UNITED STATES NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

## 9.1.4 LIGHT LOAD HANDLING SYSTEM AND REFUELING CAVITY DESIGN

### REVIEW RESPONSIBILITIES

**Primary -** Organization responsible for the review of new and spent fuel storage and handling

**Secondary -** None

### I. AREAS OF REVIEW

The primary organization reviews the light load handling system (LLHS) consisting of all structures, systems, and components (SSCs) for handling new fuel from the receiving station through refueling to loading spent fuel into the shipping or storage cask for compliance with the requirements of General Design Criteria (GDCs) 2, 5, 61, and 62. The objective of the LLHS review is to avoid criticality accidents, radioactivity releases from damage to irradiated fuel, and unacceptable personnel radiation exposures.

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The specific areas of review are as follows:

1. The design layout, which shows the functional geometric layout of the fuel handling equipment and areas, is reviewed for whether the various handling operations can be performed safely.

2. The LLHS grappling, rigging, hoisting, and transporting operations are reviewed to evaluate handling methods, selection of handling equipment, and safety devices.

3. The LLHS design is reviewed for the following aspects of individual components and of the integrated system:

   - performance and load handling requirements specified for equipment
   - electrical or mechanical interlocks to prevent criticality accidents, damage to fuel, and excessive personnel exposure
   - protections against inadvertent criticality, mechanical damage, and overheating as to the methods and equipment for transferring fuel assemblies from the reactor core to the storage location and the methods and equipment for fuel processing, inspection, or cleaning
   - design features relied upon to prevent refueling cavity draindown resulting in fuel damage and excessive personnel radiation exposure

4. The design of equipment whose failure could damage stored fuel or essential equipment is reviewed for seismic qualification.

5. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the SSCs related to this Standard Review Plan (SRP) section in accordance with 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 SRP 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.

6. 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.

Review Interfaces

Other SRP sections interface with this section are as follows:

1. SRP Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for system components.

2. SRP Sections 3.7.1 through 3.7.4, 3.8.4 and 3.8.5: review of the design analyses, procedures, and criteria for establishing the ability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena like the safe shutdown earthquake.

3. SRP Sections 3.9.1 through 3.9.3: review of codes and standards applied to the design of components, piping, and structures.

4. SRP Section 3.10: review of the seismic qualification of Category I instrumentation and electrical equipment.

5. SRP Sections 12.3 and 12.4: review of the designs of the fuel handling system and the spent fuel transfer process for whether occupational radiation exposures during spent fuel handling will be as low as reasonably achievable.

6. SRP Section 16: review of technical specifications for reactivity, power and cooling controls of fuel in storage locations

7. Chapter 17: review of quality assurance.

8. Chapter 19: review of the risk of shutdown operations when the refueling cavity is flooded as part of the applicant's Low Power and Shutdown PRA.

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

II. ACCEPTANCE CRITERIA

Requirements

The LLHS is acceptable if the integrated design of the structural, mechanical, and electrical elements, the manual and automatic operating controls, and the safety interlocks and devices provide adequate system control for the specific procedures of handling operations; if the redundancy and diversity needed to protect against malfunctions or failures are provided; and if the design complies with applicable regulations.

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

1. GDC 2 as it relates to the ability of structures, equipment, and mechanisms to withstand the effects of earthquakes.

2. GDC 5 as it relates to the capability of shared equipment and components to perform safety functions.

3. GDC 61 as it relates to radioactivity release as a result of fuel damage and the avoidance of excessive personnel radiation exposure.

4. GDC 62 as it relates to prevention of criticality accidents.

5. Title 10 of the *Code of Federal Regulations* (10 CFR) 52.47(b)(1), which requires that a DC application contain the proposed 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 plant that incorporates the DC is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission (NRC) regulations.

6. 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 COL, the provisions of the AEA, and the NRC regulations.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC regulations identified above are as follows:

1. Acceptance for meeting the relevant aspects of GDC 2 is based on Regulatory Guide (RG) 1.29, Positions C.1 and C.2.

2. Acceptance for meeting the relevant aspects of GDC 5 is embodied within the other acceptance criteria of this document.

