U.S. NUCLEAR REGULATORY COMMISSION

DESIGN SPECIFIC REVIEW STANDARD FOR mPOWER^{TM} iPWR

9.1.3 SPENT FUEL POOL COOLING AND CLEANUP SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of cooling water systems

Secondary - Organization responsible for the review of chemical engineering issues

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 but 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 review of the spent fuel pool cooling and cleanup system (SFPCCS) 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.

The specific areas of review are as follows:

1. The seismic classification and quality standards applied to the design of the spent fuel pool cooling and cleanup system to provide adequate cooling to the spent fuel during all operating conditions are reviewed on either of two bases.

    A. To satisfy the first basis, the cooling portion of the system is designed to seismic Category I (Regulatory Guide (RG) 1.29), Quality Group C (RG 1.26) guidelines.

    B. To satisfy the second basis, a spent fuel pool cooling system not designed to seismic Category I, Quality Group C guidelines is acceptable, provided that the following systems are designed to seismic Category I, Quality Group C guidelines and are protected from the effects of floods, hurricanes, tornadoes, and internally or externally generated missiles: the fuel pool make-up water system and its source; and the fuel pool building and its ventilation and filtration system.

2. This section addresses the capability of the spent fuel pool cooling, makeup, and cleanup systems to provide adequate cooling to the spent fuel during all operating and accident conditions. The review includes the following considerations:

   A. The quantity of fuel to be cooled, including the corresponding requirements for continuous cooling during anticipated operating and accident conditions.

   B. The ability of the system to maintain pool water levels above the stored fuel.

   C. The ability to provide alternate cooling capability and the associated time required for operation.

   D. Provisions to provide adequate makeup to the spent fuel pool.

   E. Provisions to preclude loss of function resulting from single active failures or failures of nonsafety-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.

3. The staff performs a secondary review of the capability and capacity of the spent fuel pool cleanup system to remove corrosion products, radioactive materials and impurities from the pool water. In addition, at the request of the primary reviewer, an evaluation is performed of the spent fuel pool cooling system materials—fluid compatibility and potential for metal corrosion degradation and compatibility of the materials of construction with service conditions.

4. <u>Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)</u>. For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's ITAAC associated with the structures, systems, and components (SSCs) related to this Design Specific Review Standard (DSRS) section in accordance with Standard Review Plan (SRP) Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this

area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

5. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

6. The review will also address the provisions for minimization of contamination of the facility and environment, the generation of radioactive waste, and the provisions to facilitate eventual decommissioning.

Review Interfaces

Other DSRS sections interface with this section as follows:

1. Review for flood protection is performed under DSRS Section 3.4.1.

2. Review of the protection against internally generated missiles is performed under DSRS Section 3.5.1.1.

3. Review of the SSCs to be protected against externally generated missiles is performed under DSRS Section 3.5.2.

4. Review of high- and moderate-energy pipe breaks is performed under DSRS Section 3.6.1.

5. Review for fire protection is performed under SRP Section 9.5.1.

6. Review of environmental qualification of mechanical and electrical equipment is performed under DSRS Section 3.11.

7. Review to verify that the limits for radioactivity concentrations are not exceeded is performed under DSRS Sections 11.1 and 11.2.

8. Review of the acceptability of the design analyses, procedures, and criteria used to establish the ability of seismic Category I 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 is

performed under DSRS Sections 3.3.1, 3.3.2, 3.5.3, 3.7.2, and SRP sections 3.7.1, 3.7.3, 3.7.4, 3.8.4, and 3.8.5.

9. Review of whether the components piping and structures are designed in accordance with applicable codes and standards is performed under DSRS Section 3.9.1 and SRP sections 3.9.2 and 3.9.3.

10. Review of the acceptability of the seismic and quality group classifications for system components is performed under DSRS Sections 3.2.1 and 3.2.2.

11. Review of the adequacy of the inservice testing program of pumps and valves is performed under DSRS Section 3.9.6.

12. Review of whether inservice inspection requirements for system components are met is performed under DSRS Section 6.6.

