

POLICY ISSUE INFORMATION

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FOR: The Commissioners

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SUBJECT: ALTERNATE APPROACHES FOR RESOLVING THE PRESSURIZED WATER REACTOR SUMP BLOCKAGE ISSUE (GSI-191), INCLUDING REALISTIC AND RISK-INFORMED CONSIDERATIONS

PURPOSE:

The purpose of this paper is to inform the Commission regarding:

1. staff plans to permit licensees to use alternate approaches for resolution of the pressurized water reactor (PWR) sump blockage issue,
2. the staff's schedule for issuing its safety evaluation report on the industry evaluation guidelines methodology, and
3. the staff's expectations for addressing chemical effects impacts on PWR sump blockage.

SUMMARY:

This paper outlines the regulatory and technical elements necessary to establish a useful and effective alternate approach to resolving Generic Safety Issue (GSI) 191, "Assessment of Debris Accumulation on PWR Sump Performance," and describes the direction the staff is taking to implement such an approach.

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BACKGROUND:

Findings from research performed to resolve the boiling water reactor (BWR) emergency core cooling system (ECCS) strainer plugging issue in the late 1990s raised questions concerning the adequacy of PWR sump designs. These findings prompted the Nuclear Regulatory Commission (NRC) to open GSI-191. The objective of GSI-191 is to ensure that post-accident debris blockage does not impede or prevent the operation of the ECCS and containment spray system (CSS) in the sump recirculation mode in the event of a loss-of-coolant-accident (LOCA) or other high-energy line break (HELB) accident which may require sump recirculation. NRC-sponsored research concluded that recirculation sump clogging is a credible concern for domestic PWRs. The research program mechanistically treated phenomena associated with debris blockage using analytical models of domestic PWRs that were generated with a combination of generic and plant-specific data. As a result of the limitations with respect to plant-specific data and other modeling uncertainties, the research results do not definitively identify whether particular PWR plants are vulnerable to sump clogging.

The staff is implementing a two-step regulatory approach to resolve GSI-191. This approach includes issuing a bulletin and a generic letter. The NRC issued Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors," in June 2003. The purpose of the bulletin was to inform PWR licensees of the potential for debris blockage of the ECCS and CSS sumps and flowpaths and to request that licensees confirm compliance with Title 10 of the Code of Federal Regulations, Part 50, Section 50.46(b)(5) (10 CFR 50.46(b)(5)) regarding long-term cooling and any other applicable regulatory requirements. Alternatively, licensees were requested to describe any compensatory measures implemented to reduce the potential risk due to post-accident debris blockage until evaluations to determine compliance are completed.

The staff is preparing to issue a generic letter to address final resolution of this issue. The draft generic letter, issued for public comment on March 31, 2004 (ADAMS Accession No. ML040830518), requested licensees to perform analyses to demonstrate compliance with 10 CFR 50.46(b)(5), considering the updated staff position regarding PWR sump performance. Although not yet issued, it is expected that the final generic letter will request the same information. Additionally, it is expected that licensees will be requested to provide information that considers the updated PWR sump design basis requirements no later than September 1, 2005. The generic letter will also request a description of, and implementation schedule for, all corrective actions, including any plant modifications that may be necessary to ensure compliance with the applicable regulations. Licensees will be requested to provide justification for any corrective actions that will not be completed by the end of the first refueling outage that begins after April 1, 2006. The staff expects that all licensees will have completed any necessary modifications, and in turn, resolved this issue by December 31, 2007.

The staff is currently reviewing PWR sump performance evaluation guidance developed by Nuclear Energy Institute (NEI) and the industry. This effort has focused on development of a deterministic and mechanistic methodology for evaluating sump performance under post-accident conditions. In conjunction with developing a deterministic approach, the staff is also developing, through interactions with industry, an alternate approach that licensees could implement to resolve GSI-191.

DISCUSSION:

Alternate Resolution Approach

For the last several years, the NRC has recognized that probabilistic risk assessment (PRA) has evolved to the point that it can be used increasingly as a tool in regulatory decisionmaking. Through its policy statement on PRA (ADAMS Accession No. ML021980535), the Commission expressed its expectation that enhanced use of PRAs will improve the regulatory process in three ways: through safety decisionmaking enhanced by the use of PRA insights; through more efficient use of agency resources; and through a reduction in unnecessary burden on the licensees.

