



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

9.2.5 ULTIMATE HEAT SINK

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of cooling water systems associated with the balance of plant

Secondary - None

I. AREAS OF REVIEW

The ultimate heat sink (UHS) is the source of cooling water to dissipate reactor decay heat and essential cooling system heat loads after a normal reactor shutdown or a shutdown following an accident, including a loss-of-coolant accident (LOCA). The UHS design must satisfy the requirements of General Design Criteria (GDCs) 2, 5, 44, 45, and 46.

The water sources that make up the UHS are reviewed to assure that they are capable of performing their safety functions. This review includes the size, type of cooling water supply (e.g., ocean, lake, natural or manmade reservoir, river, or cooling tower), makeup sources to the ultimate heat sink, and the capability of the heat sink to deliver the required flow of cooling water at appropriate temperatures for normal, accident, or shutdown reactor condition. The UHS is reviewed for whether the design code requirements that are pertinent to this review are met.

The specific areas of review are as follow:

Rev. 3 - [Month] 2007

USNRC STANDARD REVIEW PLAN

This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan is not a substitute for the NRC's 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 evaluate how the proposed alternatives to the SRP acceptance criteria provide an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in the Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of the standard format have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) will be based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," until the SRP itself is updated.

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRR_SRP@nrc.gov.

Requests for single copies of draft or active SRP sections (which may be reproduced) should be made to the U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Reproduction and Distribution Services Section, or by fax to (301) 415-2289; or by email to DISTRIBUTION@nrc.gov. Electronic copies of this section are available through the NRC's public Web site at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/>, or in the NRC's Agencywide Documents Access and Management System (ADAMS), at <http://www.nrc.gov/reading-rm/adams.html>, under Accession # [MLxxxxxxx](#).

1. The type of cooling water supply.
2. The ability to dissipate the total essential station heat load.
3. The effect of environmental conditions on UHS capability to furnish the required quantities of cooling water at appropriate temperatures and with any required chemical and purification treatment for extended times after shutdown.
4. The effect of earthquakes, tornadoes, missiles, floods, and hurricane winds on the availability of the source water. The UHS is also reviewed for whether adverse environmental conditions including freezing preclude the UHS safety function.
5. Sharing of cooling water sources in multi-unit stations.
6. Applicable design requirements like the high- and low-water levels of the source to determine their compatibility with the service water system.
7. Heat input for the UHS design as to reactor system heat, sensible heat, pump work, and station auxiliary system individual and total heat loads.
8. Inspection, Test, Analysis, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the applicant's proposed information on the ITAAC associated with the structures, systems, and components (SSCs) related to this Standard Review Plan (SRP) section is reviewed in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria - Design Certification." The staff recognizes that the review of ITAAC is performed after review of the rest of this portion of the application against acceptance criteria contained in this SRP section. Furthermore, the ITAAC are reviewed to assure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.
9. COL Action Items and Certification Requirements and Restrictions. COL action items may be identified in the NRC staff's final safety evaluation report (FSER) for each certified design to identify information that COL applicants must address in the application. Additionally, DCs contain requirements and restrictions (e.g., interface requirements) that COL applicants must address in the application. For COL applications referencing a DC, the review performed under this SRP section includes information provided in response to COL action items and certification requirements and restrictions pertaining to this SRP section, as identified in the FSER for the referenced certified design.

Review Interfaces

The listed SRP sections interface with this section as follows:

1. Sections 2.4.1 through 2.4.14: review of UHS water levels, design and inspection of water control structures (e.g., dams, slopes, canals), meteorological and natural phenomena criteria (including ice effects), and transient analysis of the cooling water inventory.
2. Sections 3.2.1 and 3.2.2: review of the acceptability of the seismic and quality group classifications for safety-related SSCs.

3. 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: review of the acceptability of the design analyses, procedures, and criteria establishing the capability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena like the safe shutdown earthquake (SSE), the probable maximum flood, and the tornado missiles.
4. Section 3.4.1: review of flood protection.
5. Section 3.5.1.1: review of the protection against internally-generated missiles.
6. Section 3.5.2: review of SSCs to be protected against externally-generated missiles.
7. Section 3.6.1: review of high- and moderate-energy pipe breaks.
8. Section 6.1.1: review of the inservice inspection requirements for system components and the compatibility of materials of construction with service conditions.
9. Section 6.3: review of the heat loads transmitted to the UHS from the reactor coolant and emergency core cooling systems.
10. Section 7.1 and Appendix 7-A: review of the adequacy of the design, installation, inspection, and testing of all instrumentation and control systems required for proper operation.
11. Section 8.3.1: review of the adequacy of the design, installation, inspection, and testing of all electrical systems required for proper operation.
12. Section 9.2.1: review of the service water system and review of the program of surveillance and control techniques to detect and control flow blockage problems due to aquatic bivalves and other fouling due to mud, silt, or corrosion products.
13. Section 9.5.1: review of fire protection.
14. Section 16.0: review of technical specifications.
15. Chapter 17: review for quality assurance.

