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

SECTION 9.2.2 REACTOR AUXILIARY COOLING WATER SYSTEMS

REVIEW RESPONSIBILITIES

Primary - Auxiliary and Power Conversion Systems Branch (APCSB)

Secondary - Reactor Systems Branch (RSB)
Electrical, Instrumentation and Control Systems Branch (EICSB)
Mechanical Engineering Branch (MEB)
Structural Engineering Branch (SEB)
Materials Engineering Branch (MTEB)

I. AREA OF REVIEW

The APCSB reviews reactor auxiliary cooling systems that are required for safe shutdown during normal, operational transient, and accident conditions, and for mitigating the consequences of an accident, or preventing the occurrence of an accident. These include closed loop auxiliary cooling systems for reactor system components, reactor shutdown equipment, ventilation equipment, and components of the emergency core cooling system (ECCS).

The review of these systems includes the pumps, heat exchangers, valves and piping, expansion tanks, makeup piping, and points of connection or interfaces with other systems. Emphasis is placed on the cooling systems for safety-related components such as ECCS equipment, ventilation equipment, and reactor shutdown equipment.

1. The APCSB reviews the capability of the auxiliary cooling systems to provide adequate cooling water to safety-related ECCS components and reactor auxiliary equipment for all planned operating conditions. The review includes the following points:

   a. The functional performance requirements of the system including the ability to withstand adverse environmental occurrences, operability requirements for normal operation, and requirements for operation during and subsequent to postulated accidents.

   b. Multiple performance functions (if required) assigned to the system and the necessity of each function for emergency core cooling and safe shutdown.

   c. The capability of the system to cope with liquid expansion or provide necessary makeup as required.

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d. The requirements for adequate net positive suction head (NPSH) for the auxiliary cooling pumps.

e. The sizing of the system for core cooling and decay heat loads and the associated design margin.

2. The APCSB review verifies that system components and piping have sufficient physical separation or shielding to protect essential portions of the system from missiles and pipe whip or from jet impingement that may result from piping cracks or breaks.

3. Other system aspects that are reviewed are:

a. The use of design and fabrication codes consistent with the assigned quality group classification and seismic category.

b. The effects of non-seismic Category I component failures on the seismic Category I portion of the system.

c. The provisions for detection, collection, and control of system leakage and the means provided to detect leakage of activity from one system to another and preclude its release to the environment.

d. The provisions to control long-term corrosion and organic fouling.

e. The requirements for operational testing and inservice inspection of the system.

f. Instrumentation and control features necessary to accomplish design functions, including isolation of components to deal with leakage or malfunctions, and actuation requirements for redundant equipment.

4. The applicant's proposed technical specifications will be reviewed for operating license applications as they relate to areas covered in this review plan.

The review of the cooling water systems will involve secondary reviews performed by other branches. The results are used by the APCSB to complete overall evaluation of the system. The secondary reviews are as follows: the RSB will identify engineered safety feature components associated with the reactor coolant system and the emergency core cooling systems that are required for operation during normal operations and accident conditions. RSB will establish cooling load functional requirements and minimum time intervals and assure that the seismic and quality group classifications for system components are acceptable. The SEB will determine the acceptability of the design analyses, procedures, and criteria used to establish the ability of Category I structures housing the system and supporting systems to withstand the effects of natural phenomena such as the safe shutdown earthquake (SSE), the probable maximum flood (PMF), and tornado missiles. The MEB will review the seismic qualification of components and confirm that the system is designed in accordance with applicable codes and standards. The MTEB will verify that inservice inspection requirements are met

for system components and, upon request, will verify the compatibility of the materials of construction with service conditions. The EICSB will determine the adequacy of the design, installation, inspection, and testing of all essential electrical components required for proper operation.

II. ACCEPTANCE CRITERIA

Acceptability of the designs of cooling water systems as described in the applicant's safety analysis report (SAR), including related sections of Chapters 2 and 3 of the SAR, is based on specific general design criteria and regulatory guides, and on independent calculations and staff judgments with respect to system functions and component selection. Listed below are specific criteria as they relate to the cooling water systems.

The design of a cooling 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 natural phenomena such as earthquakes, tornadoes, hurricanes, and floods.

