NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

## 9.2.1 STATION SERVICE WATER SYSTEM

REVIEW RESPONSIBILITIES

Primary - Plant Systems Branch (PSB)

Secondary - None

### I. AREAS OF REVIEW

The service water system (SWS) provides essential cooling to safety-related equipment and may also provide cooling to nonsafety-related auxiliary components that are used for normal plant operation. The PSB reviews the system from the service water pump intake to the points of cooling water discharge to assure conformance with the requirements of General Design Criteria 2, 4, 5, 44, 45, and 46. The ultimate heat sink (reviewed under SRP Section 9.2.5) provides the intake source of water to the SWS for long-term cooling of station features required for plant shutdown and also any special equipment required to prevent or mitigate the consequences of postulated accidents and as such is an interface system to the SWS. The SWS pump performance characteristics will be compared to the high and low water levels of the ultimate heat sink to assure that pumping capability can be provided for extended periods of operation following postulated events.

1. The PSB reviews the characteristics of the SWS components (pumps, heat exchangers, pipes, valves) with respect to their functional performance as affected by adverse operational (i.e., water hammer) and environmental occurrences including cold weather protection, by abnormal operational requirements, and by accident conditions such as a loss-of-coolant accident (LOCA) with the loss of offsite power. Since the SWS normally has requirements that relate to cooling functions during normal plant operation as well as for safety functions, the review will include an evaluation of the capability of the system to perform these multiple functions.



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

2. The PSB also reviews the design of the SWS with respect to:

   a. The capability for detection, control, and isolation of system leakage including the capability for detection and control of radioactive leakage into and out of the system and prevention of accidental releases to the environment.

   b. Measures to preclude long-term corrosion and organic fouling that would tend to degrade system performance.

   c. Provisions for system and component operational testing, including the instrumentation and control features that determine and verify that the system is operating in a correct mode (i.e., valve position, pressure and temperature indication).

   d. The effects of the failure of nonseismic Category I equipment, structures or components of safety-related portions of the SWS are taken into account in the design.

3. The PSB reviews the SWS capability to flood the reactor containment should this be required in a post-accident recovery situation.

4. The PSB reviews the system to determine that a malfunction, a failure of a component, or the loss of a cooling source will not reduce the safety-related functional performance capabilities of the system. Specifically, PSB performs the following reviews under the SRP sections indicated:

   a. Review for flood protection is performed under SRP Section 3.4.1.

   b. Review of the protection against internally-generated missiles is performed under SRP Section 3.5.1.1.

   c. Review of the structures, systems and components to be protected against externally-generated missiles is performed under SRP Section 3.5.1.4 and 3.5.2.

   d. Review of high and moderate energy pipe breaks is performed under SRP Section 3.6.1.

In addition, the PSB will coordinate other branches' evaluations that interface with the overall review of the system as follows: The Reactor Systems Branch (RSB) identifies essential components associated with the reactor coolant system and the emergency core cooling systems that are required for operation during normal operations or accident conditions. The RSB establishes accident cooling load functional requirements and minimum time intervals. The RSB performs these reviews as part of its primary review responsibility for SRP Sections 5.4.7, 5.4.8, 6.0 and 15.0. The structural and geotechnical engineering reviewer of the Engineering Branch (EB) determines the acceptability of the design analyses, procedures, and criteria used to establish the ability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena such as the safe shutdown earthquake (SSE), probable maximum flood (PMF), and tornado missiles as part as its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5. The mechanical engineering reviewer of EB determines that the

components, piping 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 mechanical engineering reviewer 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 mechanical engineering reviewer also reviews the adequacy of the inservice testing program of pumps and valves as part of its primary review responsibility for SRP Section 3.9.6. The materials engineering reviewer of EB verifies that inservice inspection requirements are met for system components as part of its primary review responsibility for SRP Section 6.6 and, upon request, verifies the compatibility of the materials of construction with service conditions. The instrumentation and control systems reviewer and the power systems reviewer of the Electrical and Instrumentation Control System Branch (EICSB) will evaluate the system controls, instrumentation, and power sources with respect to capabilities, capacity, and reliability for supplying power during normal and emergency conditions to safety-related pumps, valves and other components as part of their primary review responsibility for SRP Sections 7.1 and 8.1, respectively. The EICSB will review the signals used to isolate safety-related portions of the SWS from nonsafety-related portions in the event of postulated accidents with special emphasis paid to proper isolation of interconnected trains in the event of unusual conditions such as low pressures in the SWS or drawing low current for safety-related pumps. The reviews for Fire Protection, Technical Specifications and Quality Assurance are coordinated and performed by the Plant Systems Branch, Technical Specification Coordination Branch and the Facility Operations Branch as part of their primary review responsibility for SRP Sections 9.5.1, 16.0, and 17.0, respectively.

