UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

October 22, 2008

The Honorable Dale E. Klein
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

SUBJECT: STATUS OF RESOLUTION OF GENERIC SAFETY ISSUE-191, "ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

Dear Chairman Klein:

During the 556th meeting of the Advisory Committee on Reactor Safeguards, October 2-3, 2008, we discussed progress made towards resolving Generic Safety Issue (GSI)-191, regarding potential sump screen blockage during loss-of-coolant accidents (LOCAs). Since our last report on August 1, 2006, our Subcommittee on Thermal Hydraulic Phenomena reviewed this matter during meetings on May 16, 2007, and March 19 and September 23, 2008. During these meetings, we had the benefit of discussions with representatives of the NRC staff, the Pressurized Water Reactor Owners Group (PWROG), the public, and of the documents referenced.

We previously reported on GSI-191 on July 19, October 18, and December 10, 2004, and April 10 and August 1, 2006.

CONCLUSIONS AND RECOMMENDATIONS

1. Significant progress has been made towards resolving GSI-191.

2. All licensees have installed significantly larger sump screens and some have undertaken further actions, such as changing fibrous insulation and chemical buffer.

3. Nearly all licensees have conducted head loss testing for their new screen systems. The staff has developed adequate guidance to support its review of tests that are conducted using procedures which ensure that substantially all the fine scale debris is transported to the screens.

4. To ensure the prototypicality of tests for extrapolation to plant conditions, further guidance should be developed for the test cases in which a significant portion of the debris is allowed to settle out upstream of the screens.

5. Adequate guidance has been developed to support review of the testing of the effects of chemical reaction products on screen head loss.

6. Programs are being put in place to determine the amount of debris and chemical products that passes through sump screens, as well as their effects on core cooling. Guidance should be developed to ensure that these tests cover a wide enough range of conditions to support the staff's review of in-vessel downstream effects.

7. The staff has proposed a systematic process that, with the development of the guidance we have recommended, will provide an acceptable framework for closure of GSI-191.

BACKGROUND

Events that occurred at Barseback-2 (1992), Perry-1 (1993), and Limerick-1 (1995) resulted in substantial plugging of Boiling Water Reactor (BWR) emergency core cooling system (ECCS) strainers by debris transported to the strainers during these events. BWR licensees were, therefore, requested to implement modifications to reduce potential clogging of the strainers, to which they responded by installing larger screens.

In view of the BWR experience, GSI-191 was initiated to assess the potential for debris accumulation on the ECCS sump screen to interfere with the long-term cooling of a pressurized water reactor (PWR) core following a LOCA.

A parametric study of PWR sump screen performance concluded that screen blockage was likely and that plant-specific evaluations were necessary. This led to the issuance of Generic Letter 2004-02, which requested all PWR licensees to:

- Use an NRC-approved methodology to perform a mechanistic evaluation of the potential for the adverse effects of post-accident debris blockage and operating with debris-laden fluids to impede or prevent the recirculation functions of the ECCS and containment spray system following all postulated accidents for which the recirculation of these systems is required.

- Implement plant modifications or other corrective actions that the above evaluation identifies as being necessary to ensure system functionality.

In 2004, the Nuclear Energy Institute issued guidance which, together with the staff's safety evaluation, provided a methodology to address the first point in Generic Letter 2004-02. The effectiveness of the corrective actions taken to ensure system functionality specified in the second point has proven difficult to confirm.

On several occasions, we have reported on progress toward resolution of GSI-191. In our April 10, 2006, report, we endorsed the installation of larger screens in all PWRs as an important step in assuring that screen head losses would be acceptable. However, we were skeptical that the

matter could be considered resolved. We expressed concerns about the prototypicality of screen head loss tests, the effects of chemical reaction products, and particle/fiber mats that could form on screens. We also expressed concern that increasing screen area, though it could reduce head loss, might result in more fiber debris passing through the screens and increase downstream effects.

Since our last report, our Thermal Hydraulic Phenomena Subcommittee held three meetings to review staff and industry efforts to resolve GSI-191. The first of these was to review, among other things, head loss tests performed for four different plants and the proposed strategies to ensure adequate long-term cooling. Concern was expressed about the extrapolation of limited-scale tests to plant conditions, as well as the validity of the calculational methods being proposed to account for the reduction in debris loads at the screens due to settling. The second meeting was to review progress on resolution of downstream effects using a methodology proposed by the PWROG. Among several concerns raised at that time were the adequacy and scope of the experiments proposed to support the methodology. The third meeting was to review the progress in screen head loss testing and chemical effects analyses as well as the ongoing experiments on downstream effects.

DISCUSSION

All licensees have made significant progress in implementing the provisions of Generic Letter 2004-02 by completing installation of much larger sump screens. Almost all plants have conducted head loss tests. Review of these test results has been completed for some plants and is in progress for the others. The tests cannot be generic as plants have different layouts, sources of debris, chemical characteristics, and sump screen designs. Furthermore, some licensees have undertaken other modifications, such as replacing fibrous insulation, changing chemical buffers, and modifying water management strategies. All this has led to each plant adopting a somewhat different approach to responding to Generic Letter 2004-02.

