



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

9.1.2 SPENT FUEL STORAGE

REVIEW RESPONSIBILITIES

Primary - Auxiliary Systems Branch (ASB)

Secondary - Chemical Engineering Branch (CMEB)

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 safe and subcritical array during all credible storage conditions and to provide a safe means of loading the assemblies into shipping casks.

The ASB reviews the spent fuel storage facility design including the spent fuel storage racks, the spent fuel storage pool that contains the storage racks, the spent fuel pool liner plate, and the associated equipment storage pits to assure conformance with the requirements of General Design Criteria 2, 4, 5, 61, 62, and 63.

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, pool, and liner plate (e.g., safe shutdown earthquake, crane uplift forces, missiles, and dropped objects).
  - e. Design codes, materials compatibility, and shielding requirements.

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**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 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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- f. The use of applicable codes and standards consistent with the assigned seismic classification.
2. The ASB review of the pool's water level control system, cleanup system and cooling system is performed with the spent fuel cooling system review in SRP Section 9.1.3.
3. The ASB review of provisions to preclude dropping the spent fuel shipping cask into the pool are evaluated during the review of the cask loading pit area in SRP Section 9.1.5.
4. ASB also performs the following reviews under the SRP sections indicated:
  - a. Review of flood protection is performed under SRP Section 3.4.1.
  - b. Review of the protection against internally generated missiles as well as missiles generated by natural phenomena is performed under SRP Sections 3.5.1.1, 3.5.1.2, 3.5.2, and 3.5.1.4.
  - c. Review of structures, systems, and components to be protected against externally generated missiles is performed under SRP Section 3.5.2.

A secondary review is performed by the Chemical Engineering Branch (CMEB) and the results of its evaluation are used by ASB to complete the overall evaluation of the system. The CMEB reviews the compatibility and chemical stability of the materials wetted by the pool water. In addition, CMEB will verify that there are no potential mechanisms that will: (1) alter the dispersion of the strong fixed neutron absorbers incorporated in the design of the storage racks, and/or (2) cause physical distortion of the tubes retaining the stored fuel assemblies. The results of CMEB's evaluation are transmitted to ASB for inclusion in the spent fuel storage SER writeup.

In addition, ASB will coordinate reviews performed by other branches, and the results are used by ASB in the overall spent fuel storage evaluation. The coordinated reviews are as follows: The Structural Engineering Branch (SEB) determines the acceptability of the design analyses, procedures, and criteria used to establish the ability of seismic Category I structures to withstand the effects of natural phenomena such as safe shutdown earthquakes (SSE), the probable maximum flood (PMF), and missiles as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.4.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5. The Core Performance Branch (CPB) determines that the criticality limits are acceptable and in accordance with ANS 57.2 paragraphs 5.1.1.2.1 and 5.1.1.2.2 as part of its primary responsibility for SRP Section 4.3. The Mechanical Engineering Branch (MEB) determines that the components and structures are designed in accordance with applicable codes and standards as part of its primary review responsibility for SRP Sections 3.9.1 through 3.9.3. The MEB also determines the acceptability of the seismic and quality group classifications for system components as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. The Materials Engineering Branch (MTEB) verifies that inservice inspection requirements are met for system components as part of its primary review responsibility for SRP Section 6.6. The review for Fire Protection, Technical Specifications, and Quality Assurance is coordinated and performed by the Chemical Engineering Branch, Quality Assurance Branch, and Licensing Guidance Branch as part of their primary review responsibilities for SRP Sections 9.5.1, 16.0, and 17.0, respectively. The Equipment Qualification Branch reviews the seismic qualification of Category I instrumentation and the

environmental qualification of mechanical and electrical equipment as part of its primary review responsibility for SRP Sections 3.10 and 3.11, respectively.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

## II. ACCEPTANCE CRITERIA

Acceptability of the spent fuel storage facility design as described in the applicant's safety analysis report (SAR) is based on certain General Design Criteria and Regulatory Guides, and on independent calculations and staff judgments with respect to system functions and component selection. The design of the spent fuel storage facility is acceptable if the integrated design is in accordance with the following criteria:

