U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 9.1.3 SPENT FUEL POOL COOLING AND CLEANUP SYSTEM

REVIEW RESPONSIBILITIES

Primary - Auxiliary and Power Conversion Systems Branch (APCSB)

Secondary - Electrical, Instrumentation and Control Systems Branch (EICSB)
Structural Engineering Branch (SEB)
Mechanical Engineering Branch (MEB)
Materials Engineering Branch (MTEB)
Reactor Systems Branch (RSB)

I. AREAS OF REVIEW

All nuclear reactor plants include a spent fuel pool for the wet storage of spent fuel assemblies. The methods used to provide cooling for the removal of decay heat from the stored assemblies vary from plant to plant depending upon the individual design. The safety function to be performed by the system in all cases remains the same; that is, the spent fuel assemblies must be cooled and must remain covered with water during all storage conditions. Other functions performed by the system, not related to safety, include water cleanup for the spent fuel pool, refueling canal, refueling water storage tank and other equipment storage pools; means for filling and draining the refueling canal and other storage pools; and surface skimming to provide clear water in the storage pool.

The APCSB review of the spent fuel pool cooling and cleanup system covers the system from inlet to and exit from the storage pool and pits, the seismic Category I water source and piping used for fuel pool makeup, the cleanup system filter-demineralizers and the regenerative process to the point of discharge to the radwaste system.

1. The capability of the spent fuel pool cooling and cleanup system to provide adequate cooling to the spent fuel during all operating conditions is reviewed including the following considerations:
   a. The quantity of fuel to be cooled, including the corresponding requirements for continuous cooling during normal, abnormal, and accident conditions.
   b. The ability of the system to maintain pool water levels.
   c. The ability to provide alternate cooling capability and the associated time required for operation.

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d. Provisions to provide adequate make-up to the pool.

e. Provisions to preclude loss of function resulting from single active failures or failures of non-safety-related components or systems.

f. The means provided for the detection and isolation of system components that could develop leaks or failures.

g. The instrumentation provided for initiating appropriate safety actions.

h. The ability of the system to maintain uniform pool water temperature conditions and minimize corrosion products, fission products, and impurities in the water.

The applicant's proposed technical specifications are reviewed for operating license applications as they relate to areas covered in this review plan.

Secondary reviews are performed by other branches and the results used by the APCSB to complete the overall evaluation of the system. The secondary reviews are as follows: The SEB determines the acceptability of the design analyzes, procedures, and criteria used to establish the ability of structures housing the system and supporting systems to withstand the effects of natural phenomena such as the safe shutdown earthquake (SSE), the probable maximum flood (PMF), and tornado missiles. The MEB reviews the seismic qualification of components and confirms that the system is designed in accordance with applicable codes and standards. The RSB determines that the assigned seismic and quality group classifications for the system components are acceptable. The MTEB verifies that inservice inspection requirements are met for system components and upon request, verifies the compatability of the materials of construction with service conditions. The EICSB upon request, determines the adequacy of the design, installation, inspection, and testing of all essential electrical components required for proper operation.

II. ACCEPTANCE CRITERIA

Acceptability of the design of the spent fuel pool cooling and cleanup system, as described in the applicant's safety analysis report (SAR), including related sections of Chapters 2 and 3 of the SAR is based on specific general design criteria and regulatory guides, and on independent calculations and staff judgments with respect to system functions and component selection. Listed below are specific criteria related to the spent fuel pool cooling and cleanup systems.

