POLICY ISSUE
(Information)

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FOR: The Commissioners

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SUBJECT: STATUS OF RESOLUTION OF GSI-191, "ASSESSMENT OF [EFFECT OF] DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

PURPOSE:

The purpose of this paper is to inform the Commission of the status of the resolution of Generic Safety Issue (GSI) 191, "Assessment of [Effect of] Debris Accumulation on Pressurized-Water Reactor (PWR) Sump Performance." This paper does not address any new commitments.

SUMMARY:

The industry is making progress in developing plant-specific specifications for the type and size of PWR containment emergency core cooling system (ECCS) sump screens. Most PWR licensees intend to substantially enlarge the sump screens with passive designs, and the remaining licensees are planning to replace sump screens with active designs. As of March 24, 2006, the staff has received five requests to delay installation of sump screen modifications beyond December 31, 2007, and intends to evaluate those requests with the criteria provided in this paper.

This paper discusses (1) the status of the resolution of GSI-191, (2) staff plans for resolving GSI-191, and (3) staff activities for communicating Nuclear Regulatory Commission (NRC) expectations to licensees.

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BACKGROUND:

GSI-191 concerns the possibility that debris generated by a loss-of-coolant accident (LOCA) could accumulate on the ECCS sump screen, resulting in a loss of net positive suction head margin. Debris passing through the screen may degrade downstream components such as pumps, valves, and heat exchangers or plug or restrict heat exchanger or fuel flow channels. These phenomena may prevent the ECCS from meeting the criteria of Section 50.46 of Title 10 of the Code of Federal Regulations, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors." Section 50.46(b)(5) requires that licensees design their ECCS systems with capability for long-term cooling. After a successful system initiation, the ECCS must be able to provide cooling to maintain the core temperature at an acceptably low value for a sufficient duration.

During a high-energy primary coolant line break inside the containment of a PWR, energetic pressure waves and fluid jets would impinge on materials near the break such as thermal insulation, coatings, and concrete, damaging and dislodging them. In addition to debris generated by jet forces from the pipe rupture or latent debris in containment entrained by break or spray water flows, **debris from unqualified or degraded qualified coatings could be generated as a result of the pressure, temperature, and humidity inside the containment. Finally,** chemical products could be created by reactions between the materials in containment and the containment environment following a LOCA. A fraction of the generated debris, latent debris, disbonded coatings, and chemical products might be transported to the pool of water on the containment floor. For a number of postulated LOCA scenarios, the ECCS and containment spray system (CSS) pumps take suction from the recirculation sump, and the debris in the containment pool could subsequently accumulate on the sump screen or be transported into the ECCS and CSS.

The accumulation of the debris on the sump screen would create a debris bed, which would increase the head loss across the screen through a filtering action. If enough debris accumulated, the debris bed could reach a critical thickness such that the head loss through the screens would exceed the net positive suction head margin required to ensure the successful operation of the ECCS and CSS pumps in the recirculation mode. This sump screen clogging could result in severely degraded pump performance, eventual pump failure, and loss of the ECCS and CSS function.

Debris that passes through the sump screen could plug or cause excessive wear of close-tolerance components, deposit on surfaces within the ECCS or CSS systems, or impede coolant flow or cooling capability within the reactor vessel. These phenomena are referred to as "downstream effects." The plugging or wear might cause a component to degrade to the point where it could not perform its designated function (e.g., pump fluid, maintain system pressure, remove heat, or pass and control system flow). Debris that passes through the recirculation sump screen could lodge at a downstream flow restriction such as a high-pressure safety injection throttle valve or the fuel assembly inlet area. Debris blockage at such flow

restrictions would impede or prevent the recirculation of coolant through the reactor core, leading to inadequate core cooling. Debris could also deposit on the reactor fuel, reducing the efficiency of decay heat transfer to the recirculating fluid. Debris blockage at flow restrictions in the CSS flowpath, such as containment spray nozzles, would impede or prevent CSS recirculation, leading to inadequate containment heat removal. Debris could also accumulate in close-tolerance subcomponents of pumps and valves. The effect could be either to plug the subcomponent, thereby rendering the component unable to perform its function, or to wear critical close-tolerance subcomponents to the point of degrading component or system function.

Containment coating debris is generated from destruction of coatings within the zone of influence and from postulated failure of degraded qualified coatings and unqualified coatings outside the zone of influence. The zone of influence is the volume of space affected by the impact of energetic pressure waves and fluid jets from a high-energy line break.

