POLICY ISSUE
INFORMATION

November 26, 2014 SECY-14-0136

FOR: The Commissioners

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SUBJECT: RESPONSE TO COMMISSION DIRECTION ON SPENT FUEL POOL LIMITED TERM OPERATIONAL VULNERABILITIES

PURPOSE:

The purpose of this paper is to provide the Commission with an assessment of spent fuel pool (SFP) limited-term operational vulnerabilities, as directed by the Commission in Staff Requirements Memorandum (SRM) SRM-COMSECY-13-0030, "Staff Requirements – COMSECY-13-0030 – Staff Evaluation and Recommendation for Japan Lessons-Learned Tier 3 Issue on Expedited Transfer of Spent Fuel," dated May 23, 2014. This paper does not address any new commitments or resource implications.

BACKGROUND:

In COMSECY-13-0030, "Staff Evaluation and Recommendation for Japan Lessons-Learned Tier 3 Issue on Expedited Transfer of Spent Fuel," dated November 12, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13329A918), the staff provided the Commission with an evaluation and recommendation regarding the need for regulatory action to require the expedited transfer of spent fuel to dry cask storage. The staff concluded that expedited transfer of spent fuel to dry cask storage would provide a benefit significantly below the safety goal screening criteria, and that the expected implementation costs would not be warranted. In SRM-COMSECY-13-0030, the Commission agreed with the staff's recommendation.

In SRM-COMSECY-13-0030, the Commission directed the staff to:

> …provide an information paper (classified if necessary) to the Commission, detailing staff's views and considerations regarding the treatment of limited term operational vulnerabilities associated with the discharge of spent fuel from cores

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> into pools and explaining how agency requirements and guidance assure the protection of public health, safety and security; if new vulnerabilities or issues are identified the staff should promptly inform the Commission…

The phrase "limited term operational vulnerabilities" refers to the allowable period of time for licensee's to achieve a dispersed (e.g. 1 x 4) spent fuel configuration in the SFP following discharge from the reactor core. The staff's assessment of SFP limited term operational vulnerabilities and how current requirements assure public health, safety and security are discussed below.

DISCUSSION:

The U.S. Nuclear Regulatory Commission (NRC) has an extensive history of assessing the safety and security of spent fuel stored in pools. The NRC's regulatory activities and past studies have shown that SFPs are effectively designed to prevent accidents. In addition, the NRC has robust security requirements in place to ensure the protection of spent fuel from sabotage and that nuclear power plants operate SFPs without compromising the common defense and security or the health and safety of the public. The NRC's regulatory actions after the terrorist attacks of September 11, 2001 (9/11) and the Fukushima Dai-ichi accident have significantly enhanced the safety of SFPs.

Following the terrorist attacks of 9/11, the NRC undertook many activities to address nuclear power plant safety and security issues. Some of these activities specifically address SFP safety and security. A complete list of these activities is described in the memorandum to the Commission titled, "Documentation of Evolution of Security Requirements at Commercial Nuclear Power Plants with Respect to Mitigation Measures for Large Fires and Explosions," dated February 4, 2010 (ADAMS Accession No. ML092990438). In the course of developing the mitigating measures required by Order EA-02-026, "Order for Interim Safeguards and Security Compensatory Measures," dated February 25, 2002 (ADAMS Accession No. ML020510635, attachment contains safeguards information (SGI)), guidance was issued in a letter to all licensees entitled, "NRC Staff Guidance for Use in Achieving Satisfactory Compliance with February 25, 2002, Order Section B.5.b," dated February 25, 2005 (SGI). This guidance document included the NRC's expectation that nuclear power plants disperse recently discharged fuel in the SFP in order to reduce the likelihood of a radiological release in the event of a loss of cooling water in the SFP. This expectation was reiterated in the staff guidance for the conforming license amendments imposing the fully developed mitigating measures. The guidance on SFP mitigative measures reads as follows:

> [L]icensees are expected to put spent fuel in a 1 x 4 repeating pattern or equivalent, unless otherwise proven to be not applicable or achievable. Licensees who choose to conform to the NRC-approved resolution (NRC letter dated March 16, 2006 (ML060690339 – Official Use Only (OUO)) are expected to include the following concept in procedures: "Where feasible and practical, consistent with safe fuel handling practices, the licensee should make every attempt to pre-configure the spent fuel pool to enable direct placement of the expended assemblies from the vessel to the final distributed fuel pattern. Where this is not feasible or practical, licensees should distribute the fuel into the final pattern as soon as possible but no later than [number removed – sensitive

> information] days after subcriticality." NRC staff can also accept alternate strategies for the timing to achieve the appropriate pattern, which may be discussed in the site specific inspection assessments.