Whatever approach is adopted, the central issue is the head loss characteristics of the installed sump screen system under LOCA conditions. Scaled-down tests that can be extrapolated to plant conditions have proven difficult to design. However, some tests have taken a conservative approach in which substantially all the fine-scale debris is transported to the sump screens. Provided the order in which this debris arrives at the screen is carefully controlled such that particles arrive first, the fibers arrive next, and chemical reaction products arrive last, there is reasonable assurance that the measured head losses will bound what might be expected in the plant. There are matters related to debris preparation, debris introduction, and thin bed effects that should be taken into account. Based on its observations of several tests and the lessons learned from its test reviews, the staff has developed guidance for reviewing head loss testing for conditions where essentially all the fine-scale debris is transported to the sump screen. We concur with the staff's guidance.

For some licensees, tests are being performed under conditions in which a substantial part of the debris may settle before reaching the screens. The applicability of these tests is more problematic as the turbulence-induced suspension characteristics of scaled-down flows are difficult to relate to actual plant conditions. For tests in which credit is taken for settling of debris, the staff should develop further guidance to ensure that the measured head losses are indeed conservative or demonstrably representative of plant conditions.

Chemical products formed in LOCA environments can accumulate on the screens and cause large increases in head losses. Surrogates have been developed, and approved, to emulate these effects for use in the screen head loss tests. The guidance provided by the staff to take such effects into account is acceptable.

With regard to in-vessel downstream effects of debris that passes through the sump screens, much remains to be done. In some sense, for long-term recirculation, the core serves as a second screen in series with the sump screen, with pumps and coolers in between. The concern centers on how much debris is captured on this second screen, how it is distributed, and whether the head losses that result are low enough to ensure that core cooling is maintained. Preliminary experiments indicate fairly uniform debris layers will form. For such situations, the staff has performed calculations to evaluate acceptable levels of head loss.

The PWROG has initiated a series of tests using core configurations, flow conditions, and debris loadings that are meant to be representative of LOCA conditions. Currently, the plan calls for testing with flow rates that might arise in hot-leg breaks. These tests should encompass a wider range of conditions, including those representative of cold-leg breaks. Also, the fiber length characteristics and loading in the downstream effects tests must be carefully evaluated. Size distributions and loadings of debris used in the tests must include material representative of that which flows through the sump screen and gets into the core in the first few passes.

The staff should develop guidance with regard to the conditions and protocols for the PWROG tests to facilitate closure of issues related to in-vessel downstream effects.

A topical report on in-vessel downstream effects, which was previously submitted to the NRC staff for approval, is being revised. When this report is approved, licensees seeking approval for analyses of long-term cooling will be able to refer to this report. This will facilitate closure of in-vessel downstream effects. However, licensees will have to show that the findings in the topical report are applicable to their long-term recirculation scenarios.

The staff has proposed a systematic process for closure of GSI-191 which proceeds from licensees submitting information in response to Generic Letter 2004-02, through detailed staff review, followed by review and documentation of findings by an Integration Review Team (IRT). The IRT looks at the whole problem of assuring long-term coolability, puts the review of a specific submission in the context of others to ensure consistency, and conveys its recommendations to the management. At each step in the process, requests for additional information are made and licensee responses factored in until closure is reached. The necessary technological underpinnings for this process, with the additions noted above in regard to guidance and testing, are in place.

We endorse the closure process proposed by the staff and commend the staff for its deliberate and systematic approach to addressing a complex regulatory task.

Dr. William J. Shack did not participate in the Committee's deliberations regarding chemical effects tests.

Sincerely,

/RA/

Mario V. Bonaca
Vice-Chairman

REFERENCES

1. Andreychek, T.S., et. al., "Evaluation of Long-Term Cooling Considering Particulate and Chemical Debris in the Recirculating Fluid," Westinghouse Electric Company, WCAP-16793-NP, May, 2007, ML071580139

2. U.S. Nuclear Regulatory Commission, Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," September 13, 2004, ML042360586

3. Letter from Mario V. Bonaca, Chairman, Advisory Committee on Reactor Safeguards, to Luis A. Reyes, Executive Director for Operations, U.S. Nuclear Regulatory Commission, "Proposed Draft Final Generic Letter on Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at PWRs," July 19, 2004, ML042040160

4. Report from Mario V. Bonaca, Chairman, Advisory Committee on Reactor Safeguards, to Nils J. Diaz, Chairman, U.S. Nuclear Regulatory Commission, "Safety Evaluation of the Industry Guidelines Related to Pressurized Water Reactor Sump Performance," October 18, 2004, ML042960409

5. Letter from Mario V. Bonaca, Chairman, Advisory Committee on Reactor Safeguards, to Luis A. Reyes, Executive Director for Operations, U.S. Nuclear Regulatory Commission, "Safety Evaluation of the Industry Guidelines Related to Pressurized Water Reactor Sump Performance," December 10, 2004, ML043500452