1. General Design Criterion 2, as it relates to structures housing the facility and the facility 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 position C.3 of Regulatory Guide 1.13, the applicable portions of Regulatory Guide 1.29, Regulatory Guide 1.117, and ANS 57.2 paragraphs 5.1.1, 5.1.3, 5.1.12, 5.3.2, and 5.3.4.
2. General Design Criterion 4, as it relates to structures housing the facility and the facility itself being capable of withstanding the effects of environmental conditions and external missiles, and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks, such that safety functions will not be precluded. Acceptance for meeting this criterion is based on meeting position C.3 of Regulatory Guide 1.13, Regulatory Guides 1.115 and 1.117, as well as appropriate paragraphs of ANS 57.2.
3. General Design Criterion 5, as it relates to shared structures, systems, and components important to safety being capable of performing required safety functions.
4. General Design Criterion 61, as it relates to the facility design for fuel storage and handling of radioactive materials. Acceptance for meeting this criterion is based on conformance to position C.1 and C.4 of Regulatory Guide 1.13 and the appropriate paragraphs of ANS 57.2. Acceptance is also based on meeting the fuel storage capacity requirements noted in subsection III.1 of this SRP section.
5. General Design Criterion 62, as it relates to the prevention of criticality by physical systems or processes utilizing geometrically safe configurations. Acceptance for meeting this criterion is based on conformance to position C.1 and C.4 of Regulatory Guide 1.13 and the appropriate paragraphs of ANS 57.2.
6. 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. Acceptance for meeting this criterion is based on conformance with paragraph 5.4 of ANS 57.2.

### 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 subsection II. 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.

Upon request from the primary reviewer, the coordinating review branches will provide input for the areas of review stated in subsection I of this SRP section. The secondary review branch, CMEB, will provide an input on a routine basis for those areas of review indicated in this SRP section. The primary reviewer (ASB) obtains and uses such input as required to assure that this review procedure is complete.

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 subsection II of this SRP section. The reviewer selects and emphasizes material from this SRP section as may be appropriate for a particular case.

1. The SAR is reviewed to determine that the design bases and facility description section indicates the storage capacity provided in the design. The minimum storage capacity in the spent fuel storage pool shall be in accordance with ANS 57.2 paragraph 5.1.15, i.e., for a single unit facility the storage capacity shall equal or exceed one full core discharge plus the maximum normal fuel discharge cycle; for a dual shared storage pool facility the storage capacity shall equal or exceed one full core discharge plus two normal fuel discharge cycles. Due to a lack of sufficient away-from-reactor (AFR) storage capacity, the industry trend has been to use high density storage racks. ASB reviews high density storage on a case-by-case basis.
2. The information provided in the SAR relating to the facility design criteria, safety evaluation, system description, and the layout drawings for the spent fuel pool and storage racks is 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 and any strong fixed neutron absorbers in the storage racks is sufficient to maintain the array, when fully loaded and flooded with nonborated water, in a subcritical condition. A  $K_{eff}$  not greater than 0.95 for this condition is acceptable.
  - 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 nonsafety-related systems or structures not designed to seismic Category I that are located in the vicinity of the spent fuel storage facility are reviewed to assure that their failure will not cause an increase in  $K_{eff}$  to exceed the maximum allowable. The SAR description section, the general arrangement and layout drawings, and the tabulation of seismic design classifications for structures and systems are reviewed and evaluated to assure that this condition is met. A statement in the SAR establishing the above condition as a design criterion is acceptable at the CP review stage.
  - d. Design calculations should show that the storage racks and any anchorages can withstand the maximum fuel handling equipment uplift forces 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 fuel handling equipment is acceptable if justification is presented. The evaluation procedures identified in SRP Sections 9.1.4 and 9.1.5 are used to validate this statement.
  - e. Conventionally the plant's Technical Specification states that the weight of all loads being handled above stored spent fuel shall not exceed that of one fuel assembly and its associated handling tool. This weight and its normal carrying height above the storage racks establishes what was considered the upper bound on the potential energy available to damage the stored spent fuel if a load drop occurs. It has been subsequently noted that lighter loads handled at greater drop heights may have greater amounts of potential energy. Therefore, the following additional requirement is being made. The licensee is required to demonstrate and the reviewer to verify that the available potential energy of all lighter loads, being handled above stored spent fuel, shall not exceed that of one fuel assembly and its associated handling tool when dropped from its normal operating height above stored spent fuel.
  - 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, pool liner, and racks have been classified and designed to seismic Category I requirements. The ASB will accept a statement that the facility will be designed and constructed as a seismic Category I system. (CP)
  - b. If the spent fuel pool liner plate will not be designed and constructed to seismic Category I requirements, the spent fuel pool

liner plate is reviewed to verify that a failure of the liner plate as a result of an SSE will not cause any of the following:<sup>1</sup>

