Issue 202: Spent Fuel Pool Leakage Impacts

DESCRIPTION

Historical Background

Spent fuel pools (SFPs) at PWRs are Seismic Category I structures that contain borated water, maintain spent fuel temperatures, and provide radiation shielding. The SFPs are typically lined with stainless steel plates, joined by full-penetration welds, on the inner surface of the reinforced concrete SFP structures. The vast majority of SFPs also have leakage collection systems (channels embedded in concrete at weld seams) that are designed to collect any borated SFP water that might leak through the liner for processing as radioactive waste water.

These systems also provide a means of monitoring SFP leakage.

This issue involves the potential for long-term leakage of borated water through the SFP liners, reactor cavities, and fuel transfer canals at PWRs, to degrade the concrete support structures and associated reinforcement steel (i.e., rebar) if the leak-off channels are clogged. If not properly drained, long-term leakage of borated water through the liners will accumulate, wet the concrete behind the liner, seep through cracks in the concrete, and reach the rebar within the concrete. If not corrected, over a long period of time this condition could degrade the concrete and rebar and potentially compromise the structural integrity.

In September 2002, Salem Unit 1 identified evidence of radioactive water leakage through the interior walls or penetrations in both the auxiliary and fuel handling buildings (FHB). Investigations of the leakage by the

licensee in February 2003 revealed the radionuclide tritium in the groundwater near the FHB. Further licensee inspections identified long-term leakage of borated water from the SFP through cracks into the structural walls of the SFP. The licensee determined that the SFP leak-off channels (i.e., tell-tale drains) that drain borated SFP water collected between the pool liner and concrete walls were clogged. Since the Salem Unit 1 finding, similar conditions involving SFP structures were discovered at Indian Point and Seabrook (transfer canal). Based on

these discoveries, NRR proposed[1] that the issue be addressed as a generic issue, in accordance with NRC Management Directive (MD) 6.4, "Generic Issues Program."

Safety Significance

SFP leakage has the potential to degrade the integrity of SFP structures due to the adverse impact of borated water on concrete and its rebar. That is, borated water can seep through cracks in the concrete, reduce the inherent high alkaline environment of concrete, and possibly expose rebar in the vicinity of these cracks to mildly acidic conditions. The degree of potential degradation would be expected to vary among facilities as the SFP leak rates, concrete conditions (alkalinity, porosity, and cracking), and degree of leak-off channel flow

restrictions vary. In accordance with their corrective action programs, the licensees of plants where this condition was discovered have evaluated the short-term and long-term safety concerns (e.g., potential degradation of

the SFP basemat and potential reductions in design license margins of the SFP structures). In each case, the licensees' evaluations determined there was no immediate safety concern and no long-term degradation in the

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design license margins of the SFP structures from borated water leakage.[2,3] The potential adverse impacts of SFP leakage on groundwater and possible consequent effect of the leakage on public health and safety was evaluated in 2006 as part of an NRC task force on ground water contamination from leakage of radioactive water

from various sources at several licensee facilities.[4]

Possible Solution

Information on the impact of borated water leakage through reinforced concrete structures at PWRs is limited.

In many cases, the affected structures are subterranean and inaccessible, and leakage may not be readily detectable or repaired. The NRC issued generic communications to licensees to inform them of these conditions

and the potential adverse consequences.[5,6] Licensees are required to maintain the design license basis of plant structures, systems, and components important to safety. The NRC monitors licensee performance and responds to conditions adverse to safety and quality at plants under the reactor oversight process (ROP). Accordingly, the existing regulatory framework provides sufficient means for licensees and the NRC to prevent, detect, and correct SFP leakage conditions that could adversely impact SFP structural integrity over the long term. If industry experience were to show an adverse trend developing in this area, then research to gain additional information on the impact of borated water leakage through reinforced concrete structures might be warranted.

SCREENING ANALYSIS

The PWR licensees that discovered SFP leakage conditions described above have taken corrective actions to preclude adverse impact to the long-term integrity of the Seismic Category I structures. For these few instances, the NRC used the ROP to review and assess the condition and the licensee actions to address the condition, and determined that the licensees' actions were adequate to maintain the plants' design license basis. The NRC also issued generic communications to inform plant licensees of these conditions and their potential adverse consequences. Accordingly, this issue was considered to be adequately monitored and addressed through existing regulatory programs. The following summarizes specific SFP leakage conditions discovered at Salem, Indian Point, and Seabrook plants.

