U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

10.4.9 AUXILIARY FEEDWATER SYSTEM (PWR)

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of cooling water systems

Secondary - None

I. AREAS OF REVIEW

The auxiliary feedwater system (AFWS) normally operates during startup, hot standby and shutdown as the feedwater system for pressurized water reactor (PWR) plants. With a seismic Category I water source, it also functions as an emergency system for heat removal from the primary system when the main feedwater system is not available for emergency conditions including small-break loss-of-coolant accident (LOCA) cases. The AFWS operates over a time period sufficient either to hold the plant at hot standby for several hours or to cool down the primary system, at a rate not exceeding limits specified in technical specifications, to temperature and pressure levels at which the low pressure decay heat removal system can operate. The review verifies compliance with General Design Criteria (GDC) 2, 4, 5, 19, 34, 44, 45 and 46. The AFWS also may remove decay heat to withstand or cope with a station blackout. If so, the review also includes verification of compliance with the requirements of 10 CFR 50.63 as they relate to the AFWS design.

The AFWS is reviewed from the interfaces with the condensate storage tank (normal operation) and the seismic Category I water supply, includes all components of both flow paths (e.g., piping, controls, sensors, valves, pumps, etc.), and terminates at the connections with the steam generators. All inter-connections and cross-connections are included in the review.

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The review also includes AFWS components (e.g., pumps, valves, and piping) for their functional performance as affected by adverse environmental conditions, anticipated operational occurrences, and accident conditions (e.g., small breaks in the primary system or the loss of offsite power).

The system is reviewed for whether a single malfunction, a failure of a component, or the loss of a cooling source does not reduce the safety-related functional performance capabilities of the system.

The specific areas of review are as follows:

1. The failure of non-essential equipment or components does not affect essential functions of the system.

2 The system is capable of withstanding a single active failure.

3. The system has diverse motive power sources and can meet performance requirements with either of the assigned power sources (e.g., a system with an alternating current (AC) subsystem and a redundant steam direct current (DC) subsystem).

4. The system design precludes fluid flow instabilities (e.g., water hammer) in system inlet piping during normal plant operation or during upset or accident conditions (see SRP Section 10.4.7).

5. System leakage can be detected, collected, and controlled and portions of the system can be isolated for excessive leakage or component malfunctions.

6. There are provisions for operational testing.

7. Instrumentation and control features are provided to verify that the system is operating in an acceptable mode.

8. The system can automatically initiate auxiliary feedwater flow upon a system actuation signal.

9. The system satisfies the recommendations of Regulatory Guide (RG) 1.62 for capability to manually initiate protective action by the AFWS.

10. The system is designed to terminate auxiliary feedwater flow to a depressurized steam generator and to provide feedwater to the intact steam generator automatically. Alternatively, if the intact steam generator is shown to receive the minimum required flow without isolation of the depressurized steam generator and containment design pressure is not exceeded, operator action may be relied upon to isolate the depressurized steam generator.

11. The system possesses sufficient auxiliary feedwater flow capacity to achieve a cold shutdown. Upon request, the reviewer verifies whether the system meets the minimum flow requirements for decay heat removal.

12. The applicant's proposed technical specifications assure the continued reliability of the AFWS during plant operation (i.e., the limiting conditions for operation and the surveillance testing requirements specified are consistent with the standard technical specifications).

13. With the secondary reviewer, the primary reviewer verifies whether the system design meets the generic short- and long- term recommendations identified in NUREG-0611 and NUREG-0635. These recommendations will apply to all PWRs.

14. An AFWS reliability analysis is performed as required by Three Mile Island (TMI) Action Plan Item II.E.1.1 of NUREG-0737 and 10 CFR 50.34(f)(1)(ii) for applicants subject to 10 CFR 50.34(f).

15. The review verifies whether the design meets TMI Action Plan item II.E.1.2 of NUREG-0737 for the automatic and manual initiation of the AFWS and 10 CFR 50.62(c)(1) for automatic initiation of the AFWS in an anticipated transient without scram (ATWS). The review shall be coordinated with other responsible organizations as needed.

