$$t_{ri} = 10^a \tag{V3}$$

where

SI units: $$a = \frac{LMP}{T_i + 273} - C$$

U.S. Customary units: $$a = \frac{LMP}{T_i + 460} - C$$

and

T_i = temperature, °C (°F), of the component for the coincident operating pressure–temperature condition i under consideration

t_{ri} = allowable rupture life, h, associated with a given service condition i and stress, S_i

LMP and C are as defined in para. V303.1.3.

V303.2 Determine Creep-Rupture Usage Factor

The usage factor, u, is the summation of individual usage factors, t_i/t_{ri}, for all service conditions considered in para. V303.1. See eq. (V4).

$$u = \sum(t_i/t_{ri}) \tag{V4}$$

where

i = as a subscript, 1 for the prevalent operating condition; i = 2, 3, etc., for each of the other service conditions considered

t_i = total duration, h, associated with any service condition, i, at pressure, P_i, and temperature, T_i

t_{ri} = as defined in para. V303.1.4

V303.3 Evaluation

The calculated value of u indicates the nominal amount of creep-rupture life expended during the ser-

(a) Normal operation is 157,200 hr at 250 psig, 1,025°F.

(b) Expect up to 16,000 hr at design conditions of 250 psig, 1,050°F.

(c) Total of 2,000 hr at excursion condition of 330 psig, 1,050°F. [This is a 32% variation above the design pressure and, with the owner's approval, it complies with the criteria of para. 302.2.4. As a simplification, and in accordance with para. V301(b), this 2,000 hr total includes less severe excursions.]

Compute pressure-based equivalent stress, S_{pi}, from eq. (V1).

From Table A-1, S_d = 5.7 ksi at 1,050°F.

$$P_{max} = \frac{2(\overline{T} - c - \text{mill tol.}) \times SEW}{D - 2(\overline{T} - c - \text{mill tol.}) \times Y}$$

Letting $S = S_d$ and, in accordance with the definition of P_{max} in para. V303.1.1, $E = 1$ and $W = 1$,

$$P_{max} = 306 \text{ psi}$$

$$S_{p1} = 5.7(250/306) = 4.65 \text{ ksi}$$
$$S_{p2} = 5.7(250/306) = 4.65 \text{ ksi}$$
$$S_{p3} = 5.7(330/306) = 6.14 \text{ ksi}$$

NOTE: In eq. (V1), design pressure could be used in this example for P_{max}, as this will always be conservative. Here the actual P_{max} of the piping system is used.

The stress due to sustained loads, S_L, for each condition i, calculated in accordance with para. 320.2, is

$$S_{L1} = 3.0 \text{ ksi}$$
$$S_{L2} = 3.0 \text{ ksi}$$
$$S_{L3} = 3.7 \text{ ksi}$$

For pipe with a longitudinal weld (E = 1), W is 0.8, 0.77, and 1.0 for S_{p1}, S_{p2}, and S_{p3}, respectively. Note that condition 3 is short term, so W = 1. Also note that with

(16) ### 320.2 Stress Due to Sustained Loads

The equation for the stress due to sustained loads, such as pressure and weight, S_L, is provided in eq. (23a). Equations for the stress due to sustained bending moments, S_b, are presented in eqs. (23b1) and (23b2).

$$S_L = \sqrt{(|S_a| + S_b)^2 + (2S_t)^2} \quad (23a)$$

$$S_b = \frac{\sqrt{(I_i M_i)^2 + (I_o M_o)^2}}{Z} \quad (23b1)$$

For branch (Leg 3 in Fig. 319.4.4B), use eq. (23b2) only when I_i or I_o is based upon i, i_i, or i_o taken from Appendix D; when both I_i and I_o are determined by experimental or analytical means, e.g., ASME B31J, use eq. (23b1).

$$S_b = \frac{\sqrt{(I_i M_i)^2 + (I_o M_o)^2}}{Z_e} \quad (23b2)$$

where

I_i = sustained in-plane moment index. In the absence of more applicable data, I_i is taken as the greater of $0.75i_i$ or 1.00.

I_o = sustained out-plane moment index. In the absence of more applicable data, I_o is taken as the greater of $0.75i_o$ or 1.00.

M_i = in-plane moment due to sustained loads, e.g., pressure and weight

M_o = out-plane moment due to sustained loads, e.g., pressure and weight

The equation for the stress due to sustained longitudinal force, S_a, is

$$S_a = \frac{I_a F_a}{A_p} \quad (23d)$$

where

A_p = cross-sectional area of the pipe, considering nominal pipe dimensions less allowances; see para. 320.1

F_a = longitudinal force due to sustained loads, e.g., pressure and weight

I_a = sustained longitudinal force index. In the absence of more applicable data, I_a is taken as 1.00.

The sustained longitudinal force, F_a, includes the sustained force due to pressure, which is $P_j A_f$ unless the piping system includes an expansion joint that is not designed to carry this force itself, where P_j is the internal operating pressure for the condition being considered, $A_f = \pi d^2/4$, and d is the pipe inside diameter considering pipe wall thickness less applicable allowances; see para. 320.1. For piping systems that contain expansion joints, it is the responsibility of the designer to determine the sustained longitudinal force due to pressure in the piping system.

321 PIPING SUPPORT

321.1 General

The design of support structures (not covered by this Code) and of supporting elements (see definitions of