13. Review of Technical Specifications is performed under DSRS Section 16.0.

14. Review of quality assurance is performed under SRP Chapter 17.

15. Review of the seismic qualifications of Category I instrumentation and electrical equipment is performed under DSRS Section 3.10.

16. Review of the adequacy of the design, installation, inspection and testing of the SFPCCS instrumentation and controls important to safety is performed under DSRS Chapter 7.

17. Review of the adequacy of the design, installation, inspection and testing of onsite ac power systems required for proper operation of the SFPCCS is performed under DSRS Section 8.3.1.

18. Review of compliance with station blackout requirements is performed under DSRS Section 8.4.

19. Review for initial plant testing and plant systems ITAAC is performed under DSRS Sections 14.2 and 14.3.7.

20. Review of the adequacy of the design of the spent fuel pool area ventilation system is performed under DSRS Section 9.4.2.

The specific acceptance criteria and review procedures are contained in the referenced SRP or DSRS sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. General Design Criterion (GDC) 2 contained in Appendix A to 10 CFR Part 50, as related to structures housing the system and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, and hurricanes. Acceptance for meeting this criterion is based on conformance to positions C.1, C.2, C.6, and C.8 of RG 1.13 and position C.1 of RG 1.29 for safety-related and position C.2 of RG 1.29 for nonsafety-related portions of the system.

   This criterion does not apply to the cleanup portion of the system and need not apply to the cooling system if the fuel pool makeup water system and its source meet this criterion, the fuel pool building and its ventilation and filtration system meet this criterion, and the ventilation and filtration system meets the guidelines of RG 1.52.

   The cooling and makeup system should be designed to Quality Group C requirements in accordance with RG 1.26. However, when the cooling system is not designated Category I it need not meet the requirements of ASME Section XI for inservice inspection of nuclear plant components.

2. GDC 4 with respect to the capability of the system and the structure housing the system to withstand the effects of external missiles. Acceptance is based on meeting position C.2 of RG 1.13.

   This criterion does not apply to the cleanup system and need not apply to the cooling water system if the makeup system, its source, the building, and its ventilation and filtration system are tornado protected, and the ventilation and filtration system meets the guidelines of RG 1.52.

3. GDC 5 as related to shared systems and components important to safety being capable of performing required safety functions.

4. GDC 61 as related to the system design for fuel storage and handling of radioactive materials, including the following elements:

   A. The capability for periodic testing of components important to safety.

   B. Provisions for containment.

   C. Provisions for decay heat removal that reflects its importance to safety.

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

E. The capability and capacity to remove corrosion products, radioactive materials and impurities from the pool water and reduce occupational exposures to radiation.

5. GDC 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.

6. 10 CFR 20.1101(b) as it relates to radiation doses being kept as low as is reasonably achievable (ALARA). In meeting this regulation, RG 8.8, positions C.2.f(2) and C.2.f(3) can be used as a basis for acceptance.

7. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations.

8. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

9. 10 CFR 20.1406 as it relates to facility design and procedures for operation that will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

<u>DSRS Acceptance Criteria</u>

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified are set forth below. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), "Contents of applications; technical information." The same approach may be used to meet the requirements of 10 CFR

52.79(a)(41) for COL applications.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this DSRS section is discussed in the following paragraphs:

1. Compliance with GDC 2 requires that SSCs important to safety be designed to withstand the effects of expected natural phenomena combined with the appropriate effects of normal and accident conditions without loss of capability to perform their safety functions.

   This DSRS section describes staff positions related to the design of the spent fuel pool cooling and cleanup system. It cites RG 1.13 to describe the design basis, RG 1.26 to describe quality group classifications, and RG 1.29 to describe seismic design classifications. These positions describe the design bases needed to resist expected natural phenomena when combined with the appropriate effects of normal and accident conditions.

