UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 18, 2000

ORGANIZATION: Nuclear Energy Institute

SUBJECT: SUMMARY OF MEETING WITH THE NUCLEAR ENERGY INSTITUTE (NEI) TO DISCUSS FATIGUE OF METAL COMPONENTS FOR 60-YEAR PLANT LIFE

On May 25, 2000, representatives from NEI and other interested industry groups met with the Nuclear Regulatory Commission (NRC) staff in Rockville, Maryland, to discuss fatigue of metal components for a 60-year plant life. A list of meeting attendees is provided in Attachment 1. NEI's meeting agenda is provided in Attachment 2.

NEI stated that the purpose of the meeting was to clarify the NRC's expectations for the treatment of coolant environmental effects on component fatigue management in license renewal applications, as described in the resolution of Generic Safety Issue 190 in the memorandum from A. Thadani to W. Travers dated December 26, 1999. The industry representatives established the following objectives for a successful meeting: describe industry confusion regarding the issue of environmental effects on fatigue, articulate concerns with the issue of fatigue, envision an agreeable solution, and determine action needed to reach this solution.

The industry representatives explained that they wanted the NRC to better characterize the expectation on the treatment of fatigue environmental effects in a way that would make it clear to the plant operators how they would change their fatigue monitoring programs. The staff explained that it would be difficult to describe the program changes in much detail when there is ongoing controversy over the interpretation of the generic test data.

Industry representatives expressed concern that there is (1) unnecessary conservatism in the analyses that supported the resolution of GSI-190 for effects of coolant environment on component fatigue life, and (2) concerns with the GSI-190 analysis and evaluation. EPRI presented specific examples of conservatism in the GSI-190 analyses and models. The staff agreed that there are conservatisms in the GSI-190 analyses and models because they were intended to address the generic issue, not to change the design basis or manage the effect. However, the staff does not agree with all of the characterizations of conservatisms in the GSI-190 studies described by the industry representatives.

ASME is currently working on a revision to the code to include environmental effects of fatigue. Once completed, the code could provide a basis for the generic resolution of fatigue. However, due to the complexity of this issue and the studies involved, a generic code resolution is not expected to be completed within the time frame to support many license renewal applications currently underway.

The industry proposed that they would perform additional work to quantify the conservatisms in the fatigue analyses and models, provide a bases for reducing the conservatisms, and provide the results of any additional work performed with a revised model or input parameters. To facilitate that effort, the industry representatives requested that the NRC make the data and analysis details available. The staff agreed to provide that information in advance of the publication and distribution of the final report. The industry also proposed that they would develop a plan for full-scale testing to establish fatigue limits.

The staff agreed that the additional efforts the industry proposed could contribute substantially to the resolution of the environmental effects on fatigue and guidelines for any changes to the fatigue monitoring programs that might be needed to ensure that the associated aging effect will be adequately managed for license renewal. However, until such time as the industry provides an acceptable basis for not addressing environmental effects on fatigue or until there is a referenceable generic approach to managing environmental effects on fatigue, license renewal applicants will have to address the issue on a plant-specific basis.

NRC encouraged continued close communications on this subject and emphasized the importance of early agreement on possible changes in the modeling/analyses that the industry proposes to pursue.

Action Assignments:

- NRC - Provide the details of the data and models used in the GSI-190 evaluation in advance of the publication of the associated report. Subsequent to the meeting, the NRC issued its report on fatigue (NUREG/CR-6674, "Fatigue Analysis of Components for 60-Year Plant Life", Adams Accession #ML003724215), and made its computational code, pcPRAISE version 4.2, publicly available (Adams Accession #ML003731127).
- NRC - Develop a description of an acceptable aging management program for fatigue environmental effects in the GALL format.
- Industry - Continue efforts to reduce conservatisms in the analyses for environmental effects of fatigue, work toward a generic solution, and pursue changes in the ASME Code.
- NRC - Schedule a future meeting on fatigue with industry to discuss progress on this issue.