16. The reviewer verifies whether the system design permits operation at hot shutdown for at least four hours followed by cool down to the residual heat removal (RHR) cut-in temperature from the control room with only safety grade equipment, assuming the worst-case single active failure in accordance with Branch Technical Position (BTP) 5-4.

17. AFWS diversity and performance are reviewed for decay heat removal capability and station blackout capacity.

18. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this SRP section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this SRP section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

19. COL Action Items and Certification Requirements and Restrictions.
For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

    For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Acceptability of the seismic and quality group classifications for system components is reviewed under SRP Sections 3.2.1 and 3.2.2.

2. Acceptability of the design analyses, procedures, and criteria establishing the ability of the seismic Category I structures housing the AFW system to withstand the effects of natural phenomena like the safe shutdown earthquake (SSE), the probable maximum flood (PMF), and tornado missiles is reviewed under 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.

3. Review of the protection of essential systems and components from the effects of flooding that may result from the PMF, failure of non-seismically supported piping, or actuation of the fire protection system to verify that essential portions of the system are adequately protected from postulated flooding is performed under SRP Section 3.4.1.

4. Review of the protection of essential systems and components from the effects of internal and external missiles to verify that sufficient physical separation or shielding has been provided to protect the essential portions of the system from missiles is performed under to SRP Section 3.5.1.1 for internally generated missiles and Sections 3.5.1.3, 3.5.1.4 and 3.5.2 for externally generated missiles.

5. Review of the protection of essential systems and components from the effects of pipe whip and jet impingement that may result from high or moderate energy piping breaks or cracks to verify that sufficient physical separation or shielding has been provided to protect the essential portions of the system from postulated high and moderate energy pipe breaks is performed under SRP Section 3.6.1.

6. Review to determine whether piping, mechanical components, and support structures are designed in accordance with applicable codes and standards is performed under SRP Sections 3.9.1 through 3.9.3.

7. Review of the inservice testing program for pumps and valves is performed under SRP Section 3.9.6.

8. Review of the seismic qualification of Category I equipment, instrumentation and electrical equipment is performed under SRP Section 3.10.

9. Review of the environmental qualification of mechanical and electrical equipment is performed under SRP Section 3.11.

10. Review to verify whether system components meet inservice inspection requirements is performed under SRP Section 6.6.

11. Review of system controls, instrumentation, and power sources as to capability, capacity, and reliability during normal and emergency conditions, including ATWS and station blackout events is performed under SRP Sections 7.1, 7.3 through 7.5, 7.8 and Section 8.3.

12. Review of fire protection is performed under SRP 9.5.1.

13. Review to identify functional interfaces between essential components of the reactor coolant or emergency core cooling systems and the AFWS required for operation during normal operations or accident conditions, review to establish the post accident heat loads and the associated time intervals available for cooling various components and review of AFWS performance in anticipated transient without SCRAM (ATWS) events is performed under SRP Section 15.8.

14. Review to verify the compatibility of the materials of construction with the expected service conditions is performed under SRP Section 6.1.1.

15. Review of technical specifications is performed under SRP Section 16.0.

16. Review of quality assurance is performed under SRP Chapter 17.

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

II. ACCEPTANCE CRITERIA

Requirements

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

1. GDC 2, as related to structures housing the system and the system itself being capable of withstanding the effects of earthquakes, tornados and floods.

2. GDC 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. GDC 5, as related to the capability of shared systems and components important to safety to perform required safety functions.

4. GDC 19, as related to the design capability of system instrumentation and controls for prompt hot shutdown of the reactor and potential capability for subsequent cold shutdown.

5. GDC 34 and 44, to assure:

    A. Capability to transfer heat loads from the reactor system to a heat sink under both normal operating and accident conditions.

    B. Redundancy of components for performance of the safety function under accident conditions, assuming a single active component failure (perhaps coincident with the loss of offsite power for certain events).

