10.4.9 Emergency Feedwater System

The emergency feedwater system (EFWS) supplies water to the steam generators (SG) to restore and maintain water level and to remove decay heat following the loss of normal feedwater during design basis transient and accident conditions. This removes heat from the reactor coolant system (RCS), which is first transferred to the secondary side via the SGs, then discharged as steam to the condenser or via the SG main steam relief valves (MSRV).

10.4.9.1 Design Bases

The EFWS provides the following safety-related functions:

- Provide sufficient flow to the SGs to recover and maintain SG water inventory and remove residual heat from the RCS via the SGs and MSRVs to assist in the cooldown and depressurization of the RCS to residual heat removal (RHR) conditions under design basis transient and accident conditions.
- Isolate EFWS flow to the affected SG following a main steam line break (MSLB) to prevent overcooling the RCS with associated positive reactivity.
- Isolate emergency feedwater (EFW) pump flow to the SG with a tube rupture (SGTR) upon SG high water level to prevent SG over-fill and mitigate the potential radiological consequences of a SGTR event.
- Provide sufficient water inventory in the storage pools to support cooldown requirements.

The EFWS has the following design basis requirements and criteria:

- Safety-related portions of the EFWS are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, and external missiles, and are designed to function following such events (GDC 2).
- Safety-related portions of the EFWS are designed to withstand the effects of the postulated hazards of internal missiles, pipe whipping, and discharging fluids (GDC 4).
- Safety-related portions of the EFWS are not shared among nuclear power units (GDC 5).
- Safety-related portions of the EFWS are capable of bringing the 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 a single active failure per BTP 5-4 (Reference 1) and GDC 19.
- Safety-related portions of the EFWS have sufficient flow capacity so that the system can remove residual heat over the entire range of reactor operation and

cool the plant to the RHR system cut-in temperature assuming a single active failure with the loss of offsite power (GDC 34 and GDC 44).

- Safety-related portions of the EFWS are designed to permit appropriate periodic inspection of components important to the integrity and capability of the system (GDC 45).
- Safety-related portions of the EFWS are designed to include 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 (GDC 46).
- Safety-related portions of the EFWS are capable of automatic initiation under conditions indicative of an anticipated transient without scram (ATWS) (10 CFR 50.62).
- The EFWS is capable of providing sufficient decay heat removal during a station blackout (SBO) (10 CFR 50.63). This is a non-safety-related function.

The EFWS is a safety-related system and is not required to operate during normal plant operation. As described in Section 10.4.7, during normal power operation the heat removal function is performed by the main feedwater system (MFWS) or the startup and shutdown system (SSS).

10.4.9.2 System Description

10.4.9.2.1 General System Description

A flow diagram of the EFWS is shown in Figure 10.4.9-1—Emergency Feedwater System Flow Diagram. The EFWS has four separate trains, each consisting of a water storage pool, pump, control valves, isolation valves, piping and instrumentation. A supply header is provided that allows a cross-connection of the storage pools to the pump suctions and another header that allows cross-connection of the discharge of the pumps to the SGs. The supply headers have manual isolation valves that are normally maintained in the closed position, while the discharge header is isolated by motor-operated valves (MOV), which allow changing pump discharge alignment from the main control room (MCR).

One EFWS train is located in the lower levels of each of the Safeguard Buildings that provide separation and physical protection from external and internal hazards. The storage pools are stainless steel-lined concrete which are part of each Safeguard Building structure.

The demineralized water distribution system is used to initially fill the EFWS storage pools and can be aligned from the MCR to provide makeup to the storage pools.

Makeup to the storage pools can also be provided by hose from the fire water system or other available water sources.

The EFWS has the capability to perform its required safety-related functions following design basis transients or accidents assuming a single active failure in one EFW train and with a pump out of service for preventive maintenance in a second train. The system capacity is sufficient to remove decay heat and provide feedwater for cooldown of the RCS following a reactor trip from full power.

The EFWS design flow requirement provides 400 gpm (at 122°F) to a minimum of two SGs following a main feedwater line break when pumping against the main steam relief train (MSRT) setpoint pressure. This requirement is met assuming a single active failure and an EFW pump out for maintenance.