1. Significant releases of radioactivity due to mechanical damage to the fuel;
  2. Significant loss of water from the pool which could uncover the fuel and lead to release of radioactivity due to heatup;
  3. Loss of ability to cool the fuel due to flow blockage caused by a portion or one complete section of the liner plate falling on top of the fuel racks;
  4. Damage to safety-related equipment as a result of the pool leakage; and
  5. Uncontrolled release of significant quantities or radioactive fluids to the environs.
- c. 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 sections of the SRP contained in Chapter 3. The reviewer utilizes the information in those SRP sections, as appropriate, to assure that the analyses presented are valid. ASB will accept a statement to the effect that the storage facility is located in a seismic Category I structure that is missile and flood protected.
4. The safe handling of spent fuel assemblies necessitates the underwater transfer of spent fuel between the respective areas of the plant including spent fuel cask loading area. 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 reviewer verifies that the loading pit has been designed so that the safety function of the integrated system will be maintained during adverse environmental conditions. In addition, the reviewer verifies that the following are included in the design:
- a. An interconnecting fuel transfer canal should be capable of being isolated from the fuel pool and cask loading area. A statement in the SAR that these features are included in the design is acceptable. The reviewer uses engineering judgment to assure himself that the means provided meet the stated intent.

<sup>1</sup>The implementation of this item reflects current regulatory practice. The methods of review described herein will be used in the evaluation of submittals for operating license or construction permit applications docketed after November 17, 1977, which is based on the first application to which this method was specifically applied. Implementation for applications docketed prior to November 17, 1977 is not considered necessary since stresses induced in the fuel pool liner plate welds due to an SSE will usually be well below the maximum allowable stress levels and therefore liner failure is not considered a likely event. Even in the event that a liner plate failed, it would not likely block the coolant outlet of spent fuel assemblies completely and sufficient cooling of stored spent fuel would be maintained. Therefore, the spent fuel pool liner plate seismic design is not considered a significant safety issue and backfit is not required.

- b. In regard to the handling of heavy loads, e.g., the spent fuel shipping cask in the vicinity of the spent fuel storage pool, the reviewer is required to establish and verify in SRP Section 9.1.5 that one of the alternative approaches described in Section 5 of NUREG-0612 has been satisfied. If Sections 5.1.1 and 5.1.6 of NUREG-0612 have not been met, 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, loss of fuel pool water would not result in an unacceptable level.

#### 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. Based on the review of the applicant's proposed design criteria, design bases, and safety classification for the spent fuel storage facility and the provisions necessary to maintain a subcritical array, the staff concludes that the design of the spent fuel storage facility and supporting systems is in conformance with the Commission's regulations as set forth in General Design Criteria 2, 4, 5, 61, 62, and 63.

*This conclusion is based on the following:*

1. The applicant has met the requirements of General Design Criterion 2 by conforming with position C.3 of Regulatory Guide 1.13 and the applicable portions of Regulatory Guides 1.29 and 1.117, as well as paragraphs 5.1.1, 5.1.3, 5.1.12, 5.3.2, and 5.3.4 of ANS 57.2.
2. The applicant has met the requirements of General Design Criterion 4 pertaining to the environmental and missile protection design basis by conforming to position C.3 of Regulatory Guide 1.13 and the applicable portions of Regulatory Guides 1.115 and 1.117, as well as appropriate paragraphs of ANS 57.2.
3. The applicant has met the requirements of General Design Criterion 5 since the failure of any portion of the shared spent fuel storage facility will not impair the ability of plants systems to perform their safety function.
4. The applicant has met the requirements of General Design Criteria 61 and 62 pertaining to fuel storage, handling, criticality, and radioactivity control by conforming to positions C.1 and C.4 of Regulatory Guide 1.13 and the appropriate paragraphs of ANS 57.2.
5. The applicant has met the requirements of General Design Criterion 63 pertaining to monitoring the status of the stored spent fuel by conforming to paragraph 5.4 of ANS 57.2.

## V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff on its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced NUREG and Regulatory Guides.

## VI 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 61, "Fuel Storage and Handling and Radioactivity Control."
5. 10 CFR Part 50, Appendix A, General Design Criterion 62, "Prevention of Criticality in Fuel Storage and Handling."
6. 10 CFR Part 50, Appendix A, General Design Criterion 63, "Monitoring Fuel and Waste Storage."
7. Regulatory Guide 1.13, "Design Objectives for Light-Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations."
8. Regulatory Guide 1.29, "Seismic Design Classification."
9. Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles."
10. Regulatory Guide 1.117, "Tornado Design Classification."
11. ANS 57.2/ANSI N210-1976, "Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations."
12. NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants."