

SPENT FUEL POOL SAFETY AT OPERATING REACTORS

PROGRAM APPLICABILITY: 2515 Appendix C

60715.01 INSPECTION OBJECTIVES

To verify the safe wet storage of spent fuel at operating reactors. As a special and infrequently performed inspection, inspection requirements may be implemented on a selective basis as necessary to support the purpose of the inspection.

60715.02 INSPECTION REQUIREMENTS

02.01 Spent Fuel Pool (SFP) Coolant Inventory. Verify that design, operational, and administrative measures are in place to prevent a substantial reduction in SFP coolant inventory under normal operating and accident conditions, including technical specifications (TS) surveillance requirements for the acceptable minimum water level above the top of the irradiated fuel assemblies in the SFP. The large SFP coolant inventory assures adequate cooling of the stored fuel, provides shielding, mitigates the consequences of the design-basis fuel handling accident, and maintains some of the initial conditions assumed in the criticality safety analysis. A substantial reduction in SFP coolant inventory is prevented by design features that limit potential drainage and prevent siphoning, reliable operation of the SFP cooling system to limit evaporation of coolant, and capabilities to add make-up water to recover or maintain SFP coolant inventory using permanently installed or portable equipment.

02.02 SFP Criticality Safety. Verify that criticality controls are consistent with the nuclear criticality safety (NCS) analyses of record (AOR) in the facility's Safety Analysis Report (SAR). The NCS AOR considers the geometric arrangement of fuel determined by rack configuration, restrictions on fuel placement included in TS, neutron absorbing material, fuel assembly characteristics (e.g., fuel design, initial enrichment, burnup, and burnable neutron poison loading), soluble boron concentration, and accident conditions that may affect one or more of the preceding characteristics.

- a. Verify, by direct observations or review of selected records, that the fuel assemblies stored in the SFP satisfy technical specification requirements. Also, verify that the licensee has identified each fuel assembly placed in the SFP, recorded the parameters and characteristics of each fuel assembly, and maintained a record of each fuel assembly as a controlled document.

- b. Verify by direct observation or review of selected records that the fixed neutron poisons maintained in the SFP storage racks satisfy the parameters credited in the NCS AOR.
- c. If applicable, verify by review of selected records that SFP boron concentration satisfies technical specification requirements.

02.03 SFP Water Chemistry and Cleanliness. Verify that the SFP chemistry and cleanliness control programs maintain water purity standards, and limits on radionuclide concentration in accordance with the facility licensing basis and TS requirements (if applicable).

02.04 SFP Instrumentation, Alarms, and Leakage Detection. Verify that SFP instrumentation, alarms, and leakage detection systems are adequate to assure the safe wet storage of spent fuel consistent with the facility's licensing basis. Instrumentation and alarms should include water level, temperature, and area radiation levels. In addition, verify that wide-range SFP level instrumentation conforming to the requirements of Order EA-12-051 are in place.

02.05 Strategies to Maintain or Restore Spent Fuel Cooling. Verify that equipment, procedures, and trained personnel are adequate to implement the required strategies, consistent with plant-specific license conditions and the requirements of 10 CFR 50.54(hh)(2).

02.06 Control of Heavy Loads near the SFP. Verify control of heavy loads near and over the spent fuel pool is consistent with the facility licensing basis documented in the SAR.

02.07 Fuel Handling within the SFP. Verify that fuel handling activities unrelated to refueling outages are conducted safely and in accordance with the facility licensing basis. Note: Oversight of fuel handling activities during refueling outages is conducted under IP-71111.20 as part of the baseline inspection program.

02.08 Problem Identification and Resolution. Verify that the licensee is identifying problems related to spent fuel pool activities at an appropriate threshold and entering them in the corrective action program. For a sample of significant problems documented in the corrective action program, verify that the licensee has identified and implemented appropriate corrective actions. For additional guidance, see Inspection Procedure (IP) 71152, "Problem Identification and Resolution."

