U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

9.2.2 REACTOR AUXILIARY COOLING WATER SYSTEMS

REVIEW RESPONSIBILITIES

Primary - Plant Systems Branch ~~(PSB)~~(SPLB)[1]

Secondary - None

I. AREAS OF REVIEW

The ~~PSB~~SPLB[2] reviews reactor auxiliary cooling water systems (CWS) that are required for safe shutdown during normal operations, ~~operational transients~~anticipated operational occurrences,[3] and accident conditions and for mitigating the consequences ~~of an accident~~[4] or preventing the occurrence of an accident. These include closed loop auxiliary cooling water 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 components of the system, valves and piping, and points of connection or interfaces with other systems. Emphasis is placed on the CWS for safety-related components such as ECCS equipment, ventilation equipment, and reactor shutdown equipment. The ~~PSB~~SPLB[5] reviews reactor auxiliary cooling water systems to ensure conformance with the requirements of General Design Criteria 2, 4, 5, 44, 45, and 46.

1. The ~~PSB~~SPLB[6] 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 operational (~~i.e.~~e.g.,[7] water hammer) and 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 surge tank to perform its intended function.

d. The capability of the system to provide adequate cooling water during all operating conditions.

e. Controls to ensure that the component cooling water loop to the reactor coolant pump (RCP) seal does not automatically isolate and provisions for the control room operators to isolate the RCP seal coolant line by remote manual means (see subsection III.4.f). [8]

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

2. Other system aspects that are reviewed include:

a. The effects of nonseismic Category I component failures on the seismic Category I portion of the system.

b. 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.

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

d. The capability of the system to provide adequate cooling to the seals and bearings of all reactor coolant pumps.

e. 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.

f. A simplified reliability analyses using event-tree and fault-tree logic techniques.

~~3.~~[9] ~~PSB also performs the following reviews under the SRP sections indicated:~~

~~a. Review of flood protection is performed under SRP Section 3.4.1,~~

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

c. Review of the protection of structures, systems and components against the effects of externally-generated missiles is performed under SRP Sections 3 5.1.4 and 3.5.2, and

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) 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, transients, and accident conditions. RSB will establish cooling load functional requirements and minimum time intervals associated with safety-related components. 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) will determine the acceptability of the design analyses, procedures, and criteria used to establish the ability of Category I structures that house 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 as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1, 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 and 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 material 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 power systems reviewer of the Electrical and Instrumentation Control Systems Branch (EICSB) will determine the adequacy of the design, installation, inspection, and testing of all essential electrical components, system controls, and instrumentation required for proper operation as part of their primary review responsibilities for SRP Sections 7.1 and 8.1, respectively. The EICSB will review the signals used to isolate safety-related portions of the reactor auxiliary cooling water system 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 reactor auxiliary cooling water system or drawing low current for safety-related pumps. The review 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.

Review Interfaces[10]

1. ~~PSB~~SPLB[11] also performs the following reviews under the Standard Review Plan (SRP)[12] sections indicated:

   a. Review of 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 protection of structures, systems, and components against the effects of externally-generated missiles is performed under SRP Sections 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; ~~and~~

   e. Review of fire protection is performed under SRP Section 9.5.1.; and

   f. Review of the test program for monitoring the heat transfer capability of safety-related heat exchangers cooled by service water under SRP Section 9.2.1. If such tests indicate degradation in heat transfer capability that cannot be remedied by maintenance of the service water system, closed loop cooling systems such as the Reactor Auxiliary CWS reviewed under SRP 9.2.2 should be included in the scope of the inspection and maintenance program for service water systems, also reviewed under SRP 9.2.1.[13]

2. The ~~PSB~~SPLB[14] will coordinate other branches evaluations that interface with the overall review of the system as follows:

   a. The Reactor Systems Branch ~~(RSB)~~(SRXB)[15] 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, ~~transients~~anticipated operational occurrences,[16] and accident conditions. ~~(RSB)~~The SRXB[17] will establish cooling load functional requirements and minimum time intervals associated with safety-related components. The ~~(RSB)~~SRXB[18] performs these reviews as part of its primary review responsibility for SRP Sections 5.4.7, 5.4.8, 6.0, and 15.0.

   b. The ~~structural and geotechnical engineering reviewer of the Engineering Branch (EB)~~ Civil Engineering and Geosciences Branch (ECGB)[19] will determine the acceptability of the design analyses, procedures, and criteria used to establish the ability of Category I structures that house 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 as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1, 3.7.4, 3.8.4, and 3.8.5.