   Meeting the requirements of GDC 2 provides assurance that components of the spent fuel pool cooling and cleanup system will be designed to withstand the effects of expected natural phenomena and will be capable of performing their intended safety functions.

2. Compliance with GDC 4 requires that SSCs important to safety be designed to accommodate the effects of, and be compatible with, environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents and dynamic effects resulting from pipe whip, missiles, and discharging fluids.

   This DSRS section describes staff positions related to the design of the spent fuel pool cooling and cleanup system and cites RG 1.13 to describe the design basis, including that for protecting the spent fuel storage facility against missiles and heavy loads.

   Meeting the requirements of GDC 4 provides assurance that components of the spent fuel pool cooling and cleanup system will be designed to accommodate expected environmental conditions and will be capable of performing their intended safety functions.

3. Compliance with GDC 5 requires that SSCs important to safety not be shared among nuclear power units unless it can be shown that such sharing will not impair their ability to perform their safety functions.

This DSRS section describes staff positions related to the design of the spent fuel pool cooling and cleanup system, whose safety function is to ensure that no single failure will prevent the system from cooling the spent fuel.

Meeting the requirements of GDC 5 provides assurance that components of the spent fuel pool cooling and cleanup system will be designed to accommodate shared systems, structures and components such that no single failure will prevent the system from performing its safety function.

4. Compliance with GDC 61 requires that the fuel storage system be designed to ensure adequate safety under normal and postulated accident conditions. The system shall be designed with: the capability to permit appropriate periodic inspection and testing of components important to safety; suitable shielding for radiation protection; appropriate containment, confinement and filtering capability; residual heat removal that reflects the importance to safety of decay heat and other residual heat removal; and the capability to prevent a significant reduction in fuel storage coolant inventory under accident conditions.

   This DSRS section describes staff positions related to the design of the spent fuel pool cooling and cleanup system, including provisions for inspection and testing, containment and confinement, residual heat removal, maintenance of an adequate coolant inventory under accident conditions, and shielding and filtration capability to reduce occupational exposure to radiation. Provisions for inspection and testing are satisfied by designing essential portions of the cooling system to Quality Group C criteria. Provisions for containment are satisfied by provisions to collect and isolate leakage. Provisions for residual heat removal that reflect its importance to safety are satisfied by (1) designing essential portions of the cooling system to seismic Category I criteria and with adequate cooling capacity assuming a single active failure, and (2) providing a forced-circulation cooling capability that maintains the pool at temperatures suitable for fuel handling during routine operating conditions, including refueling. The capability to prevent a significant reduction in fuel storage coolant inventory under accident conditions is satisfied by providing adequate makeup capability and designing the SFPCCS such that the coolant can neither be drained nor siphoned below a specified level. Provisions to minimize occupational exposure to radiation are satisfied by providing the capability to remove impurities from the coolant and maintain an adequate water level for shielding of stored fuel.

   Meeting the requirements of GDC 61 provides assurance that components of the spent fuel pool cooling and cleanup system will be inspected, tested, shielded, and provided with containment, confinement, and residual heat removal capability to ensure that the system is capable of performing its intended safety function under normal and postulated accident conditions.

5. Compliance with GDC 63 requires that appropriate systems be provided in the fuel storage area to detect conditions that may result in the loss of residual heat removal capability or excessive radiation levels, and initiate appropriate safety actions.

   This DSRS section describes staff positions related to the design of the spent fuel pool cooling and cleanup system, including provisions for monitoring and detection systems.

   Meeting the requirements of GDC 63 provides assurance that components of the spent fuel pool cooling and cleanup system will be provided with monitoring and detection capabilities to ensure that the system is capable of performing its intended safety function.

6. Compliance with 10 CFR 20.1101(b) requires that the licensee use, to the extent practicable, procedures and engineering controls based on sound radiation protection principles to achieve occupational doses and doses to members of the public that are ALARA.