60715.03 INSPECTION GUIDANCE

General Guidance

The primary objective of this inspection procedure (IP) is to verify that each licensee maintaining spent fuel in wet storage implements appropriate controls and maintains adequate systems to prevent adverse radiological conditions during all modes of operation.

Specific Guidance

03.01 SFP Coolant Inventory Control. Protection against substantial loss of coolant inventory is described in the facility safety analysis report. Design features that protect against drainage are typically included in the TS addressing design features as well as the minimum acceptable

level of SFP water above the top of the irradiated fuel assemblies seated in the storage racks. Other potential causes of significant coolant inventory loss include liner leakage, leakage by seals to adjacent volumes that are drained, and excessive evaporation following loss of forced cooling.

The licensee should be knowledgeable of any potential siphon or drain paths and have plans or procedures that can identify and resolve an inadvertent/undetected drain or siphon. Procedures should include provisions for addition of make-up water to recover from loss of coolant inventory events, including radiation protection and soluble boron management in cases where the inventory loss is significant. Bulletin 94-01 and Information Notices (INs) 88-65 and 87-13 discuss some mechanisms for loss of SFP inventory and the potential consequences of these events.

The licensee should have procedures to provide for reliable forced cooling of the SFP and to respond to a loss of forced cooling. IN 93-83 discusses a scenario where recovery of forced SFP cooling may be challenging.

The licensee should conduct appropriate training to respond and mitigate a loss of SFP inventory. Response actions should be commensurate with safety and maintaining radiation exposure as low as reasonably achievable (ALARA).

The inspector should walkdown and inspect the SFP system (including all accessible points and liner penetrations) for material conditions and integrity; review any repairs conducted on the SFP liner; evaluate system configuration control for permanent and temporary systems connected to the SFP based on field conditions and licensing basis documentation; and, ascertain the seismic qualification of the SFP systems. Particular focus should be on the evaluation of system low points, active and passive drain pathways, primary and secondary makeup water supplies, and SFP boundary integrity control.

03.02 SFP Criticality Safety. Licensees typically document the NCS AOR in the facility SAR. The NCS analyses form the basis for demonstrating compliance with plant TS, compliance with NRC regulations (e.g., 10 CFR 50.68, "Criticality Accident Requirements") and adequate margin to criticality during both normal operating conditions and design-basis events. Generally, a variety of TS requirements and docketed commitments provide sufficient assurance that spent fuel storage will preclude criticality.

In many SFP NCS analyses, neutron-absorbing materials, with assumptions on dimensions and boron-10 (¹⁰B) areal density, are credited for maintaining margin to criticality in the SFP. Hence, these materials must be able to perform their safety function during both normal operating conditions and design-basis events. Unidentified or unmitigated degradation or deformation of the credited neutron-absorbing materials may reduce the safety margin, especially when subjected to additional challenges during and following design-basis events. Many licensees use integrated defense-in-depth design features to account for degradation of the neutron-absorbing material. For example, some pressurized-water reactor licensees rely on the soluble boron concentration in the SFP water to maintain a margin to criticality in accordance with the requirements of 10 CFR 50.68.

Some licensees have technical specification requirements for fuel assembly storage that require careful positioning of assemblies within the storage racks to maintain the specified safety margins. Technical specification requirements may be based on fuel assembly characteristics, specific storage patterns, or both. Fuel assembly operational records, fuel storage plans, and fuel handling procedures contribute to the proper positioning of fuel assemblies in accordance with technical specification requirements. Operating experience described in IN 14-09 indicated that proper fuel assembly positioning requires adherence to TS and careful attention to fuel handling procedures and supporting documentation. In addition, IN 14-14 informed licensees of insights associated with the storage of spent fuel in SFPs gained through study of a reference boiling water reactor SFP. The insights discussed in this IN may help optimize operating practices and event mitigation capabilities to further enhance the safety of spent fuel storage in pools. Finally, the Spent Fuel Pool Criticality Management database ([ML13212A064](#)) compiled by the Office of Nuclear Regulatory Research lists the means by which each operating spent fuel pool in the current US fleet meets its subcriticality requirement.