c. ~~The mechanical engineering reviewer of the EB~~Mechanical Engineering Branch (EMEB)[20] 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 and 3.9.3. ~~The mechanical engineering reviewer~~The EMEB[21] 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~~The EMEB[22] 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.

d. The ~~material engineering reviewer of the (EB)~~ECGB[23] 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~~.

e. The ~~material engineering reviewer of the (EB)~~Materials and Chemical Engineering Branch (EMCB) ~~verifies that inservice inspection requirements are met for system components as part of its primary review responsibility for SRP Section 6.6 and~~,[24] upon request, verifies the compatibility of the materials of construction with service conditions.

f. ~~The instrumentation and control systems reviewer and power systems reviewer of the Electrical and Instrumentation Control Systems Branch (EICSB)~~The Instrumentation and Controls Branch (HICB)[25] will determine the adequacy of the design, installation, inspection, and testing of all essential system controls and instrumentation required for proper operation as part of their primary review responsibilities for SRP Section 7.1.

The HICB will also review the signals used to isolate safety-related portions of the reactor auxiliary cooling water system 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 reactor auxiliary cooling water system or drawing low current for safety-related pumps.

g. The Electrical Engineering Branch (EELB)[26] will determine the adequacy of the design, installation, inspection, and testing of all essential electrical components required for proper operation as part of their primary review responsibilities for SRP Section 8.1. The EELB also coordinates the overall review of conformance with station blackout requirements as part of its primary review responsibility for SRP Section 8.4 (proposed).[27]

h. The ~~Technical Specification Coordination Branch~~Technical Specification Branch (TSB)[28] coordinates and performs reviews for Technical Specifications as part of its primary review responsibility for SRP Section 16.0

i. The ~~Facility Operations Branch~~Quality Assurance and Maintenance Branch (HQMB)[29] coordinates and performs reviews for Quality Assurance as part of its primary review responsibility for SRP Section ~~17.0~~17.3.[30]

For those areas of review identified as part of the primary responsibility of other branches, the acceptance criteria and methods of application are contained in the referenced SRP section.

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. The design of a CWS is acceptable if the integrated system design is in accordance with the following requirements and recommendations:

1. General Design Criterion 2 (GDC 2),[31] 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 (GDC 4),[32] as related to 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 and attendant loads (i.e., water hammer) during normal plant operation as well as during upset or accident conditions.

3. General Design Criterion 5 (GDC 5),[33] as related to shared systems and components important to safety being capable of performing required safety functions.

4. General Design Criterion 44 GDC 44),[34] as it relates to:

   a. The capability to transfer heat leads 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.

   d. Loss of cooling water to ~~reactor coolant pump (~~RCP~~)~~ seals~~,Task Action Plan items II.K.2.16 and II.K.3.25 of NUREGs-0718 and 0737 as they related to~~ as per 10 CFR 50.34(f)(1)(iii).[35]

   e. Remote manual isolation of the RCP seal coolant water by the main control room operator to permit continued long-term pump operation in an actual event.[36]

~~e.~~f. A single failure in the CWS does not result in fuel damage or reactor coolant leakage in excess of normal coolant-makeup capability. Single failure includes but is not limited to operator error, spurious activation of a valve operator, and loss of a cooling water pump.

g. A moderate-energy leakage crack or an accident that is initiated from a failure in the CWS piping does not result in excessive fuel damage or reactor coolant leakage in excess of normal coolant- makeup capability. A single active failure is considered when evaluating the consequences of this accident. Moderate leakage cracks are determined in accordance with the guidelines of Branch Technical Position ASB[37] 3-1, "Protection Against Postulated Failures in Fluid Systems Outside Containment."

h. It has been demonstrated by testing that the reactor coolant pumps will withstand a complete loss of cooling water for 20 minutes, and instrumentation in accordance with ~~IEEE 279~~ IEEE Std 603 as endorsed by Regulatory Guide 1.153,[38] that alarms in the control room is provided to detect a loss of cooling water to ensure a period of 20 minutes is available so that the operator would have sufficient time to initiate manual protection of the plant. Alternatively, if it is not demonstrated by the necessary pump testing that the reactor coolant pumps will operate for 20 minutes without operator corrective action, then:[39]

1. Instrumentation in accordance with ~~IEEE 279~~ IEEE Std 603, as endorsed by Regulatory Guide 1.153,[40] is provided consistent with the criteria for the protection system to initiate automatic protection of the plant upon loss of cooling water to a pump. For this case, the component cooling water supply to the seal and bearing of the pump may be designed to nonseismic Category I requirements and Quality Group D; or

2. The component cooling water supply to each pump is designed to be capable of withstanding a single active failure or a moderate-energy line crack as defined in Branch Technical Position ASB[41] 3-1 and to seismic Category I, Quality Group C, and ASME Section III Class 3 requirements.