C. Capability to isolate components, subsystems, or piping if required to maintain system safety function.

6. GDC 45, as related to design provisions made to permit periodic in service inspection of system components and equipment.

7. GDC 46, as related to design provisions made to permit appropriate functional testing of the system and components to assure structural integrity and leak-tightness, operability and performance of active components, and capability of the integrated system to function as intended during normal, shutdown, and accident conditions.

8. 10 CFR 50.62, as related to the design provisions for automatic initiation of the AFWS in an ATWS.

9. 10 CFR 50.63, as related to the design provisions for withstanding and recovering from a station blackout, including an acceptable degree of independence from the ac power system and the capability for removal of decay heat at an appropriate rate for an appropriate duration.

10. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations;

11. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. Acceptance for meeting the relevant aspects of GDC 2 is based in part on meeting the guidance of Position C.1 of Regulatory Guide 1.29 if any portion of the system is deemed to be safety related and the guidance of Position C.2 for nonsafety-related portions. Also, acceptance is based in part on (1) meeting the guidance of Regulatory Guide 1.117 with respect to identifying portions of the system that should be protected

from tornadoes and (2) meeting the guidance of Regulatory Guide 1.102 with respect to identifying portions of the system that should be protected from flooding.

2. Acceptance for meeting the relevant aspects of GDC 4 is based on identification of essential portions of the system as protected from dynamic effects including internal and external missiles. In part, this information should be consistent with the guidance of Regulatory Guide 1.117 with respect to identifying portions of the system that should be protected from tornado missiles and the guidance of BTP 3-3 with respect to identifying portions of the system that should be protected from the dynamic effects of pipe breaks.

3. Acceptance of GDC 5 is based on provision of information that addresses the capability of shared portions of the AFW system to perform required safety functions during an accident in one unit such that the capability to conduct a safe and orderly shutdown and cool-down in the unaffected unit(s) is not significantly affected.

4. Acceptance of GDC 19 is based on meeting BTP 5-4 with regards to cold shutdown from the control room using only safety grade equipment.

5. Acceptance of GDC 34 and 44 is based on the system having sufficient flow capacity so that the system can remove residual heat over the entire range of reactor operation and cool the plant to the decay heat removal system cut-in temperature and the system design conforming to the guidance of BTP 10-1 as it relates to AFW pump drive and power supply diversity.

   In addition, the recommendations of NUREG-0611 and NUREG-0635 shall also be met. TMI Action Plan item II.E.1.1 of NUREG 0737 and 10 CFR 50.34(f)(1)(ii) for applicants subject to 10 CFR 50.34(f) require an AFWS reliability analysis. An acceptable AFWS should have an unreliability in the range of 10^{-4} to 10^{-5} per demand exclusive of station blackout scenarios. Compensating factors (e.g., other methods of accomplishing AFWS safety functions of the AFWS or other reliable methods for cooling the reactor core during abnormal conditions) may be considered to justify a larger AFWS unavailability.

6. Acceptance of GDC 45 is based on provision of information describing how the design of the AFW system permits inservice inspection of safety-related components and equipment.

7. Acceptance of GDC 46 is based on provision of information describing how the design of the AFW system, including instrumentation, permits periodic operational functional testing of safety-related components and equipment.

8. Acceptance of 10 CFR 50.62 is based on design provisions for automatic initiation of the AFW system in an ATWS.

9. Acceptance of 10 CFR 50.63 is based on conformance with the guidance of RG 1.155 as related to the AFWS design.

<u>Technical Rationale</u>

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

1. GDC 2 requires that the design of structures, systems and components (SSCs) important to safety withstand the effects of earthquakes. RG 1.29 position C.1 identifies those SSCs that should be designed as seismic Category I to remain functional following a Safe Shutdown Earthquake (SSE). RG 1.29 position C.2 states criteria for systems with continued functions not required following an SSE but the failure of which could affect the functioning of systems important to safety. The AFWS removes heat from the reactor coolant system via the steam generators during startup and shutdown under normal operations, and during emergency or accident conditions involving a loss of normal feedwater. In an SSE, systems not designed as seismic Category I (e.g., the main feedwater system) may be damaged severely. GDC 2 provides assurance that the AFWS will perform its safety function in an SSE.