1. The design of the spent fuel pool cooling and cleanup system is acceptable if the integrated design is in accordance with the following criteria:

   a. General Design Criterion 2, as related to structures housing the system and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3 of the SAR.

   b. General Design Criterion 4, with respect to structures housing the systems and the system being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

c. General Design Criterion 5, as related to shared systems and components important to safety being capable of performing required safety functions.

d. General Design Criterion 44, to include:

   (1) The capability to transfer heat loads from safety-related structures, systems, and components to a heat sink under both normal operating and accident conditions.
   (2) Suitable redundancy of components so that safety functions can be performed assuming a single active failure of a component coincident with the loss of all offsite power.
   (3) The capability to isolate components, systems, or piping, if required, so that the system safety function will not be compromised.

e. General Design Criterion 45, as related to the design provisions to permit periodic inspection of safety-related components and equipment.

f. General Design Criterion 46, as related to the design provisions to permit operational functional testing of safety-related systems or components to assure structural integrity and system leak tightness, operability, and adequate performance of active system components, and the capability of the integrated system to perform required functions during normal, shutdown, and accident situations.

g. General Design Criterion 61, as related to the system design for fuel storage and handling of radioactive materials, including the following elements:

   (1) The capability for periodic testing of components important to safety.
   (2) Provisions for containment.
   (3) Provisions for decay heat removal.

h. The capability to prevent reduction in fuel storage coolant inventory under accident conditions.

i. General Design Criterion 63, as it relates to monitoring systems provided to detect conditions that could result in the loss of decay heat removal, to detect excessive radiation levels, and to initiate appropriate safety actions.

j. Regulatory Guide 1.13, as it relates to the system design to prevent damage resulting from the SSE.

k. Regulatory Guide 1.26 as it relates to quality group classification of the system and its components.

l. Regulatory Guide 1.29, as related to the seismic design classification of system components.

m. Branch Technical Position APCSB 3-1. as it relates to breaks in high and moderate energy piping systems outside containment.

An additional basis for determining the acceptability of the spent fuel pool cooling and cleanup system is the degree of similarity of the design with that for previously reviewed plants with satisfactory operating experience.

III. REVIEW PROCEDURES

The procedures set forth below are used during the construction permit (CP) application review to determine that the design criteria and bases and the preliminary design as set forth in the preliminary safety analysis report meet the acceptance criteria given in Section II of this review plan. For the review of operating license (OL) applications, the review procedures and acceptance criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report. The review procedures for OL applications include a determination that the content and intent of the technical specifications prepared by the applicant are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff's review.

The review procedures given below are for a typical system. Any variance of the review, to take account of a proposed unique design, will be such as to assure that the system meets the criteria of Section II. In the review, the spent fuel pool cooling and cleanup system is evaluated with respect to its capability to perform the necessary safety functions during all conditions, including normal operation and refueling, abnormal storage conditions, and accident conditions.

1. The safety function of the system for refueling and normal operations is identified by reviewing the information provided in the SAR pertaining to the design bases and criteria and the safety evaluation section. The SAR section on the system functional performance requirements is also reviewed to determine that it describes the minimum system heat transfer and system flow requirements for normal plant operation, component operational degradation requirements (i.e., pump leakage, etc.) and describes the procedures that will be followed to detect and correct these conditions should degradation become excessive. The reviewer, using failure modes and effects analyses, determines that the system is capable of sustaining the loss of any active component and evaluates, on the basis of previously approved systems or independent calculations, that the minimum system requirements (cooling load and flow) are met for these failure conditions. The system piping and instrumentation diagrams (P&IDs), layout drawings, and component descriptions are then reviewed for the following points:

   a. Essential portions of the system are correctly identified and are isolable from the nonessential portions of the system. The P&IDs are reviewed to verify that they clearly indicate the physical division between each portion and indicate required classification changes. System drawings are also reviewed to see that they show the means for accomplishing isolation and the system description is reviewed to identify minimum performance requirements for the isolation valves. For the typical system, the drawings and description are reviewed to verify that automatically operated isolation valves separate nonessential portions and components from the essential portions.

   b. Heat exchangers, pumps, valves and piping for the cooling portion of the system are designed to quality group and seismic Category I requirements in accordance with applicable criteria, as described in the system design bases and criteria, and the component classification tables. The APCSB will accept a statement that the system will be designed and constructed as a seismic category I system.

c. The stated quantity of fuel to be cooled by the spent fuel cooling system is consistent with the quantity of fuel stored, as stated in Section 9.1.2 of the SAR.