In addition to the mitigation strategies implemented after 9/11, the NRC also issued a number of orders requiring licensees to strengthen security programs. For example, the NRC required licensees to designate the SFP as part of the vital area. This required licensees to develop strategies to protect the SFP from the full range of threats represented in the design-basis threat. In order to ensure that licensees continue to apply the appropriate level of security, the NRC conducts inspections of licensee security programs on a routine basis. The inspection areas include access authorization, access control, security equipment testing, security force training, physical barriers, and intrusion detection and alarm assessment monitoring systems, among other areas. The NRC's inspection of power reactor security also includes security performance evaluations of the licensee's ability to protect the plant from the design-basis threat of radiological sabotage, which are also known as force-on-force exercises.

As discussed in NUREG-1885, "Report to Congress on the Security Inspection Program for Commercial Power Reactors and Category I Fuel Cycle Facilities: Results and Status Update," Revision 7, dated July 2014 (ADAMS Accession No. ML14184A646), the NRC's assessment of security programs during calendar year 2013 concluded that the security programs are providing adequate protection of the common defense and security and no additional actions are necessary to enhance SFP security. Consistent with standing operational guidance, the staff will promptly inform the Commission if it identifies any new vulnerabilities or issues.

NUREG-2161, "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor," dated September 2014 (ADAMS Accession No. ML14255A365) evaluated the potential benefits of strategies required in Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(hh)(2), which the NRC implemented as a result of the terrorist attacks of 9/11. NUREG-2161 found that successful implementation of mitigation strategies significantly reduces the likelihood of a release from the SFP in the event of a loss of cooling water. Additionally, NUREG-2161 found that the placement of spent fuel in a dispersed configuration in the SFP, such as the 1 x 4 pattern, would have a positive effect in promoting natural circulation, which enhances air coolability and thereby reduces the likelihood of a release from a completely drained SFP. An information notice titled, "Potential Safety Enhancements to Spent Fuel Pool Storage," dated November 14, 2014 (ADAMS Accession No. ML14218A493), has been issued to all licensees informing them of the insights from NUREG-2161. This information notice describes the benefits of storing spent fuel in more favorable loading patterns, placing spent fuel in dispersed patterns immediately after core offload, and taking action to improve mitigation strategies when the SFP contains recently discharged spent fuel.

The most recent assessments of SFP safety in NUREG-2161 and COMSECY-13-0030 evaluated seismic events because they have been identified as the largest risk contributor to SFP safety. Malevolent acts were not included in these analyses. Section 9.3 of NUREG-2161 provides an assessment of spent fuel storage in a nondispersed pattern during a refueling outage. For unmitigated cases, the analysis found that the frequency of release would not be different between a nondispersed and dispersed configuration. However, the assessment found that the mitigation equipment required by 10 CFR 50.54(hh)(2) would be less effective when the spent fuel is in a nondispersed configuration. NUREG-2161 notes that for the reference plant

and analyzed scenarios, the spent fuel is estimated to be air coolable for at least 72 hours for all but roughly 10% of the operating cycle (approximately two months). Seventy two hours would likely provide ample time for implementation of mitigating strategies.

The regulatory analysis in COMSECY-13-0030 provided a safety goal screening evaluation by multiplying a bounding initiating event frequency that damages the SFP by the consequences of the resulting radiological release. This analysis conservatively assumed that the mitigation equipment was not available to cool the spent fuel and the damage state would result in a large radiological release. Given these assumptions, a conservative high estimate was calculated for individual latent cancer fatality risk of 1.52×10^{-8} cancer fatalities per year, which is less than one percent of the Commission's safety goal. If this risk value were to be raised by the higher consequence estimates for a nondispersed configuration, noted in Tables 50 and 54 of NUREG-2161 to be on the order of two to three times larger, the SFP risk would still remain significantly below the Commission's safety goal.