   This DSRS section describes staff positions related to the design of the spent fuel pool cooling and cleanup system, including positions to achieve radiation doses in conformance with the ALARA principle. Positions in RG 8.8 regarding methods for preventing the generation and spread of contamination are provided.

   Meeting the requirements of 10 CFR 20.1101(b) provides assurance that components of the spent fuel pool cooling and cleanup system will result in radiation doses that comply with the ALARA standard.

7. The requirements of 10 CFR 20.1406 are met when the design and procedures identify provisions to detect contamination that may enter as in-leakage from other systems, identifies potential collection points such as water treatment systems or system low points, and addresses the long term control of radioactive material in the system.

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified DSRS acceptance criteria. For deviations from these specific acceptance criteria, including review of unique designs, the staff should review the applicant’s evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

Upon request from the primary reviewer, the interfacing review branches will provide input for the areas of review stated in Subsection I of this DSRS section. The secondary review branch will provide input on a routine basis for those areas of review indicated in this DSRS section.

Interim Use and Comment

The primary reviewer obtains and uses such input as necessary to ensure that this review procedure is complete.

In the review, the staff evaluates spent fuel pool cooling and cleanup system and its makeup system with respect to their capability to perform the necessary functions during all conditions, including normal operation, refueling, and accident conditions.

1. Programmatic Requirements - In accordance with the guidance in NUREG – 0800 *"Introduction," Part 2* as applied to this DSRS Section, the staff will review the programs proposed by the applicant to satisfy the following programmatic requirements. If any of the proposed programs satisfies the acceptance criteria described in Subsection II, it can be used to augment or replace some of the review procedures. It should be noted that the wording of "to augment or replace" applies to nonsafety-related risk-significant SSCs, but "to replace" applies to nonsafety-related nonrisk-significant SSCs according to the "graded approach" discussion in NUREG-0800 "Introduction," Part 2. Commission regulations and policy mandate programs applicable to SSCs that include:

    A. Maintenance Rule SRP Section 17.6 (DSRS Section 13.4, Table 13.4, Item 17), RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." and RG 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants."
    B. Quality Assurance Program SRP Sections 17.3 and 17.5 (DSRS Section 13.4, Table 13.4, Item 16).
    C. Technical Specifications (DSRS Section 16.0 and SRP Section 16.1) – including brackets value for DC and COL. Brackets are used to identify information or characteristics that are plant specific or are based on preliminary design information.
    D. Reliability Assurance Program (SRP Section 17.4).
    E. Initial Plant Test Program (Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants,"DSRS Section 14.2, and DSRS Section 13.4, Table 13.4, Item 19).
    F. ITAAC (DSRS Chapter 14).

2. The reviewer will identify the safety function of the system for refueling and normal operations by reviewing the information provided in the application pertaining to the design bases and criteria and the safety evaluation section. The application section describing 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 reviewer will evaluate the system drawings and component descriptions for the following points:

A. Essential portions of the system are correctly identified and are isolable from the nonessential portions of the system. The reviewer verifies that the drawings clearly indicate the physical division between each portion and indicate classification changes. The reviewer also ensures that system drawings show the means for accomplishing isolation and that the system description identifies minimum performance requirements for the isolation valves. For the typical system, the reviewer examines drawings and reviews descriptions to verify that adequate 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 constructed to Quality Group C and designed to seismic Category I requirements in accordance with the guidance provided in RGs 1.26 and 1.29. As an acceptable alternative, the cooling loop may be constructed to nonseismic Category I requirements, provided the spent fuel pool water makeup system and the building ventilation and filtration system are 1) designed to Quality Group C and seismic Category I requirements; 2) are protected from the effects of tornadoes; and 3) meet the single-failure requirements. Where this alternative is selected, the ventilation system provides the capability to vent steam/moisture to the atmosphere to protect safety-related components from the effects of boiling in the spent fuel pool (SFP). If necessary to limit the offsite dose consequences of spent fuel pool boiling, the ventilation and filtration system should also meet the guidelines of RG 1.52. The review for seismic design and seismic and quality group classification is performed under DSRS Sections 3.7.1 through 3.7.4, and 3.2.1 and 3.2.2, respectively.