d. For the maximum heat load with normal cooling systems in operation the temperature of the pool should be kept at or below 140°F and the liquid level in the pool is maintained. The associated parameters for the decay heat load of the fuel assemblies, the temperature of the pool water, and the heatup time or rate of pool temperature rise for the stated storage conditions are reviewed on the basis of independent analyses or comparative analyses of pool conditions that have been previously found acceptable.

e. The spent fuel pool and cooling systems have been designed so that in the event of failure of inlets, outlets, piping, or drains, the pool level will not be inadvertently drained below a point approximately 10 feet above the top of the active fuel. Pipes or external lines extending into the pool that are equipped with siphon breakers, check valves, or other devices to prevent drainage are acceptable as a means of implementing this requirement.

f. A seismic Category I makeup system and an appropriate backup method to add coolant to the spent fuel pool are provided. The APCSB evaluates the component seismic classification table to assure that the primary makeup system is designed as a seismic Category I system. The secondary (backup) system need not be a permanently installed system, nor Category I, but must take water from a Category I source. Engineering judgment and comparison with plants of similar design are used to determine that the makeup capacities and the time required to make associated hookups are consistent with heatup times or expected leakage from structural damage.

g. Design provisions have been made that permit appropriate inservice inspection and functional testing of system components important to safety. It will be acceptable if the SAR information delineates a testing and inspection program and if the system drawings show the necessary test recirculation loops around pumps or isolation valves that would be required by this program.

2. The review verifies that the system has been designed so that system functions will be maintained, as required, in the event of adverse natural phenomena such as earthquakes, tornadoes, hurricanes, and floods. The reviewer evaluates the system, using engineering judgment and the results of failure modes and effects analyses to determine the following:

   a. The failure of portions of the system, or of other systems not designed to seismic Category I standards systems and located close to essential portions of the system, or of non-seismic Category I structures that house, support, or are close to essential portions of the pool and cooling system, will not preclude essential functions. Reference to SAR Chapter 2, describing site features and the general arrangement and layout drawings, will be necessary as well as to the SAR tabulation of seismic design classifications for structures and systems. Statements in the SAR to the effect that the above conditions are met are acceptable. (CP)

   b. The essential portions of the spent fuel pool cooling system are protected from the effects of floods, hurricanes, tornadoes, and internally or externally generated missiles. Flood protection and missile protection criteria are discussed and evaluated in detail under the standard review plans for Chapter 3 of the SAR.

The reviewer utilizes the procedures identified in these plans to assure that the analyses presented are valid. A statement to the effect that the system is located in a seismic Category I structure that is tornado missile and flood protected, or that components of the system will be located in individual cubicles or rooms that will withstand the effects of both flooding and missiles is acceptable. The location and design of the system, structures, and pump rooms (cubicles) are reviewed to determine that the degree of protection provided is adequate.

3. The system design information and drawings are analyzed to assure that the following features will be incorporated. A statement that these features will be included in the design by some appropriate means is a basis for acceptance. (CP)
   a. A leakage detection system is provided to detect component or system leakage. An adequate means for implementing this requirement is to provide sumps or drains with adequate capacity and appropriate alarms in the immediate area of the system.
   b. Components and headers of the system are designed to provide individual isolation capabilities to assure system function, control system leakage, and allow system maintenance.
   c. Design provisions are made to assure the capability to detect leakage of radioactivity or chemical contamination from one system to another and to preclude long-term corrosion, organic fouling, or the spreading of radioactivity. Radioactivity monitors and conductivity monitors located in the system discharge lines are acceptable means for implementing this requirement.

4. The essential portions of the system must be protected from the effects of high and moderate energy line breaks. Layout drawings are reviewed to assure that no high or moderate energy piping systems are close to essential portions of the system, or that protection from the effects of failure will be provided. The means of providing such protection will be given in Section 3.6 of the SAR, and the procedures for reviewing this information are given in the corresponding review plans.

