_o =		$d = \frac{U}{V_L} h_o g_o^2$ =		$\lambda = \gamma + \delta$				

STRESS CALCULATIONS

ALLOWABLE	STRESS CALCULATIONS			
1.5 S_{FO}	LONGITUDINAL HUB STRESS, $S_H = M/\lambda g_1^2$			
S_{FO}	RADIAL FLANGE STRESS, $S_R = \beta M/\lambda t^2$			
S_{FO}	TANGENTIAL FLANGE STRESS, $S_T = (MY/t^2) - ZS_R$			
S_{FO}	GREATER OF .5 $(S_H + S_R)$ OR .5 $(S_H + S_T)$			

CHECK OF RADIAL BENDING STRESS AT BOLT CENTERLINE

REVERSE MOMENT	$M_G = H_G h_G = (W-H)/\left[\frac{1}{h_G} + \frac{1}{h'_G}\right]$ =			
ALLOWABLE = S_{FO}	RADIAL STRESS AT BOLT ℄, $S_R = 6M_G/\pi t^2 C$			

DATE ______	REVISED ______
COMPUTED ______	
CHECKED ______	

WELDING NECK FLANGE DESIGN —FLAT FACED

SHEET F

1 DESIGN CONDITIONS				2 GASKET	3
Design Pressure, P					$G = C - 2h_G =$
Design Temperature					$b = (C - B)/4 =$
Flange Material					$y =$
Bolting Material					$m =$

4 LOAD AND BOLT CALCULATIONS

Corrosion Allowance		$W_{m2} = b\pi G y + H'_{GY} =$	$A_m =$ greater of W_{m2}/S_a or $W_{m1}/S_b =$
Allowable Stresses — Flange — Design Temp., S_{fo}		$H_p = 2b\pi G m P =$	$A_b =$
Allowable Stresses — Flange — Atm. Temp., S_{fa}		$H'_p = {}^{hG}/_{h'G}\, H_p =$	$W = .5\,(A_m + A_b)\, S_a =$
Allowable Stresses — Bolting — Design Temp., S_b		$H = G^2\pi P/4 =$	$H'_{GY} = {}^{hG}/_{h'G}\ b\pi G y =$
Allowable Stresses — Bolting — Atm. Temp., S_a		$W_{m1} = H + H_p + H'_p =$	

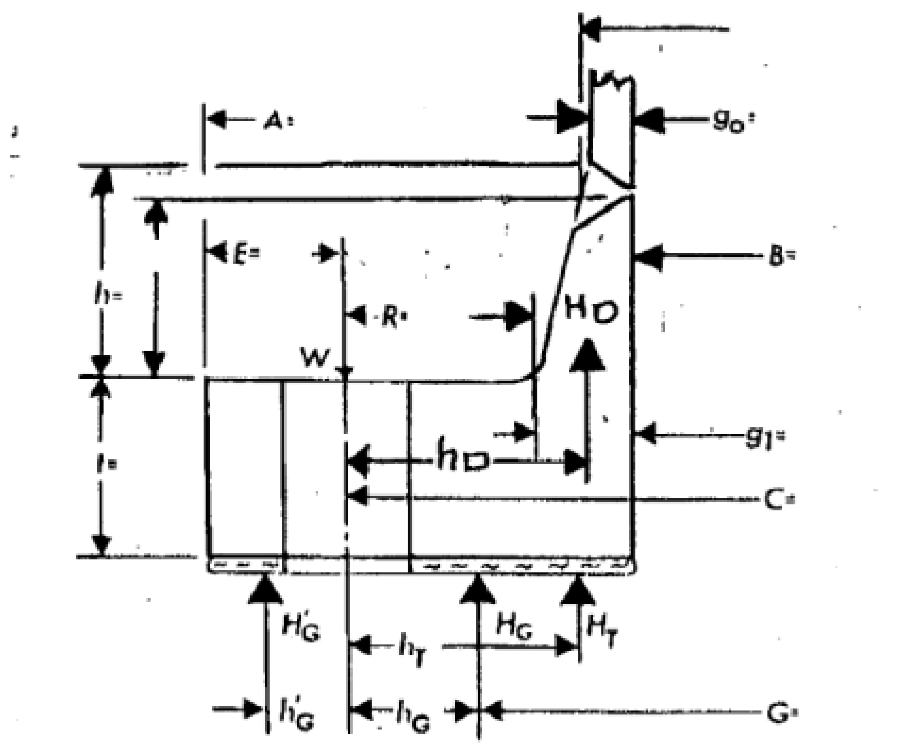
CONDITION	LOAD	× LEVER ARM	= MOMENT
5 *Operating*	$H_D = \pi B^2 P/4 =$	$h_D = R + g_1 =$	$M_D = H_D h_D =$
	$H_T = H - H_D =$	$h_T = .5(R + g_1 + h_G) =$	$M_T = H_T h_T =$
			$M_o =$
LEVER ARMS	$h_G = \dfrac{(C - B)(2B + C)}{6\,(B + C)} =$	$h'_G = \dfrac{(A - C)\,(2A + C)}{6\,(C + A)} =$	
REVERSE MOMENT	$H_G = W - H =$	$h''_G = \dfrac{h_G\, h'_G}{h_G + h'_G} =$	$M_G = H_G h_G'' =$

8 Allowable Stress	STRESS CALCULATION—*Operating*	
$1.5\ S_{fo}$	Long. Hub, $S_H = m_o/\lambda g_1^2$	=
S_{fo}	Radial Flg., $S_R = \beta m_o/\lambda t^2$	=
S_{fo}	Tang. Flg., $S_T = m_o Y/t^2 - Z S_R$	=
S_{fo}	greater of $.5(S_H + S_R)$ or $.5\,(S_H + S_T)$	=
S_{fo}	RADIAL STRESS AT BOLT CIRCLE $S_{RAD} = \dfrac{6\,M_G}{t^2\,(\pi C - n d_1)} =$	

6 K AND HUB FACTORS			
$K = A/B$	=	h/h_o	=
T	=	F	=
Z	=	V	=
Y	=	f	=
U	=	$e = F/h_o$	=
g_1/g_o	=	$d = \dfrac{U}{V}\, h_o g_o^2$	=
$h_o = \sqrt{B g_o}$	=		

7 STRESS FORMULA FACTORS	
$t =$	=
$\alpha = te + 1$	=
$\beta = 4/3\ te + 1$	=
$\gamma = \alpha/T$	=
$\delta = t^3/d$	=
$\lambda = \gamma + \delta$	=
$m_o = M_o/B$	=

If bolt spacing exceeds $2a + t$, multiply m_o in above equations by: $\sqrt{\dfrac{\text{Bolt spacing}}{2a + t}}$



______ # Bolts

TAYLOR FORGE INTERNATIONAL, INC.
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Computed__________ Date__________ __________

Checked__________ Number__________