For those areas of review identified above as being the responsibility of other branches, the acceptance criteria and their methods of application are contained in the SRP sections identified as the primary review responsibility of those branches.

## II. ACCEPTANCE CRITERIA

Acceptability of the design of the service water system, 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. Listed below are specific criteria as they relate to the SWS.

The design of the service water system is acceptable if the integrated system design is in accordance with the following criteria:

1. General Design Criterion 2, as related to structures housing the system and the system itself being capable of withstanding the effects of earthquakes. Acceptance is based on meeting the guidance of Regulatory Guide 1.29, Position C.1 for safety-related portions and Position C.2 for nonsafety-related portions.

2. General Design Criterion 4, as related to effect of missiles inside and outside of containment, effects of pipe whip, jets and environmental conditions resulting from high and moderate energy line breaks and dynamic effects associated with flow instabilities and loads (e.g., water hammer) during normal plant operation as well as during upset or accident conditions.

3. General Design Criterion 5, as related to the capability of shared systems and components important to safety being capable of performing required safety functions.

4. General Design Criterion 44, as related to transferring heat from structures systems and components important to safety, to an ultimate heat sink. Acceptance is based on the following:

   a. The capability to transfer heat loads from safety-related structures, systems, and components to a heat sink under both normal operating and accident conditions.

   b. Component redundancy so that the safety function can be performed assuming a single active component failure coincident with the loss of offsite power.

   c. The capability to isolate components, subsystems, or piping if required so that the system safety function will not be compromised.

   d. Meeting task action plan item II.K.1-C.1.22 of NUREG-0694 for boiling water reactors regarding automatic and manual actions necessary when the main feedwater system is not operable.

   e. Meeting task action plan item II.K.1.22 of NUREG-0718 for B&W plants regarding automatic and manual actions for proper functioning of the auxiliary heat removal systems when the main feedwater system is not operable.

5. General Design Criterion 45, as related to design provisions to permit inservice inspection of safety-related components and equipment.

6. General Design Criterion 46, as related to design provisions to permit operational functional testing of safety-related systems and components.

## III. REVIEW PROCEDURES

The procedures set forth below are used during the construction permit (CP) application review to determine that the design criteria and bases and the preliminary design as set forth in the preliminary safety analysis report meet the acceptance criteria given in subsection II. For review of operating license (OL) applications, the review procedures and acceptance criteria are utilized to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report.

Upon request from the primary reviewer, the coordinating review branches will provide input for the areas of review stated in subsection I. The primary reviewer obtains and uses such input as required to assure that this review procedure is complete.

As a result of the various SWS designs provided, there will be variations in system requirements. For the purpose of this SRP section, a typical system is assumed which has fully redundant systems, with each of the systems having an identical essential (safety features) portion and an identical non-essential

portion (used for normal operation). For cases where there are variations from the typical arrangement, the reviewer will adjust the review procedures given below. However, the system design will be required to meet the acceptance criteria given in subsection II. Also, the reviewer will need to refer to SRP sections for other systems that would interface with the SWS. depending upon the nature and conditions of the ultimate heat sink cooling water (e.g., salt water).

1. The SAR is reviewed to determine that the system description and piping and instrumentation diagrams (P&IDs) show the SWS equipment that is used for normal operation, and the minimum system heat transfer and flow requirements for normal plant operation. The system performance requirements will also be reviewed to determine that it describes component allowable operational degradation (e.g., pump leakage) and describes the procedures that will be followed to detect and correct these conditions when they became excessive.

2. The reviewer, using the results of failure modes and effects analyses as appropriate, comparisons with previously approved systems, or independent calculations, determines that the system is capable of sustaining the loss of any active component and meeting minimum system requirements (cooling load and flow) for the degraded conditions. The system P&IDs, layout drawings, and component descriptions and characteristics are then reviewed for the following points:

   a. Essential portions of the SWS are correctly identified and are isolable from the non-essential portions of the system. The P&IDs are reviewed to verify that they clearly indicate the physical division between each portion and indicate the required classification changes. System drawings are also reviewed to see that they show the means for accomplishing isolation and the SAR description is reviewed to identify minimum performance requirements for the isolation valves. The drawings and descriptions are reviewed to verify that automatically operated isolation valves separate non-essential portions and components from the essential portions. Special consideration is given to the case of redundant interconnected trains to assure the operation of at least one safety-related train by proper isolation in the event of an accident or transient.