All four EFWS trains are powered from separate emergency buses, each backed by an emergency diesel generator (EDG), with trains 1 and 4 also capable of being powered from the diverse station blackout diesel generators (SBODG).

10.4.9.2.2 Component Description

The EFWS safety-related piping and components are designed and constructed in accordance with Quality Group C and Seismic Class I requirements, except for the containment isolation boundary piping and valves that are Quality Group B. Table 3.2.2-1 provides the seismic design and other design classifications for components in the EFWS. The EFWS piping and component pressure retaining parts are constructed of austenitic stainless steel. The EFWS materials conform to the requirements and regulatory guidance in Section 6.1.1. EFWS component data information is provided in Table 10.4.9-1—Emergency Feedwater System Component Data and material specifications are provided in Table 10.4.9-2—Emergency Feedwater Material Specifications.

10.4.9.2.2.1 EFW Pumps

The four EFW pumps are centrifugal multistage barrel-type design. The pump casings have top-mounted suction and discharge flanges. The pump and motor are horizontally mounted on a common base plate. The pump and motor bearings are oil lubricated and the thrust bearings are air cooled. The pumps utilize a single cartridge-type mechanical seal that does not require external seal water.

The pump bearing temperatures are monitored by sensors located on the outer ring of the rolling elements. Pump vibration is monitored by vibration sensors located on the pump bearing housings.

The EFW pumps are driven directly by ac motors utilizing flexible couplings. The motor bearings and winding temperatures are monitored, as is motor bearing vibration.

Pump minimum flow requirements are controlled by the minimum flow check valve on the pump discharge.

Two check valves are located in the piping from each pump to prevent steam from reaching the pump suction. Temperature instrumentation is provided upstream of the in-containment check valve to detect any heat-up resulting from leakage past the check valve. Alarms are provided in the MCR to alert the operators that back leakage has occurred. Plant procedures are required calling for prompt operator action to address the potential for unacceptable EFWS pump suction conditions. System maintenance and operating procedures will include specific guidance and precautions to preclude the occurrence of steam binding of the EFWS pumps.

10.4.9.2.2.2 EFW Storage Pools

The EFW storage pools are located in the Safeguard Buildings. The storage pools are made of concrete with a stainless steel liner. The usable volume of the pools is approximately 110,000 gal for trains 1 and 4 and 95,600 gal for trains 2 and 3.

Each storage pool includes a top-mounted manway, an overflow pipe, and a vent line. If required for maintenance, an EFW pool can be drained to the Plant Drainage System. The pool will be recirculated and sampled prior to draining. Draining is accomplished by manual valve alignment and starting of the drain pump.

Wide range and narrow range storage pool level indication is provided in the MCR and a local manometer is provided in the EFW pump rooms. Storage pool temperature is also indicated in the MCR.

10.4.9.2.2.3 EFW Active Valves

EFW Flow Control Valves

The EFW flow control valves are motor-operated control valves that limit EFW pump flow to a depressurized SG and prevent pump runout. The valves include an adjustable mechanical stop that is set to limit the maximum flow. The valve is positioned on its mechanical stop (standby) during normal plant operation. During EFW pump operation, the valve is automatically positioned to provide the design flow of 400 gpm.

EFW Steam Generator Level Control Valves

The SG level control valves are motor operated control valves that are in the open position (standby) during normal plant operation and receive an open signal upon an EFW actuation on low SG level or a loss of offsite power (LOOP) with safety injection

(SI). The valves will close automatically on high SG level to prevent SG overfill following a SGTR. These valves maintain the SGs at the set level by adjusting the EFW pump flow rate. The valves also can be manually closed from the MCR to isolate EFW flow to an affected SG.

EFW Steam Generator Isolation Valves

The EFW SG isolation valves are motor operated gate valves that are in the open position during normal plant operation and receive a closure signal upon SG high level following a SGTR to prevent SG overfill and provide the outside containment isolation boundary. The valves also can be manually closed from the MCR to isolate EFW flow to an affected SG.