2. GDC 2 requires that the design of structures, systems and components (SSCs) important to safety withstand the effects of tornadoes. RGs 1.76 and 1.117 identify the characteristics of a design bases tornado (DBT) and those SSCs that should be designed to remain functional following a DBT. The AFWS removes heat from the reactor coolant system via the steam generators during startup and shutdown under normal operations, and during emergency or accident conditions involving a loss of normal feedwater. In the event of a DBT, systems not designed to withstand these effects may be severely damaged. GDC 2 provides assurance that the AFWS will perform its safety function in the event of a DBT.

3. GDC 2 requires that the design of structures, systems and components (SSCs) important to safety withstand the effects of floods. RGs 1.59 and 1.102 identify the characteristics of a design basis flood (DBF) and those SSCs that should be designed to remain functional following a DBF. The AFWS removes heat from the reactor coolant system via the steam generators during startup and shutdown under normal operations, and during emergency or accident conditions involving a loss of normal feedwater. In the event of an DBF or internal flooding, systems not designed to withstand these effects may be severely damaged. GDC 2 provides assurance that the AFWS will perform its safety function in the event of a DBF.

4. GDC 4 requires the protection of SSCs important to safety from external missiles, internally-generated missiles, and the dynamic effects of pipe breaks. The AFWS safety function is to remove decay heat from the reactor coolant system following a loss of normal feedwater, by providing an emergency source of feedwater to the steam generators. Normal feedwater may be lost as a result of numerous anticipated operational occurrences and design basis accidents that may involve missile generation or piping failures. External missiles may be generated by natural phenomena, such as tornados, or may result from onsite or nearby industrial accidents. The failure of systems with high internal or kinetic energies can generate internal missiles as a result of component failure and fragmentation. In addition to missiles, failure of high-energy piping systems, and to a lesser extent moderate-energy systems, can result in pipe whip, jet impingement, flooding, and other environmental conditions that can effect the operability of safety-related systems like AFWS. GDC 4 provides assurance of AFWS protection from anticipated environmental conditions and events so it can support removal of reactor decay heat.

5. GDC 5 prohibits the sharing of SSCs important to safety among nuclear power units unless such sharing can be demonstrated not to significantly impair their ability to perform safety functions including in the event of an accident in one unit, an orderly shutdown and cool-down of the remaining units. The AFWS safety function is emergency heat removal from and the shutdown and cool-down of the reactor coolant system to low-pressure residual heat removal system cut-in conditions. If the AFWS is shared between units, its ability to accomplish these functions for both units simultaneously must be demonstrated. GDC 5 provides assurance that equipment failures and events occurring in one unit will not propagate to the other units of the site.

6. GDC 19 establishes requirements for design of control room instrumentation and controls for prompt hot shutdown and subsequent cold shutdown of the reactor. BTP 5-4 provides guidance for compliance with GDC 19 for achieving cold shutdown from the control room with only safety grade equipment. The AFWS is required for safe shutdown of the reactor during normal and accident conditions, including cool-down of the reactor to the cut-in conditions for low-pressure residual heat removal. GDC 19 and BTP 5-4 ensure the availability of adequate instrumentation and controls for the required safety function under all anticipated conditions.

7. GDC 34 and 44 establish the requirements to assure the capability to transfer heat from the reactor to a heat sink under normal and accident conditions with sufficient redundancy and isolation capability to accomplish the safety function with a single failure of an active component with or without a coincident loss of offsite power. The capability to transfer heat loads during normal and accident conditions is necessary to maintain fuel, reactor pressure boundary, and containment integrity. The AFWS transfers the heat from the reactor coolant system via the steam generators. Suitable redundancy adds assurance of system capability to perform the safety function in the event of system or component failures. The capability to isolate components, subsystems, or piping if required provides assurance that the AFWS will accomplish the safety function of reactor coolant system heat removal by ensuring delivery of feedwater from functional supplies to functional steam generators. For these criteria, the AFWS should have low unreliability in reducing the core damage frequency due to loss of reactor coolant system heat removal capability. Compliance with the design criteria provides assurance that heat removal will be accomplished and reactor coolant system and fuel integrity will be maintained.