Specific to GSI-191, the Commission recently requested the staff to “implement an aggressive, realistic plan to achieve resolution and implementation of actions related to PWR ECCS sump concerns.” One such resolution path that the staff is considering involves the LOCA break size used in PWR sump analyses. For example, it is well understood that the amount of debris generation to be expected following a LOCA is dependent on the break size, and generally that less debris would be generated with a smaller LOCA break size (although less debris generation may be worse in certain situations when considering debris type and break location). The staff is already working to risk-inform 10 CFR 50.46 to redefine the design basis large-break LOCA break size based on expected LOCA frequencies. A comparable approach for use in GSI-191 resolution would identify a “debris generation” break size which would be used to distinguish between customary and more realistic design basis analyses. To this end, the NRC staff is working to develop alternative approaches which consider realistic and risk-informed elements for use in resolution of GSI-191, and are informed by and consistent with ongoing staff efforts to risk-inform 10 CFR 50.46. The GSI-191 alternate resolution approach is intended to be at least as conservative as any forthcoming revision to 10 CFR 50.46.

On May 25, June 17, and June 29, 2004, the staff met with NEI, industry representatives, and stakeholders in category 2 meetings to discuss alternate realistic and risk-informed approaches for resolution of the PWR sump issue. Throughout these meetings, both NRC and NEI staff presented proposals regarding technical and regulatory elements of alternative approaches, and progress is being made toward reaching an acceptable alternative approach.

The alternative approach includes elements which are both realistic and risk-informed. For such an approach, licensees would continue to perform design basis long-term cooling evaluations and satisfy design basis criteria for all LOCA break sizes up to a new “debris generation” break size. The “debris generation” break size is smaller than a double-ended rupture of the largest pipe in the reactor coolant system (RCS). Long-term cooling must be assured for breaks between the new “debris generation” break size and the double-ended rupture of the largest pipe in the RCS, but the evaluation may be more realistic than a customary design basis evaluation, consistent with the small likelihood of the break occurring. Additionally, any physical modifications to plant equipment or operator actions credited to demonstrate mitigative capability for these larger breaks would not necessarily need to be safety-related or single-failure-proof. Changes to the existing facility designs and credit for operator actions would include risk calculations, consistent with Regulatory Guide 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis.” Licensees would need to ensure that the changes to the

facility design would have sufficient reliability to provide reasonable assurance that SSCs will perform their intended function.

While not a component of the 10 CFR 50.46 ECCS evaluation model, the calculation of sump performance is necessary to determine if the sump and the residual heat removal system are configured properly to provide enough flow to ensure long-term cooling, which is an acceptance criterion of 10 CFR 50.46. Therefore, the staff considers the modeling of sump performance as the validation of assumptions made in the ECCS evaluation model. The modeling of sump performance is a boundary calculation for the ECCS evaluation model, and acceptable sump performance is required for demonstrating long-term core cooling capability (10 CFR 50.46 (b)(5)). On this basis, such an alternative approach might require plant-specific license amendment requests or requests for exemptions from the regulations, depending on each licensee's chosen resolution approach. Licensees could request, on a plant-specific basis, exemptions from requirements associated with demonstrating long-term core cooling capability (10 CFR 50.46 (b)(5)). For example, exemptions from the requirements of 10 CFR 50.46(d) may be required if a licensee chose to classify new equipment as non-safety-related or non-single-failure proof. For purposes of GSI-191 resolution, exemption requests would not be applicable to the other acceptance criteria of 10 CFR 50.46 (peak cladding temperature, maximum cladding oxidation, maximum hydrogen generation, and coolable geometry), and would be submitted in accordance with existing NRC regulations (10 CFR 50.12). License amendment requests may be needed for changes in analytical methodology or assumptions. Licensees would assess the need for license amendment requests in accordance with the requirements of 10 CFR 50.59.

NRC staff review and acceptance of such plant-specific license amendment or exemption requests would consider the following elements:

- ▶ Application of the principles of Regulatory Guide 1.174. (defense-in-depth, safety margins, delta core damage frequency, delta large early release fraction)
- ▶ Consistency with NUREG-0800 (Standard Review Plan), Section 19, "Use of Probabilistic Risk Assessment in Plant-Specific, Risk-Informed Decisionmaking: General Guidance."
- ▶ Design basis, deterministic analyses necessary to verify compliance with 10 CFR 50.46 (b)(5) for break sizes up through the "debris generation" break size.
- ▶ Acceptable mitigative capability up through the double-ended rupture of the largest pipe in the RCS. The equipment needed for mitigative capability would have some functional reliability requirements, but would not necessarily need to be safety-related or single-failure-proof.