5. The SAR descriptive information, P&IDs, layout drawings, and system analyses are reviewed to assure that essential portions of the system will function following design basis accidents, assuming a concurrent single active component failure. The reviewer evaluates failure mode and effects analyses presented in the SAR to assure function of required components, trace the availability of these components on system drawings, and check that minimum system flow, makeup, and heat transfer requirements are met for each degraded situation over the required time spans. For each case the design will be acceptable if minimum system requirements are met.

6. The spent fuel pool cleanup system and various auxiliary systems are designated as non-safety-related systems and are designed accordingly (non-seismic Category I). These systems are evaluated to assure that their failure cannot affect the functional performance of any safety-related system or component. The relationship and proximity between the non-safety system and safety-related systems or components are determined by reviewing the integrated structure and component layout diagrams. Independent analyses, engineering judgement, and comparisons with previously approved systems

are used to verify that where a non-safety-related system interconnects or interfaces with the cooling system, its failure by any event or malfunction will not preclude adequate functional performance of the cooling system.

7. The cleanup system is also reviewed to assure that it has been designed with the capability to maintain acceptable pool water conditions. The P&IDs and associated information provided in the SAR is reviewed to verify the following:
   a. A means has been provided for mixing to produce a uniform temperature throughout the pool.
   b. The cleanup components have the capacity and capability to remove corrosion products, fission products, and impurities so that water clarity and quality will enable safe operating conditions in the pool.
   c. The capability for processing the refueling canal coolant during refueling operations has been provided.
   d. Provisions to preclude the inadvertent transfer of spent filter and demineralized media to any place other than the radwaste facility have been provided.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that his review supports conclusions of the following type, to be included in the staff's safety evaluation report:

"The spent fuel pool cooling and cleanup system includes all components and piping of the system from inlet to and exit from the storage pool and pits, the seismic Category I water source and piping used for fuel pool makeup, the cleanup system filter-deminerlizers and the regenerative process to the point of discharge to the radwaste system. The scope of review of the spent fuel pool cooling and cleanup system for the _____plant included layout drawings, process flow diagrams, piping and instrumentation diagrams, and descriptive information for the system and the supporting systems that are essential to safe operation. [The review has determined the adequacy of the applicant's proposed design criteria and design bases for the spent fuel pool cooling and cleanup system regarding the requirements for continuous cooling during normal, abnormal, and accident conditions. (CP)] [The review has determined that the applicant's analysis of the design of the spent fuel pool cooling and cleanup systems and supporting systems is in conformance with the design criteria and design bases. (OL)]

"The basis for acceptance in the staff review has been conformance of the applicant's designs, design criteria, and design bases for the spent fuel pool cooling and cleanup systems and its supporting systems to the Commission's regulations as set forth in the general design criteria, and to applicable regulatory guides, branch technical positions, and industry standards.

"The staff concludes that the design of the spent fuel pool cooling and cleanup system conforms to all applicable regulations, guides, staff positions, and industry standards and is acceptable."

V. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."

3. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems and Components."

4. 10 CFR Part 50, Appendix A, General Design Criterion 44, "Cooling Water."

5. 10 CFR Part 50, Appendix A, General Design Criterion 45, "Inspection of Cooling Water System."

6. 10 CFR Part 50, Appendix A, General Design Criterion 46, "Testing of Cooling Water System."

7. 10 CFR Part 50, Appendix A, General Design Criterion 61, "Fuel Storage and Handling and Radioactivity Control."

8. 10 CFR Part 50, Appendix A, General Design Criterion 63, "Monitoring Fuel and Waste Storage."

9. Regulatory Guide 1.13, "Fuel Storage Facility Design Basis."

10. Regulatory Guide 1.26, "Quality Group Classification and Standards for Water-, Steam-, and Radioactive Waste-Containing Components of Nuclear Power Plants."

11. Regulatory Guide 1.29, "Seismic Design Classification," Revision 1.

12. Branch Technical Position APCSB 3-1, "Protection Against Postulated Piping Failure in Fluid Systems Outside Containment," attached to Standard Review Plan 3.6.1.

SRP 9.1.4