Readme Supplement

CAEPIPE

Version 6.80

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Annexure A

Operating Stress for NDE

Operating Stress for NDE

The stress (Sopr) due to operating loads (pressure, weight and thermal load T_1) is calculated as

$$S_{opr} = S_a + \sqrt{(S_b)^2 + (2S_t)^2} \leq S_{all}$$

where

$$S_a = \left[\frac{PD}{4t} + \frac{F}{A} \right]_{Operating1}$$

$$S_b = \left[\frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z} \right]_{Operating1}$$

$$S_t = \left[\frac{M_t}{2Z} \right]_{Operating1}$$

P = maximum of CAEPIPE input pressures P1, P2 and P3

D = outside diameter

t = nominal wall thickness

$A =$ un-corroded cross-sectional area of the pipe

$F =$ longitudinal force

$i_i =$ in-plane stress intensification factor according to analysis code selected in CAEPIPE

$i_o =$ out-of-plane stress intensification factor according to analysis code selected in CAEPIPE

Note: If the analysis code selected provides only the stress intensification I, then $i_i = i_o = i$.

$M_i =$ in-plane bending moment

$M_o =$ out-of-plane bending moment

$M_t =$ torsional bending moment

Z = un-corroded section modulus; for reduced outlets / branch connections, effective section modulus

$S_{all} = f(1.25 S_{cold} + 0.25 S_{hot}) + S_{hot}$

$f =$ stress range reduction factor $= 6/N^{0.2}$

N = Number of equivalent full-range thermal cycles

S_{cold} = basic allowable stress at T_{ref}

S_{hot} = basic allowable stress at CAEPIPE input temperature T_1

Annexure B

Flange Stress Calculations

ASME Section VIII Div. 1 – Appendix 2

ASME Section VIII Div. 1 – Appendix 2

Notation

The symbols described below are used in the formulas for the design of flanges

A = outside diameter of flange

A_b = cross-sectional area of the bolts using the root diameter of the thread

A_m = total required cross-sectional area of bolts taken as greater of A_{m1} and A_{m2}

A_{m1} = total cross-sectional area of bolts at root of thread or section of least diameter under stress, required for the operating conditions

$= \frac{W_{m1}}{S_b}$

A_{m2} = total cross-sectional area of bolts at root of thread or section of least diameter under stress

$= \frac{W_{m2}}{S_a}$

B = inside diameter of flange

B' = inside diameter of reverse flange

b = effective gasket or joint-contact-surface seating width

b_0 = basic gasket seating width (from Table 2-5.2)

C = bolt-circle diameter

c = basic dimension used for the minimum sizing of welds

e = factor = $\frac{F}{h_o}$

d = factor = $\frac{U}{V} h_0 g_0^2$ for integral type flanges

d = factor = $\frac{U}{V_L} h_0 g_0^2$ for loose type flanges

e = factor = $\frac{F}{h_o}$ for integral type flanges

e = factor = $\frac{F_L}{h_o}$ for loose type flanges

F = factor for integral type flanges (from Fig. 2-7.2)

F_L = factor for loose type flanges (from Fig. 2-7.4)

f = hub stress correction 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.)

G = diameter at location of gasket load reaction

g0 = thickness of hub at small end

g1 = thickness of hub at back of flange

H = total hydrostatic end force = $0.785G^2P$

H_D = hydrostatic end force on area inside of flange = $0.785B^2P$

H_G = gasket load (difference between flange design bolt load and total hydrostatic end force) = W – H

H_P = total joint-contact surface compression load = 2b x 3.14 $G_m P$

H_T = difference between total hydrostatic end force and the hydrostatic end force on area inside of flange = $H-H_D$

h = hub length

h_D = radial distance from the bolt circle, to the circle on which H_D acts, as prescribed in Table 2-6

h_G = radial distance from gasket load reaction to the bolt circle = $\frac{(C-G)}{2}$

h_o = factor = $\sqrt{Bg_0}$

h_T = distance from the bolt circle, to the circle on which H_T acts, as prescribed in Table 2-6

K = ratio of outside diameter of flange to inside diameter of flange = A / B

L = factor = $\frac{(te+1)}{T}+\frac{t^3}{d}$

M_D = component of moment due to H_D = $H_D h_D$

M_G = component of moment due to H_G = $H_G h_G$

M_T = component of moment due to H_T = $H_T h_T$

M_o = total moment acting upon the flange for the operating conditions or gasket seating as may apply

M_o = $W\frac{(C-G)}{2}$ for gasket seating condition

M_o = $H_D h_D + H_G h_G + H_T h_T$ for operating condition

N = width used to determine the basic gasket seating with b_0, based upon the possible contact width of the gasket (see Table 2-5.2)

P = internal design pressure

R = radial distance from bolt circle to point of intersection of hub and back of flange. For integral and hub flanges, R = (C-B / 2) – g1

S_a = allowable bolt stress at reference temperature

S_b = allowable bolt stress at design temperature

S_f = allowable stress for material of flange at design temperature (operating condition)