EFW Minimum Flow Check Valves

The EFW minimum flow check valves prevent backflow and also open when the EFW pump is running. If flow to the SG is below the minimum required pump flow, the bypass flow path is opened to provide the minimum EFW pump flow back to the storage pool. This minimum recirculation path automatically closes when the SG injection flow increases above the minimum required pump flow. The design temperature of the minimum recirculation valve and piping conservatively reflects the increased temperature of the recirculation flow.

The check valve minimum flow path capability is sized to provide the required minimum pump flow of approximately 88 gpm. This value of required minimum recirculation flow is based on preliminary vendor information, which will be refined during the pump procurement process and confirmed by vendor performed analysis and/or testing. The objective will be to use the minimum recirculation flow that provides stable flow conditions with respect to rotor and hydraulic stability, as well as acceptable thermal conditions as required by IE Bulletin 88-04. The concern identified in IE Bulletin 88-04 that is related to the potential dead heading of one or more pumps that have a minimum flow line common to two or more pumps does not apply to the U.S. EPR design since each pump has a separate and independent minimum flow recirculation line.

EFW Isolation Check Valves

The EFW containment isolation check valves provide the inside containment isolation boundary and prevent the backflow of contaminated liquid outside the containment following an SGTR.

EFW Supply Header and Discharge Header Isolation Valves

The supply header isolation valves and the discharge header isolation valves are maintained closed during normal plant operation and can be opened, as necessary, to change component alignments. The discharge header isolation valves are motor operated and also have manual hand wheels so that they can be operated from the MCR or locally.

10.4.9.2.2.4 EFWS Piping

The EFWS piping is routed to minimize the potential for destructive water hammer during startup. The EFWS piping connects directly to the SGs so it is not directly impacted by pressure transients in the main feedwater (MFW) piping. The EFWS piping continuously rises from the containment penetration to the connection with the SG. Each EFWS injection path also includes a check valve within the containment. Within the SGs, the EFW flow is routed through a split ring header. EFWS flow exits the ring header via vertical tubes so that the ring header is maintained full of water.

Piping in the EFWS is required to be maintained full of water. Procedures are required to assure that the piping is properly filled, vented, and maintained full of water. System maintenance and operating procedures will also include guidance and precautions to be exercised during system and component testing when changing valve alignments or when starting or stopping of pumps.

10.4.9.2.2.5 Electrical Power Supply

Each EFWS train receives power from a separate Class 1E emergency power system. In the event of loss of normal onsite and offsite power, power is supplied by the EDGs. The level control valves, SG isolation valves, and discharge header cross-connect valves are also provided uninterruptible battery power.

In addition, EFWS trains 1 and 4 can be powered from the SBODGs.

A more detailed description of the onsite power systems is provided in Section 8.3.

10.4.9.2.3 System Operation

10.4.9.2.3.1 Normal Plant Operation

During normal plant operation, the heat removal function is performed by the MFWS or the SSS. The EFWS is maintained in standby condition ready for actuation. The EFWS is aligned as follows:

- The EFWS pumps are available on standby, ready to start.
- The SG level control valves are open.
- The flow control valves are closed at their mechanical stop.
- The SG isolation valves are open.

- The discharge header isolation valves are closed.
- The pool supply header isolation valves are closed.
- The storage pools are full of water.
- The pump room chilled water–air heat exchanger fans are switched off.

10.4.9.2.3.2 Abnormal Operating Conditions

Loss of Normal Feedwater

The loss of normal feedwater flow (MFWS and SSS) results in the automatic actuation of the EFWS when any SG reaches low level. A minimum of two EFWS trains are available to restore and maintain SG water inventory during RCS cooldown to RHR system entry conditions.

Short-Term Loss of Offsite Power

The loss of the non-emergency AC power supply results in the loss of the MFWS and SSS. As the main steam system pressure increases following reactor trip, the main steam relief isolation valves (MSRIV) upstream of the main steam relief control valves (MSRCV) are automatically opened to the atmosphere. The EDGs start upon the loss of normal power and supply power to the EFWS pumps, which actuate upon a SG low level.

Check Valve Leakage

Steam leakage from the SG to the EFWS pumps during standby conditions is prevented by two check valves. Should leakage occur, temperature instrumentation detects the resulting high-temperature condition and provides an alarm in the MCR to alert the operators to close the EFWS isolation valve and to promptly perform any other required actions to return the affected pump train to service.

