

ASME Code Section XI Nonmandatory Appendix K Update

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The views expressed herein are those of the authors and do not reflect the views of the U.S. Nuclear Regulatory Commission.

Historical Background

RPV Integrity Regulations



- NRC has been evaluating regulatory positions on RPV integrity
- NRC revisited RG 1.161 in order to ensure a solid technical foundation for rulemaking
- NRC sees value in withdrawing the RG, in favor of referring to ASME Code Section XI Nonmandatory Appendix K

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Technical Background

RG 1.161/ASME Section XI, Nonmandatory Appendix K



- Procedures acceptable to NRC staff for determining required upper shelf energy (USE)
- Regulatory limit: 75 ft-lb initially, 50 ft-lb throughout the life of the plant
- Methodology is based upon elastic-plastic fracture mechanics
 - Estimate J
 - Estimate J_R
 - Apply acceptance criteria to calculate alternative USE

Technical Background

Eason Correlations



- RG 1.161 references lower bound empirical correlations for estimating J_R , see NUREG/CR-5729

$$J = CI (\Delta a)^{C2} \exp[CS(\Delta a)^{C3}]$$

$$\text{Charpy Model: } \ln CI = a_1 + a_2 \ln CVN + a_3 T + a_4 \ln B,$$

$$C2 = d_1 + d_2 \ln CI + d_3 \ln B,$$

$$\text{Cu-}\phi\text{ Model: } \ln CI = a_1 + a_2 \text{Cu}(\phi)^{a_3} + a_4 T + a_5 \ln B,$$

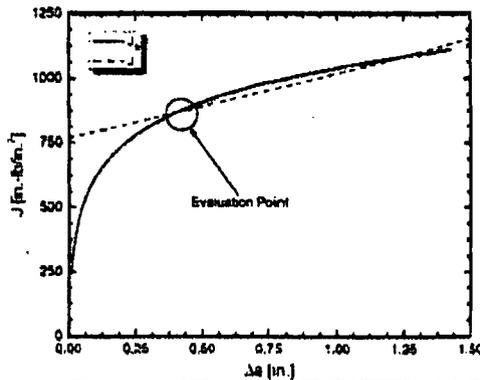
$$C3 = d_1 + d_2 \ln CI + d_3 \ln B,$$

$$\text{CVN}_p \text{ Model: } \ln CI = a_1 + a_2 \text{Cu}(\phi)^{a_3} + a_4 T + a_5 \ln B + a_6 \ln CVN_p,$$

Technical Background

Acceptance Criteria

- Initiation: $J < J_R$ at $\Delta a = 0.1$ in, $SF = 1.15$
- Stability: $\frac{\partial J}{\partial a} < \frac{\partial J_R}{\partial a}$ at $J = J_R$, $SF = 1.25$



Technical Review

RG 1.161

- Refer to PVP2012-78227
- Improved discussion of the J_R correlation limitations
- Possible update of the J_R correlations, of particular interest: $\phi < 10^{18}$ n/cm²
- Justification of crack tip temperature input
- Improved discussion of Crack Driving Force Diagram approach
- Added discussion of J-Tearing Modulus and Failure Assessment Diagram approaches

RG 1.161 vs. Appendix K

Differences



- Material resistance properties
 - RG 1.161 endorses J_R correlations developed by Eason in NUREG/CR-5729, 1991
 - Appendix K states that the J_R curve "shall be a conservative representation of the toughness of the controlling beltline material at upper shelf temperatures in the operating range"
- Evaluation of the crack stability criterion
 - RG 1.161 endorses one method: "direct application"
 - Appendix K endorses three methods: crack driving force diagram, failure assessment diagram, J/Tearing Modulus procedure

Conclusions

RG 1.161/ASME App K



- NRC RES has performed a technical assessment of RG 1.161
- If ASME App K is updated to satisfy NRC comments, NRC would consider withdrawing the RG
- J_R correlations may need to be included in App K
- Updating the J_R correlations offer significant technical challenges
- From Gary Stevens: What does the WGFE plan to do with App K, if anything? What is the schedule?