



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

SECTION 9.1.2

SPENT FUEL STORAGE

REVIEW RESPONSIBILITIES

Primary - Auxiliary and Power Conversion Systems Branch (APCSB)

Secondary - Mechanical Engineering Branch (MEB)
 Structural Engineering Branch (SEB)
 Materials Engineering Branch (MTEB)
 Reactor Systems Branch (RSB)
 Core Performance Branch (CPB)
 Radiological Assessment Branch (RAB)

I. AREAS OF REVIEW

Nuclear reactor plants include storage facilities for the wet storage of spent fuel assemblies. The safety function of the spent fuel pool and storage racks is to maintain the spent fuel assemblies in a subcritical array during all credible storage conditions and to provide a safe means for the confinement and cask loading of the assemblies.

The APCSB reviews the spent fuel storage facility design including the spent fuel storage racks, the spent fuel storage pool that contains the storage racks, and the associated equipment storage pits. The cooling system is reviewed independently.

1. The facility and components are reviewed with respect to the following:
 - a. The quantity of fuel to be stored.
 - b. The design and arrangement of the storage racks for maintaining a subcritical array during all conditions.
 - c. The degree of subcriticality provided along with the analysis and associated assumptions.
 - d. The effects of external loads and forces on the spent fuel storage racks and pool (e.g., safe shutdown earthquake, crane uplift forces, missiles, and dropped objects).
 - e. Design codes, materials compatibility, and shielding requirements;
2. The provisions to preclude dropping the spent fuel shipping cask into the pool are reviewed separately in conjunction with the review of the cask loading pit area.

 USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to Revision 2 of the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555

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3. The APCSB review of the provisions for maintaining the pool level and cooling is discussed in conjunction with the spent fuel cooling system review.
4. The applicant's proposed technical specifications are reviewed at the operating license (OL) stage, 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 facility. The secondary reviews are as follows: the SEB determines the acceptability of the design analyses, procedures, and criteria used to establish the ability of structures housing the facility 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 components, piping, and structures are 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, upon request, the compatibility of the materials of construction with service conditions. The CPB verifies, upon request, that the k_{eff} of loaded storage racks is acceptable. The RAB reviews the adequacy of the shielding design and the radiation monitoring system.

II. ACCEPTANCE CRITERIA

Acceptability of the spent fuel storage facility design 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 storage facility.

1. The design of the spent fuel storage facility is acceptable if the integrated design is in accordance with the following criteria:
 - a. General Design Criterion 2, as related to structures housing the facility and the facility 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 3, as related to protection against fire hazards.
 - c. General Design Criterion 4, as related to structures housing the facility and the facility itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks, such that safety functions will not be precluded.
 - d. General Design Criterion 5, as related to shared systems and components important to safety being capable of performing required safety functions.

- e. General Design Criterion 61, as related to the facility 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 or confinement.
 - (3) The capability to prevent reduction in fuel storage coolant inventory under accident conditions.
- f. General Design Criterion 62, as related to the prevention of criticality by physical systems or processes utilizing geometrically safe configurations.
- g. General Design Criterion 63, as it relates to monitoring systems provided to detect conditions that could result in the loss of decay heat removal capabilities, to detect excessive radiation levels, and to initiate appropriate safety actions.
- h. Regulatory Guide 1.13, as it relates to the fuel handling and storage facility design to prevent damage resulting from the SSE, to prevent loss of water from the fuel pool that could uncover the fuel, and to protect the fuel from mechanical damage.
- i. Regulatory Guide 1.29, as related to the seismic design classification of facility components.
- j. Fuel storage capacity and criticality limits as discussed in III.1 and III.2 below.

An additional basis for determining the acceptability of the spent fuel storage facility is the degree of similarity of the design with that for previously reviewed plants with satisfactory operating experience.

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) application review to determine that the design criteria and bases and the preliminary design meet the acceptance criteria given in Section II of this plan. For the review of the operating license (OL) application, the review procedures and acceptance criteria will be utilized to verify that the initial design criteria and bases have been appropriately implemented in the final design. The OL review includes verification that the content and intent of the technical specifications prepared by the applicant are in agreement with 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 storage system. Any variance of the review, to take account of a proposed unique design, will be such as to assure that the facility design conforms to the criteria in Section II. The reviewer selects and emphasizes material from this review plan, as may be appropriate for a particular case.