10.4.9.2.3.3 Accident Conditions

Small Break Loss of Coolant Accident (SBLOCA)

A small break loss of coolant accident (SBLOCA) results in a loss of reactor coolant inventory which cannot be compensated for by the chemical and volume control system (CVCS). The loss of primary coolant results in a decrease in reactor coolant pressure and pressurizer level. The EFWS is automatically started if SG low level is reached. On safety injection signal, partial cool down is initiated to enable medium head safety injection (MHSI) flow.

A minimum of two EFWS trains are available to restore and maintain SG water inventory during RCS cooldown to RHR system entry conditions.

Steam Generator Tube Rupture (SGTR)

An SGTR results in a leak of primary coolant into the affected SG. The EFWS is utilized to assist in RCS cooldown, as necessary. In addition, EFWS flow to the affected SG can be isolated manually after 30 minutes or by the automatic closure of the SG isolation valve and the level control valve upon SG high level. The associated EFWS pump is shut down manually. A minimum of two EFWS trains are normally available to restore and maintain SG water inventory during RCS cool down to RHR system entry conditions.

In the unlikely event of an SGTR in one SG coincident with a single failure of another EFWS train and a third EFWS pump out for maintenance, only one intact SG is fed initially by the EFWS. Within 30 minutes, the operator opens the required discharge header isolation MOVs to align the EFWS pump feeding the affected SG to feed an intact SG.

The EFWS maintains SG water inventory during RCS cooldown to RHR system entry conditions.

Main Steam Line Break (MSLB)

A MSLB results in a significant reduction of RCS pressure and temperature and associated positive reactivity. At break initiation the secondary side pressure falls, a reactor trip occurs and the main steam isolation valves (MSIV) close. The EFWS pump aligned to the affected SG automatically starts upon SG low level. The EFWS pump flow to the depressurized SG is limited by the flow control valve to protect the pump against run-out flow and to prevent RCS overcooling. The flow to the affected SG is isolated manually from the MCR within 30 minutes. A minimum of two EFWS trains are normally available to restore and maintain SG water inventory.

In the unlikely event of an MSLB on one loop coincident with a single failure of another EFWS train and a third EFW pump out for maintenance, only one intact SG is fed initially by the EFWS. Within 30 minutes, the operator will open the required discharge header isolation MOVs to align the EFWS pump feeding the affected SG to feed an intact SG.

The EFWS maintains SG water inventory during RCS cooldown to RHR system entry conditions.

Main Feedwater Line Break (MFWLB)

A main feedwater line break (MFWLB) results in a significant loss of SG water mass leading to a RCS heat-up. The MFWLB accident is the most limiting accident for EFWS flow. The break results in a reactor trip and closure of the MSIVs. The main steam relief train opens and low level in all the SGs is reached. The EFWS is automatically actuated and the EFWS pump flow to the depressurized SG is limited by the flow control valve to protect the pump against runout flow. The flow to the affected SG is isolated manually from the MCR within 30 minutes. A minimum of two EFWS trains are normally available to restore and maintain SG water inventory.

In the unlikely event of an MFWLB on one loop coincident with a single failure of another EFWS train and a third EFWS pump out for maintenance, only one intact SG is fed initially by the EFWS. Within 30 minutes, the operator opens the required discharge header isolation MOVs to align the EFWS pump feeding the affected SG to feed an intact SG.

The EFWS maintains SG water inventory during RCS cooldown to RHR system entry conditions.

10.4.9.3 Safety Evaluation

The design of the EFWS satisfies GDC 2 regarding protection from the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, and external missiles.

- The Reactor Building and Safeguard Buildings that house the EFWS are Seismic Category I designed structures that are also located and designed to provide protection from flood, hurricane/tornado winds and missiles. Section 3.4, Section 3.5, Section 3.7, and Section 3.8 provide the bases for the adequacy of the structural design of these buildings with respect to natural phenomena.
- The safety-related EFWS components are designed to Seismic Category I requirements in accordance with RG 1.29. Position C.1, to perform their safety functions during and following a safe shutdown earthquake (SSE). The non-safety-related portions of the EFWS are designed in conformance with RG 1.29, Position C.2.