5. General Design Criterion 45 (GDC 45),[42] as related to the design provisions to permit inservice inspection of safety-related components and equipment.

6. General Design Criterion 46 (GDC 46),[43] as related to the design provisions to permit operational functional testing of safety-related systems or components to ensure:

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.

Technical Rationale[44]

The technical rationale for application of these acceptance criteria to reviewing the CWS is discussed in the following paragraphs:[45]

1. Compliance with GDC 2 requires that nuclear power plant structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquake, tornado, hurricane, flood, tsunami, and seiche without loss of capability to perform their intended safety functions.

   The function of the reactor auxiliary CWS is to provide adequate cooling water to reactor system components, reactor shutdown equipment, ventilation equipment, and components of the ECCS during normal operations, anticipated operational occurrences, and accident conditions. GDC 2 applies to this SRP section to ensure that the CWS can withstand the effects of all appropriate combinations of seismic and dynamic effects resulting from these natural phenomena without loss of capability to perform its design safety functions.

   Meeting the requirements of GDC 2 provides assurance that the reactor auxiliary CWS and associated equipment will be capable of operating during the most severe historical natural phenomena, in combination with appropriate normal operations and accident conditions, without loss of capability to perform their intended safety functions.[46]

2. Compliance with GDC 4 requires that structures, systems, and components important to safety be designed to accommodate the effects of, and be compatible with, environmental conditions associated with normal operations, maintenance, testing, and postulated accidents, including loss-of-coolant accidents (LOCAs) and dynamic effects resulting from pipe whip, missiles, and discharging fluids.

   GDC 4 applies to this SRP section because the reviewer evaluates the CWS and its associated equipment to verify their capability to continue functioning in a manner that will ensure safe shutdown during normal operations, anticipated operational occurrences, and accident conditions. In addition, the CWS must be able to mitigate the consequences, or prevent the occurrence, of an accident caused by exposure to environmental conditions associated with normal operations, maintenance, testing, or postulated accidents, including LOCAs and dynamic effects resulting from pipe whip, missiles, and discharging fluids. SRP Section 9.2.2 provides guidance acceptable to the staff for complying with these requirements.

   Meeting the requirements for GDC 4 provides assurance that the reactor auxiliary CWS and its associated components will continue to perform required safety functions while being exposed to environmental conditions associated with normal operations, maintenance, testing, and postulated accidents, including LOCAs and dynamic effects resulting from pipe whip, missiles, and discharging fluids.[47]

3. Compliance with GDC 5 requires that structures, systems, and components important to safety shall not be shared by nuclear power units unless it can be shown that such sharing

will not significantly impair their ability to perform their intended safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

GDC 5 applies to this SRP section because the reviewer evaluates the use of the reactor auxiliary CWS in multiple-unit plants to ensure that an accident in one unit will not significantly affect the capability to conduct a safe and orderly shutdown and cooldown in other units. SRP Section 9.2.2 provides guidance acceptable to the staff for complying with these requirements.

Meeting the requirements of GDC 5 provides assurance that the reactor auxiliary CWS and its associated components will continue performing their required safety functions even if they are shared by multiple nuclear power units.[48]

4. Compliance with GDC 44 requires that a system be provided to transfer heat from structures, systems, and components important to safety. The system must be capable of functioning under normal operating and accident conditions, assuming a single failure concurrent with the loss of offsite power.

GDC 44 applies to this SRP section because the reviewer evaluates the reactor auxiliary CWS to ensure its capability to continue performing its intended safety functions during normal operations, anticipated operational occurrences, and accident conditions, assuming a single failure concurrent with the loss of offsite power. SRP Section 9.2.2 provides guidance acceptable to the staff for complying with these requirements.