   b. Essential portions of the SWS, including the isolation valves separating essential and non-essential portions, are classified Quality Group C and seismic Category 1. Components and system descriptions in the SAR that identify mechanical and performance characteristics are reviewed to verify that the above seismic and safety classifications have been included, and that the P&IDs indicate any points of change in piping quality group classification.

   c. Design provisions have been made that permit appropriate inservice inspection and functional testing of system components important to safety. It will be acceptable if the SAR information delineates a testing and inspection program and if the system drawings show the necessary test recirculation loops around pumps or isolation valves that would be required by this program.

d. The review of seismic design is performed by the structural and geotechnical reviewer of EB and the review for seismic and quality group classification is performed by the mechanical engineering reviewer of EB as indicated in subsection I of this SRP section.

3. The reviewer determines that the safety function of the system will be maintained, as required, in the event of adverse environmental phenomena such as earthquakes, tornadoes, hurricanes, and floods, or in the event of certain pipe breaks or loss of offsite power. The reviewer uses engineering judgment, the results of a failure mode and effects analyses, and the results of reviews performed under other SRP sections to verify the following:

   a. The failure of portions of the system or of other systems not designed to seismic Category I and located close to essential portions of the system, or of non-seismic Category I structures that house, support, or are close to essential portions of the SWS, will not preclude operation of the essential portions of the SWS. Reference to SAR Chapter 2 describing site features and the general arrangement and layout drawings will be necessary as well as the SAR tabulation of seismic design classifications for structures and systems. Statements in the SAR that verify that the above conditions are met are acceptable. (CP)

   b. The essential portions of the SWS are protected from the effects of floods, hurricanes, tornadoes, and internally or externally generated missiles. Flood protection and missile protection criteria are discussed and evaluated in detail under the Section 3 series of the SRP. The reviewer will utilize the procedures identified in these SRP sections to assure that the analyses presented are valid. A statement to the effect that the system is located in a seismic Category I structure that is tornado missile and flood protected or that components of the system will be located in individual cubicles or rooms that will withstand the effects of both flooding and missiles is acceptable. The location and the design of the system, structures, and pump rooms (cubicles) are reviewed to determine that the degree of protection provided is adequate.

   c. The SWS pumps will have sufficient available net positive suction head (NPSH) at the pump suction locations considering low water levels. Reference to SRP Section 2.4, which indicates the lowest probable water level of the heat sink, and to drawings indicating the elevation of service water pump impellers will be necessary. An independent calculation verifying the applicant's conclusion will be necessary for acceptance.

   d. Provisions are made in the system to detect and control leakage of radioactive contamination into and out of the system. It will be acceptable if the system P&IDs show radiation monitors located on the system discharge and at components susceptible to leakage, and these components can be isolated by one automatic and one manual valve in series.

e. The essential portions of the system are protected from the effects of high and moderate energy line breaks. Layout drawings are reviewed to assure that no high or moderate energy piping systems are close to essential portions of the SWS, or that protection from the effects of failure will be provided. The means of providing such protection will be given in Section 3.6 of the SAR and the procedures for reviewing this information are given in the corresponding SRP sections.

f. Essential components and subsystems necessary for safe shutdown can function as required in the event of loss of offsite power. The system design will be acceptable if the SWS meets minimum system requirements as stated in the SAR assuming a concurrent failure of a single active component, including a single failure of an auxiliary electric power source. The SAR is reviewed to determine that for each SWS component or subsystem affected by the loss of offsite power, system flow and heat transfer capability meet or exceed minimum requirements. The results of failure modes and effects analyses are considered in assuring that the system meets these requirements. This will be an acceptable verification of system functional reliability.

g. Provisions are made for protection of the essential service water supply from potential failures or malfunctions caused by freezing, icing, and other adverse environmental conditions. Statements in the SAR that would indicate that safety grade heating sources will be used for this purpose, considering the equipment necessary for safe shutdown, will be acceptable.

4. The descriptive information, P&IDs, SWS drawings, and failure modes and effects analyses in the SAR are reviewed to assure that essential portions of the system can function following design basis accidents assuming a concurrent single active component failure. The reviewer evaluates the failure mode and effects analysis presented in the SAR to assure function of required components, traces the availability of these components on system drawings, and checks that the SAR contains verification that minimum system flow and heat transfer requirements are met for each accident situation for the required time spans. For each case the design will be acceptable if minimum system requirements are met.