3. Acceptance for meeting the relevant aspects of GDC 61 is based in part on the guidelines of American National Standards Institute/American Nuclear Society (ANSI/ANS) 57.1-1992.

4. Acceptance for meeting the relevant aspects of GDC 62 is based in part on ANSI/ANS 57.1-1992.

The SRP is not a substitute for the NRC regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and to evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations

Technical Rationale

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

1. GDC 2 requires that SSCs important to safety be designed to resist the effects of natural phenomena like earthquakes.

GDC 2 applies to SRP Section 9.1.4 because it specifies the natural phenomenon (i.e., earthquake) that must be considered in the LLHS and refueling cavity design. If not considered, an earthquake could overload LLHS and refueling cavity SSCs and cause unsafe conditions (e.g., a fuel assembly drop with the potential for a release of radioactive materials from damaged irradiated fuel or criticality accidents) or unacceptable personnel radiation exposures. SRP Section 9.1.4 cites RG 1.29, Position C.1 for safety-related portions and Position C.2 for nonsafety-related design portions. These positions provide guidance for meeting these requirements.

Compliance with GDC 2 assures that LLHS and refueling cavity SSCs will perform their intended function of safely carrying loads that, if dropped, could cause unsafe conditions, and keeping personnel exposure to radiation within acceptable limits.

2. GDC 5 requires that SSCs important to safety not be shared among nuclear power units unless such sharing can be shown not to significantly impair their ability to perform safety functions, including, in case of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

   GDC 5 requirements ensure essential independence of the LLHS SSCs in the event of shared use in multiple-unit plants. The shared use in multiple-unit plants, therefore, will not affect the LLHS safety function significantly. SRP Section 9.1.4 provides guidance to meet these requirements.

   Compliance with GDC 5 provides assurance that the LLHS and its SSCs will continue to perform their required safety functions when the LLHS is shared among nuclear power units and that safe handling of fuel will not be jeopardized.

3. GDC 61 requires that fuel storage and handling, radioactive waste, and other systems that may contain radioactive materials be designed for adequate safety under normal and postulated-accident conditions.

   SRP Section 9.1.4 addresses handling of fuel and spent fuel which, if dropped, mishandled, or damaged, could cause releases of radioactive materials or unacceptable personnel radiation exposures. ANSI/ANS 57.1-1992 provides guidance for meeting these requirements. In addition, SRP Section 9.1.4 provides guidance to address the GDC 61 requirement to provide suitable radiological shielding (i.e., retaining water in the refueling cavity and fuel transfer canals), residual heat removal capability, and prevention of a significant reduction in coolant inventory under accident conditions.

   Compliance with GDC 61 provides reasonable assurance that releases of radioactive materials and unacceptable personnel radiation exposures from damage to irradiated fuel will be avoided.

4. GDC 62 requires prevention of criticality in the fuel handling and storage system by physical systems or processes, preferably by geometrically safe configurations.

   GDC 62 requirements ensure that fuel handling and storage SSCs will be controlled so criticality will not be reached, ensuring the safety of the public. ANSI/ANS 57.1-1992 provides guidance for meeting these requirements.

Compliance with GDC 62 provide assurance that the LLHS will operate under adequately safe conditions and avoid criticality accidents and consequent releases of radioactive materials from damage to or changes in fuel, ensuring acceptable levels of personnel radiation exposure.

## III. REVIEW PROCEDURES

The LLHS provides for handling of fuel assemblies and light loads like control rods, and burnable poison rods. The general objective of the review is to confirm that the LLHS design precludes system malfunctions or failures that could cause criticality accidents, a release of radioactivity, or excessive personnel radiation exposures. There are variations in the designs of proposed handling systems; hence, there are variations in system requirements and the type and number of loads handled. For the purpose of this review, the LLHS does not include equipment used to handle heavy loads (i.e., weights exceeding that of one fuel assembly and its handling tool).