Christopher I. Grimes, Chief
License Renewal and Standardization Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Project No. 690

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NRC MEETING WITH NEI TO DISCUSS FATIGUE OF METAL
COMPONENTS FOR A 60-YEAR PLANT LIFE
ATTENDANCE LIST
MAY 25, 2000

NAME	ORGANIZATION
KEITH WICHMAN	NRC/NRR/DE
ED HACKETT	NRC/RES/DET/MEB
MICHAEL MAYFIELD	NRC/RES/DET
JACK STROSNIDER	NRC/NRR/DE
JOHN FAIR	NRC/NRR/DE/EMEB
DOUG KALINOUSKY	NRC/RES/DET/MEB
KHALID SHAUKAT	NRC/RES/DET
JOE MUSCARA	NRC/RES/DET
TAMARA BLOOMER	NRC/NRR/DRIP/RLSB
DAVID TERAO	NRC/NRR/DE/EMEB
OMID TABATABAI-YAZDI	NRC/NRR/DRIP/RLSB
KAMAL MANOLY	NRC/NRR/DE/EMEB
CHRIS GRIMES	NRC/NRR/DRIP/RLSB
JIM STRNISHA	NRC/NRR/DRIP/RLSB
PETER J. KANG	NRC/NRR/DRIP/RLSB
GENE IMBRO	NRC/NRR/DE/EMEB
WILLIAM BURTON	NRC/NRR/DRIP/RLSB
FRED SIMONEN	PNNL
MIKE DANTZLER	SCE&G
JAMES LaBORDE	SCE&G
FRED POLASKI	PECO
NOEL DUDLEY	NRC/ACRS
LARRY D. SMITH	CONSTELLATION NUCL. SVCS.
GREG ROBISON	DUKE
DOUG WALTERS	NEI
STEVE HALE	FPL
JOHN CAREY	EPRI
MICHAEL HENIG	DOMINION (VA PWR)
ROBERT E. NICKELL	EPRI CONSULTANT
RAYMOND M. TO	ENTERGY
JON HORNBUCKLE	SOUTHERN NUCLEAR
J. MICHAEL DAVIS	DUKE ENERGY
DAVID STELLFOX	McGRAW-HILL
GARY STEVENS	STRUCTURAL INTEGRITY
EDWARD WENZINGER	SCIENTECH

Attachment 1

Fatigue of Metal Components for 60-Year Plant Life

May 25, 2000

NRC Offices

Attachment 2

Purpose of Meeting

- Describe utility confusion on the issue of coolant environment effects on component fatigue life
- Determine if the meeting participants can envision an acceptable solution
- Determine what is needed to reach this acceptable solution

Introduction:

What The Utilities Are Reading

- Pressure Vessel Research Council (Greg Hollinger) letter to ASME - October 31, 1999
- NRC License Renewal Position (Chris Grimes' Statement) from Fatigue Meeting - November 17, 1999
- NRC Research (John Craig) letter to ASME - December 1, 1999
- NRC Research (Ashok Thadani) letter to EDO (Travers) closing GSI-190 - December 26, 1999
- EPRI letter to ASME - March 3, 2000
- Standard Review Plan for the Review of License Renewal Applications for Nuclear Power Plants Draft - April 21, 2000 (specifically, Sections 4.3.1.2 and 4.3.2.2)
- One that seems missing: Office Director Letter covering GSI resolution per NUREG-0933 to all licensees. Released yet?

Introduction:

Industry Perspective

- Distinguish between "industry action" and "applicant action"
  - Industry action: investigation of environmental effects on component fatigue life
  - Applicant action: manage fatigue aging effects

Introduction:
Industry Perspective

- From what the utilities are reading, it seems that if we were to take a less conservative approach to re-doing fatigue calculations, our hardware might leak. Is this what the issue is all about?
- Or is my current design not fully conservative such that my hardware might leak?

Introduction:
Industry Perspective

- Acceptance of ALWR design vs. current design. The utilities need help better understanding the perceived difference between the design methodologies used.
- The utilities see the need for options that the applicant can take to manage fatigue aging effects.