Meeting the requirements of GDC 44 provides assurance that the reactor auxiliary CWS and its associated components will continue performing their required safety functions, assuming a single failure concurrent with the loss of offsite power.[49]

5. Compliance with 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.

GDC 45 applies to this SRP section because the reviewer evaluates the reactor auxiliary CWS to verify that appropriate periodic inspection of important components (e.g., heat exchangers and piping) will ensure the integrity and capability of the system to perform its safety-related functions during normal operations, anticipated operational occurrences, and accident conditions. In addition, the CWS must be able to mitigate the consequences, or prevent the occurrence, of an accident. SRP Section 9.2.2 describes staff positions related to the design and inspection of the CWS, including guidance for inspecting the system and its components.

Meeting the requirements of GDC 45 provides assurance that important components of the CWS can be inspected, thereby ensuring the integrity and the system and its capability to perform its design safety functions.[50]

6. Compliance with 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 components, as well as the operability of the system as a whole, at conditions as close to the design basis as practical.

GDC 46 applies to this SRP section because the reviewer evaluates the CWS to verify that periodic pressure and functional testing of the system will ensure the leaktight integrity and operability of its components, as well as the operability of the system as a whole, at conditions as close to the design basis as practical. SRP Section 9.2.2 describes staff positions related to the inspection of the reactor auxiliary CWS, including periodic testing of the system and its components.

Meeting the requirements of GDC 46 provides assurance that components of the reactor auxiliary CWS can and will be tested, thereby ensuring that it will be capable of performing its intended safety functions.[51]

III. REVIEW PROCEDURES

The procedures set forth below are used during the standard design certification or construction permit (CP) application review to determine that the design criteria and bases and the preliminary design as set forth in the preliminary SAR meet the acceptance criteria given in subsection II of this SRP section. For the review of operating license (OL) or combined license (COL)[52] applications, the review procedures and acceptance criteria given in subsection II will be used to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final SAR.

One of the main objectives in the review of a 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 nonsafety-related because they do not perform any safety function. To determine the safety category of a reactor auxiliary[53] CWS, the ~~PSB~~SPLB[54] 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.

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

In view of the various designs provided, the procedures set forth below are for a typical reactor auxiliary[55] CWS 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 ensure that the system meets the criteria of subsection II. The reviewer will select and emphasize material from this SRP section, 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 used to:

a. Remove heat from the reactor primary coolant system 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 describes 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 nonessential 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 nonessential portions and components from the essential portions. Special consideration is given to the case of redundant interconnected trains to ~~assure~~ ensure[56] operation of at least one safety-related train by proper isolation in the event of an accident or ~~transient~~ anticipated operational occurrences.[57]

b. Essential portions of the CWS, including the isolation valves separating seismic Category I portions from the nonseismic portions, are Quality Group C 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. The review of seismic design is performed by the ~~structural and geotechnical reviewer of~~

~~(EB)~~ECGB[58] and the review for seismic and quality group classification is performed by the ~~mechanical engineering reviewer of (EB)~~EMEB[59] as indicated in subsection I of this SRP section.

c. The system is designed to provide water makeup as necessary. Cooling water systems that are closed loop systems are reviewed to ensure that the surge tanks have sufficient capacity to accommodate expected leakage from the system for seven days or that a seismic source of makeup can be made available within a time frame consistent with the surge tank capacity (time zero starts at low level alarm). The surge tank and connecting piping are reviewed to ensure 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 ensure that in the event of a header rupture, the loss of the entire contents of the surge tank will not occur.

d. 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 ensure 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.

e. Design provisions are made that permit appropriate inservice inspection and functional testing of system components important to safety. ~~The applicant should ensure that~~ [60]The SAR information delineates a testing and inspection program and the system drawings show the necessary test recirculation loops around pumps or isolation valves necessary for this program.

f. 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 ensure 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 SRP sections.

g. Essential components and subsystems (i.e., those necessary for safe shutdown) can function as required in the event of a loss of offsite power and instrument air systems. 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 or instrument air systems, system flow and heat transfer capability exceed minimum requirements. The results of failure-modes and -effects analyses are considered in ensuring that the system meets these requirements. This will be an acceptable verification of system functional reliability. The effects of loss of

cooling water to RCP seals as a result of loss of power will be reviewed as indicated in ~~Task Action Plan items II.K.2.16 and II.K.3.25 of NUREGs-07I8 and 0737.~~10 CFR 50.34(f)(1)(iii) and clarified in subsection III.4.e of this SRP section.[61]