For SFPs in facilities under a period of extended operation (i.e., renewed licenses), NUREG-1801, Rev. 2, describes attributes of an acceptable aging management program for neutron-absorbing materials other than Boraflex™.

03.03 SFP Water Chemistry and Cleanliness. Proper maintenance and operation of SFP systems is necessary to maintain water quality and radionuclide concentrations at acceptable levels. Maintenance of water quality is necessary to prevent degradation of the spent fuel and other materials stored in the SFP (e.g., control rod blades, neutron absorber materials, and core instrument strings). Proper SFP water treatment programs also prevent the buildup of excessive concentrations of radionuclides. Verify that the licensee maintains SFP water purity limits for pH, conductivity, chlorides, fluorides, and sulfates consistent with the facility licensing basis and technical TS requirements (if applicable).

03.04 SFP Instrumentation, Alarms, and Leakage Detection. Review and evaluate whether the SFP instrumentation, alarms and leakage detection systems are adequate to assure the safe wet storage of spent fuel. This review should include SFP water level and temperature instrumentation, calibration, alarm setpoints, and alarm response procedures. SFP leakage collection systems, associated alarms, level and/or flow instrumentation, and collection and trending of data should also be evaluated.

The SFP water level instrumentation and alarms should ensure that any significant loss of inventory will be promptly detected by operations personnel. Response to alarm procedures should require a leakage assessment and contingency actions including makeup, cooling, and radiological considerations, as appropriate. The instrumentation and alarms should be periodically calibrated in accordance with facility procedures. Wide-range level instrumentation installed pursuant to Order EA-12-051 should be verified for compliance with order requirements. These requirements ensure additional mitigation capability is in place in the unlikely event in which degrading conditions occur in the SFPs. (Ref. IN 14-14)

Similarly, the SFP water temperature instrumentation and alarms should ensure that any sustained loss of forced cooling will be detected promptly to allow recovery actions by

operations personnel before the pool reaches saturation conditions. Response to alarm procedures should include assessment of forced cooling systems and contingency actions to recover cooling. The instrumentation and alarms should be periodically calibrated in accordance with facility procedures.

Leakage detection systems should be verified to be functional and routinely monitored. Assess design and maintenance of the leakage detection system to verify the system will provide indication of leakage and includes provisions for isolation in the event leakage could exceed makeup system capacity. Note that operating experience described in IN 04-05 described the obstruction of leakage detection lines at an operating pressurized water reactor due to the accumulation of boric acid, mineral salts, and other contaminants. For facilities lacking SFP leak detection capability, the inspector should also review data from the licensee's environmental monitoring program to determine if there are indications of SFP leakage into the environment.

03.05 Strategies to Maintain or Restore Spent Fuel Cooling. Review licensee procedures used to implement the guidance and strategies intended to maintain or restore spent fuel pooling capabilities under the circumstances associated with loss of large areas of the plant due to explosions or fire (§50.54(hh)(2)). Although these strategies are within the scope of triennial fire protection inspections as part of the baseline, specific SFP-related strategies can be verified as part of this procedure. For additional guidance, see IP-71111.05T, "Fire Protection (Triennial)" or IP-71111.05XT, "Fire Protection – NFPA 805 (Triennial)," as appropriate. Related strategies to implement the requirements of Order EA-12-049 for spent fuel cooling should also be evaluated.

03.06 Control of Heavy Loads near the SFP. The inspection effort should assess licensee control of heavy loads in the vicinity of the SFP. The inspector should review the licensee's plans and analysis for lifting and rigging of heavy loads to verify that the safe load path analysis for any component removal and reinstallation is technically sound and consistent with the facility's licensing basis. The inspection should focus on the impact of heavy load lifting operations on the SFP and support systems, and common support systems for any other operating reactor unit(s) at the site.

