

Historical Perspectives and Insights on ACRS Review of PWR Sump Performance

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INTRODUCTION

The 1992 clogging of intake strainers for containment spray water during an incident at Barsebäck-2, a BWR in Sweden, renewed the focus of regulators around the world on safety questions associated with strainer clogging which, until then, had been considered as resolved.

In light of insights gained during the assessment of BWR suction strainers and oversight of BWR plant-specific evaluations and modifications, Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on PWR Sump Performance," was initiated to assess the potential for debris accumulation on Emergency Core Cooling System (ECCS) sump screens to interfere with the long-term cooling of a pressurized water reactor (PWR) core following a loss of coolant accident (LOCA).

For over 50 years the Advisory Committee of Reactor Safeguards (ACRS) has had a continuing statutory responsibility for providing independent reviews of, and advice on, the safety of proposed or existing reactor facilities and the adequacy of proposed reactor safety standards. The ACRS has played a continuing role toward resolution of the PWR sump performance issue. In particular the Committee raised the issues such as chemical effects and downstream blockage and cooling effects that were not originally considered.

This paper presents an overview of technical issues surrounding PWR sump performance and its impact on long term cooling and containment atmospheric cleanup requirements during design basis accidents. It then summarizes the past observations and recommendations regarding the sump performance issue made in the Committee's reports.

PWR SUMP PERFORMANCE ISSUE

The containment sump in a pressurized water reactor is a part of the ECCS. Debris blockage of the sump

screens during a design basis LOCA could impede the long-term operation of the ECCS or containment spray systems. Debris can also pass through sump screens and have adverse effects on the flow and heat transfer in downstream components including pumps and fuel assemblies.

Technical issues surrounding the debris accumulation on PWR sumps and its impact on long-term cooling and containment atmospheric cleanup requirements during design basis accidents are highly complex. Included are the debris generation by jet impingement from the pipe rupture, transport of the generated debris and foreign material (latent debris) in the containment to water pools formed on the containment floor, chemical reactions in a post-accident containment environment that generates debris as precipitates, accumulation of debris on the recirculation sump screens, and the potential for debris to pass through sump screens and subsequently lodge at downstream flow restricted locations such as fuel assemblies.

ACRS REVIEW OF PWR SUMP PERFORMANCE

ACRS review of the PWR sump performance issue has a long history, dating back to early 1980s, when the Committee discussed containment emergency sump performance as a part of Unresolved Safety Issue (USI) A-43. Since 2001, the ACRS Subcommittee on Thermal-Hydraulic Phenomena has held numerous meetings to discuss issues associated with GSI-191 (Ref. 1). The Committee has issued ten letter reports on the subject since that time.

In its September 14, 2001 letter (Ref. 2), the ACRS recommended that the NRC Staff "expeditiously resolve GSI-191" and "if plant-specific analyses are required as part of the resolution, guidance for performing these analyses be developed."

In a December 20, 2005 Staff Requirements Memorandum (Ref. 3), the Commission directed the ACRS to “make among its highest priorities its role in the resolution of GSI-191.” The Commission also directed the staff to “expedite efforts to provide the ACRS with information necessary to make its assessment and recommendations.” The Commission further noted that it “continues to value the independent technical views of the ACRS on significant matters under consideration by the agency.”

On several occasions, the ACRS has reported on progress toward resolution of GSI-191. In its April 10, 2006 report (Ref. 4), the ACRS endorsed the installation of larger screens in all PWRs as an important step in assuring that screen head losses would be acceptable. However, the ACRS 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. The Committee 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.

In its September 17, 2010 report (Ref. 5), the ACRS noted that those measures taken or being taken, with regard to sump screen blockage by 46 of 69 PWR plants are satisfactory, and there is now a clear path forward to resolving GSI-191 provided that in-vessel effects can be dealt with. These measures include increases in sump screen area in all plants, removal of fibrous and particulate insulation in some, and changes of buffering chemicals in others. The measures needed are plant specific and require testing under representative LOCA conditions. Guidance has been developed for such testing to confirm the adequacy of the measures taken for a specific plant. With regard to downstream effects, the Committee noted that “what is not clear is whether the measures taken to resolve the GSI-191 issue with regard to sump screen blockage, while going a long way towards alleviating problems, will be sufficient to also resolve GSI-191 for potential in-vessel blockage.” Extensive testing of downstream blockage effects is underway and the impact of the results still requires assessment though it is already clear that many of the measures that have already been taken to mitigate screens blockage effects have also mitigated downstream effects.

Most of the plants that have not yet achieved closure with regard to sump screen blockage have large amounts of fibrous insulation. In 2010, the Commission directed the NRC staff to submit a policy paper on approaches to close GSI-191, addressing factors such as worker radiation dose and hazardous material exposures, and

risk-informed versus deterministic approaches (Ref. 6). In SECY-10-0113, the staff presented various options for bringing GSI-191 to closure. In its September 17, 2010 report (Ref. 5), the ACRS concluded that the option which maintains the current holistic resolution process and the option which would develop risk-informed guidance that takes into account the lower probability of large-break loss of coolant accidents (LOCAs), are both acceptable, provided that a reasonable schedule for reaching resolution is adopted.

REFERENCES

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4. Report dated April 10, 2006, from Graham B. Wallis, Chairman, ACRS, to Nils J. Diaz, Chairman, U.S. NRC, Subject: Generic Safety Issue-191, "Assessment of Debris Accumulation on PWR Sump Performance."
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6. U.S. NRC, “Staff Requirements Memorandum – Briefing on Resolution of Generic Safety Issue (GSI) – 191, Assessment of Debris Accumulation on Pressurized Water (PWR) Sump Performance,” May 17, 2010.