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

II. ACCEPTANCE CRITERIA

Requirements

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

1. GDC 2 as to capability of structures housing the system and the system itself to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods.

2. GDC 5 as to capability of shared systems and components important to safety to perform required safety functions.
3. GDC 44 as to:
 - A. The capability to transfer heat loads from safety-related SSCs to the heat sink under both normal operating and accident conditions.
 - B. Suitable component redundancy so that safety functions can be performed assuming a single, active component failure coincident with loss of offsite power.
 - C. The capability to isolate components, systems, or piping if required so safety functions are not compromised.
4. GDC 45 as to the design provisions to permit inservice inspection of safety-related components and equipment.
5. GDC 46 as to the design provisions to permit operation functional testing of safety-related systems or components.
6. 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 plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations;
7. 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.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for review described in Subsection I of this SRP section. The SRP is not a substitute for the NRC's 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 evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. Protection Against Natural Phenomena

Information that addresses the requirements of GDC 2 regarding the capability of structures housing the UHS and the UHS itself to withstand the effects of natural phenomena will be considered acceptable if the guidance of Regulatory Guide (RG) 1.27, Positions C.2 and C.3 are appropriately addressed.

2. Sharing of Structures, Systems, and Components

Information that addresses the requirements of GDC 5 regarding the capability of shared systems and components important to safety to perform required safety functions will be considered acceptable if the use of the UHS in multiple-unit plants during an accident in one unit does not significantly affect the capability to conduct a safe and orderly shutdown and cool-down in the other unaffected unit(s).

3. Cooling Water System

Information that addresses the requirements of GDC 44 regarding consideration of the cooling water system will be considered acceptable if the guidance of RG 1.27, Positions C.2 and C.3; RG 1.72, Positions C.1, C.4, C.5, C.6, and C.7.; and American National Standards Institute/American Nuclear Society (ANSI/ANS) 5.1 are applied appropriately.

4. Cooling Water System Inspection

Information that addresses the requirements of GDC 45 regarding the inspection of cooling water systems will be considered acceptable if the design of the UHS permits inservice inspection of safety-related components and equipment.

5. Cooling Water System Testing

Information that addresses the requirements of GDC 46 regarding the testing of cooling water systems will be considered acceptable if the UHS is designed for testing of safety-related systems or components for structural integrity and leak-tightness, operability, performance of active components, and the capability of the system to function as intended under accident conditions

Technical Rationale

The technical rationale for application of these requirements to reviewing this SRP section is discussed in the following paragraphs:

1. GDC 2 requires that nuclear power plant SSCs important to safety be designed to withstand the effects of natural phenomena like earthquake, tornado, hurricane, flood, tsunami, and seiche without loss of capability to perform intended safety functions.

GDC 2 applies to this SRP section because the reviewer considers UHS capability to withstand natural phenomena. The UHS must be able to provide an adequate supply of cooling water to cool the reactor and its essential support systems under all plausible conditions. RG 1.27 describes methods acceptable to the staff for ensuring UHS capability to withstand the effects of natural phenomena, including earthquakes.

GDC 2 requirements provide assurance that SSCs comprised by the plant's ultimate heat sink have been designed to withstand the most severe natural phenomena likely to occur.

2. GDC 5 requires that SSCs important to safety not be shared by nuclear power units unless such sharing can be shown not to impair their capability to perform intended safety functions.

RG 1.27 describes staff positions on UHS design for sharing of SSCs. GDC 5 applies to any multi-unit facility in which a UHS portion is shared by two or more units.

GDC 5 requirements provide assurance that, in an active or a passive failure at a multi-unit site, the sharing of UHS SSCs will not affect the safe shutdown of any unit.

3. GDC 44 requires systems to transfer heat from SSCs important to safety to a UHS. Systems must be able to function under normal and accident conditions, assuming a single failure.

GDC 44 applies to this SRP section because the reviewer evaluates the UHS design, including assumptions for heat loads, redundancy of components, capability to isolate components, and single failures. RGs 1.27 and 1.72 describe guidance acceptable to the staff for UHS design and fiberglass piping for spray pond applications. In addition, ANSI/ANS-5.1 describes methods acceptable to the staff for calculating residual decay energy.

GDC 44 requirements provide assurance that the UHS will function as designed to transfer heat from SSCs as required under normal and accident conditions, assuming a single failure.

4. GDC 45 requires that the cooling water system be designed to permit appropriate periodic inspection of important components (e.g., heat exchangers and piping) to ensure the integrity and capability of the system.