Additional information on lifting heavy loads is available in Generic Letter 81-07, "Control of Heavy Loads," and NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants."

03.07 Fuel Handling within the SFP. No additional Guidance.

03.08 Problem Identification and Resolution. No additional Guidance.

60715.04 RESOURCE ESTIMATE

For planning purposes the direct inspection effort to accomplish this procedure is estimated to be 46 hours.

60715.05 REFERENCES

Bulletin 94-01, "Potential Fuel Pool Draindown Caused by Inadequate Maintenance Practices at Dresden Unit 12"

10 CFR 50.68, "Criticality Accident Requirements"

Information Notice (IN) 95-38, "Degradation of Boraflex Neutron Absorber in Spent Fuel Storage Racks"

IN 93-70, "Degradation of Boraflex Neutron Absorber Coupons"

IN 2009-26, "Degradation of Neutron-Absorbing Materials in the Spent Fuel Pool"

IN 12-13, "Boraflex Degradation Surveillance Programs and Corrective Actions in the Spent Fuel Pool"

IN 14-14, "Potential Safety Enhancements to Spent Fuel Pool Storage"

IN 90-33, "Sources of Unexpected Occupational Radiation Exposures at Spent Fuel Storage Pools"

IN 88-65, "Inadvertent Drainages of Spent Fuel Pools"

IN 87-43, "Gaps in Neutron-Absorbing Material in High-Density Spent Fuel Storage Racks"

IN 87-13, "Potential for High Radiation Fields Following Loss of Water from Fuel Pool"

IN 83-29, "Fuel Binding Caused by Fuel Rack Deformation"

Generic Letter (GL) 78-11, "Review and Acceptance of Spent Fuel Storage and Handling Applications"

GL 80-113, "Control of Heavy Loads"

GL 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks"

Licensee Site-Specific Final Integrated Plan and NRC Safety Evaluation covering EA-12-049, "Order Modifying Licenses with Regard to Mitigation Strategies for Beyond-Design-Basis External Events" (ML12056A045) and EA-12-051, "Order Modifying Licenses with Regard to Reliable Spent Fuel Pool Instrumentation" (ML12056A044).

IN 14-09, "Spent Fuel Storage or Transportation System Misloading"

IN 04-05, "Spent Fuel Leakage to Onsite Groundwater"

NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants: Resolution of Generic Technical Activity A-36"

Inspection Manual Chapter 0308, Attachment 3, Appendix L, "Technical Basis for the B.5.b Significance Determination Process"

IP 71111.05T, "Fire Protection (Triennial)"

IP 71111.05XT, "Fire Protection – NFPA 805 (Triennial)"

IP 71111.20, "Refueling and Other Outage Activities"

Nuclear Energy Institute 06-12, "B.5.b Phase 2 & 3 Submittal Guideline," Revision 2 (ML070090060)

Technical Letter Report – "Spent Fuel Pool Criticality Management Spreadsheet: A Compilation of the Means Used to Meet Subcriticality Requirements for all Operating Domestic Spent Fuel Pools," USNRC, Office of Nuclear Regulatory Research, December 21, 2011 (ML113550241)

"Spent Fuel Criticality Management Database," USNRC, Office of Nuclear Regulatory Research (ML13212A064)

NUREG-1801, "Generic Aging Lessons Learned (GALL) Report," Revision 2

END

ATTACHMENT 1

Revision History for IP 60715

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment and Feedback Resolution Accession Number (Pre-Decisional, Non-Public)
N/A	ML15247A049 10/30/15 CN 15-22	This new procedure was added to the ROP under IMC-2515, Appendix C, to address, in part, issues identified by the OIG in OIG-15-A-06, "Audit of NRC's Oversight of Spent Fuel Pools." Researched commitments for the last four years and found none.	N/A	ML15247A163