The procedures listed here are used in the construction permit or DC review to determine whether LLHS design criteria and bases and the preliminary LLHS design described in the Safety Analysis Report (SAR) meet the acceptance criteria of Subsection II of this SRP section. For operating license (OL) or COL reviews, the procedures verify whether the design criteria and bases are implemented appropriately in the LLHS final design.

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

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, 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.

1. The LLHS system performance requirements are reviewed for whether they cover the handling system concept used in the design and describe the component and subsystem functions within the integrated system. The reviewer verifies whether the LLHS physical arrangement for stored fuel and fuel handling areas has been described sufficiently to establish that the various handling operations can be performed safely. Descriptive information regarding the physical arrangement should establish that fuel handling equipment maintains: a large margin to criticality by precluding handling of more assemblies than has been shown to be safely subcritical, adequate cooling for irradiated fuel, adequate shielding for radiation protection for operators, and adequate clearance to reduce the potential for mechanical damage to fuel during transfer. The LLHS must include capability for removal of spent fuel from the facility.

2. The reviewer verifies whether the applicant's selected consensus standards, engineering codes, or manufacturing association standards are adequate and appropriate for the LLHS.

3. The SAR information is reviewed for whether the specific arrangement of the system and subsystems and the load handling paths are described for locations of objects that could damage fuel or cause a criticality accident. The SAR description of operating and test procedures is reviewed for whether load proof-testing, design-rated load testing, nondestructive testing, preventive checks, and attachment of the load ensure reliable load-handling operations. The reviewer covers the following points:

A. Performance and design criteria applied to specific components comply with consensus standards and provide for reliable fuel handling.

B. The instrumentation and control system, including the limit and safety devices necessary to maintain safety in a component failure within the system, are reviewed to determine whether the control system adequately limits loads or limits load movement, assuming a single failure, to prevent fuel damage to the extent that a release of radioactivity, a criticality accident, or significant radiation exposure could occur.

C. The fuel transfer carriage and other devices (inspection stands, cleaning stands, and fuel processing stands) are reviewed to determine whether the design adequately protects against inadvertent criticality, unacceptable radiation exposure, mechanical damage, and overheating. The fuel transfer system is reviewed for the adequacy of provisions to prevent damage to fuel assemblies especially during the time it receives or transfers them to other LLHS equipment. The LLHS load with the potential to cause the greatest damage to stored fuel should be identified for the fuel handing accident evaluation.

D. To preclude a catastrophic draindown of the refueling cavity, based on operating experience associated with IE Bulletin 84-03, “Refueling Cavity Water Seals” and IN 84-93, “Potential for Loss of Water from the Refueling Cavity,” the refueling cavity design should include:

   i. A robust refueling cavity water seal that is built to appropriate engineering codes, or manufacturing association standards, will not catastrophically fail during a seismic event, and is not vulnerable to a single failure (passive or active) that results in a gross failure that significantly affects the refueling cavity water level. It should also be protected from dropped objects.

   ii. An evaluation of all paths capable of inadvertently draining the refueling cavity, the potential for, and consequences of the refueling cavity to drain through these paths (i.e., manways, drain lines, etc.). The design of the cavity should be configured to assure sufficient water will be retained above fuel temporarily placed in the upender or other safe laydown location such that the worst-case draindown scenario will allow operators to add inventory before: (1) the loss of adequate shielding for personnel, (2) postulated boiling of the water, and (3) top of active fuel is reached. For example, there should be no non-seismic piping or openings below the top of any safe laydown location of the fuel. Note: SRP Section 19.0 evaluates operational assumptions for shutdown risk, for example the use of nozzle dams.

   iii. Design provisions so that any leakage that occurs is readily identified and corrected. The applicant should describe controls that will be established to prevent inadvertent draining of the refueling cavity. Adequate procedures, properly calibrated refueling cavity water level instrumentation, and alarms are considered to be important in the mitigation of any loss-of-cavity-water accident. Operating procedures

should address a draindown evolution and periodic maintenance and inspection of the refueling cavity water seal.