C. The stated quantity of fuel to be cooled by the spent fuel cooling system is consistent with the quantity of fuel stored.

D. The minimum heat removal capacity with the forced-circulation cooling system in operation, the pool at the design temperature of the structure, and the heat sink at its maximum design temperature is greater than 0.3 percent of the reactor rated thermal power. If the spent fuel pool is shared between multiple reactors, the minimum heat removal capacity must be equal or greater than the combined 0.3 percent of each of the reactors rated thermal power. The cooling system retains at least half of its full heat removal capacity assuming a single active failure. This capacity provides reasonable assurance that the pool temperature will remain within design bounds for the structure during full core discharges to the spent fuel pool when the forced-circulation cooling system is in operation, and ensures that significant heat removal capacity will remain available when an active component is unavailable due to a single failure or maintenance. The forced cooling capacity remaining following a single failure is adequate due to the low probability that the single failure would occur coincident with maximum decay heat load and the maximum heat sink temperature.

E. The spent fuel pool and cooling systems are 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 3 meters (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.

   When the spent fuel pool is designed with passive heat removal capability, the pool should be designed so that in the event of failure of inlets, outlets, piping, or drains, the pool level will not be inadvertently drained below the higher of two elevations: (1) 3 meters (10 feet) above the top of the active fuel, or (2) below the minimum water level needed to provide at least 72 hours of decay heat removal (without crediting an active makeup system) and still maintaining the stored fuel covered. 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, Quality Group C makeup system and an appropriate backup method to add coolant to the spent fuel pool are provided. If the forced-circulation cooling system is designed to seismic Category I, Quality Group C standards, the backup system need not be a permanently installed system, or Category I, but should take water from a seismic Category I source. Otherwise, the backup system should also be permanently installed, physically separate and independent from the primary makeup system, and designed to seismic Category I, Quality Group C standards. The minimum makeup capacity for each system exceeds the larger of the pool leakage rate assuming spent fuel pool liner perforation resulting from a dropped fuel assembly or the evaporation rate necessary to remove 0.3 percent of the reactor rated thermal power, or 0.3 percent of the combined reactor rated thermal power if the pool is shared between reactors. The design permits initiation of makeup water flow through either system from locations remote from the operating floor surrounding the pool surface. Engineering judgment and comparison with plants of similar design are used to determine that the time necessary to align systems and connect makeup systems not permanently installed is 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.

A statement that essential portions of the spent fuel pool cooling and makeup systems are included in the inservice inspection program per DSRS Section 6.6 and the inservice testing program of DSRS Section 3.9.6 is acceptable.

H. The system design provides adequate SFP cooling capacity for routine operations, including refueling. The staff reviews either a bounding evaluation of potential refueling conditions or a method of performing outage-specific evaluations described in the SAR. The largest heat load placed on the SFPCCS heat exchangers is imposed by refueling offloads, which are deliberate, planned evolutions. As a result, if necessary for adequate cooling of the fuel, factors that increase heat load (e.g., power increases, decay time reductions, or storage capacity increases) may be offset by operational factors that reduce heat load (e.g., longer decay times or transfer of fewer fuel assemblies to the SFP) or that increase heat removal capability (e.g., scheduling offloads for periods of reduced ultimate heat sink temperature or optimizing cooling system performance).

   Considering the preceding measures to manage the heat load relative to cooling capability, the staff evaluates the following criteria:

   i. the SAR describes a method of performing decay heat load calculations using a conservative model that evaluates multiple fission product groups and considers offload size, decay time, power history, and inventory of previously discharged assemblies.

   ii. the SAR describes a method of calculating heat removal capability for a bulk SFP temperature of 60 °C (140 °F) and considering ultimate heat sink temperature, cooling system flow rates, and heat exchanger performance (i.e., fouling and tube plugging margin).

   iii. the SAR describes appropriate administrative controls in the SAR to ensure that the full heat removal capability at a SFP temperature of 60 °C (140 °F) will exceed the calculated decay heat load at all times during the refueling offload.

