Readme Supplement

for

Version 6.2

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SST Systems, Inc.
1798 Technology Drive, Suite 236
San Jose, California 95110
USA.

Tel: (408) 452-8111
Fax: (408) 452-8388
Email: info@sstusa.com
www.sstusa.com

InfoPlant Technologies Pvt. Ltd.
7, Crescent Road
Bangalore – 560001
India.

Tel: +91-80-40336999
Fax: +91-80-41494967
Email: iplant@vsnl.com
www.infoplantindia.com

Annexure A

ANSI B31.3 (2008)

B31.3 (2008)

Allowable Internal Pressure

For straight pipes and bends, the allowable pressure is calculated using Eq. (3a) for straight pipes and Eq. (3c) with I = 1.0 for bends from paras 304.1.2. and 304.2.1. respectively.

$$P_a = \frac{2SEWt_a}{D - 2Yt_a}$$

where

P_a = allowable pressure

S = allowable stress as provided in para. 302.3.1 (a)

E = joint factor (input as material property) from Table A-1A or A-1B from para. 302.3.3. and para 302.3.4.

W = Weld Joint Strength Reduction Factor from para. 302.3.5 (e) and as per Table 302.3.5 is implemented in CAEPIPE as follows. T_{max} below denotes maximum operating temperature (i.e., max of T1, T2 and T3 in CAEPIPE.

With Material Type in CAEPIPE = CS

W = 1.0 with T_{max} <= 800^0 F (or 427^0 C)

W = 0.64 with T_{max} > 1200^0 F (or 649^0 C) and

For T_{max} > 800^0 F (or 427^0 C) and <= 1200^0 F (or 649^0 C), the values of W are taken from Table 302.3.5.

W for intermediate temperatures are linearly interpolated.

With Material Type in CAEPIPE = FS

W = 1.0 with T_{max} <= 900^0 F (or 482^0 C)

W = 0.5 with T_{max} > 900^0 F (or 482^0 C)

With Material Type in CAEPIPE = AS or NA

W = 1.0 with T_{max} <= 950^0 F (or 510^0 C)

For T_{max} > 950^0 F (or 510^0 C), the values of W are taken as per Table 302.3.5.

W for intermediate temperatures are linearly interpolated.

For Other Material Types in CAEPIPE

W = 1.0 with T_{max} <= 800^0 F (or 427^0 C)

W = 1 – 0.000909 (T_{max} – T_{cr}) for T_{max} > 800^0 F (or 427^0 C)

where, T_{cr} is taken as 800^0 F

t_a = available thickness for pressure design

= t_n × (1 - mill tolerance/100) - corrosion allowance “c”

(Any additional thickness required for threading, grooving, erosion, corrosion, etc. should be included in corrosion allowance.)

t_n = nominal pipe thickness

D = outside diameter

d = inside diameter

Y = Pressure coefficient from Table 304.1.1, valid for t_a < D/6, and

$$Y = \frac{d + 2c}{D + d + 2c}$$, valid for $t_a \geq D/6$

For closely spaced miter bends, the allowable pressure is calculated using Eq. (4b) from para 304.2.3.

$$P_a = \frac{SEWt_a(R - r)}{r(R - r/2)}$$

where

r = mean radius of pipe = $(D - t_n)/2$

R = effective bend radius of the miter (see para. 304.2.3 of code for definition)

For widely spaced miter bends, the allowable pressure is calculated using Eq. (4c) from para. 304.2.3 as

$$P_a = \frac{SEWt_a^2}{r(t_a + 1.25 \tan\theta \sqrt{rt_a})}$$

where

θ = miter half angle

Sustained Stress

The stress (S_L) due to sustained loads (pressure, weight and other sustained mechanical loads) is calculated from para 302.3.5(c).

$$S_L = \frac{PD}{4t_s} + \frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z_m} \leq S_h$$

where

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

D = outside diameter

t_s = wall thickness used for sustained stress calculation after deducting corrosion allowance from the nominal thickness

t_s = nominal thickness – corrosion allowance

i_i = in-plane stress intensification factor

i_o = out-of-plane stress intensification factor

M_i = in-plane bending moment

M_o = out-of-plane bending moment

Z_m = corroded section modulus; for reduced outlets, effective section modulus

S_h = hot allowable stress

Sustained plus Occasional Stress

The stress (S_{Lo}) due to sustained and occasional loads is calculated as the sum of stress due to sustained loads (S_L) and stress due to occasional loads (S_o) such as earthquake or wind. Wind and earthquake are not considered concurrently (see para. 302.3.6).