The design of the safety-related portions of the EFWS satisfies GDC 4 regarding potential dynamic effects, such as pipe whip, jet impingement, and missile impacts caused by equipment failure or events outside the plant. The analysis of a postulated high-energy line failure is provided in Section 3.6.1 and Section 3.6.2. The analysis for missiles is provided in Section 3.5.

An occurrence of an internal hazard does not prevent the ability of the EFWS to perform its safety functions or result in a common mode failure of redundant trains. Each of the four EFWS trains outside of the containment is located in a separate Safeguard Building; therefore, only one train can be physically affected by an internal hazard (fire or flood). The physical location (separate buildings) of the EFWS containment isolation valves prevents both valves from being affected by any single internal hazard. The EFWS components are located in the Safeguard Buildings (SBs) and the Reactor Building (RB). No piping has been identified which could result in internally generated missiles, pipe whip, or jet impingement forces that could impact operation of the EFWS. Refer to Section 3.6.1 for information regarding the plant design for protection against postulated piping failures in fluid systems outside of containment.

- Each EFWS train, including the storage pools, is located within a Safeguard Building which is Seismic Category I and provides protection from external missiles. External missiles are addressed in Section 3.5.
- EFWS components located within the Reactor Building are qualified for accident environmental conditions (radiation, temperature, pressure, and humidity). EFWS components located in the Safeguard Buildings are qualified for accident environmental radiation conditions. The Safeguard Building heating, ventilation and air conditioning (HVAC) system maintains acceptable environmental conditions for operation of the active EFWS equipment. Refer to Section 3.11 for equipment qualification.

The design of the safety-related portions of the EFWS satisfies GDC 5 regarding sharing of systems. The EFWS is not shared among nuclear power units.

The design of the safety-related portions of the EFWS satisfies GDC 19 and Reference 1 regarding the capability to support RCS cooldown using only safety grade equipment and assuming any single active failure. Required actions can be performed from the MCR, with the exception that the manual supply header isolation valves may need to be realigned to provide access to the inventory of the four storage pools. Sufficient water inventory is available for six to eight hours of EFWS operation before this action is necessary.

- The water inventory of the four EFW storage pools can be aligned to any available EFWS pump train. The total credited inventory of the four EFW storage pools is 411,200 gallons. This volume is greater than the 365,000 gallons required to perform the bounding BTP 5-4 cooldown described in Section 5.4.7.3.2.

  The non-safety demineralized water distribution system with more than 260,000 gallons of water available provides the normal make-up supply for the EFW storage pools. If needed, the fire water distribution system can be used to provide approximately 280,000 gallons of additional make-up water to the EFW storage pools from standpipes located in each Safeguard Building.

The design of the safety-related portions of the EFWS satisfies GDC 34 and 44 regarding 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 coincident with a single active failure and loss of offsite power.

- The EFWS has the capability to remove the full range of decay heat from the RCS during design basis transient and accident conditions. The system has suitable redundancy, as demonstrated by a failure modes and effects analysis (FMEA) to withstand a high-energy pipe break, a single active failure, and LOOP and still perform its safety functions. Refer to Table 10.4.9-3—Emergency Feedwater System Failure Analysis.

- The EFWS automatically initiates upon a system actuation signal. The EFWS also satisfies the recommendations of RG 1.62 regarding the capability of manual initiation of protective actions.
- The EFWS meets the applicable recommendations of NUREG-0611 (Reference 2) and NUREG-0635 (Reference 3) with the exception to GS-5 and GL-3.

From a reliability perspective, the EFWS design satisfies the requirements of the TMI Action Plan item II.E.1.1 of NUREG 0737 (Reference 4) and 10 CFR 50.34(f)(1)(ii) for applicants subject to 10 CFR 50.34(f). An acceptable AFWS should have unreliability in the range of 10-4 to 10-5 per demand exclusive of station blackout scenarios. The EFWS achieves this reliability target, as described in Table 10.4.9-5—EFWS Unreliability Results, through a combination of redundancy and diversity.