S_H = calculated longitudinal stress in hub

S_R = calculated radial stress in flange

S_T = calculated tangential stress in flange

T = factor involving K (from Fig. 2-7.1)

t = flange thickness

U = factor involving K (from Fig. 2-7.1)

V = factor for integral type flanges (from Fig. 2-7.3)

V_L = factor for loose type flanges (from Fig. 2-7.5)

W = flange design bolt load, for the operating condition or gasket seating

= W_{m1} for operating condition

= $\frac{(A_m + A_b)S_a}{2}$ for gasket seating condition

W_{m1} = minimum required bolt load for the operating conditions

W_{m2} = minimum required bolt load for gasket seating

w = width used to determine the basic gasket seating width b0, based upon the contact width between the flange and the gasket (see Table 2-5.2)

Y = factor involving K (from Fig. 2-7.1)

y = gasket or joint-contact-surface unit seating load

Z = factor involving K (from Fig. 2-7.1)

Calculation of Flange Stresses

The stresses in the flange shall be determined for both the operating conditions and gasket seating condition, in accordance with the following formulas:

(1) <u>Integral type flanges</u>

Longitudinal hub stress $S_H = \dfrac{fM_O}{Lg_1^2 B} < 1.5S_f$

Radial flange stress $S_R = \dfrac{(1.33te+1)M_O}{Lt^2 B} < S_f$

Tangential flange stress $S_T = \dfrac{YM_O}{t^2 B} - ZS_R < S_f$

Combined stress

$\dfrac{S_H + S_R}{2} < S_f$ and

$\dfrac{S_H + S_T}{2} < S_f$

(2) <u>Loose type flanges with hubs</u>

Longitudinal hub stress $S_H = \dfrac{fM_O}{Lg_1^2 B} < 1.5S_f$

Radial flange stress $S_R = \dfrac{(1.33te+1)M_O}{Lt^2 B} < S_f$

Tangential flange stress $S_T = \dfrac{YM_O}{t^2 B} - ZS_R < S_f$

Combined stress

$\dfrac{S_H + S_R}{2} < S_f$ and

$\dfrac{S_H + S_T}{2} < S_f$

where,

L = factor = $\dfrac{(te+1)}{T} + \dfrac{t^3}{d}$

d = factor = $\dfrac{U}{V_L} h_0 g_0^2$

e = factor = $\dfrac{F_L}{h_o}$

V_L = factor for loose type flanges (from Fig. 2-7.5)

F_L = factor for loose type flanges (from Fig. 2-7.4)

(3) Loose type flanges without hubs

Longitudinal hub stress $S_H = 0$

Radial flange stress $S_R = 0$

Tangential flange stress $S_T = \frac{YM_O}{t^2 B} < S_f$

Combined stress

$\frac{S_H + S_R}{2} < S_f$ and

$\frac{S_H + S_T}{2} < S_f$

where,

L = factor = $\frac{(te+1)}{T} + \frac{t^3}{d}$

d = factor = $\frac{U}{V_L} h_0 g_0^2$

e = factor = $\frac{F_L}{h_o}$

V_L = factor for loose type flanges (from Fig. 2-7.5)

F_L = factor for loose type flanges (from Fig. 2-7.4)

(4) Optional type flanges (calculated as loose flanges without hubs)

Longitudinal hub stress $S_H = 0$

Radial flange stress $S_R = 0$

Tangential flange stress $S_T = \frac{YM_O}{t^2 B} < S_f$

Combined stress

$\frac{S_H + S_R}{2} < S_f$ and

$\frac{S_H + S_T}{2} < S_f$

where,

L = factor = $\frac{(te+1)}{T} + \frac{t^3}{d}$

d = factor = $\frac{U}{V_L} h_0 g_0^2$

e = factor = $\frac{F_L}{h_o}$

V_L = factor for loose type flanges (from Fig. 2-7.5)

F_L = factor for loose type flanges (from Fig. 2-7.4)

(5) Reverse type flanges

Longitudinal hub stress $S_H = \frac{fM_O}{L_r g_1^2 B'} < 1.5 S_f$

Radial flange stress $S_R = \frac{(1.33te_r + 1)M_O}{L_r t^2 B'} < S_f$

Tangential flange stress $S_T = \frac{Y_r M_O}{t^2 B} - ZS_R \frac{0.67te_r + 1}{1.33te_r + 1} < S_f$

Combined stress

$\frac{S_H + S_R}{2} < S_f$ and

$\frac{S_H + S_T}{2} < S_f$

where,

L_r = factor = $\frac{(te_r + 1)}{T} + \frac{t^3}{d_r}$

d_r = factor = $\frac{U_r}{V} h_0 g_0^2$

e_r = factor = $\frac{F}{h_o}$

h_o = factor = $\sqrt{Ag_0}$

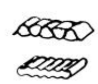
$$\alpha_r = \frac{1 + 0.668\frac{(K+1)}{Y}}{K^2}$$