8. GDC 45 establishes the requirements for periodic inspection of cooling water systems to ensure the integrity and capability of the system to transfer heat loads from SSCs important to safety. The AFWS safety function is to provide emergency cooling capability for the reactor coolant system in the event of an accident. The periodic testing of the system for compliance with GDC 45 assures system capability to perform its intended function.

9. GDC 46 establishes the requirements for functional testing of cooling water systems. This testing assures the integrity and operability of the cooling water system and its components necessary for the removal of heat loads from SSCs important to safety. The AFWS safety function is to provide emergency cooling capability for the reactor coolant system, in the event of an accident, by transferring heat from the reactor coolant system via the steam generators. GDC 46 assures AFWS provides assurance that the AFWS

will be capable of performing its intended function to remove reactor decay heat following anticipated operational occurrences and design basis accidents.

10. 10 CFR 50.62 requires that pressurized water reactors have equipment diverse form the reactor protection system to initiate the AFW system under conditions indicative of an ATWS. The AFWS is required to assure adequate removal of heat from the reactor coolant system during an ATWS.

11. 10 CFR 50.63 requires that all light-water-cooled nuclear power plants be able to withstand and recover from a station blackout. RG 1.155 provides guidance for compliance with 10 CFR 50.63. As many safety systems necessary to remove decay heat from the reactor are dependent on AC power, station blackout consequences can be severe. In a station blackout at facilities where no alternate AC power source is provided, the capability to cool the reactor core depends on the availability of systems not reliant upon AC power or on the ability to restore AC power in a timely manner. The AFWS is required for removal of decay heat in the event of a station blackout and must have sufficient capability and capacity to perform the heat removal function for an appropriate duration. To ensure such capability, motive power for motors, pumps, valves, controls and instrumentation for at least one auxiliary feedwater train of adequate capacity for station blackout is verified to be provided that is independent of the normal and emergency AC power systems. Compliance with 10 CFR 50.63 and the positions of RG 1.155 on capability to withstand or cope with a station blackout provides protection against unacceptable offsite radiological consequences should both offsite and onsite emergency AC power systems fail concurrently.

III. REVIEW PROCEDURES

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

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant’s evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

The procedures below are used during the construction permit (CP) 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 operating license (OL) or applications, the procedures 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. The procedures for OL applications also 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.

Upon request from the primary reviewer, the coordinating review organizations 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 is complete.

For the purpose of this SRP section, a typical system is assumed which has redundant auxiliary feedwater trains, with a 50-percent capacity motor-driven pump in each train feeding directly to the steam generators, and a 100-percent capacity steam turbine-driven pump able to supply either of the redundant trains. The pumping capacity should permit the system to hold the plant at hot standby and subsequently to cool down the reactor at specified cool-down rates. The 50-percent capacity pump should have sufficient capacity for decay heat removal following any accident or transient although cool down to RHR cut in temperature may take longer than design. This capability should also be met for conditions involving a small-break area LOCA or a pipe break outside containment.

1. The SAR is reviewed to determine that the system description and piping and instrumentation diagrams (P&IDs) identify the AFWS equipment and arrangement that is used for normal operation and for safe plant shutdown (essential) operation. The system P&IDs, layout drawings, and component descriptions and characteristics are then reviewed to verify that:

   A. Minimum performance requirements are sufficient for the various AFWS functions.

   B. Essential AFWS portions can be isolated from nonessential portions, so that system performance is not impaired by a nonessential component failure.

   C. Component and system descriptions in the SAR include appropriate seismic and quality group classifications, and the P&IDs indicate any points of change in piping quality group classification.