Salem Unit 1: NRC and licensee reviews identified long-term leakage of the SFP through structural cracks to onsite groundwater. A visual inspection of the tell-tale leak-off drains revealed significant blockage with

boric acid and calcium deposits. The licensee concluded that the blocked leak-off drains resulted in SFP water accumulation in the annulus area between the concrete pool wall and stainless steel liner, which eventually resulted in leakage of the water through construction joints and cracks in the SFP and FHB walls. The licensee initiated action to clear the drains to establish flow in the tell-tales and effectively drain the annulus area.

Subsequently, the tell-tale drain rate held steady at about 100 gallons/day from liner leakage that was not specifically located or repaired. The leakage is being collected and processed as radioactive waste. Licensee monitoring of leakage did not proactively detect the leakage. Rather, a personnel contamination

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[3] Letter to W. Lewis (PSEG) from A. Burritt (U.S. Nuclear Regulatory Commission), "Salem Nuclear Generating Station"NRC Integrated Inspection Report 05000272/2007002 and 05000311/2007002," U.S. Nuclear Regulatory Commission, May 11, 2007. [ML071350075]

[4] "Liquid Radioactive Release Lessons Learned Task Force Final Report," U.S. Nuclear Regulatory Commission, September 1, 2006. [ML062650312]

[5] Information Notice 2004-05, "Spent Fuel Pool Leakage to Onsite Groundwater," U.S. Nuclear Regulatory Commission, March 3, 2004. [ML040580454]

[6] Information Notice 2006-13, "Ground-Water Contamination Due to Undetected Leakage of Radioactive Water," U.S. Nuclear Regulatory Commission, July 10, 2006. [ML060540038]

event prompted

identification of the through-wall leakage. The NRC issued Information Notice No. 2004-05[7] to inform the industry of this event.

The licensee initiated an assessment of potential long-term effects on the structure due to boric acid attack. The assessment covered an extended period of time to effectively simulate long-term boric acid effects on representative concrete specimens, including rebar. The licensee's assessment determined that the design license basis for the SFP structural integrity was maintained for the life of the plant, including during possible

license extension. The licensee committed to routine monitoring of the leak-off flow of the tell-tale drain channels.

Indian Point 2: This plant does not have a SFP leak collection system, and has a history of leakage of borated water which may potentially affect the concrete and steel reinforcement. The licensee and NRC reviewed

the SFP and concluded that the crack did not affect the SFP wall structural integrity. However, groundwater contamination was detected.

Seabrook: The licensee experienced sporadic leakage from its cask loading and transfer canal area during flood-up to support refueling. The area was drained after outages. The cause of this leakage was repaired, and a licensee analysis of the structural integrity of the canal did not identify any resulting adverse conditions. However, groundwater contamination was detected.

CONCLUSION

In addition to 10 CFR 50, Appendices A and B, industry standards existed to ensure a proper and timely evaluation of leaks that may develop in SFPs and the resultant impact on their concrete structures. The concerns of this issue involved long-term degradation of the structures and the adequacy of individual licensee corrective actions for this condition. Therefore, consistent with MD 6.4 and Generic Issues Program

improvements described in SECY-07-0022,[8] this issue was eliminated from further assessment as a generic issue. Additional research on the adverse impact of borated water on SFP concrete and its rebar might be warranted if the industry experienced an increasing adverse trend of this condition with the potential to degrade

the design license basis of the structures.[9]

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[7] Information Notice 2004-05, "Spent Fuel Pool Leakage to Onsite Groundwater," U.S. Nuclear Regulatory Commission, March 3, 2004. [ML040580454]

[8] SECY-07-0022, "Status Report on Proposed Improvements to the Generic Issues Program," U.S. Nuclear Regulatory Commission, January 30, 2007. [ML063460239]

[9] Memorandum for B. Sheron from K. O"Brien, "Results of Initial Screening of Generic Issue 202, 'Spent Fuel Pool Leakage Impacts,'" May 30, 2007. [ML071450125]