T_r = $\frac{Z + 0.3}{Z - 0.3}\alpha_r T$

U_r = $\alpha_r U$

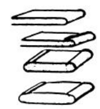
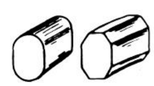
Y_r = $\alpha_r Y$

TABLE 2-5.1
GASKET MATERIALS AND CONTACT FACINGS[1]
Gasket Factors m for Operating Conditions and Minimum Design Seating Stress y

Gasket Material	Gasket Factor m	Min. Design Seating Stress y, psi (MPa)	Sketches	Facing Sketch and Column in Table 2-5.2
Self-energizing types (0 rings, metallic, elastomer, other gasket types considered as self-sealing)	0	0 (0)	. . .	. . .
Elastomers without fabric or high percent of asbestos fiber:				
Below 75A Shore Durometer	0.50	0 (0)		(1a),(1b),(1c),(1d), (4),(5); Column II
75A or higher Shore Durometer	1.00	200 (1.4)		
Asbestos with suitable binder for operating conditions:				
$\frac{1}{8}$ in. (3.2 mm) thick	2.00	1,600 (11)		(1a),(1b),(1c),(1d), (4),(5); Column II
$\frac{1}{16}$ in. (1.6 mm) thick	2.75	3,700 (26)		
$\frac{1}{32}$ in. (0.8 mm) thick	3.50	6,500 (45)		
Elastomers with cotton fabric insertion	1.25	400 (2.8)		(1a),(1b),(1c),(1d), (4),(5); Column II
Elastomers with asbestos fabric insertion (with or without wire reinforcement):				
3-ply	2.25	2,200 (15)		(1a),(1b),(1c),(1d), (4),(5); Column II
2-ply	2.50	2,900 (20)		
1-ply	2.75	3,700 (26)		
Vegetable fiber	1.75	1,100 (7.6)		(1a),(1b),(1c),(1d), (4)(5); Column II
Spiral-wound metal, asbestos filled:				
Carbon	2.50	10,000 (69)		(1a),(1b); Column II
Stainless, Monel, and nickel-base alloys	3.00	10,000 (69)		
Corrugated metal, asbestos inserted, or corrugated metal, jacketed asbestos filled:				
Soft aluminum	2.50	2,900 (20)		(1a),(1b); Column II
Soft copper or brass	2.75	3,700 (26)		
Iron or soft steel	3.00	4,500 (31)		
Monel or 4%–6% chrome	3.25	5,500 (38)		
Stainless steels and nickel-base alloys	3.50	6,500 (45)		

(continued)

TABLE 2-5.1
GASKET MATERIALS AND CONTACT FACINGS[1] (CONT'D)
Gasket Factors *m* for Operating Conditions and Minimum Design Seating Stress *y*

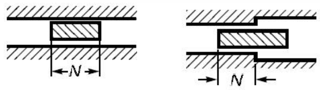
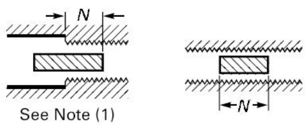
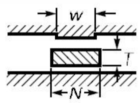
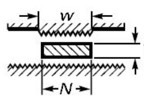
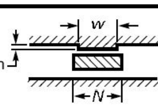
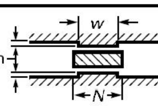
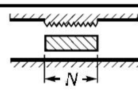
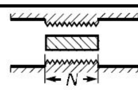
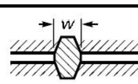
Gasket Material	Gasket Factor *m*	Min. Design Seating Stress *y*, psi (MPa)	Sketches	Facing Sketch and Column in Table 2-5.2
Corrugated metal:				
Soft aluminum	2.75	3,700 (26)		
Soft copper or brass	3.00	4,500 (31)		(1a),(1b),(1c),(1d); Column II
Iron or soft steel	3.25	5,500 (38)		
Monel or 4%–6% chrome	3.50	6,500 (45)		
Stainless steels and nickel-base alloys	3.75	7,600 (52)		
Flat metal, jacketed asbestos filled:				
Soft aluminum	3.25	5,500 (38)		
Soft copper or brass	3.50	6,500 (45)		(1a),(1b),(1c),[2] (1d)[2];(2)[2]; Column II
Iron or soft steel	3.75	7,600 (52)		
Monel	3.50	8,000 (55)		
4%–6% chrome	3.75	9,000 (62)		
Stainless steels and nickel-base alloys	3.75	9,000 (62)		
Grooved metal:				
Soft aluminum	3.25	5,500 (38)		
Soft copper or brass	3.50	6,500 (45)		(1a),(1b),(1c),(1d), (2),(3); Column II
Iron or soft metal	3.75	7,600 (52)		
Monel or 4%–6% chrome	3.75	9,000 (62)		
Stainless steels and nickel-base alloys	4.25	10,100 (70)		
Solid flat metal:				
Soft aluminum	4.00	8,800 (61)		
Soft copper or brass	4.75	13,000 (90)		(1a),(1b),(1c),(1d), (2),(3),(4),(5); Column I
Iron or soft steel	5.50	18,000 (124)		
Monel or 4%–6% chrome	6.00	21,800 (150)		
Stainless steels and nickel-base alloys	6.50	26,000 (179)		
Ring joint:				
Iron or soft steel	5.50	18,000 (124)		
Monel or 4%–6% chrome	6.00	21,800 (150)		(6); Column I
Stainless steels and nickel-base alloys	6.50	26,000 (179)		

NOTES:

(1) This Table gives a list of many commonly used gasket materials and contact facings with suggested design values of *m* and *y* that have generally proved satisfactory in actual service when using effective gasket seating width *b* given in Table 2-5.2. The design values and other details given in this Table are suggested only and are not mandatory.