One key element of Regulatory Guide 1.174 involves assurance that defense-in-depth is maintained. Although a "debris generation" break size would be selected to distinguish between customary and more realistic design basis analyses, licensees would demonstrate acceptable mitigative capability for LOCA break sizes up through a double-ended rupture of the largest pipe in the RCS. This philosophy is consistent with recent recommendations made by

the Advisory Committee on Reactor Safeguards (ACRS) in its April 27, 2004, letter to the Chairman. However, it is very important to note that an alternative approach for resolving GSI-191 would not redefine the design basis LOCA break size.

The “debris generation” break size to distinguish between customary and more realistic design basis analyses is defined as follows:

- ▶ All American Society of Mechanical Engineers (ASME) Code Class 1 PWR auxiliary piping (attached to RCS main loop piping) up to and including a double-ended rupture of any of these lines.
- ▶ RCS main loop piping (hot, cold and crossover piping) up to a size equivalent to the area of a double-ended rupture of a 14 inch schedule 160 pipe (approximately 196.6 square inches).

The selection of a break size equivalent to the area of a double-ended rupture of a 14 inch schedule 160 pipe for RCS main loop piping generally bounds attached auxiliary piping sizes in PWRs, and is also consistent with 10 CFR 50.46 rulemaking direction (at this time). As mentioned previously, in developing this alternate approach for GSI-191 resolution, the staff intends to remain consistent with the ongoing 10 CFR 50.46 rulemaking effort.

Interactions between the staff and NEI have yielded this alternative GSI-191 resolution approach, which considers realistic and risk-informed elements. NEI documented significant portions of this alternative approach and submitted a revised Section 6 of the evaluation guidelines report on July 13, 2004. The alternative approach discussed in this NEI document incorporates many of the technical and regulatory elements discussed throughout the public meetings on this topic. The staff will review the NEI methodology and document its review as part of the NEI evaluation guidelines safety evaluation report (SER). The staff will note exceptions to and supplement the NEI methodology through the SER, as necessary. The NEI evaluation guidelines SER is scheduled to be issued in October 2004.

Schedule Status

On July 16, 2004, Los Alamos National Laboratory (LANL), the contractor working with the staff to review the NEI evaluation guidelines, stopped work due to security and safety concerns. Work was restarted on July 28, 2004; however, certain infrastructure and administrative work remains on hold. Because of this delay, the staff could not provide the Advisory Committee on Reactor Safeguards (ACRS) a draft safety evaluation in time to support a September full committee meeting. The ACRS has asked for a complete safety evaluation a month prior to a full committee meeting. The next opportunity for a full committee meeting is October 7-9. The staff revised a number of intermediary milestones to minimize the impact of this contractor delay. The delay results in rescheduling the issuance of the GSI-191 SER from September 30, 2004, to October 29, 2004, to accommodate the revised ACRS review schedule. This schedule revision will not impact the planned final resolution date for GSI-191, which will remain the end of 2007.

Chemical Effects

The chemical effects impact on PWR sump performance is still being evaluated, and an integrated test program has been developed through a collaborative effort between the NRC and industry. Initial testing is expected to begin in August 2004, and be completed in December 2004. This schedule is also adversely impacted by the recent LANL work stoppage. In order to address chemical effects on a plant specific basis, licensees will initially need to evaluate whether the chemical effects test parameters are sufficiently bounding for their plant specific conditions. If plant specific materials are not bounded by the chemical effects test parameters, licensees should provide technical justification to use any results from the chemical effects tests in their plant specific evaluation. If deleterious chemical effects are observed during these tests, licensees should evaluate the sump screen head loss consequences of this effect in an integrated manner with other postulated post-LOCA effects. In addition, a licensee who chooses to modify their plant sump screens prior to the completion of chemical effects testing and analysis of the test results should consider potential chemical effects in order to ensure a second plant modification is not necessary should deleterious chemical effects be observed during testing. The staff's SER documenting its review of the NEI evaluation guidelines will include this position.

RESOURCES:

There are resources in the budget for GSI-191 resolution through FY2006. The NRR budget for FY2005 and FY2006 includes 2 FTE for each year. The total estimated resources to support the technical work necessary to review and approve license amendment requests and risk-informed exemption requests is considered part of the expected NRR workload involving licensing actions.

COORDINATION:

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

The Office of the Chief Financial Officer has reviewed this Commission paper for resource implications and has no objections.

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