NRC Staff Perspectives and Activities on Environmentally-Assisted Fatigue

Gary L. Stevens
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research

Canadian Nuclear Safety Commission (CNSC)
Workshop on CANDU Fatigue Management Program Development

National Arts Center
53 Elgin Street
Ottawa, Canada

February 16-17, 2011

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Summary

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- NRC Staff Perspectives on Environmentally-Assisted Fatigue (EAF)
  - License Renewal Evaluations
  - ASME Code Activities
  - EPRI's Advisory Panel
  - EAF Evaluation for New Plants
- Current NRC Research Activities
- Questions

NRC Staff Perspectives on EAF

License Renewal Evaluations

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- The NRC Staff expects to see EAF evaluations for a set of sample components* for each unit that applies for license renewal
- EAF performed in accordance with GALL Revision 2 (ML103490041):
  - For carbon steel: May use either NUREG/CR-6583 with ASME carbon steel/low alloy steel fatigue curve **OR** NUREG/CR-6909 with ASME or NUREG/CR-6909 carbon steel fatigue curve **OR** an NRC-approved alternative
  - For stainless steel: May use either NUREG/CR-5704 with ASME stainless steel fatigue curve **OR** NUREG/CR-6909 with NUREG/CR-6909 stainless steel fatigue curve **OR** an NRC-approved alternative
  - For Alloy 600: NUREG/CR-6909 with NUREG/CR-6909 stainless steel fatigue curve **OR** an NRC-approved alternative
- Any new or refined evaluations should use all six stress components
- Analyst judgments need to be well-documented and a basis provided
  - Issues such as attached piping loads and cycle counting/load pairing should be carefully considered and an adequate basis provided for any assumptions made

* **From the GALL Report: This sample set should include the locations identified in NUREG/CR-6260 and additional plant-specific component locations in the reactor coolant pressure boundary if they may be more limiting than those considered in NUREG/CR-6260.**

NRC Staff Perspectives on EAF

ASME Code Activities

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- There are currently four Code Cases in development in Section III on the topic of EAF:
  - Fatigue Curves (issued, Code Case N-761)
  - F_{en} (issued, Code Case N-792)
  - Strain Rate Code Case (still in progress)
  - Flaw (or Damage) Tolerance (still in progress)
    - Similar to Section XI Nonmandatory Appendix L
- NRC Staff Positions:
  - Fatigue Curve Code Case (N-761)
    - The NRC Staff voted negative on this item
    - The NRC Staff is amenable to the adoption of revised fatigue curves that address EAF
    - The current Code Case does not have an adequate technical basis
    - The curves should "align" with Code-adopted F_{en} values for a given set of input (DO, T, strain rate) parameters
    - Argonne/NRC Staff are providing comments to the relevant ASME Committee for its consideration for a revised Technical Basis (and possibly Code Case revision) that would be acceptable to the NRC Staff

NRC Staff Perspectives on EAF

ASME Code Activities (cont'd)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- NRC Staff Positions (cont'd):
  - F_{en} Code Case (N-792)
    - The NRC Staff voted in favor of this item
    - The Code Case adopted NUREG/CR-6909 methodology except for a strain amplitude threshold
      - The strain amplitude modification is conservative
      - The NRC Staff is investigating the strain amplitude issue as a part of our on-going research activities
  - Strain Rate Code Case
    - The NRC Staff has not yet investigated this item
    - The NRC Staff is investigating strain rate calculation methodology as a part of our on-going research activities

NRC Staff Perspectives on EAF

ASME Code Activities (concluded)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- NRC Staff Positions (cont'd):
  - Flaw (or Damage) Tolerance Code Case
    - The NRC Staff voted negative on the adoption of flaw tolerance methodology in Section III of the Code
    - The NRC Staff believes robust demonstration of meeting fatigue limits is necessary for new plants to allow for fatigue-compliant designs similar to the current operating fleet of reactors
    - The allowance for the possibility of fatigue flaws in vessel design is contrary to the philosophy behind Section III

NRC Staff Perspectives on EAF

EPRI's Advisory Panel

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- EPRI has formed an Advisory Panel on EAF
  - The panel is an industry group of EAF experts advising the Materials Reliability Project (MRP)
- The NRC Staff is not a member of EPRI's Advisory Panel on EAF
- The NRC Staff has been attending Advisory Panel meetings as an observer
  - The NRC Staff finds this forum to be a useful way to dialogue with the industry on EAF issues
  - The NRC Staff is interested in what the industry is pursuing from an awareness point-of-view
  - The NRC Staff is evaluating the EAF round-robin sample problem developed by the Advisory Panel as a check on the industry's approach to solving EAF problems

NRC Staff Perspectives on EAF

EAF Evaluation for New Plants

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- The NRC Staff expects new plant applicants to evaluate pressure boundary components exposed to the reactor coolant using RG 1.207 (NUREG/CR-6909) methodology
  - "In so doing, this guide describes a method that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable to support reviews of applications that the agency expects to receive for new nuclear reactor construction permits or operating licenses under 10 CFR Part 50; design certifications under 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants" (Ref. 3); and combined licenses under 10 CFR Part 52 ***that do not reference a standard design***." *[emphasis added]*
- EAF evaluation of RPV core support structures is not currently addressed
  - The NRC Staff will consider the need to include RPV core support structures after completion of current EAF research activities (i.e., in 2012)

NRC Staff Perspectives on EAF

Current NRC Research Activities

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Research is being performed to support the following activities:
  1. Technical Basis for High Energy Line Break (HELB) Postulated Break Locations for Affected Piping Systems in Operating Plants Requesting License Renewal and in New Plant Applications
  2. Solve EPRI EAF Advisory Panel sample problem
- Potential for joint NRC/EPRI research via the NRC/EPRI Memorandum of Understanding (MOU)
  - Allows for reduction of duplication of efforts

Questions

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

?