(2) The surface of a gasket having a lap should not be against the nubbin.

TABLE 2-5.2
EFFECTIVE GASKET WIDTH[2]

Facing Sketch (Exaggerated)	Basic Gasket Seating Width b_o Column I	Basic Gasket Seating Width b_o Column II
(1a) 	$\frac{N}{2}$	$\frac{N}{2}$
(1b)  See Note (1)		
(1c)  $w \leq N$	$\frac{w+T}{2}; \left(\frac{w+N}{4} \text{ max}\right)$	$\frac{w+T}{2}; \left(\frac{w+N}{4} \text{ max}\right)$
(1d)  See Note (1) $w \leq N$		
(2) $^{1}/_{64}$ in. nubbin  $w \leq N/2$	$\frac{w+N}{4}$	$\frac{w+3N}{8}$
(3) $^{1}/_{64}$ in. nubbin  $w \leq N/2$	$\frac{N}{4}$	$\frac{3N}{8}$
(4)  See Note (1)	$\frac{3N}{8}$	$\frac{7N}{16}$
(5)  See Note (1)	$\frac{N}{4}$	$\frac{3N}{8}$
(6) 	$\frac{w}{8}$	. . .

(continued)

TABLE 2-6
MOMENT ARMS FOR FLANGE LOADS UNDER OPERATING CONDITIONS

	h_D	h_T	h_G
Integral type flanges [see Fig. 2–4 sketches (5), (6), (6a), (6b), and (7)]; and optional type flanges calculated as integral type [see Fig. 2-4 sketches (8), (8a), (9), (9a), (10), (10a), and (11)]	$R + 0.5g_1$	$\frac{R + g_1 + h_G}{2}$	$\frac{C - G}{2}$
Loose type, except lap-joint flanges [see Fig. 2-4 sketches (2), (2a), (3), (3a), (4), and (4a)]; and optional type flanges calculated as loose type [see Fig. 2-4 sketches (8), (8a), (9), (9a), (10), (10a), and (11)]	$\frac{C - B}{2}$	$\frac{h_D + h_G}{2}$	$\frac{C - G}{2}$
Lap-type flanges [see Fig. 2-4 sketches (1) and (1a)]	$\frac{C - B}{2}$	$\frac{C - G}{2}$	$\frac{C - G}{2}$

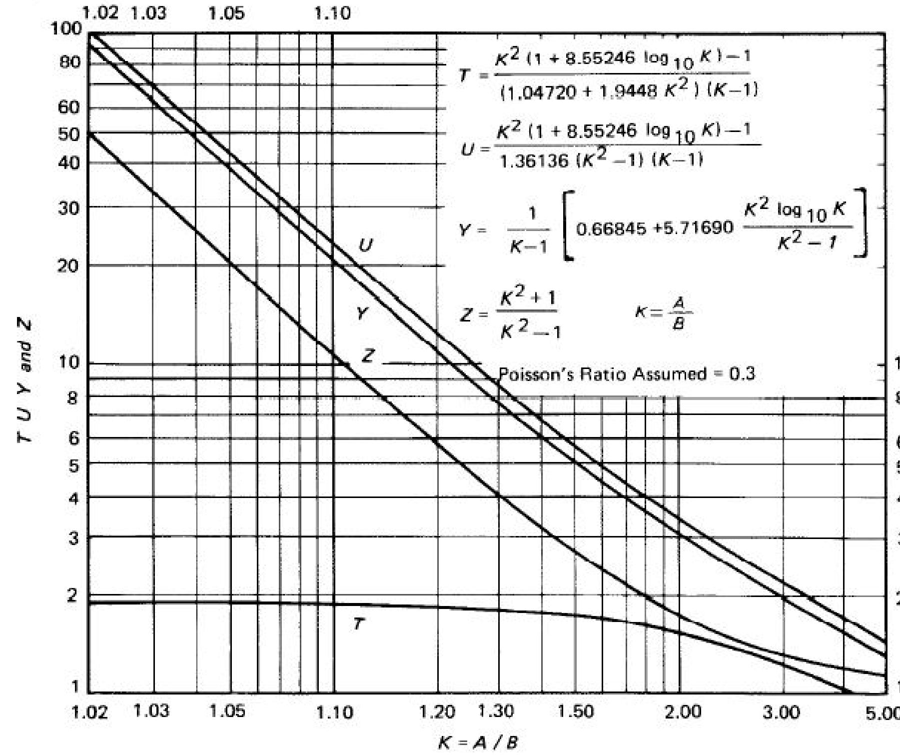


FIG. 2-7.1 VALUES OF *T*, *U*, *Y*, AND *Z*
(Terms Involving K)