Meeting the requirements of GDC 45 provides assurance that components and equipment of the ultimate heat sink can and will be inspected, thereby ensuring that the system will perform its intended safety function.

5. GDC 46 requires that the cooling water system be designed to permit appropriate periodic pressure and functional testing to ensure the leaktight integrity and operability of its components, as well as the operability of the system as a whole, under conditions as close to the design basis as practical.

Meeting the requirements of GDC 46 provides assurance that components and equipment of the ultimate heat sink can and will be tested, thereby ensuring that the system will perform its intended safety function.

III. REVIEW PROCEDURES

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

For each area of review specified in subsection I of this SRP section, the review procedure is identified below. These review procedures are based on the identified SRP acceptance criteria. For deviations from these specific acceptance criteria, the staff should review the applicant's

evaluation of how the proposed alternatives to the SRP criteria provide an acceptable method of complying with the relevant NRC requirements identified in subsection II.

Availability of an adequate supply of water for the UHS is a basic requirement for any nuclear power plant. There are various methods for satisfying the requirement (e.g., a large body of water like an ocean, lake, natural or manmade reservoir, a river, cooling ponds or towers, or such combinations). The UHS design tends to be unique for each nuclear plant, depending upon its geographical location. For purposes of this SRP section, typical procedures are established for identifying UHS essential features. For installations where these general procedures are not completely adequate, the reviewer supplements them as necessary.

1. The safety analysis report (SAR) is reviewed for the overall arrangement and type of UHS proposed. The reviewer verifies that the UHS is designed to maintain system function as required in adverse environmental phenomena including freezing and loss of offsite power. The reviewer evaluates the system for whether:
 - A. The heat inputs in the UHS design are conservative. The reviewer makes an independent evaluation of the applicant's calculated heat loads. The UHS heat loads include heat due to decay of radioactive material, sensible heat, pump work, and the heat load from the operation of the station auxiliary systems serving and dependent upon the UHS.
 - B. Operational data from plants of similar design confirm, where possible, the heat input values for sensible heat, pump work, and station auxiliary systems.
2. The reviewer verifies whether:
 - A. The total essential station heat load and system flow requirements of the service water system are compatible with the UHS heat rejection capability.
 - B. The UHS can dissipate the maximum possible total heat load, including that of a LOCA under the worst combination of adverse environmental conditions, even freezing, and can cool the unit (or units, including a LOCA for one unit of a multi-unit station with one heat sink) for a minimum of 30 days without makeup unless acceptable makeup capabilities can be demonstrated. This capability is verified by independent check calculations.
 - C. The single failure of any SSCs will not prevent the UHS from performing its safety functions.
3. For plants with UHS cooling towers the reviewer determines, in addition, whether:
 - A. The results of failure modes and effects analyses show that the mechanical systems (fans, pumps, and controls) can withstand a single, active failure in any of these systems, including an auxiliary electric power source failure, and deliver water in the quantities and at temperatures required for safe shutdown.
 - B. Adequate net positive suction head can be provided to all essential pumps with water level variations in the basins. This determination is verified by independent calculations.

- C. The towers can provide the design cooling water temperature under the worst combination of adverse environmental conditions, even freezing, and the basins can supply water for 30-day cooling at the required temperature without makeup unless acceptable makeup capabilities can be demonstrated. This determination is verified by independent calculations.
4. Reactor sites that utilize large natural or manmade water sources, which for all practical purposes have an infinite supply of water, are reviewed as described in subsections III.1 and III.2 of this SRP section, and in addition the reviewer determines:
- A. By reviewing the SAR preliminary site and plant arrangement sketches (construction permit) and site drawings and plant arrangement drawings (operating license) whether the intake and outlet conduits (open or closed type) are properly separated to prevent recirculation or water temperature stratification.
 - B. Whether manmade earth dam, dike, or other SAR structure design bases include requirements for withstanding the design basis natural phenomena or combinations of such phenomena at historically recorded intensities. In a failure of a dam, dike, or other structure not designed to withstand the design basis natural phenomena (particularly the SSE), sufficient water must remain in the source pool for a 30-day minimum cooling water supply with adequate cooling capability so that the required service water system inlet cooling water temperature is not exceeded.
5. For reviews of DC and COL applications under 10 CFR Part 52, the reviewer should follow the above procedures to verify that the design set forth in the safety analysis report, and, if applicable, site interface requirements meet the acceptance criteria. For DC applications, the reviewer should identify necessary COL action items. With respect to COL applications, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit, or other NRC-approved material, applications, and/or reports.

After this review, SRP Section 14.3 should be followed for the review of Tier I information for the design, including the postulated site parameters, interface criteria, and ITAAC.