6. Report from Graham B. Wallis, Chairman, Advisory Committee on Reactor Safeguards, to Nils J. Diaz, Chairman, U.S. Nuclear Regulatory Commission, "Generic Safety Issue 191 - Assessment of Debris Accumulation on PWR Sump Performance," April 10, 2006, ML061020275

7. Letter from Graham B. Wallis, Chairman, Advisory Committee on Reactor Safeguards, to Luis A. Reyes, Executive Director for Operations, U.S. Nuclear Regulatory Commission, Generic Safety Issue 191 - Assessment of Debris Accumulation on PWR Sump Performance, August 1, 2006, ML062190098

8. Nuclear Energy Institute, NEI-04-07, “Pressurized Water Reactor Sump Performance Evaluation Methodology,” May 28, 2004, ML041550279, ML041550332, ML041550359, ML041550380

9. U.S. Nuclear Regulatory Commission, “Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02,” Nuclear Energy Institute Guidance Report (Proposed Document Number NEI 04-07), “Pressurized Water Reactor Sump Performance Evaluation Methodology,” December 6, 2004, ML043280641

10. “Knowledge Base for Emergency Core Cooling System Recirculation Reliability," Prepared by U.S. Nuclear Regulatory Commission for the Principal Working Group 1 (PWG-1), International Task Group, Committee on the Safety of Nuclear Installations, Organization for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA), NEA/CSNI/R (95) 11, February 1996

11. U.S. Nuclear Regulatory Commission, Information Notice 93-34, “Potential for Loss of Emergency Cooling Function Due to a Combination of Operational and Post-LOCA Debris in Containment," April 26,1993

12. U.S. Nuclear Regulatory Commission, Bulletin 95-02, "Unexpected Clogging of a Residual Heat Removal (RHR) Pump Strainer While Operating in Suppression Pool Cooling Mode," October 17, 1995

13. D. V. Rao, B. Letellier, C. Shaffer, S. Ashbaugh, and L. Bartlein, "GSI-191 Technical Assessment: Parametric Evaluation for Pressurized Water Reactor Recirculation Sump Performance," NUREG/CR-6762, Volumes 1-4, August, 2002, ML022470074, ML022470076, ML022470093, ML022480182, ML022480262

8. Nuclear Energy Institute, NEI-04-07, “Pressurized Water Reactor Sump Performance Evaluation Methodology,” May 28, 2004, ML041550279, ML041550332, ML041550359, ML041550380

9. U.S. Nuclear Regulatory Commission, “Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02,” Nuclear Energy Institute Guidance Report (Proposed Document Number NEI 04-07), “Pressurized Water Reactor Sump Performance Evaluation Methodology,” December 6, 2004, ML043280641

10. “Knowledge Base for Emergency Core Cooling System Recirculation Reliability," Prepared by U.S. Nuclear Regulatory Commission for the Principal Working Group 1 (PWG-1), International Task Group, Committee on the Safety of Nuclear Installations, Organization for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA), NEA/CSNI/R (95) 11, February 1996

11. U.S. Nuclear Regulatory Commission, Information Notice 93-34, “Potential for Loss of Emergency Cooling Function Due to a Combination of Operational and Post-LOCA Debris in Containment," April 26,1993

12. U.S. Nuclear Regulatory Commission, Bulletin 95-02, "Unexpected Clogging of a Residual Heat Removal (RHR) Pump Strainer While Operating in Suppression Pool Cooling Mode," October 17, 1995

13. D. V. Rao, B. Letellier, C. Shaffer, S. Ashbaugh, and L. Bartlein, "GSI-191 Technical Assessment: Parametric Evaluation for Pressurized Water Reactor Recirculation Sump Performance," NUREG/CR-6762, Volumes 1-4, August, 2002, ML022470074, ML022470076, ML022470093, ML022480182, ML022480262

Distribution:

CSantos	ADias	DBessette
HNourbakhsh	GShukla	MBanerjee
PWen	ZAbdullahi	SDuraiswamy
HVandermolen	CLBrown	DWidmeyer
MLee	JFlack	VMurphy
JDelgado	NColeman	CJaegers
TBloomer	BChamp	ABates
SMcKelvin	LMike	RidsSECYMailCenter
RidsEDOMailCenter	RidsNMSSOD	RidsNSIROD
RidsFSMEOD	RidsRESOD	RidsOIGMailCenter
RidsOGCMailCenter	RidsOCAMailCenter	RidsOCAAMailCenter
RidsNRROD	RidsNROOD	CAntonescu

Accession No: ML082810710 **Publicly Available (Y):** Y **Sensitive (N):** N
Viewing Rights: X NRC Users or ☐ ACRS Only or ☐ See Restricted distribution

OFFICE	ACRS	SUNSI Review	ACRS	ACRS	ACRS
NAME	DBessette	DBessette	CSantos/ADias	EMHackett	EMH for WJS
DATE	10/ 21 /08	10/ 21 /08	10/ 21 /08	10/ 22 /08	10/ 22 /08

OFFICIAL RECORD COPY