2. General Design Criterion 4, with respect to structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

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

4. General Design Criterion 44, to include:

   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 safety functions can be performed assuming a single active component failure coincident with the loss of offsite power.

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

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

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

   a. Structural integrity and system leak tightness.

b. Operability and adequate performance of active system components.

c. Capability of the integrated system to perform required functions during normal, shutdown, and accident situations.

7. Regulatory Guide 1.26, as related to the quality group classification of systems and components.

8. Regulatory Guide 1.29, as related to the seismic design classification of system components.

9. Branch Technical Position APCSB 3-1, as related to high and moderate energy breaks in piping systems outside containment.

An additional basis for determining the acceptability of a cooling water system will be the degree of similarity of the design with that of previously reviewed plants with satisfactory operating experience.

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 Section II of this plan. For the review of operating license (OL) applications, 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 as set forth in the final safety analysis report.

The procedures for OL reviews include a determination that the content and intent of the technical specifications prepared by the applicant are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff's review.

One of the main objectives in the review of a cooling water system (CWS) is to determine its function with regard to safety. Some cooling systems are designed as safety-related systems in their entirety, others have only portions of the system that are safety related, and others are classified as non-safety-related because they do not perform any safety function. In order to determine the safety category of a cooling water system, the APCSB will evaluate its necessity for achieving safe reactor shutdown conditions or for accident prevention or accident mitigation functions. The safety functions to be performed by these systems in all designs are essentially the same, however, the method used varies from plant to plant depending upon the individual designer.

In view of the various designs provided, the procedures set forth below are for a typical cooling water system designed entirely as a safety-related system. Any variance of the review procedures to take account of a proposed unique design will be such as to assure that the system meets the criteria of Section II. The reviewer will select and emphasize material from this review plan, as may be appropriate for a particular case.

1. The information provided in the SAR pertaining to the design bases and design criteria, and the system description section are reviewed to verify that the equipment used and the minimum system heat transfer and flow requirements for normal plant operations are identified. A review of the system piping and instrumentation diagrams(P&IDS) will show which components of the system are utilized to:

   a. Remove heat from the reactor primary coolant system equipment necessary to achieve a safe reactor shutdown.

   b. Provide essential cooling for containment components or systems such as the sprays, ventilation coolers, or sump equipment.

   c. Provide cooling for decay heat removal equipment.

   d. Provide cooling for emergency core cooling pump bearings or other emergency core cooling equipment necessary to prevent or mitigate the consequences of an accident.

2. The system performance requirements section is reviewed to determine that it limits allowable component operational degradation (e.g., pump leakage) and describes the procedures that will be followed to detect and correct these conditions when degradation becomes excessive.

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

   a. Essential portions of the CWS 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 required classification changes. System drawings are reviewed to see that they show the means for accomplishing isolation and the SAR description is reviewed to identify minimum performance of the isolation valves. The drawings and description are reviewed to verify that automatically operated isolation valves separate non-essential portions and components from the essential portions.

   b. Essential portions of the CWS, including the isolation valves separating seismic Category I portions from the non-seismic portions, are Quality Group C or higher and seismic Category I. System design bases and criteria, and the component classification tables are reviewed to verify that the heat exchangers, pumps, valves and piping of essential portions of the system will be designed to seismic Category I requirements in accordance with the applicable criteria.

c. The system is designed to cope with liquid expansion or to provide water makeup as necessary. Where the cooling water systems are closed loop systems, surge tanks are generally provided to accommodate liquid volume changes due to changes in temperature or leakage and to receive system makeup water as required. The surge tank and connecting piping are reviewed to assure that makeup water can be supplied to either header in a split header system. Redundant surge tanks (one to each header) or a divided surge tank design are acceptable to assure that in the event of a header rupture the loss of the entire contents of the surge tank will not result.

d. Net positive suction head (NPSH) requirements for the cooling water pumps are met during normal operations and accident conditions, including conditions of extreme low water levels. The review of the system design information and the system and station drawings locating the cooling water system in the facility identifies the components and water levels necessary to provide NPSH for the cooling water pump. Independent analyses and engineering judgment are used in conjunction with pump performance curves to assure that the design and the location of the pump and components are such as to maintain appropriate NPSH requirements.