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 UHS review included the size, type of cooling supply (e.g., large body of water, ocean, lake, natural or manmade reservoir, river, pond, or cooling tower), and makeup sources. The review has determined the adequacy of the applicant's proposed UHS design criteria, design bases, and safety classification and the requirements for cooling water delivery for a safe shutdown during normal and accident conditions. The UHS and its supporting systems meet seismic Category I, Quality Group C requirements. The staff concludes that the UHS design is

acceptable and meets the requirements of GDCs 2, 5, 44, 45, and 46. This conclusion is based on the following findings:

1. The applicant meets GDC 2 requirements for capability to withstand the effects of natural phenomena like earthquakes, tornadoes, tornado missiles, hurricanes, and floods. Acceptance is based on RG 1.27, Positions C.2 and C.3.
2. The applicant meets GDC 5 requirements for sharing of SSCs by demonstrating that such sharing does not affect the safe shutdown of any unit in an active or passive failure.
3. The applicant meets GDC 44 UHS requirements. Acceptance is based on RG 1.27, Positions C.2 and C.3; RG 1.72, Positions C.1, C.4, C.5, C.6, and C.7; and ANSI/ANS 5.1.
4. The applicant meets GDC 45 requirements for inservice inspection of the safety-related components and equipment by demonstrating the accessibility of the UHS system for periodic inspections.
5. The applicant meets GDC 46 requirements for periodic pressure and functional testing to ensure structural and leaktight integrity, operability, and performance of its active components, and operability of the system as a whole by demonstrating the capability to operate the system at full capacity during normal startup or shutdown procedures or during normal operation without degrading the system to provide for a safe shutdown or to mitigate the consequences of an accident.

For DC and COL reviews, the findings will also summarize (to the extent that the review is not discussed in other SER sections) the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable, and interface requirements and combined license action items relevant to this SRP section.

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.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

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 44, "Cooling Water."

4. 10 CFR Part 50, Appendix A, GDC 45, "Inspection of Cooling Water System."
5. 10 CFR Part 50, Appendix A, GDC 46, "Testing of Cooling Water System."
6. RG 1.27, "Ultimate Heat Sink for Nuclear Power Plants."
7. RG 1.72, "Spray Pond Piping made from Fiberglass-Reinforced Thermosetting Resin."
8. NRC Inspection Manual Chapter IMC-2504, "Construction Inspection Program - Non-ITAAC Inspections," issued April 25, 2006.
9. ANS 5.1, "Decay Heat Power for Light Water Reactors," October 1979.

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, which 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.

SRP Section 9.2.5

Description of Changes

This SRP section affirms the technical accuracy and adequacy of the guidance previously provided in draft Revision 3, dated June 1996, of this SRP section. See ADAMS accession number ML052070520.

In addition, this SRP section was administratively updated in accordance with NRR Office Instruction LIC-200, Revision 1, "Standard Review Plan (SRP) Process." The revision also adds standard paragraphs to extend application of this updated SRP section to prospective applicant submissions pursuant to 10 CFR Part 52.

The technical changes are incorporated in Revision 3, dated [Month] 2007:

Review Responsibilities - Reflects changes in review branches resulting from reorganization and branch consolidation. Change is reflected throughout the SRP.

1. General editorial and formatting changes.
 2. Deleted Branch Technical Position ASB 9-2, and replaced with the current industry standard, ANSI/ANS 5.1.
- I. AREAS OF REVIEW
1. Expanded review interface #1 (SRP Sections 2.4.1 through 2.4.14).
 2. Added review interface #2 (SRP Sections 3.2.1 and 3.2.2).
- II. ACCEPTANCE CRITERIA
1. Removed seismic guidance (Regulatory Guide 1.29) because it is covered in review interface #2.
 2. Removed reference to inspection of water control structures (Regulatory Guide 1.127) because this guidance does not belong here and it is covered in review interface #1.
 3. In "Technical Rationale" #2, changed the document which describes staff positions on UHS design for sharing of SSCs from SRP Section 9.2.5 to Regulatory Guide 1.27.
- III. REVIEW PROCEDURES
1. Removed guidance referring to inspection of water control structures because it does not belong here and it is covered in review interface #1.
 2. Removed section about surveillance and control techniques to detect and control the incidence of flow blockage problems because this is covered under review interface #12.
 3. Removed sections dealing with requirements for withstanding design basis natural phenomena because they are covered in review interfaces# 2-8.

4. Removed seismic guidance and quality group classifications, because they are covered in review interface #2.

IV. EVALUATION FINDINGS

1. Removed references to seismic classification, quality group classification, dam and water control structure design and inspection because they are covered in the review interfaces as listed above.

V. IMPLEMENTATION

VI. REFERENCES

1. Removed reference to Regulatory Guide 1.29.
2. Removed reference to Branch Technical Position ASB 9-2.
3. Removed reference to Regulatory Guide 1.127.
4. Removed reference to "Federal Guidelines for Dam Safety."
5. Removed reference to Generic Letter 89-13.