   D. Design provisions have been made that permit appropriate in service inspection and functional testing of system components important to safety. A testing and inspection program described in the SAR and system drawings showing the necessary recirculation loops around pumps or isolation valves as may be required by this program are acceptable in satisfying this provision.

   E. Design provisions have been made that ensure detection and mitigation of steam binding of the AFWS pumps due to back-leakage from the main feedwater system (MFWS) through isolation valves between the AFWS and the MFWS. This issue is described in IE Bulletin 85-01, “Steam Binding of Auxiliary Feedwater Pumps,” October 29, 1985.

   F. Design provisions have been incorporated to provide proper minimum flow for pump cooling under all flow conditions, regardless of the water source (condensate storage facility or alternate safety-related water source) in use.

   G. Design features have been incorporated to provide for automatic switch-over to the safety-related water supply without an interruption in water flow or incorporation of significant gas volumes in the flow stream that could result in water hammer or gas binding of the pumps.

   H. Design features have been incorporated to provide for automatic initiation of the AFWS under conditions indicative of an ATWS.

2. The reviewer verifies that the system safety function will be maintained as required, in the event of adverse environmental phenomena, breaks or cracks in fluid system piping outside containment, system component failures, loss of an onsite motive power source, or loss of offsite power. The reviewer uses engineering judgment and the results of failure modes and effects analyses to determine that:

   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 AFWS, will not preclude operation of the essential portions of the AFWS. Reference to SAR sections 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 AFWS 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 Section 3 series. The location and design of the system, structures, and pump rooms (cubicles) are reviewed to determine that the degree of protection provided is adequate. A statement to the effect that the system is located in a seismic Category I structure that is tornado missile and flood protected, or the components of the system will be located in individual seismic Category I cubicles or rooms that will withstand the effects of both flooding and missiles is acceptable.

   C. Essential components and subsystems necessary for safe shutdown can function as required in the event of loss of offsite power. The SAR is reviewed to see that for each AFWS component or subsystem affected by the loss of offsite power, system flow and heat transfer capability meet minimum requirements. Statements in the SAR and the results of failure modes and effects analyses are considered in assuring that the system meets these requirements.

   D. The system is designed with adequate redundancy to accommodate a single active component failure without loss of function. This includes redundant piping and valves from the condensate storage tank (or other primary source) to the AFW pump suctions.

   E. Diversity in pump motive power sources and essential instrumentation and control power sources has been provided. The diverse system including pump(s), controls and valves should be independent of offsite and onsite AC power sources in accordance with the guidelines of BTP 10-1.

   F. The system is designed with adequate instrumentation to automatically initiate auxiliary feedwater flow to the steam generators upon receipt of an actuation signal. The initiation signal should start all auxiliary feedwater pumps and supporting systems, align the auxiliary feedwater sources, and open flow paths from the auxiliary feedwater pumps to the steam generator(s). The system is also designed with the capability to manually initiate the necessary protective actions. The AFWS is designed with redundant instrumentation so that the system will automatically limit (may be flow limiting orifice rather than

instrumentation) or terminate auxiliary feedwater flow to a depressurized steam generator, and to assure that the minimum required flow is directed to the intact steam generator(s). The electrical portion of this review is performed by the organization responsible for instruments & controls. If a flow limiter is used then it must be demonstrated that sufficient flow still goes to the intact steam generator and containment design pressure is not exceeded by the AFW flow to the depressurized generator.

G. The AFWS is designed with sufficient flow capacity so that the system can remove residual heat over the entire range of reactor operation and cool the plant to the decay heat removal system cut-in temperature. This review is performed by the organization(s) responsible for review of reactor systems.

H. The AFWS components are designed to function with the anticipated water quality of raw water systems when they are used as the safety-related, seismically qualified source of water. In particular, the design should incorporate provisions for the filtration and removal of particulate debris that could clog components used for throttling of flow.

I. The AFWS air-operated safety-related components are designed to perform their safety functions during all design-basis events, including a loss of the normal instrument air system. This design verification should include a review of air-operated component failure positions to verify that they are correct for assuring performance of required safety functions. This issue is described in Generic Letter 88-14, “Instrument Air Supply System Problems Affecting Safety-Related Equipment.”