- There are four complete trains, each normally aligned to a separate SG. The supply and discharge headers can be configured to allow the pumps to feed any combination of SGs.
- Each EFWS train receives power from a separate Class 1E emergency power system. In the event of loss of normal onsite and offsite power, power is supplied by the EDGs. The level control valves, SG isolation valves, and discharge header cross-connect valves are also provided uninterruptible vital battery power.
- The system has suitable redundancy, as demonstrated by a single active failure analysis to withstand a single active failure and still perform its safety functions. Refer to Table 10.4.9-3 for a summary of the evaluation.
- The EFWS is not required to operate following a normal loss of the MFWS, as the SSS pump is actuated automatically. The SSS actuation reduces the frequency of EFWS actuation and increases the reliability of the plant overall decay heat removal capability.
- EFWS trains 1 and 4, including pump room cooling, are powered from the two non-Class 1E SBODGs.
- Critical EFWS valves and instrumentation are provided with uninterruptible emergency power.

From a diversity perspective, the design of the EFWS and its power supplies consists of four AC motor-driven, centrifugal EFW pumps. Each pump is located in a separate Safeguard Building with separate heating, ventilation, and air conditioning (HVAC), and is provided emergency power from a separate emergency diesel generator (EDG). Two EFW pumps and associated room cooling can also be powered from an alternate AC source of power consisting of two, diverse station blackout diesel generators

(SBODG). The SBODGs and the SBO Building Ventilation System are included in the Reliability Assurance Program discussed in Section 17.4.1. The alternate AC power supply diesels have the capability and quality requirements to support use to address beyond design basis common cause failure events.

- The following U.S. EPR design features enhance the plant's ability to address common cause failures of the EFWS:
  - The EDGs are housed in two separate buildings, with two units per building, each in a different fire area. The buildings do not share control power, HVAC, or engine cooling.
  - Diversity exists between the EDGs and the SBODGs, including the difference in nominal size and models; location in separate areas; and exclusion of shared control power, HVAC, engine cooling, or fuel systems. The cooling system for the EDG transfers heat utilizing a water-to-water heat exchanger, while the corresponding system for the SBODG transfers heat from water-to-air. There are no environment-related events or single active failures than can simultaneously disable both the SBODGs and EDGs.
  - Diversity in maintenance and testing of the EFWS and support systems will be provided through several methods, such as using different crews or varying schedules (staggered vs. sequential).
  - The EFWS normal and makeup water supplies are clean water stored in tanks or pools that are not susceptible to common-mode failures caused by blockage.
  - Detailed equipment specifications, vendor quality assurance (QA) of equipment manufacturing, owner oversight of manufacturing activities, shop testing, and pre-service and in-service inspection will reduce the risk of hardware-related common-cause factors. QA and testing programs will be established for the EFWS-related hardware.
- In the unlikely event that the emergency feedwater capability is lost due to a common cause failure, the effects are reduced by the plant's large primary and secondary water inventories. Analysis of a postulated loss of the EFWS without taking mitigating actions shows that the time to steam generator dry-out is greater than 1.5 hours, and that the core remains covered with sub-cooled water for greater than 2 hours. The analysis of this beyond design basis event assumed:
  - A LOOP with the plant running at full-load steady state power.
  - Normal operating steam generator and pressurizer levels.
  - Best estimate decay heat curve.
  - Primary and secondary temperature and pressure conditions, and latent heat as calculated by S-RELAP5.

This extended coping time provides time for compensatory actions to initiate decay heat removal. For example, following a loss of normal and emergency AC power, two EFW pumps can be energized from the alternate source of AC power and the pumps started from the control room within 30 minutes of the initiating event. The SBO timeline is further described in Section 8.4.2.6.2.

Depending on the initiating event, other compensatory measures that may be used for decay heat removal include:

- Removing core decay heat using the plant's safety-related feed and bleed capability.
- Removing core decay heat using the plant's non-safety-related Startup Feedwater system or the plant's non-safety-related Main Feedwater system.

The design of the EFWS satisfies GDC 45 as is relates to provisions for periodic inservice inspection of system components and equipment as described in Section 10.4.9.4.

The design of the EFWS satisfies GDC 46 regarding provisions made to permit appropriate functional testing of the system and components, as described in Section 10.4.9.4.