The NRC and industry have implemented multiple mechanisms to alleviate the potential for SFP radioactivity release scenarios as a possible vulnerability, including ensuring that equipment would be readily available to mitigate a loss of cooling water in the SFP. To ensure compliance with Order EA-02-026, which was subsequently codified in 10 CFR 50.54(hh)(2), the Nuclear Energy Institute (NEI) provided detailed guidance in "NEI-06-12: B.5.b Phase 2 & 3 Submittal Guideline," Revision 2, dated December 2006 (ADAMS Accession No. ML070090060). The NRC endorsed this guidance on December 22, 2006 (ADAMS Accession No. ML063560235 – OUO) for compliance with those requirements. Under 10 CFR 50.54(hh)(2) all licensees are required to implement strategies such as those provided in NEI-06-12. NEI's guidance specifies that portable, power-independent pumping capabilities must be able to provide at least 500 gallons per minute (gpm) of bulk water makeup to the SFP, and at least 200 gpm of water spray to the SFP. Recognizing that the SFP is more susceptible to a release when in a nondispersed configuration, the guidance also specifies that the portable equipment is to be capable of being deployed within 2 hours for a nondispersed configuration, from the time plant personnel diagnose that external SFP makeup is required, and within 5 hours when the SFP is in a dispersed (e.g. 1 x 4 pattern) configuration. The NRC found the NEI guidance to be an effective means for mitigating the potential loss of large areas due to fires or explosions.

Specific licensee mitigation strategies have been captured in individual licensing basis documents, including safety evaluations, inspection reports, and license conditions. For the majority of SFPs, the approved strategies include passive measures related to the storage of the recently discharged fuel and mitigation capabilities. However, the staff also approved exceptions to the strategies for some pressurized-water reactor (PWR) sites where it is not plausible for cooling water to be lost because the SFP is located below-grade.

Following the Fukushima Dai-ichi accident, the NRC has taken extensive actions to ensure that portable equipment is available to mitigate a loss of cooling water in the SFP. On March 12, 2012, the NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735). This order required licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and SFP cooling capabilities following a beyond-design-basis external event. The NRC endorsed the NEI guidance to meet the requirements of this order. That guidance also establishes additional mechanisms for mitigating a loss of SFP cooling water beyond that required by

10 CFR 50.54(hh)(2), such as installing a remote connection for SFP make-up water that can be accessed away from the SFP refueling floor. These requirements will ensure additional mitigation capability is in place, beyond that required by 10 CFR 50.54(hh)(2), in the unlikely event in which degrading conditions occur in the SFPs.

Based on an informal staff assessment of licensee SFP operational practices, the staff found that licensees generally place spent fuel intended for permanent discharge into a final dispersed (e.g. 1 x 4 pattern) configuration immediately. However, nondispersed configurations in the SFP are a common occurrence at PWR sites during refueling outages when the full-core is discharged into the SFP. This practice is employed to facilitate reactor vessel maintenance and inspection activities when there are a limited number of available fuel storage locations in the SFP. Except for major component replacements, the duration of these temporary discharges has been on the order of 1 to 2 weeks. The staff also conducted a limited sampling of plants that are transitioning to decommissioning status and found that these licensees are placing the spent fuel into the SFP in a dispersed configuration immediately upon discharge from the reactor. As with sites in operation, SFP safety for decommissioning favilities is assured through plant specific license conditions and other requirements. These requirements ensure that SFPs are adequately protected and measures remain in place for cooling and makeup capability after the plant ceases commercial operation.

CONCLUSION:

In summary, the staff's assessment of SFP limited term operational vulnerabilities, as described in this paper, is that current requirements for SFP mitigation measures are sufficient to ensure adequate protection of public health and safety, as well as common defense and security. In COMSECY-13-0030, the staff concluded that the risks from potential SFP accidents are a small contributor to the overall risks for public health and safety (less than one percent of the Commission's quantitative health objectives). As discussed in that paper, the additional risk associated with the storage of spent fuel assemblies in a nondispersed configuration for a limited period of time does not provide a sufficient safety benefit to justify proceeding with regulatory action.

As directed by SRM-COMSECY-13-0030, the staff completed an assessment of potential SFP limited term operational vulnerabilities. In addition to preexisting requirements, the NRC required numerous safety improvements after the terrorist attacks of 9/11, and the Fukushima Dai-ichi accident. These initiatives have enhanced the safety of SFPs. Additionally, after 9/11, the NRC required licensees to put in supplemental security measures. These enhancements help provide a high level of assurance that a terrorist attack cannot impact the SFP safety systems. In conclusion, the staff finds that SFPs are safe and secure and that no additional regulatory action is necessary at this time.

COORDINATION:

The Office of the General Counsel reviewed this package and has no legal objection.

/RA/
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