e. The system is designed for removal of heat loads during normal operation and of emergency core cooling heat loads during accident conditions, with appropriate design margins to assure adequate operation. A comparative analysis is made of the system flow rates, heat levels, maximum temperature, and heat removal capabilities with similar designs previously found acceptable. To verify performance characteristics of the system, an independent analysis may be made.

f. Design provisions are 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.

g. Essential portions of the system are protected from the effects of high energy and moderate energy line breaks. The system description and layout drawings will be reviewed to assure that no high or moderate energy piping systems are close to essential portions of the CWS 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 review plans.

h. Essential components and subsystems (i.e., those necessary for safe shutdown) can function as required in the event of a loss of offsite power. The system design will be acceptable in this regard if the essential portions of the CWS meet minimum system requirements as stated in the SAR assuming a concurrent failure of a single active component, including a single failure of any auxiliary electric power source. The SAR is reviewed to determine that for each CWS component or

subsystem affected by the loss of offsite power, system flow and heat transfer capability 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.

3. The system design information and drawings are analyzed to assure that the following features will be incorporated.

   a. A leakage detection system is provided to detect component or system leakage. An adequate means for implementing this criterion is to provide sumps or drains with adequate capacity and appropriate alarms in the immediate area of the system.

   b. Components and headers of the system are designed to provide individual isolation capabilities to assure system function, control system leakage, and allow system maintenance.

   c. Design provisions are made to assure the capability to detect leakage of radioactivity or chemical contamination from one system to another, to preclude long-term corrosion, organic fouling, or the spreading of radioactivity. Radioactivity monitors and conductivity monitors should be located in the system component discharge lines to detect leakage. An alternate means is to prevent leakage from occurring by operating the system at higher pressure to assure that leakage is in the preferred direction.

4. The reviewer verifies that the system has been designed so that system functions will be maintained, as required, in the event of adverse environmental phenomena such as earthquakes, tornadoes, hurricanes, and floods. The reviewer evaluates the system using engineering judgment and the results of failure modes and effects analyses to determine the following:

   a. The failure of portions of the system or of other systems not designed to seismic Category I standards 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 CWS, will not preclude essential functions. The review will identify these non-seismic category components or piping and assure that appropriate criteria are incorporated to provide isolation capabilities in the event of failure. Reference to SAR Chapter 2, describing site features, and the general arrangement and layout drawings will be necessary as well as to the SAR tabulation of seismic design classifications for structures and systems.

   b. The essential portions of the CWS 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 standard review plans for Chapter 3 of the SAR. The reviewer will utilize the procedures identified in these review plans 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 design of the system, structures, and pump rooms (cubicles) are reviewed to determine that the degree of protection provided is adequate.

5. The descriptive information, P&IDs CWS drawings, and failure modes and effects analysis in the SAR are reviewed to assure that essential portions of the system will 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 information 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.

IV. EVALUATION FINDINGS

The reviewer verifies 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 reactor auxiliary cooling water systems include pumps, heat exchangers, valves and piping, expansion tanks, makeup piping, and the points of connection or interfaces with other systems. The scope of review of the cooling water systems for the _____ plant included layout drawings, process flow diagrams, piping and instrumentation diagrams, and descriptive information for the cooling water systems and the auxiliary supporting systems that are essential to operation of the cooling water systems. [The review has included the applicant's proposed design criteria and design bases for the cooling water systems, the adequacy of those criteria and bases, and the requirements for continuous cooling (if necessary) during all conditions of plant operation. (CP)] [The review has included the applicant's analysis of the manner in which the design of the cooling water systems and auxiliary supporting systems demonstrates conformance to the design criteria and bases. (OL)]

"The basis for acceptance in the staff review has been conformance of the applicant's designs and design criteria for the cooling water systems and necessary auxiliary supporting systems to the Commission's regulations as set forth in the general design criteria, and to applicable regulatory guides, staff technical positions, and industry standards.

"The staff concludes that the design of the cooling water systems conforms to all applicable regulations, guides, staff positions, and industry standards, and is acceptable."

V. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, General Design Criterion 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 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 System."

7. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive Waste-Containing Components of Nuclear Power Plants."

8. Regulatory Guide 1.29, "Seismic Design Classification," Revision 1.

9. Branch Technical Position APCSB 3-1, "Protection Against Postulated Piping Failure in Fluid Systems Outside Containment," attached to Standard Review Plan 3.6.1.

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