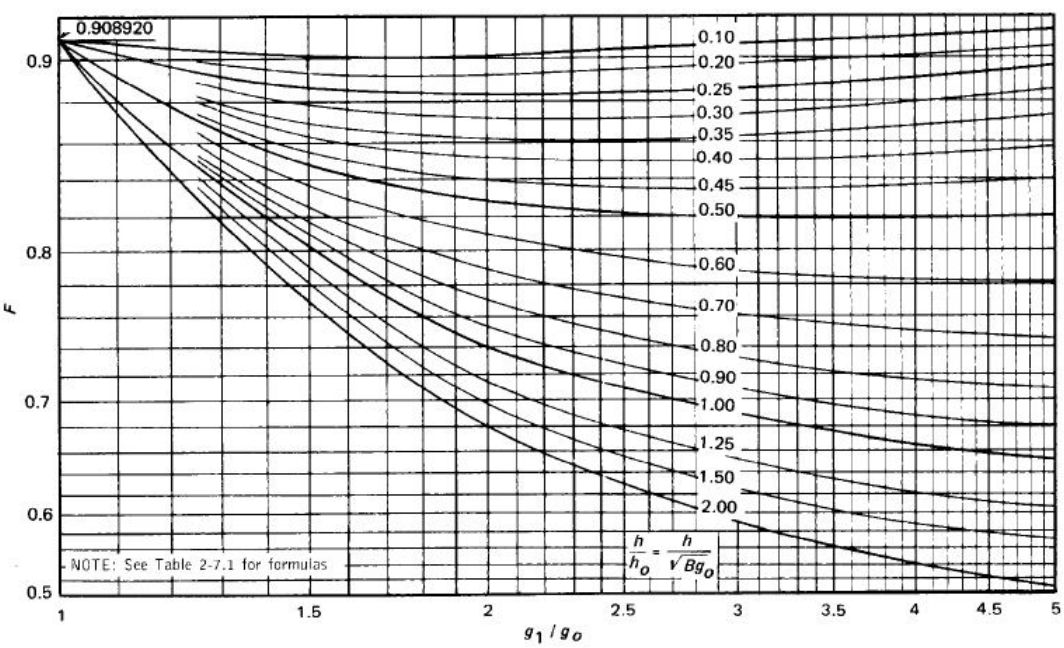


FIG. 2-7.2 VALUES OF *F*
(Integral Flange Factors)

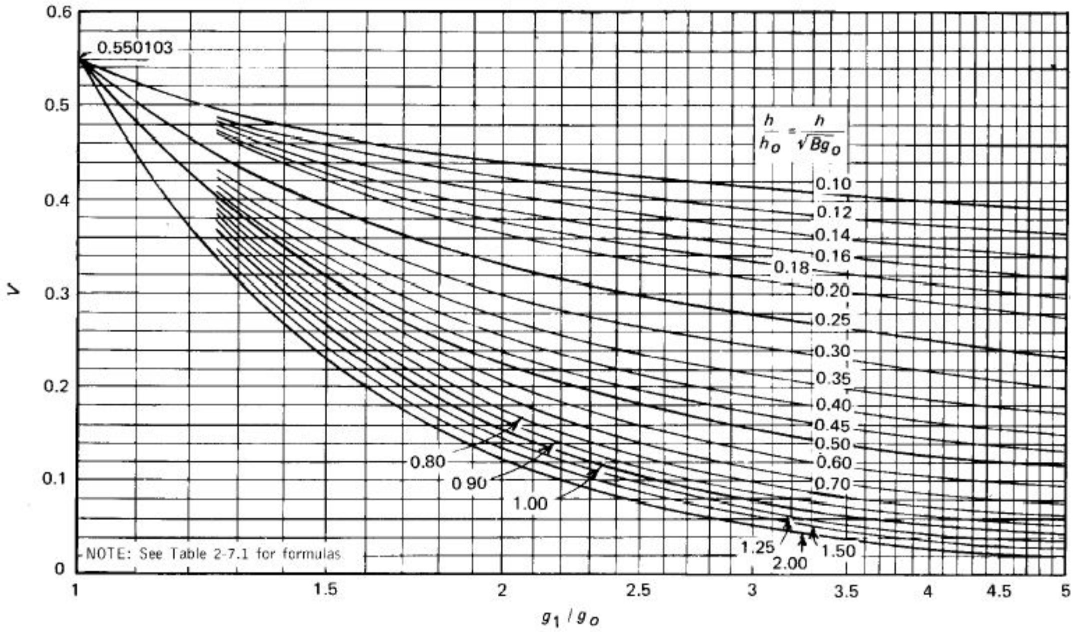


FIG. 2-7.3 VALUES OF V
(Integral Flange Factors)