The design satisfies 10 CFR 50.62 regarding provisions for automatic initiation in an ATWS. A diverse low SG level EFWS actuation signal is provided for ATWS mitigation.

The design of the EFWS satisfies 10 CFR 50.63 regarding the capability for responding to a SBO. Station blackout is addressed in Section 8.4.

- Trains 1 and 4 of the EFWS are powered from the SBODGs, including the air recirculation fans of the room coolers for these EFWS pumps. The cooling medium for these coolers is supplied by the safety chilled water system (SCWS), which is also powered by the SBODGs.
- The EFWS water inventory required to meet SBO requirements is 166,000 gallons. This is based on the EFWS providing the necessary flow for decay heat removal while remaining in the hot standby conditions for eight hours.

10.4.9.4 Inspection and Testing Requirements

During fabrication of the EFWS components, tests and inspections are performed and documented in accordance with code requirements to verify quality construction. As necessary, performance tests of components are performed in the vendor facility. The EFWS is designed and installed to permit in-service inspections and tests in accordance with ASME operation and maintenance (OM) code requirements (Reference 5).

The EFWS components are inspected and tested as part of the initial plant startup. Refer to Section 14.2 (test abstract #020, #021, #153, #154 and #195) for initial plant startup test program. Consistent with the recommendations of Reference 2, a 48-hour endurance test is performed on the EFWS pumps to demonstrate the pumps have the capability for continuous operation over an extended time period without failure. The layout of the system pumps, valves, and piping facilitate periodic inspection. Adequate room and accessibility is provided to conduct the required examinations.

The EFWS is a standby system that is not routinely operated, except for testing. After the plant is brought into operation, tests to verify proper operation of the EFWS components are conducted. These tests supplement the system level tests by verifying acceptable performance of each active component in the EFWS. Pumps and valves are tested in accordance with Reference 5. The capability to perform quarterly full-flow testing is provided. The inservice testing program is described in Section 3.9.6 and the surveillance requirements for the EFWS are detailed in Chapter 16.

10.4.9.5 Instrumentation Requirements

10.4.9.5.1 Automatic Safety Functions

EFWS indications, alarms, and control devices are provided in Table 10.4.9-4—Emergency Feedwater System Indicating, Alarm, and Actuation Control Devices. The following sections provide a description of EFWS automatic control functions.

10.4.9.5.1.1 EFW Pump Flow Control and Run-out Protection

This function protects the EFWS pumps against run-out flow due to low backpressure associated with pumping to a depressurized SG. The pump overflow protection limits the pump discharge flow as follows:

- The pump discharge flow is compared to a setpoint of approximately 400 gpm plus design margin.
- A proportional integral controller adjusts the position of the flow control valve according to the deviation between the measured flow and the setpoint.
- If the flow in the line falls below 25 percent of the setpoint (approximately 100 gpm), the valve is closed to its mechanical stop position.

10.4.9.5.1.2 EFWS Actuation on Low Steam Generator Level

The EFWS is actuated to remove residual heat upon a loss of normal feedwater (MFWS and SSS), as indicated by SG low level. EFWS actuation consists of:

- Opening the SG isolation valves (already open at standby).
- Opening the SG level control valves (already open at standby).

- Starting the EFWS pumps.

10.4.9.5.1.3 EFWS Isolation on High Steam Generator Level

This safety-related function limits the release of radioactive water via the MSRVs due to overfilling a SG that has experienced an SGTR as indicated by high SG level. The EFWS isolation of the affected SG consists of:

- Closing the SG isolation valve.
- Closing the SG level control valve.

In addition, the operators manually trip the corresponding EFW pump.

These actions are also initiated at the start of partial cooldown to a SG pressure of 870 psia following an SGTR upon a high-high SG level or high steam line radiation signal.

10.4.9.5.1.4 EFW Pump Trip during Diesel Loading Sequence (following LOOP)

Each EFW pump is tripped during the emergency diesel loading sequence following a LOOP and then sequenced on to the diesel, as needed.