3. The reviewer 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 and located close to essential portions of the system, or of nonseismic Category I structures that house, support, or are close to essential portions of the pool and cooling system, will not preclude essential functions. Statements to the effect that the above conditions are met are acceptable. Reference to site features, the general arrangement and layout drawings, and the seismic design classifications for structures and systems included with the application will be necessary.

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 in detail in the respective DSRS sections.

   The reviewer utilizes the procedures identified in these plans to ensure 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 staff reviews the location and design of the system, structures, and pump rooms (cubicles) to determine that the degree of protection provided is adequate.

4. The reviewer analyzes the system design information and drawings to ensure that features to contain radioactivity will be incorporated. A statement that these features will be included in the design by the following means is a basis for acceptance:

   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 ensure system function, control system leakage, and allow system maintenance.

   C. Design provisions are made to ensure the capability to detect leakage of radioactivity from one system to another. Radioactivity monitors and conductivity monitors located in the system discharge lines are acceptable means for implementing this requirement.

5. Descriptive information, drawings, and system analyses are reviewed to ensure 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 ensure the 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

alarms are provided to notify operators of the degraded condition and essential functions can credibly be restored.

6. The spent fuel pool cleanup system and various auxiliary systems are designated as nonsafety-related systems and are designed accordingly (nonseismic Category I). The reviewer evaluates these systems to ensure that their failure cannot affect the functional performance of any safety-related system or component. The relationship and proximity between the nonsafety-related system and safety-related systems or components are determined by reviewing the integrated structure and component layout diagrams. Independent analyses, engineering judgment, and comparisons with previously approved systems are used to verify that where a nonsafety-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 staff also reviews the cleanup system to ensure that it has been designed with the capability to maintain acceptable pool water conditions. The staff reviews the descriptive information and drawings provided in the application to verify the following:

   A. The secondary reviewer reviews the cleanup system to verify it has the capacity and capability to remove corrosion products, radioactive materials, and impurities so that water clarity and quality will enable safe operating conditions in the pool. This includes instrumentation and sampling to monitor the water purity and need for demineralizer resin replacement, including the chemical and radiochemical limits such as conductivity, gross gamma and iodine activity, demineralizer differential pressure, pH and crud level, which are used to initiate corrective action.

   B. The capability for processing the refueling canal coolant during refueling operations has been provided.

   C. Provisions to preclude the inadvertent transfer of spent filter and demineralized media to any place other than the radwaste facility have been provided.

8. For reviews under 10 CFR Part 50, the procedures set forth above 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 SAR meet the acceptance criteria given in Subsection II of this DSRS section. For the review of operating license (OL) applications, the review procedures are used to determine that the acceptance criteria and bases have been appropriately implemented in the final design as set forth in the final SAR. 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.

9. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

10. For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

    For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the staff's technical review and analysis support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the basis for those conclusions.

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-demineralizers 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 includes 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 portions of systems essential for adequate cooling and maintenance of an adequate fuel storage coolant inventory have been identified and are designed to seismic Category I, Quality Group C standards because they are necessary to remove decay heat from the spent fuel and to prevent fuel damage that could lead to unacceptable releases of radioactivity.

Accordingly, the staff concludes that the design of the spent fuel pool cooling and cleanup system and its makeup system meets the requirements of GDC 2, 4, 5, 61, and 63. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2 with respect to safety-related portions of the system being protected against natural phenomena. Acceptance is based on having met the guidelines of RG 1.13, position C.1, which recommends a seismic Category I design for necessary portions of the spent fuel storage facility; position C.2, regarding protection against winds and wind generated missiles; position C.6, as it relates to the system being capable of withstanding earthquakes without loss of coolant

that would uncover the fuel; and position C.8, which recommends a seismic Category I makeup system with appropriate redundancy or a backup from a Category I water source. Acceptance is also based on having met the seismic design requirements of RG 1.29, position C.1, for safety-related portions of the system necessary for adequate cooling to prevent excessive radioactivity releases (position C.1.p of RG 1.29) and position C.2 as it relates to the failure of nonsafety-related portions of the system.