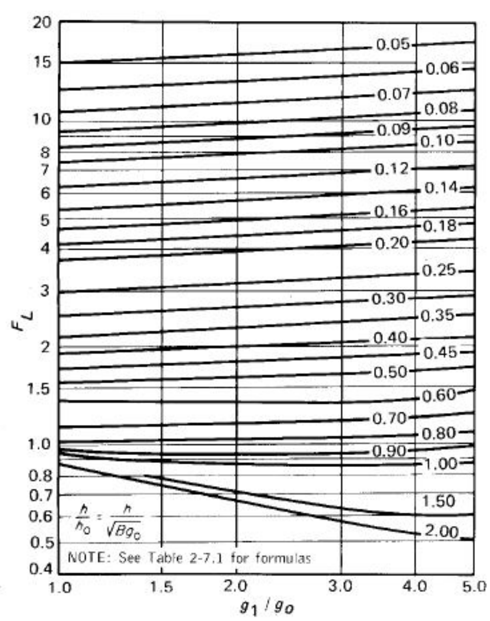


FIG. 2-7.4 VALUES OF F_L
(Loose Hub Flange Factors)

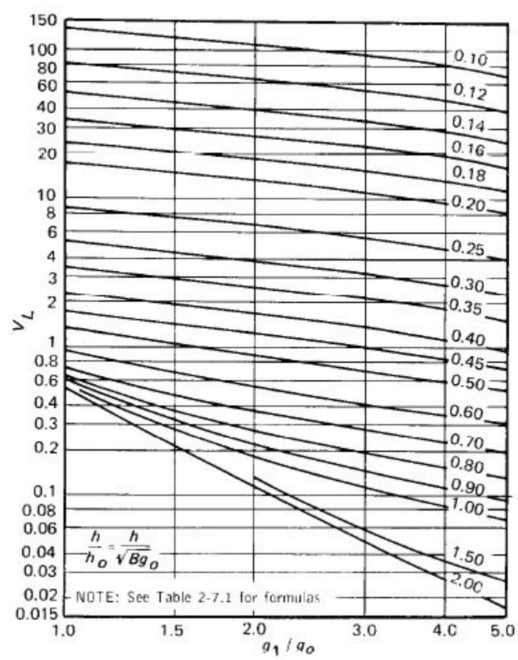


FIG. 2-7.5 VALUES OF V_L
(Loose Hub Flange Factors)

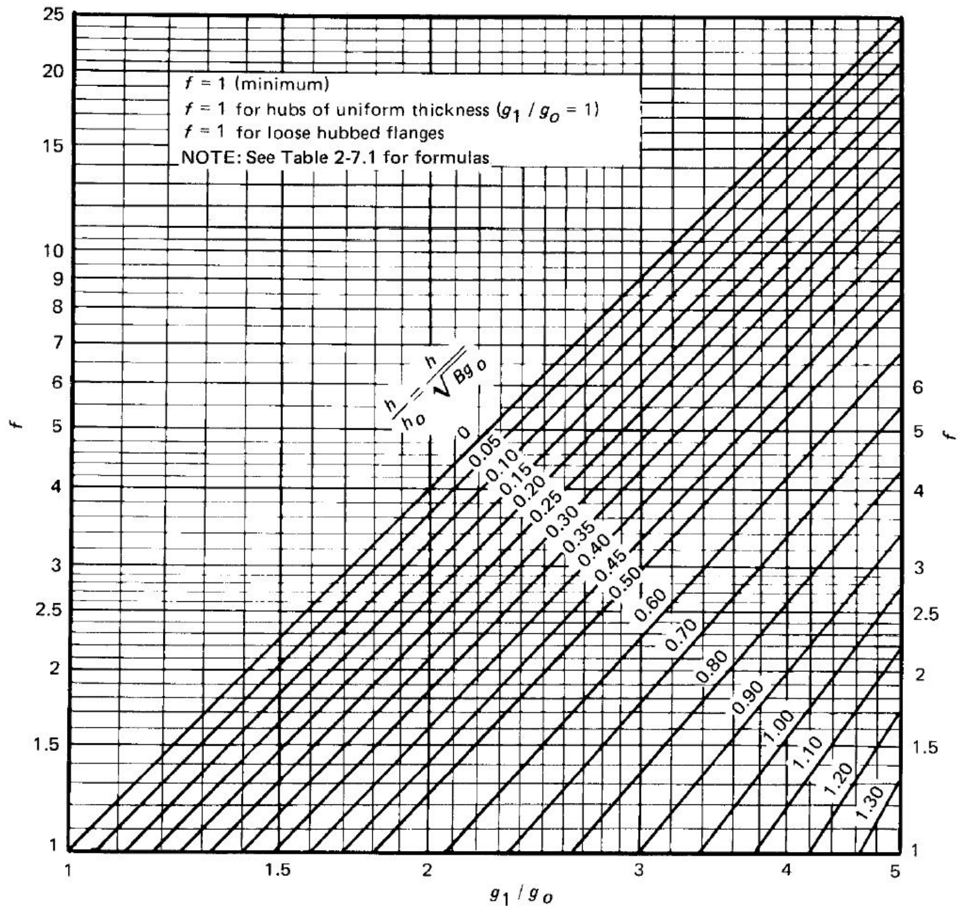


FIG. 2-7.6 VALUES OF f
(Hub Stress Correction Factor)

Verification and Validation

Problem 1:

(Example on page 19 Chapter 40 “Bolted-Flange Joints and Connections” by William J. Koves on “Companion Guide to the ASME Boiler & Pressure Vessel Code” by K .R. Rao [2001], American Society of Mechanical Engineers, U.S.)

