Case N-889
Reference Stress Corrosion Crack Growth Rate Curves for Irradiated Austenitic Stainless Steels in Light Water Reactor Environments
Section XI, Division 1

Inquiry: When performing an analytical evaluation of a flaw in accordance with IWB-3132.3, what stress corrosion crack growth rate curves may be used for irradiated austenitic stainless steels exposed to light water reactor environments?

Reply: It is the opinion of the Committee that the stress corrosion crack growth rate curves for analytical evaluation of flaws in irradiated austenitic stainless steels exposed to light water reactor environments given below may be used.

1 INTRODUCTION
Stress corrosion cracking (SCC) growth rates in materials vary under the combined effects of three primary variables: material susceptibility, environment aggressiveness, and loading severity. Irradiation affects each of these primary variables. The crack growth rate reference curves in this Case use irradiated yield stress to represent the effects of radiation.

2 NOMENCLATURE

\[ A, B = \text{intermediate results, yield stress model, MPa} \]
\[ a = \text{crack depth, in. (mm)} \]
\[ C = \text{coefficient for a particular environment, } \left( \text{in.} / \text{hr} \right) / \left( \text{ksi} \right) \left( \text{ksi} \sqrt{\text{m}} \right)^{n} \left( \text{mm} / \text{s} \right) / \left( \text{MPa} \right) \left( \text{MPa} \sqrt{\text{m}} \right)^{n} \]
\[ d = \text{irradiation dose, dpa, for light water reactors; 1} \times 10^{20} \text{ n/cm}^{2}, E > 1 \text{ MeV} \]
\[ da/dt = \text{crack growth rate, in./hr (mm/s)} \]
\[ K = \text{Mode I stress intensity factor, ksi} \sqrt{\text{in.}} \]
\[ m, m' = \text{temperature coefficient, yield stress model, } 1/\text{°C} \]
\[ r = \text{pre-irradiation strengthening parameter, dimensionless} \]
\[ S_T = \text{temperature adjustment function, dimensionless} \]
\[ T_F, T_C = \text{application temperature, °F (°C)} \]
\[ T_K = \text{application temperature in Kelvin, K} \]
\[ n = \text{fitted exponent on } K, \text{ dimensionless} \]
\[ v = \text{fitted exponent on } \sigma_{0.2}, \text{ dimensionless} \]
\[ \sigma_{0.2} = \text{irradiated yield stress, ksi (MPa)} \]

3 SCOPE
This Case provides reference stress corrosion crack growth rate curves for use in flaw growth evaluations for irradiated austenitic stainless materials in pressurized and boiling water reactor environments.

3.1 APPLICABLE MATERIALS
Materials covered by this Case are wrought austenitic stainless steels and cast austenitic stainless steels (cast equivalents of Series 300 stainless steels) and associated weld metals including the HAZ (Series 300 stainless steels).

This Case is not applicable to wrought Type 321 or to dissimilar metal welds.

3.2 APPLICABLE TEMPERATURE RANGE
(a) The equations and reference curves within this Case are applicable to the metal temperature ranges shown in Table 1.

(b) An adjustment term, \( S_T \), is provided to adjust the reference curves for application temperature within stated ranges shown in Table 1. The reference temperature for Figures 1, 1M, and 2 is 550°F (288°C). All application temperatures other than 550°F (288°C) require the calculation of the adjustment term \( S_T \).

3.3 APPLICABLE WATER ENVIRONMENT
The applicable water environment for a Boiling Water Reactor (BWR) and a Pressurized Water Reactor (PWR) is defined in Table 1.

3.4 APPLICABLE LOADING
(a) The applicable loading range acting on the crack includes quasi-static and constant loading.
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2 NOMENCLATURE

\( A_i, B_i \) Intermediate results, yield stress model, MPa

\( C \) Coefficient for a particular environment, \((\text{in./hr})/(\text{ksi}^{m/\text{ksi}} \cdot \text{in.})\) \(\left(\text{[mm/s]}/(\text{MPa})^{(\text{MPa} \cdot \text{m}^{m/\text{MPa}})}\right)\)

\( K \) Mode I stress intensity factor, ksi \(\cdot\) in.

\( S_T \) Temperature adjustment function, dimensionless

\( T_r, T_C \) Application temperature, °F [°C]

\( T_K \) Application temperature in Kelvin, °K

\( a \) Crack depth, in. [mm]

\( d \) Irradiation dose, dpa, for light water reactors

\( 1 \text{ dpa} \equiv 7 \times 10^{20} \text{n/cm}^2, E > 1 \text{ MeV} \)

\( \frac{da}{dt} \) Crack growth rate, in./hr [mm/s]

\( m, m' \) Temperature coefficient, yield stress model, \(1/\text{°C}\)

\( r \) Pre-irradiation strengthening parameter, dimensionless

\( \eta \) Fitted exponent on \( K \), dimensionless

\( \nu \) Fitted exponent on \( \sigma_{0.2} \), dimensionless

\( \sigma_{0.2} \) Irradiated yield stress, ksi [MPa]

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