For temp <= 427^0 C or 800^0 F

$$S_{Lo} = \frac{P_{peak} D}{4t_s} + \left[\frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z_m}\right]_{sust} + \left[\frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z_m}\right]_{occasional} \leq 1.33 S_h$$

For temp > 427^0 C or 800^0 F

$$S_{Lo} = \frac{P_{peak} D}{4t_s} + \left[\frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z_m} \right]_{sust} + \left[\frac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z_m} \right]_{occasional} \leq 0.9 W S_y$$

where

Z_m = corroded section modulus; for reduced outlets, effective section modulus

P_{peak} = peak pressure = (peak pressure factor) x P

S_y = yield strength at maximum temperature and

W = 1.0 for Austenetic stainless steel and 0.8 for all other materials

Expansion Stress

The stress (S_E) due to thermal expansion is calculated using Eq. 17 from para. 319.4.4

$$S_E = \sqrt{S_b^2 + 4S_t^2} \leq S_A$$

where

$S_b =$ resultant bending stress = $\dfrac{\sqrt{(i_i M_i)^2 + (i_o M_o)^2}}{Z}$

$S_t =$ torsional stress = $\dfrac{M_t}{2Z}$

M_t = torsional moment

Z = uncorroded section modulus as per para. 319.3.5; for reduced outlets, effective section modulus

$S_A = f(1.25 S_C + 0.25 S_h)$, Eq. (1a) of para. 302.3.5(d)

$f =$ stress range reduction factor from Eq. (1c) of para. 302.3.5 (d) = $6N^{-0.2}$

where f >= 0.15 and f <= 1.0

S_c = allowable stress at cold temperature

When S_h is greater than S_L, the allowable stress range may be calculated as

$S_A = f[1.25(S_C + S_h) - S_L]$, Eq. (1b) of para. 302.3.5(d).

This is specified as an analysis option “Use liberal allowable stresses”, in the menu Options->Analysis on the CAEPIPE Code tab.

Note:

Refer Annexure B for the details of “Thickness” and the “Section Modulus” used for weight, pressure and stress calculations.

Annexure B

Thickness and Section Modulus used in Weight, Pressure and Stress Calculations for ANSI B31.x Codes

Particulars	Allowable Pressure	Pipe Weight	Sustained Stress	Expansion Stress	Occasional Stress
B31.1 (2007)					
Pipe Thickness used	Nominal Thk. x (1-mill tolerance/100) – Corrosion allowance	Nominal Thickness	Nominal Thickness	-	Nominal Thickness
Section Modulus used	-	-	Uncorroded Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch, effective section modulus
B31.3 (2008)					
Pipe Thickness used	Nominal Thk. x (1-mill tolerance/100) – Corrosion allowance	Nominal Thickness	Nominal Thickness - Corrosion allowance	-	Nominal Thickness – Corrosion allowance
Section Modulus used	-	-	*Corroded* Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch, effective section modulus	*Corroded* Section Modulus; For Branch, effective section modulus
B31.4 (2006)					
Pipe Thickness used	Nominal Thk – Corrosion allowance	Nominal Thickness	Nominal Thickness	-	Nominal Thickness
Section Modulus used	-	-	Uncorroded Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch effective section modulus
B31.5 (2001)					
Pipe Thickness used	Nominal Thk. x (1-mill tolerance/100) – Corrosion	Nominal Thickness	Nominal Thickness	-	Nominal Thickness

Particulars	Allowable Pressure	Pipe Weight	Sustained Stress	Expansion Stress	Occasional Stress
	allowance				
Section Modulus used	-	-	Uncorroded Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch, effective section modulus
B31.8 (2003)					
Pipe Thickness used	Nominal Thk. x (1-mill tolerance/100) – Corrosion allowance	Nominal Thickness	Nominal Thickness	-	Nominal Thickness
Section Modulus used	-	-	Uncorroded Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch, effective section modulus	Uncorroded Section Modulus; For Branch, effective section modulus

Note:

1. Corrosion allowance includes thickness required for threading, grooving, erosion, corrosion etc.

2. Uncorroded section modulus = section modulus calculated using the nominal thickness.

3. Corroded section modulus = section modulus calculated using the “corroded thickness”

Corroded thickness = nominal thickness – corrosion allowance

4. Effective section modulus = section modulus calculated using effective branch thickness, which is lesser of $i_i t_b$ or t_h
where, t_b = branch nominal thickness, t_h = header nominal thickness, i_i = in-plane SIF at branch