Flange Details:

Flange Type : **Integral Flanges**

Flange Outside Diameter [A] = 39.125 (inch)

Flange Inside Diameter [B] = 32 (inch)

Flange Thickness [t] = 2 (inch)

Small End Hub Thickness [g0] = 0.5 (inch)

Large End Hub Thickness [g1] = 1.125 (inch)

Hub Length [h] = 2.75 (inch)

All. Stress @ Design Temp [sf] = 19600 (psi)

All. Stress @ Ref. Temp [sfa] = 20000 (psi)

Modulus @ Design Temp [E] = 2.7E+7 (psi)

Modulus @ Ref. Temp [Ea] = 2.92E+7 (psi)

Bolting Information:

Bolt Circle Diameter = 37 (inch)

Number of Bolts = 36

Bolt Diameter = 1 (inch)

All. Stress @ Ref. Temp [sa] = 25000 (psi)

All. Stress @ Design Temp [sb] = 25000 (psi)

Gasket Information:

Gasket Outside Diameter = 35.5 (inch)

Gasket Inner Diameter = 33.5 (inch)

Leak Pressure Ratio [m] = 3.00

Gasket Seating Stress [y] = 10000 (psi)

Facing Sketch = 1

Facing Column = 1

Load Data:

Design Pressure = 414 (psi)

Design Temperature = 500 (F)

Axial Force = 1000 (lb)

Bending Moment = 200 (ft-lb)

Allowable Pressure = 665 (psi)

Comparison of Results:

Flange Stresses	Text Book Results (psi)	CAEPIPE (psi)	CAESAR II (psi)
Operating condition			
Longitudinal Hub (SH)	24150	24152	24227
Radial Flange (SR)	11590	11590	11636
Tangential Flange (ST)	7230	7232	7205
0.5(SH + SR)	17870	17871	17932
0.5(SH + ST)	15690	15692	15716
Gasket Seating Condition			
Longitudinal Hub (SH)	15270	15269	15292
Radial Flange (SR)	7330	7327	7345
Tangential Flange (ST)	4570	4572	4547
0.5(SH + SR)	11300	11298	11318
0.5(SH + ST)	9900	9921	9920

Problem 2:

(Example from “Taylor Forge & Pipe Works, 1961”)

Flange Details:

Flange Type : Loose Flanges with Hubs
Flange Outside Diameter [A] = 40.375 (inch)
Flange Inside Diameter [B] = 33.25 (inch)
Inside Diameter of Reverse Flange [B'] = 20 (inch)
Flange Thickness [t] = 2.125 (inch)
Small End Hub Thickness [g0] = 0.875 (inch)
Large End Hub Thickness [g1] = 1.125 (inch)
Hub Length [h] = 2.5 (inch)
All. Stress @ Design Temp [sf] = 17500 (psi)
All. Stress @ Ref. Temp [sfa] = 17500 (psi)
Modulus @ Design Temp [E] = 2.7E+7 (psi)
Modulus @ Ref. Temp [Ea] = 2.92E+7 (psi)

Bolting Information:

Bolt Circle Diameter = 38.25 (inch)
Number of Bolts = 44
Bolt Diameter = 1 (inch)
All. Stress @ Ref. Temp [sa] = 20000 (psi)
All. Stress @ Design Temp [sb] = 20000 (psi)

Gasket Information:

Gasket Outside Diameter = 35.75 (inch)
Gasket Inner Diameter = 34.25 (inch)
Leak Pressure Ratio [m] = 2.75
Gasket Seating Stress [y] = 3700 (psi)
Facing Sketch = 1
Facing Column = 1

Load Data:

Design Pressure = 400 (psi)
Design Temperature = 500 (F)
Axial Force = 1000 (lb)
Bending Moment = 200 (ft-lb)
Allowable Pressure = 665 (psi)

Comparison of Results:

Flange Stresses	**Text Book Results (psi)**	**CAEPIPE (psi)**	**CAESAR II (psi)**
Operating condition			
Longitudinal Hub (SH)	20800	21153	21214
Radial Flange (SR)	11100	11110	11155
Tangential Flange (ST)	13800	13826	13797
0.5(SH + SR)	15950	16132	16185
0.5(SH + ST)	17300	17489	17506
Gasket Seating Condition			
Longitudinal Hub (SH)	14400	14623	15095
Radial Flange (SR)	7660	7681	7938
Tangential Flange (ST)	9500	9558	9818
0.5(SH + SR)	11030	11152	11517
0.5(SH + ST)	11950	12091	12457