1. The quantity of spent fuel to be stored onsite forms the basis for the design capacity of the fuel pool and the number of storage racks provided. The SAR is reviewed to determine that the design basis and facility description section has stated the storage capacity provided by the design. The SARs for recent light water reactor applications have stated that the storage space provided is consistent with the maximum number of spent fuel assemblies unloaded from the core during the refueling cycle plus the fuel contained in a full core load (e.g., 1-1/3 core for a single unit plant and 1-2/3 core for a dual unit facility).
2. The information provided in the SAR pertaining to criticality safety of the spent fuel storage facility is evaluated, based in part on previously approved facilities or on independent calculations by CPB upon request. The facility design criteria, safety evaluation, system description and the layout drawings for the spent fuel pool and storage racks are reviewed to verify that:
 - a. Criticality information (including the associated assumptions and input parameters) in the SAR must show that the center-to-center spacing between fuel assemblies in the storage racks is sufficient to maintain the array, when fully loaded and flooded with nonborated water, in a subcritical condition. A k_{eff} of less than about 0.95 for this condition is acceptable. An independent criticality analysis will not be performed when the design of the storage racks and physical characteristics of the fuel (e.g., enrichment, rod size, number of rods, spacing, and shims) is the same or is demonstrated in the SAR to be less reactive than those of similar facilities which have been licensed.
 - b. The design of the storage racks is such that a fuel assembly cannot be inserted anywhere other than in a design location.
 - c. Failures of systems or structures not designed to seismic Category I standards and located in the vicinity of the spent fuel storage facility will not cause a decrease in the degree of subcriticality provided. Reference to the SAR description section and the general arrangement and layout drawings will be necessary, as well as the tabulation of seismic design classifications for structures and systems. A statement in the SAR establishing the above condition as a design criterion is acceptable. (CP)
 - d. Design calculations should show that the storage racks and the anchorages can withstand the maximum uplift forces available from the crane without an increase in k_{eff} or a decrease in pool water inventory. A statement in the SAR that excessive forces cannot be applied due to the design of the crane handling system is acceptable if justification is presented. The evaluation procedures identified in Standard Review Plan 9.1.4 are used to validate this statement.
 - e. The spent fuel storage pool and racks are designed to preclude damage from dropped heavy objects.

- f. Sharing of storage facilities in multi-unit plants will not increase the potential for the loss of pool water or decrease the degree of subcriticality provided.
3. The reviewer verifies that the safety function of the facility will be maintained, as required, if the facility is subjected to adverse natural phenomena such as earthquakes, tornadoes, hurricanes, and floods. In making this determination, the reviewer considers the following points:
 - a. The facility design basis and criteria and the component classification tables are reviewed to verify that the spent fuel storage facility including the storage pool and racks have been classified and designed to seismic Category I requirements. The APCS will accept a statement that the facility will be designed and constructed as a seismic Category I system. (CP)
 - b. The essential portions of the spent fuel storage system are reviewed to verify that protection from the effects of floods, hurricanes, tornadoes, and internally or externally generated missiles is provided. Flood protection and missile protection criteria are discussed in the standard review plans for Chapter 3 of the SAR. The reviewer utilizes the procedures of those review plans, as appropriate, to assure that the analyses presented are valid. APCS will accept a statement to the effect that the facility 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 rooms that will withstand the effects of both flooding and missiles.
4. The wet storage of spent fuel assemblies for safe handling also necessitates the underwater transfer of spent fuel to a loading area for shipment in spent fuel casks. The SAR is reviewed to verify that the design basis and facility description section has stated that a separate spent fuel shipping cask loading area (pit) has been provided adjacent to the spent fuel pool. The loading pit, by virtue of its proximity to the spent fuel pool, is subjected to the same adverse environmental phenomena. Accordingly, the reviewer verifies that the loading pit has been designed so that the safety function of the integrated system will be maintained during these environmental conditions. In addition, the reviewer verifies that the following are included in the design:
 - a. An interconnecting canal between the fuel pool and the loading pit should be provided to permit the underwater transfer of fuel to the shipping cask, with provisions for isolating from the fuel pool. A statement in the SAR that these elements are included in the design is acceptable. The reviewer uses engineering judgment to assure himself that the means provided meet the intent stated.
 - b. The SAR safety evaluations, results of design calculations, and the general arrangement and layout drawings should show that the spent fuel loading pit has been designed to withstand the loads from dropped heavy objects including the shipping cask, and that the loading area is not an integral part of the storage pool floor

so that if a dropped object should breach the pit area, the drainage would not lower the fuel pool water to an unacceptable level. The review of cranes and other elements of the fuel handling system to assure that the design of these components minimizes the likelihood of dropping heavy loads is done under Standard Review Plan 9.1.4.

IV. EVALUATION FINDINGS

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

"The spent fuel storage facility includes the spent fuel storage racks, the spent fuel storage pool that contains the storage racks, and the associated equipment storage pits. The scope of review of the spent fuel storage facility for the _____ plant included layout drawings, piping and instrumentation diagrams, and descriptive information for the facility and the auxiliary supporting systems that are essential to the operation of the facility. [The review has determined the adequacy of the applicant's proposed design criteria and design bases for the spent fuel storage facility and the provisions necessary to maintain a subcritical array during all normal, abnormal, and accident conditions. (CP)] [The review has determined that the applicant's analysis of the design of the spent fuel storage facility and auxiliary supporting systems is in conformance with the design criteria and bases. (OL)]

"The basis for acceptance in the staff review has been conformance of the applicant's designs and design criteria for the spent fuel storage facility and necessary auxiliary 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 storage facility 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 3, "Fire Protection."
3. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."
4. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems, and Components."
5. 10 CFR Part 50, Appendix A, General Design Criterion 61, "Fuel Storage and Handling and Radioactivity Control."

6. 10 CFR Part 50, Appendix A, General Design Criterion 62, "Prevention of Criticality in Fuel Storage and Handling."
7. 10 CFR Part 50, Appendix A, General Design Criterion 63, "Monitoring Fuel and Waste Storage."
8. Regulatory Guide 1.13, "Fuel Storage Facility Design Basis."
9. Regulatory Guide 1.29, "Seismic Design Classification," Revision 1.

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SRP 9.1.3