EPRI Evaluation of Fatigue Environmental Effects and Conclusions Regarding Need for Fatigue Monitoring Program

- The PNNL risk study used appropriate bounding assumptions to estimate contributions to core damage frequency (CDF) for 47 of the most fatigue-sensitive Class 1 component locations in seven types of LWRs (e.g., older vintage CE plants)
- The extension of these bounding calculations showed only six component locations (e.g., PWR surge line elbows, PWR RPV outlet nozzles, BWR recirculation system RHR return lines) with sufficiently high through-wall cracking frequency to serve as the basis for risk-informed inspection
- The extension of the CDF calculations to through-wall cracking frequency and leakage rates, using the bounding assumptions, is too conservative and should not be used as a basis for license renewal requirements, nor can they serve as the basis for risk-informed management of potential reactor water environmental effects

EPRI Evaluation of Fatigue Environmental Effects and Conclusions Regarding Need for Fatigue Monitoring Program (Continued)

- Conservatisms in the transient definitions, analytical procedures, fatigue design curves, and other elements of the ASME Code explicit fatigue design process appear to more than compensate for reactor water environmental effects
  - need for additional fatigue environmental effects tests on stainless steel in low oxygen reactor water

- Existing utility fatigue management programs are adequate for license renewal

Conservatisms in the GSI 190 evaluation (PNNL Risk Study)

- Design basis stresses assumed from NUREG/CR-6260. Experience shows that actual stresses less severe.
- Data on strain rates not available in NUREG/CR-6260, so very slow strain rates assumed for essentially all transients, giving maximum environmental effect.
- Most adverse temperatures (from environmental standpoint) assumed for all stress cycles.
- There was no endurance limit shown at high end of the fatigue (S-N) curve, indicating potential for very low allowable cycles for low stress amplitudes (Figure 1 of paper)

Conservatisms in the GSI 190 evaluation (PNNL Risk Study), Continued

- Stresses for crack growth were not adjusted for local stress concentrations and probably not for K_e
- Through-wall stress distributions not available from NUREG/CR-6260, so not clear how crack growth evaluated. It is only stated that stress was attenuated.
- No consideration that stresses vary around the pipe circumference - NUREG/CR-6260 only gave maximum value of stress amplitude.
- No consideration given to location-to-location stress differences in plant systems - NUREG/CR-6260 only provided stresses for worst locations.

Uncertainties* in the PNNL Risk Study

- All components simulated as pipe geometry with a circumferential crack. Effect of assumption unknown.
- A log-normal parameter Z was used in the crack growth rate curve for carbon steel. A similar parameter C was used for austenitic stainless steel. No basis provided.
- Crack growth rate equations had $R = K_{min}/K_{max}$ dependency. Not possible to compute exact stress levels from data in NUREG/CR-6260. Unclear on approach used.

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*These uncertainties might be resolved when the report is published and available for industry review

Industry Actions

- Perform additional pc-PRAISE code calculations, relaxing some of the most conservative assumptions, in order to obtain a more realistic estimate of the probability of crack initiation and growth at fatigue-sensitive component locations
- Obtain additional low-cycle fatigue data for wrought and cast austenitic stainless steels in reactor water environments, using hourglass and/or notched fatigue specimens subjected to strain fields, flow rates and oxidizing conditions typical of components in service
- Develop a cooperative in-service inspection program between a number of PWR utilities to inspect one or two of the most fatigue-sensitive component locations (e.g., surge line elbow), in order to determine the extent of any fatigue crack initiation and growth

Industry Actions (Continued)

- Perform a review of available reactor water environmental effects data for relevance to plant operating environments
- Revise EPRI technical report TR-105759, *An Environmental Factor Approach to Account for Reactor Water Effects in Light Water Reactor Pressure Vessel Piping and Fatigue Evaluations,* considering recommendations of the PVRC Steering Committee on Cyclic Life & Environmental Effects
- Develop a plan and cost to test representative portions of full-scale piping systems subjected to severe thermal gradient loadings in order to determine their actual fatigue limit

Conclusions

Industry actions are intended to affirm the adequacy of existing fatigue management programs