Problem 3:

(Example 10.5 on page 209 Chapter 10 on “CASTI Guidebook to ASME Section VIII Div.1 – Pressure Vessels – Third Edition”)

Flange Details:

Flange Type : Reverse Flanges

Flange Outside Diameter [A] = 49 (inch)

Flange Inside Diameter [B] = 48.25 (inch)

Inside Diameter of Reverse Flange [B'] = 20.25 (inch)

Flange Thickness [t] = 5.25 (inch)

Small End Hub Thickness [g0] = 0.375 (inch)

Large End Hub Thickness [g1] = 1.375 (inch)

Hub Length [h] = 6 (inch)

All. Stress @ Design Temp [sf] = 12000 (psi)

All. Stress @ Ref. Temp [sfa] = 20000 (psi)

Modulus @ Design Temp [E] = 2.7E+7 (psi)

Modulus @ Ref. Temp [Ea] = 2.92E+7 (psi)

Bolting Information:

Bolt Circle Diameter = 44 (inch)

Number of Bolts = 32

Bolt Diameter = 1.25 (inch)

All. Stress @ Ref. Temp [sa] = 25000 (psi)

All. Stress @ Design Temp [sb] = 21000 (psi)

Gasket Information:

Gasket Outside Diameter = 24 (inch)

Gasket Inner Diameter = 22 (inch)

Leak Pressure Ratio [m] = 2.50

Gasket Seating Stress [y] = 10000 (psi)

Facing Sketch = 1

Facing Column = 1

Load Data:

Design Pressure = 150 (psi)

Design Temperature = 800 (F)

Axial Force = 1000 (lb)

Bending Moment = 200 (ft-lb)

Allowable Pressure = 665 (psi)

Comparison of Results:

Flange Stresses	**Text Book Results (psi)**	**CAEPIPE (psi)**	**CAESAR II (psi)**
Operating condition			
Longitudinal Hub (SH)	2060	2257	2055
Radial Flange (SR)	280	307	280
Tangential Flange (ST)	1340	1314	1336
0.5(SH + SR)	1170	1282	1168
0.5(SH + ST)	1700	1785	1695
Gasket Seating Condition			
Longitudinal Hub (SH)	9220	10082	9220
Radial Flange (SR)	1260	1372	1257
Tangential Flange (ST)	6000	7004	5997
0.5(SH + SR)	5240	5727	5239
0.5(SH + ST)	7610	8543	8703

Problem 4:

(Example from KEDKEP CONSULTING, INC. dated May 27, 2008)

Flange Details:

Flange Type : Loose Flanges without Hubs / Optional Flanges
Flange Outside Diameter [A] = 38.4 (inch)
Flange Inside Diameter [B] = 32 (inch)
Inside Diameter of Reverse Flange [B'] = 32 (inch)
Flange Thickness [t] = 4 (inch)
Small End Hub Thickness [g0] = 0.001 (inch)
Large End Hub Thickness [g1] = 0.001 (inch)
Hub Length [h] = 0.001 (inch)
All. Stress @ Design Temp [sf] = 20000 (psi)
All. Stress @ Ref. Temp [sfa] = 20000 (psi)
Modulus @ Design Temp [E] = 2.7E+7 (psi)
Modulus @ Ref. Temp [Ea] = 2.92E+7 (psi)

Bolting Information:

Bolt Circle Diameter = 36 (inch)
Number of Bolts = 28
Bolt Diameter = 1 (inch)
All. Stress @ Ref. Temp [sa] = 25000 (psi)
All. Stress @ Design Temp [sb] = 25000 (psi)

Gasket Information:

Gasket Outside Diameter = 32.75 (inch)
Gasket Inner Diameter = 32 (inch)
Leak Pressure Ratio [m] = 0.50
Gasket Seating Stress [y] = 0 (psi)
Facing Sketch = 2
Facing Column = 2

Load Data:

Design Pressure = 300 (psi)
Design Temperature = 295 (F)
Axial Force = 1000 (lb)
Bending Moment = 200 (ft-lb)
Allowable Pressure = 665 (psi)

Comparison of Results:

Flange Stresses	Text Book Results (psi)	CAEPIPE (psi)	CAESAR II (psi)
Operating Condition			
Longitudinal Hub (SH)	0	0	3
Radial Flange (SR)	0	0	0
Tangential Flange (ST)	10577	10569	10618
0.5(SH + SR)	0	0	1.5
0.5(SH + ST)	0	0	5310.5
Bolt Stress	16378	16371	16445
Gasket Seating Conditon			
Longitudinal Hub (SH)	0	0	3
Radial Flange (SR)	0	0	0
Tangential Flange (ST)	12147	11987	12166
0.5(SH + SR)	0	0	1.5
0.5(SH + ST)	0	0	6085
Bolt Stress	0	0	124