3. The reviewer verifies that the design has features to meet the generic recommendations of NUREG-0611 and NUREG-0635. For additional short term recommendation No. 2 regarding AFW pump endurance tests, a 48 hour test is acceptable rather than the 72 hour test specified in the NUREGs. The reviewer coordinates with the I&C reviewer to assure that the instrumentation and control system aspects of these recommendations are met by the system design.

4. The reviewer verifies that an AFWS reliability evaluation has been performed in accordance with 10 CFR 50.34(f)(1)(ii) as clarified in item II.E.1.1 of NUREG-0737. The reliability analysis is reviewed to determine the potential for AFW system failure under various loss of main feedwater transients. The AFWS unreliability is determined based on analysis using methods and data presented in NUREG-0611 and NUREG-0635. As an alternative to determining AFWS unreliability using the methods of NUREG-0611 and NUREG-0635, AFWS unreliability may be established through probabilistic risk assessment methods accepted by the staff [e.g., NUREG/CR 2300 and NUREG/CR 2815]. The acceptance criteria of 10^{-4} to 10^{-5} per demand (exclusive of station blackout scenarios) must be met regardless of the method selected.

5. The reviewer coordinates with the organizations responsible for power distribution and controls to assure that the AFWS has sufficient capability, capacity, and independence from essential and nonessential ac power to provide adequate decay heat removal for withstanding or coping with, as applicable, and recovering from, a station blackout in accordance with 10 CFR 50.63 and RG 1.155, Positions C.3.2.2, C.3.3.2, and C.3.3.4.

For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

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

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases of those conclusions.

The AFWS includes all components and equipment from the condensate storage tank (normal operation) or the seismic Category I emergency water supply (including valves and cross connections) to the connection with the steam generators. The AFWS is designed to seismic Category I requirements because system operation is necessary to mitigate the consequences of an accident. This design includes an automatic seismic Category I, tornado-protected supply of water to the auxiliary feedwater pump suction. Based on the review of the applicant's proposed design criteria, design bases and safety classification for the auxiliary feedwater system, and system performance requirements during normal, abnormal, and accident conditions, the staff concludes that the design of the auxiliary feedwater system and supporting systems is acceptable and meets the Commission's regulations in 10 CFR 50.62, 10 CFR 50.63, and GDCs 2, 4, 5, 19, 34, 44, 45, and 46. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2 with respect to protection against the effects of earthquakes. The safety-related portions of the AFWS are designed to seismic Category I requirements in accordance with position C.1 of RG 1.29 and the nonsafety-related portions are designed in accordance with position C.2 of RG 1.29.

2. The applicant has met the requirements of GDC 2 with respect to protection against the effects of tornadoes. The safety-related portions of the AFWS are designed to withstand the effects of a design bases tornado as described in RGs 1.76 and 1.117.

3. The applicant has met the requirements of GDC 2 with respect to protection against the effects of floods. The safety-related sections of the AFWS are designed to withstand the effects of floods as described in RGs 1.59 and 1.102.

4. The applicant has met the requirements of GDC 4 with respect to protection against the effects of pipe breaks and missiles. Acceptance is based on the locations of AFWS

pumps and trains in individual cubicles which separate redundant components and are protected against the effects of internal and external missiles.

5. The applicant has met the requirements of GDC 5 with respect to sharing of SSCs. Acceptance is based on the failure of any component including a pipe break and single active failure not preventing the safe shutdown and cool down of either unit (together or singularly).

6. The applicant has met the requirements of GDC 19 as related to the design capability of system instrumentation and controls for prompt hot shutdown of the reactor and potential capability for subsequent cold shutdown. The AFWS design meets the requirement of BTP 5-4 which requires the capability to bring primary plant temperature to the RHR cut-in point following four hours at hot standby from the control room using only safety grade equipment and assuming any single active failure.