4. The system design information and drawings are analyzed to ensure 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 ensure system function, control system leakage, and allow system maintenance.

   c. Design provisions are made to ensure the capability to detect leakage of radioactivity or chemical contamination from one system to another. Radioactivity monitors and conductivity monitors should be located in the system component discharge lines to detect leakage. An alternative means is to prevent leakage from occurring by operating the system at higher pressure to ensure that leakage is in the preferred direction.

   d. The system is designed to provide cooling to the reactor coolant pump seals and bearings during normal plant operating conditions, ~~anticipated transients~~anticipated operational occurrences,[62] and following postulated accidents. Instrumentation in accordance with ~~IEEE 279~~ IEEE Std 603 as endorsed by Regulatory Guide 1.153,[63] with alarms in the control room should be provided to detect a loss of cooling water in order to ensure that a period of 20 minutes is available to the operator to initiate manual protection of the plant, if necessary. ~~It has been demonstrated by testing that the reactor coolant pumps could potentially operate with loss of cooling water for 20 minutes without the need for operator action.~~

      ~~As an alternative to pump testing, the reviewer verifies that:~~

      ~~(1) Instrumentation in accordance with IEEE 279 is provided consistent with the criteria for the protection system to initiate automatic protection of the plant upon loss of water to a pump. For this case, the component cooling water supply to the seal and bearing of the pump may be designed to nonseismic Category I requirements and Quality Group D, or~~

      ~~(2) The component cooling water supply to each pump is designed to be capable of withstanding a single active failure or a moderate-energy line crack as defined in Branch Technical Position ASB 3-1 and to seismic~~

~~Category D, Quality Group C, and ASME Section III, Class 3 requirements.~~[64]

e. For new PWRs applications, design provisions are made to provide for RCP seal integrity during station blackout. Acceptable provisions include a diverse injection/cooling system that may be powered from the alternate ac (AAC) source for station blackout and that is independent of non-AAC source-backed injection/cooling systems and associated support systems to the extent practicable. Where a system for RCP seal injection/cooling is required specifically to meet the station blackout duration, the system should conform with position C.3.3.4 of Regulatory Guide 1.155 regarding ability to actuate and control the system from appropriate locations.

As an alternative to providing for independent RCP seal cooling, the applicant may provide adequate testing data in support of the proposed RCP seal design, thus demonstrating that seal integrity will be maintained after extended loss of seal injection and cooling.[65]

f. Design provisions are made for isolation of component cooling water supply and return lines to the RCP by remote manual means only. Design provisions are made to ensure that the control room operator has the necessary information to determine when it is appropriate to isolate the lines by remote manual means and how soon the lines should be isolated if the lines become a release path from the containment during a LOCA.[66]

5. 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 nonseismic 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 nonseismic category components or piping and ensure 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 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 SRP sections for Chapter 3 of the SAR. The reviewer will use the procedures identified in these SRP sections to ensure 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.

6. The descriptive information, P&Ids, CWS drawings, and failure-modes and -effects analyses in the SAR are reviewed to ensure that essential portions of the system will function following design basis accidents assuming a concurrent single, active component failure. The reviewer evaluates the information presented in the SAR to determine the ability of required components to function, 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.

7. The SAR is reviewed to ~~assure~~ ensure that the applicant has committed to address the potential for water hammer in the auxiliary cooling water systems and ~~will~~has provided[67] means for prevention, or avoidance, such as venting and filling capability and operating procedures for avoidance of water hammer. Guidance for water hammer prevention and mitigation is found in NUREG-0927 (Reference 12).[68]

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[69]

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and ~~his~~ that the[70] review supports conclusions of the following type to be included in the staff's safety evaluation report (SER):[71]

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. Portions of the reactor auxiliary cooling water systems that are necessary for safe shutdown, accident prevention or accident mitigation are designed to seismic Category I and Quality Group C requirements. Based on the review of the applicant's proposed design criteria, design bases, and safety classification for the reactor auxiliary cooling water systems with regard to the requirements for providing adequate cooling water for the safety-related ECCS components and reactor auxiliary equipment for all conditions of plant operation, the staff concludes that the design of the reactor auxiliary cooling water systems 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 systems 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 and attendant loads (i.e., water hammer) with respect to impairment of the required functions of auxiliary cooling 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 components and piping at high points in liquid filled systems which is normally idle and in which voids could occur. These vents should be located for ease of operation and 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 after pump shutdown or during standby,[72] means should be provided for a slow system fill upon pump start to avoid water hammer or the system should be designed to maintain function following an inadvertent water hammer occurrence.

   c. Operating and maintenance procedures shall be reviewed by the applicant to ~~assure~~ ensure that adequate measures are taken to avoid water hammer due to voided line conditions.