5. The SAR is reviewed to assure that the applicant has described all the automatic and manual actions necessary for proper functioning of the service water system when the main feedwater system is not operable. The design will be acceptable in this regard if sufficient detail is presented to provide reasonable assurance that the requirements of items II.K.1.22 of NUREG-0718 and II.K.1-C.1.22 of NUREG-0694 are property implemented.

6. The SAR is reviewed to assure that the applicant has committed to address the potential for water hammer in open loop systems and will provide for venting and filling of such systems, operating procedures for avoidance of water hammer, and that the system is designed to maintain functioning following an inadvertent water hammer occurrence.

## IV. EVALUATION FINDINGS

The reviewer determines that sufficient information has been provided and his review supports conclusions of the following type, to be included in the staff's safety evaluation report.

The service water system (SWS) includes all components and piping from the SWS pump intake to the points of cooling water discharge. Portions of the SWS that are necessary for safe shutdown accident prevention, or accident mitigation are designed to seismic Category I, Quality Group C requirements. Based on the review of the applicant's proposed design criteria, design bases and safety classification for the service water system regarding the requirements for continuous cooling of safety-related components necessary for a safe plant shutdown, the staff concludes that the design of the service water system is acceptable and meets the requirements of General Design Criteria 2, 4, 5, 44, 45, and 46. This conclusion is based on the following:

1. The applicant has met the requirements of General Design Criterion 2 with respect to safety-related portions of the system being capable of withstanding the effects of earthquakes. Acceptance is based on meeting Regulatory Guide 1.29 position C.1 for the safety-related portions and position C.2 for the nonsafety-related portions.

2. The applicant has met the requirements of GDC 4 with respect to the effects of missiles inside and outside of containment, effects of pipe whip, jets and environmental conditions resulting from high and moderate energy line breaks and dynamic effects associated with flow instabilities (i.e., water hammer loads) with respect to impairment of the required service water systems during normal plant operations, and under upset or accident conditions. Acceptance with respect to effects of water hammer is based on the following:

   a. Vents shall be provided for venting of components and piping at high points in liquid filled, but normally idle piping (or systems) where voiding can occur. These vents should be designed for ease of operational testing on a periodic basis.

   b. Consideration will be given to voiding which can occur following pump shutdown, or during standby. If the system design is such that voiding could occur, means should be provided for a slow system fill upon pump start for avoidance of water hammer or that the system be designed to maintain functioning following an inadvertent water hammer occurrence.

   c. operating and maintenance procedures will be reviewed by the applicant to assure that sufficient measures have been taken for avoiding water hammer (e.g., rapid fill due to pump start, periodic fill and vent checks, avoidance of sudden valve movement, or realignment).

3. The applicant has met the requirements of General Design Criterion 5 with respect to sharing of structures, systems and components by

demonstrating that such sharing does not significantly impair the ability of the service water system to perform its safety function, including in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

4. The applicant has met the requirements of General Design Criterion 44 with respect to cooling water by providing a system to transfer heat from structures, systems and components important to safety to an ultimate heat sink. The applicant has demonstrated that the service water system can transfer the combined heat load of these structures, systems, and components under normal operating and accident conditions assuming loss of offsite power and a single failure and that portions of the system can be isolated so that the safety function of the system will not be compromised. The applicant has also met task action plan items II.K.1-C.1.22 of NUREG-0694 and II.K.1.22 of NUREG 0718 in meeting General Design Criterion 4.

5. The applicant has met the requirements of General Design Criterion 45 with respect to inspection of cooling water systems by providing a service water system which permits inservice inspection of safety-related components and equipment.

6. The applicant has met the requirements of General Design Criterion 45 with respect to testing of cooling water systems by providing a service water system design which permits operational functional testing of the system and its components.

## V. IMPLEMENTATION

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

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

Implementation scheudles for conformance to parts of the method discussed herein are contained in the referenced Regulatory Guide, NUREGs and implementation of acceptance criterion subsection II.2 is as follows:

(a) Operating plants and OL applicants need not comply with the provisions of this revision.

(b) CP applicants will be required to comply with the provisions of this revision.

## 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 44, "Cooling Water."

5. 10 CFR Part 50, Appendix A, General Design Criterion 45, "Inspection of Cooling Water System."

6. 10 CFR Part 50, Appendix A, General Design Criterion 46, "Testing of Cooling Water Systems."

7. Regulatory Guide 1.29, "Seismic Design Classification."

8. NUREG-0694, "TMI-Related Requirements of New Operating Licenses."

9. NUREG-0718, "Proposed Licensing Requirements for Pending CP's and Manufacturing License."