7. The applicant has met the requirements of GDC 34 and 44 because the AFWS design has the capability to transfer heat loads, including decay heat from the reactor, during normal operating and accident conditions assuming any single active failure. The system has suitable redundancy such that it can withstand a pipe break and single active failure and still perform its safety function. The system design also has sufficient diversity such that it meets the requirements of BTP 10-1.

   In addition to meeting these GDC, the applicant has also met the generic recommendations identified in NUREG-0611 and NUREG-0635 and has performed a reliability analysis in accordance with 10 CFR 50.34(f)(1)(ii) as clarified in NUREG-0737, item II.E.1.1. The results of the reliability analyses were acceptable since it was shown that the AFWS has an unreliability in the range of 10^{-4} to 10^{-5} per demand.

8. The system pumps, valves, heat exchangers and piping, to the extent practicable, are designed and located to facilitate periodic inspection as required by GDC 45 by providing adequate accessibility to conduct the required examinations.

9. The applicant has met the requirements of GDC 46. Acceptance is based on the AFWS design including the capability for testing through the full operational sequence that brings the system into operation for reactor shutdown and for loss-of-coolant accidents, including operation of applicable portions of the protection system and the transfer between normal and emergency buses.

10. The applicant has met the requirements of 10 CFR 50.63. Acceptance is based on the AFWS design providing for sufficient decay heat removal in a station blackout in accordance with Positions 3.2.2, 3.3.2 and 3.3.4 of RG 1.155.

11. The applicant has met the requirements of 10 CFR 50.62. Acceptance is based on the AFWS design providing for automatic initiation of the AFWS under conditions indicative of an ATWS.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

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

VI. REFERENCES

1. 10 CFR 50.62, "Requirements for reduction of risk from anticipated transients without scram (ATWS) events for light-water nuclear power plants."

2. 10 CFR 50.63, "Loss of all alternating current power."

3. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

4. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Dynamic Effects Design Bases."

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

6. 10 CFR Part 50, Appendix A, General Design Criterion 19, "Control Room."

7. 10 CFR Part 50, Appendix A, General Design Criterion 34, "Residual Heat Removal."

8. 10 CFR Part 50, Appendix A, General Design Criterion 44, "Cooling Water."

9. 10 CFR Part 50, Appendix A, General Design Criterion 45, "Inspection of Cooling Water System."

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

11. Regulatory Guide 1.102, “Flood Protection for Nuclear Power Plants.”

12. Regulatory Guide 1.117, “Tornado Design Classification.”

13. Regulatory Guide 1.155, "Station Blackout."

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

15. Regulatory Guide 1.59, “Design Basis Floods for Nuclear Power Plants.”

16. Regulatory Guide 1.62, "Manual Initiation of Protective Actions."

17. Regulatory Guide 1.76, “Design Basis Tornado for Nuclear Power Plants.”

18. Branch Technical Position 5-4, "Design Requirements of the Residual Heat Removal System".

19. Branch Technical Position 10-1, "Design Guidelines for Auxiliary Feedwater System Pump Drive and Power Supply Diversity for Pressurized Water Reactor Plants" .

20. NUREG-0611 "Generic Evaluation of Feedwater Transients and Small Break Loss-of-Coolant Accidents in Westinghouse - Designed Operating Plants," January 1980.

21. NUREG-0635 "Generic Evaluation of Feedwater Transients and Small Break Loss-of- Coolant Accidents in Combustion Engineering - Designed Operating Plants," January 1980.

22. NUREG-0737 "Clarification of TMI Action Plan Requirements," November 1980.

23. NUREG/CR-2300, "PRA Procedures Guide", January 1983.

24. NUREG/CR-2815, "Probabilistic Safety Analysis Procedures Guide", January 1984.

25. IE Bulletin 85-01, "Steam Binding of Auxiliary Feedwater Pumps," October 29, 1985.

26. Generic Letter 88-14, “Instrument Air Supply System Problems Affecting Safety-Related Equipment,” August 8, 1988.

PAPERWORK REDUCTION ACT STATEMENT

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

PUBLIC PROTECTION NOTIFICATION

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