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 reactor auxiliary cooling water systems to perform their 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 reactor auxiliary cooling water systems 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.

5. The applicant has met the requirements of General Design Criterion 45 with respect to inspection of cooling water systems by providing reactor auxiliary cooling water systems

design features which permit inservice inspection of safety-related components and equipment.

6. The applicant has met the requirements of General Design Criterion 46 with respect to testing of cooling water systems by providing reactor auxiliary cooling water systems design features which permit operational functional testing of the system and its components.

7. Also in meeting the requirements of General Design Criterion 44, the applicant has demonstrated that:

   a. The system can withstand a loss of power without damage to RCP seals in accordance with ~~items II.K.16 and II.K.25 of NUREGs-0718 and 0737.~~ the requirements of 10 CFR 50.34(f)(1)(iii) and the guidance of subsection III.4.e of this SRP section.[73]

   b. The RCP seal coolant lines will not automatically isolate.

   c. The main control room operator will have the necessary information and basis to determine when it is appropriate to isolate the lines by remote manual means and how fast the lines should be isolated.[74]

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[75]

V. IMPLEMENTATION

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

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[76] Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's Regulations, the method described herein will be used by the staff in its evaluation of 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.[77]

~~Implementation schedules 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.~~[78]

VI. REFERENCES

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

2. General Design Criterion 4, "Environmental and ~~Missile~~ Dynamic Effects Design ~~Basis~~ Bases," of Appendix A to 10 CFR Part 50.[79]

3. General Design Criterion 5, "Sharing of Structures, Systems, and Components," of Appendix A to 10 CFR Part 50.

4. General Design Criterion 44, "Cooling Water," of Appendix A to 10 CFR Part 50.

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

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

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

~~8. NUREG-0718 "Proposed Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License."~~[80]

~~9. NUREG-0737 "Clarification of TMI Action Plan Requirements."~~[81]

8. Regulatory Guide 1.155, "Station Blackout."[82]

9. Branch Technical Position SPLB 3-1, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment" (attached to SRP Section 3.6.1).[83]

10. IEEE Std 603-1980, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," The Institute of Electrical and Electronics Engineers, Inc.[84]

11. 10 CFR 50.34(f), "Contents of Applications, Technical Information, Additional TMI-Related Requirements."[85]

12. Regulatory Guide 1.153, "Criteria for Power, Instrumentation, and Control Portions of Safety Systems."[86]

13. NUREG-0927, Revision 1, "Evaluation of Water Hammer Occurrences in Nuclear Power Plants," March 1984.[87]

SRP Draft Section 9.2.2
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Current PRB name and abbreviation	Changed PRB to SPLB.
2.	Current PRB name and abbreviation	Changed PRB to SPLB.
3.	SRP-UDP format item	Changed to implement GSI B-3.
4.	Editorial	Deleted unnecessary repetition of "of an accident."
5.	Current PRB name and abbreviation	Changed PRB to SPLB.
6.	Current PRB name and abbreviation	Changed PRB to SPLB.
7.	Editorial	Changed "i.e.," to "e.g."
8.	Integrated Impact No. 504	Added Subsection I.1.e in accordance with Integrated Impact No. 504.
9.	SRP-UDP format item	Relocated all lined-out text under "Review Interfaces."
10.	SRP-UDP format item	Added "Review Interfaces" to AREAS OF REVIEW and organized in numbered paragraph form to describe how SPLB reviews aspects of the CWS under other SRP sections and how the branches support the review of the CWS. Wording was preserved.
11.	Current PRB abbreviation	Changed PRB to SPLB.
12.	Editorial	Defined SRP.
13.	Potential Impact 25830	Added a Review Interface to SRP 9.2.1 for review of the heat exchanger test, inspection and maintenance program in accordance with GL 89-13.
14.	Current PRB abbreviation	Changed PRB to SPLB.
15.	Current PRB name and abbreviation	Changed PRB to Reactor Systems Branch (SRXB).
16.	SRP-UDP format item	Changed to implement GSI B-3.
17.	Current PRB abbreviation	Changed PRB to SRXB.
18.	Current PRB abbreviation	Changed PRB to SRXB.
19.	Current PRB name and abbreviation	Changed PRB Civil Engineering and Geosciences Branch (ECGB) and specified responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1, 3.7.4, 3.8.4 and 3.8.5.
20.	Current PRB abbreviation and name	Changed PRB to Mechanical Engineering Branch (EMEB).
21.	Current PRB abbreviation	Changed PRB to EMEB.
22.	Current PRB abbreviation	Changed PRB to EMEB.