4. The SAR information for the LLHS equipment, including equipment storage areas, is reviewed to determine whether a seismic event could cause damage to spent fuel or essential equipment. Equipment necessary to preclude inadvertent criticality should be designed consistently with RG 1.29, Position C.1. Equipment failure of which could damage stored fuel or other equipment essential for plant safety should be designed consistently with RG 1.29, Position C.2.

5. 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. 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.

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

6. 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 review and calculations (if applicable) support conclusions of the following type to be included in the staff's Safety Evaluation Report (SER). The reviewer also states the bases for those conclusions.

The LLHS includes all components and equipment for moving fuel and other related light loads between the receiving area, storage areas, and reactor vessel. After review of the applicant's proposed LLHS design criteria, design bases, and requirements for safe operation, the staff concludes that the design of the LLHS and supporting systems (including the refueling cavity) complies with NRC regulations in GDCs 2, 5, 61, and 62. This conclusion is based on the following findings:

1. The system design meets GDC 2 requirements for protection of safety-related equipment and spent fuel from the effects of earthquakes. Criterion 2 is met because the system is designed in accordance with RG 1.29, Position C.1 for safety-related portions and Position C.2 for nonsafety-related portions of the system.

2. The system meets GDC 5 requirements for sharing of SSCs because such sharing does not impair the system's safety function.

3. The system also meets the requirements of GDCs 61 and 62 for prevention of unacceptable radioactivity releases, unacceptable radiation exposure, and criticality

accidents. These criteria are met because the system is designed in accordance with ANSI/ANS 57.1-1992 guidelines.

For DC and COL reviews, the findings will also summarize the staff's evaluation of the requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP 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 SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

## VI. REFERENCES


1. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems and Components."

3. 10 CFR Part 50, Appendix A, GDC 61, "Fuel Storage and Handling and Radioactivity Control."

4. 10 CFR Part 50, Appendix A, GDC 62, "Prevention of Criticality in Fuel Storage and Handling."

5. ANSI/ANS 57.1-1992, "Design Requirements for LWR Fuel Handling Systems."

6. IE Bulletin 84-03, "Refueling Cavity Water Seals."

7. IN 84-93, "Potential for Loss of Water from the Refueling Cavity."

8. RG 1.29, "Seismic Design Classification."

9. Temporary Instruction 2515/66, "Refueling Cavity Water Seals."

**PAPERWORK REDUCTION ACT STATEMENT**

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

**PUBLIC PROTECTION NOTIFICATION**

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

**STANDARD REVIEW PLAN SECTION 9.1.4**
**Description of Changes**

**Section 9.1.4 "LIGHT LOAD HANDLING SYSTEM AND REFUELING CAVITY DESIGN"**

This Standard Review Plan (SRP) section affirms the technical accuracy and adequacy of the guidance previously provided in Section 9.1.4, Revision 3, dated March 2007 of this SRP. See the Agencywide Documents Access and Management System (ADAMS) Accession No. ML070380200.

This section has been updated primarily to reflect operating experience associated with IE Bulletin 84-03, "Refueling Cavity Water Seals."

Technical changes incorporated in this revision include:

1. Changed title to include "refueling cavity design."

I. AREAS OF REVIEW

1. Clarified the description of the LLHS to also consist of the refueling process, and storage casks.

2. Added refueling cavity draindown prevention design features as part of the LLHS review.

3. Technical specifications were added as a review interface.

II. ACCEPTANCE CRITERIA

1. Discussion of GDC 61 was edited to state SRP Section 9.1.4 provides guidance to address the refueling cavity.

III. REVIEW PROCEDURES

1. Statement was added to clarify that the LLHS must include the capability to removed spent fuel from the facility.

2. Guidance for the design and review of the refueling cavity was added.

IV. REFERENCES

1. Three references to refueling cavity operating experience were added.