February 25, 2000

MEMORANDUM TO: Edmund J. Sullivan, Chief
NDE and Metallurgy Section
Materials & Chemical Engineering Branch
Division of Engineering

FROM: Shou-nien Hou ***/ra/***
NDE and Metallurgy Section
Materials & Chemical Engineering Branch
Division of Engineering

SUBJECT: TRIP REPORT - PVRC COMMITTEE MEETINGS

During February 7-9, 2000, I attended the Pressure Vessel Research Council (PVRC) meetings in Tampa, Florida. The committees which I participated in as a member include Steering Committee on Cyclic Life and Environmental Effects (CLEE), Committee on Dynamic Analysis and Testing (DAT), and Committee on Piping, Nozzles and Vessels (PNV). Highlights of these Committee meeting follow.

CLEE Committee Meeting

- I was requested to make a presentation (Attachment 1) to the committee on recent NRC activities related to environmental effects on fatigue, including findings and resolutions of GSI-190, its impact on staff positions on fatigue for license renewal, staff consensus on effective environmental correction factors (the "Z" factors), staff concerns on related issues, and NRC expectation on the ASME Code committee works. My presentation resulted in the following response:

  -- Reaction of CLEE members on resolution of GSI-190 appeared favorable. Discussions were focus on clarification of related issues, and they appeared to understand that the resolution was based on an integrated consideration on risk, design margins, and defense-in-depth.

  -- As a response to my inquiry on status of ASME Code modification, a draft letter (Attachment 2) from John Ferguson, Chairman of ASME Board of Nuclear Codes and Standards (BNCS) to John Craig, Director of DET/RES/NRC was distributed by the CLEE. The draft letter was intended to reponse to Craig's letter dated December 1, 1999, which requested the ASME Code to address issues related to effects of reactor water environment on fatigue life of nuclear plant components. However, the Ferguson letter only mentioned ASME SC III and SC XI efforts and their joint efforts with NRC staff and contractors, and it did not address specific NRC concerns. Judging from their muted response to my inquiry, it appeared that no actual progress was made by the ASME Code Committees. Spencer Bush of CLEE is also a member of the BNCS. He urged that NRC should pay special attention to a joint meeting on February 28, 2000 (see Attachment 2) of Subcommitte on Design and Subgroup on Design of SC III, and

Subgroup on Evaluation of Standards of SC XI. As indicated in the Ferguson letter, NRC participation in the meeting was requested for outlining issues and developing a plan of action for resolution.

- M. Higuchi from Japan presented the status and progress of on-going and planned activities in Japan regarding environmental effects on fatigue (Atachment 3), including S-N data, evaluation method, piping and vessel verification tests, and tests for effects of strain rate, temperature, and dissolved oxygen on fatigue life. Recent publications on related subjects were also introduced.

- For creating a model for the crack growth rate, effects of stress corrosion should be considered. Such effects are likely in the BWR environment, but is negligible in the PWR environment. As published in NUREG/CR-6176, ANL had conducted some testing on fatigue crack growth in austenitic stainless steels. However, testing on low-oxygen environments was planned and not yet conducted. For developing Code procedures applicable for both BWR and PWR environments, CLEE is soliciting GE input for formulating da/dN and da/dt for the crack growth under a BWR environment.

DAT Committee Meeting

- Code Case 2211 was first approved in 1994 and reaffirmed in 1999. In the past, over pressure protection was accomplished by relying on RCS relief valves, which may not always ensure safety due to potential uncertainty in valve operability. The Code Case provides an alternative approach for protection through system design. DAT discussed the possible further revision of the Code Case using risk based approach.

- A draft of a final report on a heat exchanger fluid mechanics study was complete and on the process of DAT balloting for publication as a Welding Research Council (WRC) Bulletin. However, a concern was raised that the analytical solutions by a computer program were not verified against experimental data. The report is currently under further DAT review for resolving member's comments.

- A study on vortex-induced fluid forces on oscillating cylinders by Robert D. Blevins was complete, including resolution of all DAT comments. A final report of the study was published in the November/December WRC Progress Report. This report is available on request.

- A study on response of burried piping to surface impact loads by A. Gupta is complete and is under final editoral checks for publication as a WRC Bulletin.

PNV Committee Meeting

- The task group on plastic design had an intense discussion on comments from the PNV members on a draft final report. The comments were on the following difficulties of running a plastic analysis:

  -- Material behavior in a plastic region is difficult to define accurately.

-- Lack of guidance on how to formulate boundary conditions at local regions.

-- Lack of procedures on handling weld joints, which are locations of stress concentration.

-- Plastic analysis results are likely incompatible with “shake down” mechanism and limits which were assumed and widely accepted by the ASME Code.

-- It is difficult to verify a plastic analysis program. If verified by testing, component-spectic effects need to be properly considered. If verified by simplified ASME Code analysis, accuracy of Code analysis results is very much in question.

-- Plastic analysis modeling is complex and much more costly and time consuming than equivalent elastic analysis using Code equations. Thus even though a set of generic guidance may be developed on plastic analysis, its application is likely to be restricted to case-specific evaluation.

-- The draft final report will be further revised to resolve comments.

Attachments: As stated

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Presentation to PVRC Steering Committee for Cyclic Life and Environmental Effects in Nuclear Application

NRC ACTIVITIES

2/8/2000 by S. Hou

- **Resolution of GSI-190**

  -- **<u>Methodology</u>:**

  Using probabilistic fracture mechanics code to evaluate core damage frequencies (CDF), and the leakage and failure probabilities, with (ANL data) and without (ASME S-N curves) environmental effects, of 47 reactor coolant pressure boundary components from 7 operating plants.

  -- **<u>Impact of 60-year environmental effects</u>:**

  (A) Increase failure probability about a factor of 100. (Significant)

  (B) Increase CDF about 1E-06. (Insignificant)

  (C) Increase leakage probability several orders to values 1E-03 to 1E-01. (Significant)

  -- **<u>Resolution</u>:**

  (A) Applies only to 10 CFR 54 for license renewal (LR) of operating plants for 60 years.

ATTACHMENT 1

(B) No new or additional generic requirements -- No backfitting.

(C) No change in staff position.

(D) Per Part 54, aging effects on fatigue must be addressed, including environmental effects.

(E) Each LR licensee should implement an acceptable fatigue monitoring program

-- Resolution is based on an integrated consideration on risk, design margins, and defense-in-depth

☆ Draft SRP/LR identifies fatigue as a time-limited aging analysis (TLAA) that must be evaluated per 10 CFR 54.21(c).

☆ Fatigue monitoring programs for first two LR applicants were reviewed

-- Monitoring usage factors and considering environmental effects at high fatigue locations.

☆ Expeditious effort by ASME is urged, through Code revision, to establish industry consensus standard on method for accounting environmental effects

☆ **Staff consensus on the “Effective” environmental correction factors (the Z factors)**

Mr. John W. Craig
Director
Division of Engineering Technology
Office of Nuclear Regulatory Research
United States Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Mr. Craig,

We have received your letter of December 1, 1999 requesting that ASME address issues related to effects of reactor water environment on fatigue life of light water reactor components.

As you pointed out these issues have been under discussion for a number of years. A presentation of the findings of the PVRC study has been made to Subcommittee Design (SC-D) and Subgroup Design (SG-D) of Subcommittee III (SC III). This item has been on the agenda of SC-D and their Subgroup on Fatigue Strength which are charged with reviewing the technical adequacy of new design rules and making recommendations to book subcommittees as to whether these rules should be adopted. SG-D of SC III is then responsible for reviewing the applicability to nuclear components of any new rules recommended by SC Design and for proposing any changes in Section III rules to SC III.

In addition Subcommittee XI (SC XI) has been reviewing the results to determine their impact on Section XI ISI rules and on the fatigue evaluation criteria and methodology of Appendix L which permits the usage factor evaluation given in Section Ill.

There currently is not a consensus regarding the need to make any changes to the Code to address these effects. Issues being discussed, which need to be addressed by both SC III and SC XI, include actual service experience versus results predicted by laboratory tests, margins needed for fatigue acceptance criteria, and the extent to which fatigue cracking is a safety issue.

We accept your offer to have NRC staff and contractors work with our committees on this matter. While we recognize that they will be coming to meetings as supporters of your specific requests, we hope that they will be open to other proposals and that they can influence NRC's positions on this matter if deemed appropriate by them.

Because of your letter and the possible effect on Plant Life Extension evaluations, we are moving this item to the high priority list in SC III. A joint meeting of SC-D, SG-D and Subgroup Evaluation Standards of SC XI will be held on Monday evening February 28th in Daytona Beach, Florida during the next Boiler and Pressure Vessel meeting. The purpose of this meeting is to outline the issues and develop a plan of action for resolution. We believe that it is important for NRC representatives to attend this meeting and we request that they be prepared to make a short (10- 15 minute) presentation on your

request. We would appreciate your advising Richard Barnes (rwbarnes@ican.net), Chair of SG-D, as to whether you will be able to accommodate this request.

Thank you for your letter. Under ASME Codes and Standards Redesign we are committed to prioritizing actions to ensure our primary efforts are spent on items which count the most to our users. Your input is very helpful to this process.

Sincerely,

John H. Ferguson
Vice President
Nuclear Codes and Standards

CC:
G.M. Eisenberg
D.A. Canonico, BPV Standards Committee
OF. Hedden, SC XI
C.J. Pieper, SC III
R.A. Barnes, SG-D
D.P. Jones, SC-D
R.E. Gimple, SC XI
W.H. Bamford, SGES
D.W. Peltola, SWGPLEX

JAPANESE ACTIVITIES ON CYCLIC LIFE AND ENVIRONMENTAL EFFECTS FOR NUCLEAR APPLICATIONS

Makoto Higuchi

Presented to the Steering Committee on CLEE
PVRC Winter Meeting, February 8, 2000
Safety Harbor Resort and Spa
Safety Harbor, Florida

ON GOING PROJECT

1. JAPEIC EFT Project
   - The EFT project had started in 1994, then will continue to 2006.
   - To obtain many fatigue S-N data for several kinds of material in a wide variety of environments (temperature and dissolved oxygen) and strain rate conditions.
   - To establish the appropriate fatigue evaluation method for operating nuclear plants based on obtained results.

2. JAPEIC SAF Project
   - The SAF project had started in 1991, then will continue to 2000.
   - To assess the integrity of aged plants during operation, assuming that the equipment and piping of the aged plants have small cracks.
   - 12B piping model verification test (crack growth test in air and water)
   - 1/2.5-scale RPV vessel model verification test
   - Crack growth evaluation (crack growth test in air and water using small specimens)

3. Other projects

   - EAC-J (EAC round robin tests for alloy 600)
   - Private companies etc.: IHI MHI Hitachi, Toshiba and NRIM

ATTACHMENT 3

PROGRESS OF EFT PROJECT

The test results obtained until the end of March in 2000 may be about 40% of the whole tests scheduled.

The all of tests scheduled in this fiscal year should be finished and the annual report will be completed until the end of March in 2000.

The test data obtained in this fiscal year may be offered to PVRC in the spring or fall meeting in 2000 and one paper concerning the effect of water flow rate on environmental fatigue life was submitted to the 2000 ASME PVP Conference held in Seattle.

The future project plan is not fixed. It is re-examined in every year. However, the total amount of tests will be reduced because of reducing fund.

The new working group to study the evaluation method has been started in June. The tentative evaluation methods to assess the effects of water environment on fatigue lives for carbon, low alloy and austenitic stainless steels may be proposed until the end of this fiscal year.

EFT- Fundamental Fatigue Tests in LWR Environments

To collect fundamental fatigue data, such as the effects of strain rate, temperature and dissolved oxygen on environmental fatigue life for structural materials used in the pressure boundary of LWR components. Following tests are presently performed:
(1) STS410 (Low-S) CS BM in simulated BWR environment
(2) STS410 (Low-S) CS WM in simulated BWR environment
(3) STS410 (High-S) CS BM in simulated BWR environment
(4) Type 316NG SS BM in simulated BWR environment (New item)
(5) Type 316 SS BM in simulated PWR environment
(6) SCS 14A SS Casts in simulated PWR environment (New item)
(7) STS480 CS BM in simulated PWR environment

EFT Fatigue Tests of Plant Component Models in LWR Environments

To characterize and evaluate the parameters expected in operating plants

(1) Effects of varying strain rate on fatigue life for CS and SS (IHI)

(2) Effects of varying temperature on fatigue life (MHI)

(3) Effects of notch on fatigue life (Toshiba)

(4) Effects of biaxial straining on fatigue life (MHI) (Discontinued ?)

(5) Cumulative fatigue damage (IHI)

(6) Effects of water flow rate on fatigue life (Hitachi)

(7) Determination of the crack initiation lifetime in environments

(MHI, IHI, Hitachi, Toshiba)

PUBLICATION FROM JAPAN

1. 2000 ASME PVP Conference

Six papers have been submitted in the environmental fatigue sessions in ASME PVP

Conference held in Seattle, July 22 to 27, in 2000.

(1) Effect of Water Flow Rate on Fatigue Life, of Carbon Steel in Simulated BWR Water Environment (A. Hirano and M. Yamamoto (Hitachi), T Shoji (Tohoku Univ.), K. Sakaguchi and K. lida (JAPEIC)) (EFT)
(2) Fatigue Life Reduction in PWR Water Environment for Stainless Steels (K. Tsutsumi, H. Kanasaki and T Umakoshi (MHI), I Nakamura and S. Urata (KEPCO))
(3) Revised Proposal of Fatigue Life Correction Factor Fen for Carbon and Low Alloy Steels in LWR Water Environments
(M. Higuchi (IHI))
(4) Validation of Modified Rate Approach for Environmental Fatigue Evaluation (K. Kishida (IHI))
(5) An Example of BWR Operational Thermal Cycles in Japan (T Terakado, T. Sakai and H. Ohata (The Japan Atomic Power Co.))
(6) Environmental Fatigue Evaluation on Japanese Nuclear Power Plants (H. Ohata (JAPC'), I Inagaki (TEPCO), K. Bunno (KEPCO), 0. Maekawa (Toshiba), T Umakoshi (MHI) and M. Hisatsune (Hitachi))