Item	Source	Description
23.	Current PRB abbreviation	Changed PRB for SRP Section 6.6 to ECGB. Text associated with the interface for material compatibility reviews was relocated to a separate review interface with the EMCB.
24.	Current PRB abbreviation	Separated and relocated the material compatibility review interface, and identified the current responsible PRB.
25.	Current PRB name and abbreviation	Changed PRB to Instrumentation and Controls Branch (HICB) and specified responsibility for SRP Section 7.1.
26.	Current PRB abbreviation	Changed PRB to Electrical Engineering Branch (EELB) and specified responsibility for SRP Section 8.1.
27.	SRP-UDP Integration of SBO Issues	Added a review interface describing how review of conformance with SBO requirements is accomplished under new SRP Section 8.4.
28.	Current PRB name	Changed PRB Technical Specifications Branch (TSB) and specified responsibility for SRP Section 16.0.
29.	Current PRB name	Changed PRB to Quality Assurance and Maintenance Branch (HQMB) and specified responsibility for SRP Section 17.3.
30.	SRP-UDP format item	Specified 17.3 as the current QA section.
31.	Editorial	Introduced "GDC 2" as initialism for "General Design Criterion 2."
32.	Editorial	Introduced "GDC 4" as initialism for "General Design Criterion 4."
33.	Editorial	Introduced "GDC 5" as initialism for "General Design Criterion 5."
34.	Editorial	Introduced "GDC 44" as initialism for "General Design Criterion 44."
35.	Integrated Impact No. 503	Deleted "Task Action Plan items II.k.2.16 and II.k.3.25 of NUREGs-0718 and 0737 as they related to..." and replaced with 10 CFR 50.34(f)(1)(iii). References to these TMI items as they relate to RCP seals is clarified by SRP 9.2.2 Section III.4.e.
36.	Integrated Impact No. 504	Added Subsection II.4.e in accordance with Integrated Impact No. 504 and renumbered remaining subsections.
37.	Current BTP acronyms	Added acronym, "SPLB," to identify the Branch Technical Position.

Item	Source	Description
38.	Integrated Impact No. 979	Deleted "IEEE 279" and added "IEEE Std 603 as endorsed by Regulatory Guide 1.153."
39.	Editorial	Added ", then:" for clarity and lead-in to paragraphs that follow.
40.	Integrated Impact No. 979	Deleted "IEEE 279" and added "IEEE Std 603 as endorsed by Regulatory Guide 1.153."
41.	Current BTP acronyms	Added acronym, "SPLB," to identify the Branch Technical Position.
42.	Editorial	Introduced "GDC 45" as initialism for "General Design Criterion 45."
43.	Editorial	Introduced "GDC 46" as initialism for "General Design Criterion 46."
44.	SRP-UDP format item	Added "Technical Rationale" to ACCEPTANCE CRITERIA and formatted into numbered paragraphs to describe the basis for referencing the GDC.
45.	SRP-UDP format item	Added lead-in sentence for "Technical Rationale."
46.	SRP-UDP format item	Added technical rationale for GDC 2.
47.	SRP-UDP format item	Added technical rationale for GDC 4.
48.	SRP-UDP format item	Added technical rationale for GDC 5.
49.	SRP-UDP format item	Added technical rationale for GDC 44.
50.	SRP-UDP format item	Added technical rationale for GDC 45.
51.	SRP-UDP format item	Added technical rationale for GDC 46.
52.	SRP-UDP format item	Added references to standard design certification and combined license.
53.	Editorial	Added a modifier "reactor auxiliary" to CWS for clarity.
54.	Current PRB abbreviation	Changed PRB to SPLB.
55.	Editorial	Added a modifier, "reactor auxiliary," to CWS for clarity.
56.	Editorial	Changed "assure" to "ensure" (global for this section).
57.	SRP-UDP format item	Changed to implement GSI B-3.
58.	Current PRB abbreviation	Changed PRB to ECGB.
59.	Current PRB abbreviation	Changed PRB to EMEB.
60.	Editorial	Eliminated an incorrect phrase.
61.	Integrated Impact No. 503	Deleted reference to TMI Action Plan. Superseded by 10 CFR 50.34(f)(1)(iii) and new Subsection III.4.e.

