

Assess Debris Accumulation on PWR Sump Performance, GSI-191

Findings from research and industry operating experience have raised questions concerning the adequacy of PWR sump designs. Research findings demonstrated that the amount of debris generated by a high-energy line break (HELB) could be greater, the debris could be finer (and thus more easily transportable), and that certain combinations of debris (e.g., fibrous material plus particulate material) could result in a substantially greater head loss than an equivalent amount of either type of debris alone. In 1996, these findings prompted the U.S. Nuclear Regulatory Commission (NRC) to open Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on PWR Sump Performance." This resulted in additional research in the late 1990s. GSI-191 focuses on reasonable assurance that the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46(b)(5) are met. This rule requires maintaining long-term core cooling after initiation of the ECCS. The objective of GSI-191 is to ensure that post accident debris blockage will not impede operation of the emergency core cooling system (ECCS) and containment spray system (CSS) in recirculation mode at PWRs during LOCAs or other HELB accidents for which sump recirculation is required. The NRC completed its initial research of GSI-191 in 2002 and documented the results in a parametric study which concluded that sump clogging at PWRs was a credible concern.

GSI-191 research concluded that debris clogging of sump strainers could lead to recirculation system ineffectiveness as a result of a loss of net positive suction head (NPSH) for the ECCS and CSS pumps. Resolution of GSI-191 involves two distinct but related safety concerns: (1) potential clogging of the sump strainers that results in ECCS and/or CSS pump failure; and (2) potential clogging of flow channels within the reactor vessel by debris that penetrates or bypasses the sump strainer (in-vessel effects). Clogging at either the strainer or in-vessel channels can result in loss of the long-term cooling safety function. An issue that has already been addressed is the potential for debris to adversely affect pumps, valves, and other components downstream of the sump strainers.

After completing the technical assessment of GSI-191, the NRC issued Bulletin 03-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML031600259), on June 9, 2003. As a result of the emergent issues discussed in Bulletin 03-01, the NRC staff requested an expedited response from PWR licensees on the status of their compliance with the regulatory requirements concerning the ECCS and CSS recirculation functions based on a mechanistic analysis. All PWR licensees responded to Bulletin 03-01. The NRC staff reviewed all licensee Bulletin 03-01 responses and found them acceptable.

In developing Bulletin 03-01, the NRC staff recognized that it might be necessary for licensees to undertake complex evaluations to determine whether regulatory compliance exists in light of the concerns identified in the bulletin and that the methodology needed to perform these evaluations was not currently available. As a result, that information was not requested in Bulletin 03-01, instead licensees were informed that the NRC staff was preparing a generic letter (GL) that would request this information. GL 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004 (ADAMS Accession No. ML042360586), was the follow-

on information request referenced in Bulletin 03-01. This document set the expectations for resolution of PWR sump performance issues identified in GSI-191, to ensure the reliability of the ECCS and CSS at PWRs. NRR requested and obtained the review and endorsement of the GL from the CRGR (ADAMS Accession No. ML040840034).

GL 2004-02 requested that addressees perform an evaluation of the ECCS and CSS recirculation functions in light of the information provided in the letter and, if appropriate, take additional actions to ensure system function. Additionally, addressees were requested to submit the information specified in this letter to the NRC. This request was based on the potential for debris to adversely affect ECCS and CSS functions during design basis accidents.

Resolution of GSI-191 has been more difficult than anticipated. Based on the interactions with stakeholders and the results of the industry testing, the NRC staff in 2012 developed three options that were considered to be effective ways to resolve GSI-191. These options were documented and proposed to the Commission in SECY-12-0093, "Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance," dated July 9, 2012 (ADAMS Accession No. ML121310648). The options are summarized as follows:

- Option 1 allows licensees to demonstrate compliance with 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," through approved models and test methods. Plants that use Option 1 for closure will be relatively low fiber plants with less than 15 grams of fiber per fuel assembly.
- Option 2 allows implementation of additional mitigative measures and additional time for licensees to resolve issues through further industry testing or use of a risk informed approach.
 - Option 2 Deterministic: Industry is performing additional testing and analysis to increase in-vessel debris limits and documenting this work in a topical report for NRC review and approval. The topical report has been submitted to the NRC.
 - Option 2 Risk Informed: This option allows risk-informing the effects of debris on long term cooling. South Texas Project (STP) is the pilot for this effort and their submittal is currently under review by the NRR staff.
- Option 3 involves separating the regulatory treatment of the sump strainer and in-vessel effects. The strainer will be evaluated deterministically (as in Option 1) and in-vessel issues will be treated using a risk-informed methodology.

The options allowed industry alternative approaches for resolving GSI-191. The Commission issued a Staff Requirement Memorandum on December 14, 2012 (ADAMS Accession No. ML12349A378), approving all three options for closure of GSI-191.

In June 2013 South Texas Project (STP) (ADAMS Accession No. ML13175A211) submitted a pilot license amendment, and exemption requests to implement a risk-informed approach to resolving GSI-191. The initial submittal was superseded in its entirety by a revised version dated November 13, 2013 (ADAMS Accession No. ML13323A183). The licensee evaluated the risk associated with debris by comparing the performance of the as-built plant to an ideal plant that has no debris-related issues. The staff is currently reviewing the application and has issued requests for additional information (RAIs). The licensee has responded to the RAIs and the

staff is currently reviewing the responses as well as a supplement to the LAR that was received in August 2015. The staff and the licensee met with Advisory Committee on Reactor Safeguards (ACRS) Subcommittees on Thermal-Hydraulics Phenomena and Reliability and PRA on September 3, 2014. Additional subcommittee meetings and a full-committee ACRS meeting are planned prior to the NRC completing its review of the application.

Other plants choosing the risk informed option for resolution of GSI-191 will submit applications in a staggered schedule after STP is approved. The following is a list of plants that have chosen the risk-informed option for resolution of GSI-191:

- STP Units 1 and 2 (Pilot)
- Callaway
- Diablo Canyon Units 1 and 2
- Palisades
- Seabrook
- St Lucie Units 1 and 2
- Turkey Point Units 3 and 4
- Vogtle Units 1 and 2
- Wolf Creek
- Calvert Cliffs 1 and 2 (recently changed to the risk-informed option)

In addition, the NRC staff is coordinating the development of a risk-informed proposed rulemaking, 10CFR50.46c, with the review of the Option 2B plants. The Commission directed the staff to develop a risk-informed option to 10 CFR 50.46 long term core cooling requirement with respect to debris. Lessons learned from the review of the STP application are being incorporated into regulatory guidance for implementation of this rule. The public comment period for the draft version of the guidance (Draft Guide 1322) closed on July 6, 2015 and over 200 comments were received. The staff is currently working to address these comments and anticipates publishing a final version of the guidance (Regulatory Guide 1.229) in parallel with the final rule in 2016.

Several Option 1 plants have closed GL 2004-02. The Option 2 and 3 plants will be closed as information that demonstrates compliance with the regulations is received by the NRC.

The Commissioners' Technical Assistants are briefed by the staff every six months on the status of the closure of GSI-191.