In 2004, the staff developed a generic letter (GL) to assist the resolution of GSI-191. In a June 1, 2004, letter commenting on a draft of the proposed GL, the Nuclear Energy Institute (NEI) requested a 5-month extension of the due date (from April 1, 2005, to September 1, 2005) for the requested information, in part to allow licensees time to address chemical effects (ML041550866). The NRC granted this request and changed the due date for licensees submitting the information requested in the GL to September 1, 2005.

On September 13, 2004, the NRC issued the final version of the GL as GL 2004-02, “Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors (PWRs).” This GL requested all PWR licensees (1) to use an NRC-approved methodology to perform a mechanistic evaluation of the potential for post-accident debris blockage and operation with debris-laden fluids to impede or prevent the recirculation functions of ECCS and CSS following all postulated accidents for which these recirculation functions are required and (2) to implement plant modifications or other corrective actions which the evaluation identifies as necessary to ensure system functionality by December 31, 2007. If they could not complete all corrective actions by December 31, 2007, licensees were asked to describe how they would meet the applicable regulatory requirements referenced in the GL until the corrective actions were completed.

On December 6, 2004, the staff issued a safety evaluation of a May 28, 2004, NEI report (ML041550279) on “Pressurized Water Reactor Containment Sump Evaluation Methodology.” The NEI report, in conjunction with the staff’s safety evaluation (ML043280007 and ML043280008), provided a method acceptable to the staff for evaluating PWR sump performance as requested in the GL.

DISCUSSION:

Status of Licensee GL responses

The GL requested licensees to provide a significant amount of information by September 1, 2005, so that the NRC would have assurance that effective corrective actions were being taken. The September 2005 licensee GL responses revealed that licensees of 66 of the 69 PWRs committed to replace sump screens; the licensees of the remaining 3 PWRs had previously replaced their sump screens.

However, despite the fact that the staff gave the industry an additional 5 months to respond to the GL at the NEI's request, much of the information submitted by licensees was incomplete. For example, the September 2005 licensee GL responses revealed that licensees did not appear to have made significant progress in addressing chemical, downstream, and coatings issues. Two PWR licensees indicated that they would not meet the December 2007 deadline for completing sump modifications.

The staff recently sent requests for additional information to PWR licensees to supply the information missing from the September 2005 GL responses. In a letter dated February 28, 2006, NEI stated that the effort necessary to prepare responses to the requests for additional information on the originally requested schedule would divert resources and attention from the plant strainer modifications and jeopardize the current modification schedules. The staff agreed with the NEI proposal and licensees will now provide supplements to their GL responses by December 31, 2006, for licensees that complete sump screen modifications by that date; and within 90 days of outage completion (but not later than December 31, 2007) for licensees that complete sump screen modifications after 2006.

Criteria for Evaluating Delay of Hardware Changes

The industry has been developing an understanding of certain aspects of chemical and coatings behavior in a post-LOCA environment and establishing an acceptable methodology for evaluating downstream effects. We believe that some licensees may find it difficult to meet the December 2007 deadline for installing a sump screen system that fully demonstrates conformance with the functional requirements. Several licensees have either requested or are planning to request extensions to delay implementation of sump modifications to beyond December 31, 2007. Although the GL stated that the new mechanistic licensing basis should be effective on December 31, 2007, when modifications were to be completed, the staff will consider reasonable extension requests to delay the implementation of final hardware modifications. Provided such extension requests are found acceptable, the new mechanistic licensing basis will be invoked after the modifications are completed.

Proposed extensions to permit changes at the next outage of opportunity after December 2007 may be acceptable if, based on the licensee's request, the staff determines that:

- the licensee has a plant-specific technical/experimental plan with milestones and schedule to address outstanding technical issues with enough margin to account for uncertainties and

- the licensee identifies mitigative measures to be put in place prior to December 31, 2007, and adequately describes how these mitigative measures will minimize the risk of degraded ECCS and CSS functions during the extension period.

For proposed extensions beyond several months, a licensee's request will more likely be accepted if the proposed mitigative measures include temporary physical improvements to the ECCS sump or materials inside containment to better ensure a high level of ECCS sump performance.

Status of Research Activities

The NRC, in collaboration with the Electric Power Research Institute, conducted testing to address concerns about the formation of chemical reaction products in the ECCS containment pool. The testing showed that (1) chemical products/precipitates and gelatinous-like material can form under certain chemical environments in a PWR containment pool during the post-LOCA recirculation phase and (2) changes to important containment parameters such as pool temperature and pH, insulation debris type, and debris concentrations can affect the type and nature of chemical byproducts that form.