Item	Source	Description
62.	SRP-UDP format item	Changed to implement GSI B-3.
63.	Integrated Impact No. 979	Deleted "IEEE 279" and added "IEEE Std 603 as endorsed by Regulatory Guide 1.153."
64.	Integrated Impact No. 503	Deleted existing text which is replaced by new text that follows.
65.	**Integrated Impact 503**, SRP-UDP Integration of SBO Issues	Added review with respect to RG 1.155 position C.3.3.4 for RCP seal injection/cooling systems that are required to assure RCP seal integrity for the duration of a station blackout. Since subsection III.4.e is based upon positions stated in the CE System 80+ FSER but not officially imposed on currently operating plants as part of the resolution of GSI 23 (not resolved for current plants), added clarification that the procedure is applicable to new applications only.
66.	Integrated Impact No. 504	Added section III.4.f in accordance with Integrated Impact No. 504.
67.	Editorial	Revised to be more positive.
68.	PRB Comment	Added reference to NUREG-0927 in response to PRB comment, NRC Memo Li to Lyons dated November 1, 1995.
69.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
70.	SRP-UDP format item	Modified to eliminate the use of a gender-specific pronoun.
71.	Editorial	Provided "SER" as initialism for "safety evaluation report."
72.	SRP-UDP format item	Modified for readability.
73.	Integrated Impact No. 503	Deleted references to TMI items and NUREGs. Replaced with 10 CFR 50.34 (f)(1)(iii) and subsection III.4.e.
74.	Integrated Impact No. 504	Added subsections IV.7.b and c in accordance with Integrated Impact No. 504 and reformatted for clarity.
75.	SRP-UDP Format Item, Implement 10 CFR 52 Related Changes	To address design certification reviews a new paragraph was added to the end of the Evaluation Findings. This paragraph addresses design certification specific items including ITAAC, DAC, site interface requirements, and combined license action items.
76.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.

Item	Source	Description
77.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
78.	Editorial	Deleted implementation schedules information. Implementation schedules are no longer required since this SER pertains to Evolutionary, System 80+, and other future plants.
79.	Editorial	Updated title for GDC 4.
80.	Editorial	Deleted NUREG-0718, item 8, from SRP 9.2.2 Section VI REFERENCES. Superseded by the addition of Subsection III.4.e.
81.	Editorial	Deleted NUREG-0737, item 9, from SRP 9.2.2 Section VI REFERENCES. Superseded by the addition of Subsection III.4.e.
82.	**Integrated Impact 503**	Added reference listing for RG 1.155 since it is cited in subsection III.4.e.
83.	Editorial	Added (new) Reference 8 to subsection VI. The reference was cited in the text but not included in the list of references.
84.	Integrated Impact No. 979	Added (new) Reference 9 to subsection VI. IEEE Std 603-1980 is now cited in the text in place of IEEE 279.
85.	Editorial	Added Reference 10 to subsection VI. The reference was cited in the text but not included in the list of references.
86.	Integrated Impact No. 979	Added Reference 11 to subsection VI. IEEE Std 603-1980 is now cited in the text in place of IEEE 279 and is invoked by Regulatory Guide 1.153.
87.	PRB Comment	Added reference to NUREG-0927 in response to PRB comment, NRC Memo Li to Lyons dated November 1, 1995.

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Integrated Impact No.	Issue	SRP Subsections Affected
503	RCP seal integrity after an extended loss of seal injection or coolant.	II.4.d, III.3.g, III.4.d, III.4.e, IV.7, VI.8
504	Non-isolation of CCW supply and return lines to RCP seals on a safety injection signal.	I.1.e, II.4.e, III.4.f, IV.7.b & c
979	Cite IEEE Std 603-1980 in place of IEEE 279	II.4.h, II.4.h.1, III.4.d. VI.9, and VI.11
1081	Revise Review Procedures associated with TMI action plan items II.K.3.25 and II.K.2.16.	Not processed
1096	Refer to Revision Options Checklist 1081 for recommended changes to SRP Section 9.2.2 related to this issue.	Not processed