2. The design meets the requirements of GDC 4 with regard to protection against the effects of externally generated missiles; it is in accordance with position C.2 of RG 1.13 because no loss of watertight integrity or fuel damage occur in the event of tornado missiles.

3. The design meets the requirements of GDC 5 regarding the sharing of safety-related structures, systems, and components because no single failure will prevent the system from performing its safety-related functions, which are maintaining water inventory over the stored fuel and cooling the spent fuel.

4. The system is designed in accordance with the requirements of GDC 61 as it relates to the system design for fuel storage because the system has the following design capabilities: the system has the capability for periodic testing of components important to safety; the system has the capability to remove decay heat from the spent fuel under both normal operating and accident conditions; the system has redundancy so that decay heat can be removed assuming a single active failure; the system is designed to provide suitable shielding by maintaining a minimum water level above the fuel; the system provides appropriate containment of radioactivity by collecting and providing a means for detecting leakage; and the system is designed to prevent reduction in fuel storage coolant inventory under accident conditions in accordance with position C.6 of RG 1.13. The spent fuel pool cleanup portion of the system (1) provides the capability and capacity of removing radioactive materials, corrosion products, and impurities from the pool water and thus meets the requirements of Criterion 61 as it relates to appropriate filtering systems for fuel cooling and storage, (2) reduces occupational exposure to radiation by removing radioactive materials from the pool water and thus meets the requirements of 10 CFR 20.1101(b) as it relates to maintaining radiation exposures ALARA and, (3) retains radioactive materials and crud in the pool water in the demineralizer and filters and thus meets positions C.2.f(2) and C.2.f(3) of RG 8.8.

5. The system design meets the requirements of GDC 63 since it has provisions to detect the loss of heat removal function through the use of loss of flow, level, and temperature alarms, and to detect conditions that would result in excessive radiation through the use of coolant low level alarms and radiation monitoring alarms. The above alarms provide adequate notification of abnormal conditions for operators to initiate timely actions to ensure the safety functions are satisfied due to the large coolant inventory within the storage pool.

6. The applicant meets 10 CFR 20.1406 requirements for minimization of contamination of the facility and the environment, and for avoiding design features that would interfere with eventual decommissioning.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower™-specific design certification (DC), or combined license (COL) applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower™ and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM-COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor (SMR) reviews including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower™ -specific DC, COL, or ESP applications submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the Standard Review Plan (SRP) revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9) as long as the mPower™ DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47 (a)(9). Alternatively, the staff may supplement the DSRS section by adding the appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.79 (a)(41), for COL applications.

VI. REFERENCES

1. 10 CFR Part 20, Subpart B, § 20.1101(b), "Radiation Protection Programs."

2. 10 CFR Part 20, Subpart B, § 20.1406, "Minimization of Contamination."

3. 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena."

4. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."

5. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems and Components."

6. 10 CFR Part 50, Appendix A, GDC 61, "Fuel Storage and Handling and Radioactivity Control."

7. 10 CFR Part 50, Appendix A, General Design Criterion 63, "Monitoring Fuel and Waste Storage."

8. Regulatory Guide (RG) 1.13, "Fuel Storage Facility Design Basis."

9. RG 1.26 "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."

10. RG 1.29, "Seismic Design Classification."

11. RG 1.52, "Design, Testing, and Maintenance Criteria for Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."

12. RG 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable.

13. RG1.28, "Quality Assurance Program Criteria (Design and Construction)".

14. 10 CFR 50.65, "Requirements for monitoring the effectiveness of maintenance at nuclear power plants."