A series of NRC-sponsored head loss tests are underway to determine the potential for chemical products to increase the head loss associated with sump screen debris beds. The first test series is investigating the head loss caused by the formation of calcium phosphate due to the reaction of dissolved calcium in environments buffered with trisodium phosphate. Calcium silicate insulation is a prominent source of dissolved calcium in some plants, but other insulation materials and uncoated concrete are also sources. The objective of this test series is to realistically encompass expected post-LOCA containment pool conditions.

The initial results demonstrate that there could be a significant head loss contribution from chemical products associated with calcium silicate/trisodium phosphate containment pool environments. Testing of calcium silicate concentrations representative of reported plant conditions has resulted in significant head loss in these chemical environments due to the formation of chemical products. The NRC issued Information Notice 2005-26 (ML052570220) and follow-on Supplement 1 (ML060170102) to provide the results of head loss tests in an environment containing calcium silicate and trisodium phosphate. The staff is continuing head loss testing for chemical byproducts that developed in simulated PWR sump pool environments that use chemical species other than trisodium phosphate to buffer pH. This testing will be completed in spring 2006.

In addition to research on chemical effects, research is being conducted to address concerns about head loss from debris and about coatings transport. Testing is underway to evaluate head loss associated with standard PWR containment debris materials and to provide data that will be used to develop analytical head loss correlations. Testing is also underway to evaluate the transportability of coating chips to the sump screen and to understand chip characteristics that may affect transportability. Both testing activities will be completed in spring 2006.

Public Meetings With Licensees, Industry, and Advisory Committee on Reactor Safeguards (ACRS)

The staff has held regular public meetings with PWR licensees to share information on the NRC-sponsored test program and to provide feedback on related industry activities. Such meetings were held in December 2004 and January, April, June, September, and November 2005. On February 2, 2006, the staff met with the Palisades nuclear power plant licensee to discuss its plan to temporarily remove trisodium phosphate buffering agent from the containment. This change is intended to reduce uncertainty with regard to sump screen

performance resulting from chemical effects associated with calcium silicate/trisodium phosphate until the licensee makes a permanent change to the screen, plant insulation material, and/or the buffering agent. During the meeting the staff asked questions regarding various technical aspects of the proposed change. The licensee stated that they would address these aspects in a license amendment request.

On February 9, 2006, the staff held a public meeting with the industry regarding the status of resolution of GSI-191. The staff expressed concerns with the September 2005 licensee responses to the GL and reemphasized the need for the licensees to meet the December 2007 date for completing sump performance modifications and corrective actions. The staff and industry discussed results from recent chemical effects head loss testing for calcium silicate/trisodium phosphate environments and the status of ongoing research. Also, the licensees of 6 PWRs using calcium silicate insulation and trisodium phosphate buffering agent inside containment discussed actions taken or planned relevant to the Information Notice 2005-26 Supplement. The staff considered the meeting effective in communicating the staff's concerns and expectations regarding licensee GL responses.

The staff continues to interact with the ACRS on GSI-191. In February 2006, the staff met with the ACRS Thermal-Hydraulics Phenomena Subcommittee to discuss progress and future plans on GSI-191 issues. The staff briefed the ACRS Full Committee on March 9, 2006. On March 24, 2006, the ACRS provided a letter to the Commission on GSI-191. In general, the letter supports the staff's emphasis on near-term improvements to containment sumps to reduce the risk of sump screen clogging. In addition, the ACRS calls for the staff to develop improved predictive methods and guidance in several technical areas related to GSI-191. The staff is reviewing the letter and developing a response.

Audits of Selected Licensees

The staff is conducting audits to verify the adequacy of sump modifications and corrective actions in response to the GL. The staff audited two volunteer pilot plants (Crystal River and Fort Calhoun) in 2005. The pilot audits were intended to contribute to the resolution of GSI-191 by providing timely feedback on the implementation of the NRC-approved methodology. For example, the first pilot audit conducted at Crystal River revealed that the licensee used an approach that seemed reasonable to design replacement sump screens. The staff is currently conducting two audits (at Oconee and Watts Bar) and plans to conduct six more audits during 2006 and 2007.

RESOURCES:

The staff plans for resolving GSI-191 discussed in this paper are not expected to require additional resources. The impact of the application of the revised GL extension criteria on NRC resources is expected to be minimal in FY 2007 and beyond.

COORDINATION:

The Office of the General Counsel has no legal objection to this paper.

/RA/

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