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(b) Metal temperatures covered by the reference equations range between room temperature and 650°F (343°C).

4 FATIGUE CRACK GROWTH RATE REFERENCE CURVES

(a) The fatigue crack growth rate, da/dN, of the material is characterized in terms of the range of the applied stress intensity factor, ΔK. This characterization is generally in the form of eq. (1)

$$\frac{da}{dN} = C_0 \, \Delta K^n \quad (1)$$

where

C_0 = scaling parameter that accounts for the effect of loading rate and environment on fatigue crack growth rate
n = slope of the log (da/dN) versus log (ΔK) curve

n and C_0 are parameters dependent on the material and environmental conditions

(b) The fatigue crack growth rate of the material is affected by R ratio (K_{min}/K_{max}), loading rate, and environmental conditions. These variables are accounted for in the definition of C_0 as defined below:

$$C_0 = C \, S_T \, S_R \, S_{ENV} \quad (2)$$

where

C = nominal fatigue crack growth rate constant
S_{ENV} = parameter defining the environmental effects on fatigue crack growth rate
S_R = parameter defining the effect of R ratio on fatigue crack growth rate
S_T = parameter defining the effect of temperature on fatigue crack growth rate

These parameters should be based on crack growth data obtained from specimens of the same material specification and product form, or suitable alternative. Material variability, environment, test frequency, mean stress, and other variables that affect the data should be considered .

(c) The reference fatigue crack growth rate curves are plotted as normalized da/dN versus ΔK where

$$\left.\frac{da}{dN}\right|_{\text{Normalized}} = \frac{da/dN}{S_T S_R S_{ENV}} \quad (3)$$

(E) 5 REFERENCE CURVES FOR WROUGHT AUSTENITIC STAINLESS STEELS

(a) Fatigue crack growth rate of wrought austenitic stainless steels and associated weld metals in pressurized water reactor environments can be characterized in terms of the range of the applied stress intensity factor, ΔK as defined by eq. 4(a)(1). The fatigue crack growth rate is dependent on temperature, R ratio, and environment as defined below.

(b) The parameter S_{ENV} is dependent on loading rise time for the variation in loading during a transient. The loading rise time, T_R, is the period of time in seconds for which the stress is increasing during a stress cycle. The loading rise time, which excludes hold times and time periods for which the stress is decreasing during the cycle, includes the time periods from minimum stress to steady state and from steady state to maximum stress. Hold times include periods in which the change in stress does not exceed 1,000 psi/hr (1.92 kPa/s).

(c) Reference fatigue crack growth rate curves of wrought austenitic stainless steels and associated weld metals exposed to pressurized water reactor environments are given in Figure 1 (Figure 1M) in normalized form in accordance with eq. 4(c)(3).

(1) For Type 304 and Type 316 stainless steels and associated weld metals,

(U.S. Customary Units)

$$C = 4.43 \times 10^{-7} \text{ for } \Delta K \geq \Delta K_{th}$$

$$C = 0 \text{ for } \Delta K < \Delta K_{th}$$

$$n = 2.25$$

$$S_R = 1.0 \text{ for } R < 0$$

$$S_R = 1 + e^{8.02(R - 0.748)} \text{ for } 0 \leq R < 1.0$$

$$S_T = e^{-2516/T_K} \text{ for } 300°F \leq T \leq 650°F$$

$$S_T = 3.39 \times 10^5 e^{[(-2516/T_K) - 0.0301 T_K]} \text{ for } 70°F \leq T < 300°F$$

$$S_{ENV} = T_R^{0.3}$$

where

da/dN = fatigue crack growth rate, in./cycle
ΔK = stress intensity factor range, $\left(\text{ksi}\sqrt{\text{in.}}\right)$
T_K = $[(T-32)/1.8] + 273.15$, k
T = metal temperature, °F
T_R = loading rise time, sec
ΔK_{th} = 1.00 $\left(\text{ksi}\sqrt{\text{in.}}\right)$

When $T_R < 1$ sec, set $T_R = 1$ sec

(SI Units)

$$C = 9.10 \times 10^{-6} \text{ for } \Delta K \geq \Delta K_{th}$$