10.4.9.5.1.5 Steam Generator Level Control

The SG level is controlled as follows:

- The SG level measurement is compared to the SG level setpoint.
- A level controller adjusts the position of the level control valve according to the deviation between measured level and the setpoint.

10.4.9.5.2 EFWS Manual Control Safety-Related Functions

In addition to the automatic functions, the EFWS has the capability to manually perform the following safety-related functions:

- EFWS actuation and control.
- EFW isolation following an MSLB.
- EFW pump injection to another unaffected SG following an MFWLB.

10.4.9.6 References

1. NUREG-0800, BTP 5-4, “Design Requirements of the Residual Heat Removal System,” U.S. Nuclear Regulatory Commission, Revision 4, March 2007.

2. NUREG-0611, Technical Report: “Review of the Vogtle Units 1 and 2 Auxiliary Feedwater System Reliability Analysis,” U.S. Nuclear Regulatory Commission, October 1985.

3. NUREG-0635, Technical Report: “Generic Evaluation of Feedwater Transients and Small Break Loss-of-Coolant Accidents in Combustion Engineering Designed Operating Plants,” U.S. Nuclear Regulatory Commission, January 1980.

4. NUREG 0737, “Clarification of TMI Action Plan Requirements,” TMI Action Plan item II.E.1.1, U.S. Nuclear Regulatory Commission, November 1980.

5. ASME OM-2004, “Code for Operation and Maintenance of Nuclear Power Plants,” The American Society of Mechanical Engineers, 2004.

Table 10.4.9-1—Emergency Feedwater System Component Data

Emergency Feedwater Storage Pools		
Quantity		4
Type		Protected reinforced concrete structure
Liner		Austenitic stainless steel
≈ Available Volume		110,000 gal – Pools 1 and 4
		95,600 gal – Pools 2 and 3
Design Code		ACI 349
Seismic Design		Seismic Category I
Emergency Feedwater Pumps		
Pump	Quantity	4
	Type	Horizontal centrifugal, multistage
	Design Flow (@ 122°F)	400 gpm
	TDH	3570 ft
	NPSH Required	14 ft
	NPSH Available	39 ft
	Material	See Table 10.4.9-2
	Design Code	ASME Section III, Class 3
	Seismic Design	Seismic Category I
Motor	Horsepower	650 HP
	Power Supply	6.9 kV, 60 Hz, 3 phase, Class 1E
	Design Code	NEMA
	Seismic Design	Seismic Category I
	Classification	1E

Table 10.4.9-2—Emergency Feedwater Material Specifications
Sheet 1 of 2

Component	Material
Tanks (liner)	SA-182 Grade F304[1, 2]
	SA-182 Grade F304L[1]
	SA-182 Grade F316[1, 2]
	SA-182 Grade F316L[1]
	SA-240 Type 304[1, 2]
	SA-240 Type 304L[1]
	SA-240 Type 316[1, 2]
	SA-240 Type 316L[1]
	SA-479 Type 304[1, 2]
	SA-479 Type 304L[1,]
	SA-479 Type 316[1, 2]
	SA-479 Type 316L[1]
Process Piping	SA-312 Grade TP304L[1, 2,4]
Fittings	SA-182 Grade F304L[1]
	SA-403 Grade WP304L Class S[1, 2]
Valves	SA-182 Grade F304[1, 2]
	SA-182 Grade F304L[1]
	SA-182 Grade F316[1,2]
	SA-182 Grade F316L[1]
	SA-351 Grade CF3[5]
	SA-351 Grade CF3A[5]
	SA-351 Grade CF3M[5]
	SA-479 Type 304[1, 2]
	SA-479 Type 304L[1]
	SA-479 Type 316[1, 2]
	SA-479 Type 316L[1]

Table 10.4.9-2—Emergency Feedwater Material Specifications
Sheet 2 of 2

Component	Material
Pump	SA-182 Grade F304[1, 2]
	SA-182 Grade F304L[1]
	SA-182 Grade F316[1, 2]
	SA-182 Grade F316L[1]
	SA-336 Grade F304[1, 2]
	SA-336 Grade F304L[1, 2]
	SA-336 Grade F316[1, 2]
	SA-336 Grade F316L[1, 2]
	SA-194 Grade 6 [3]
	SA-564 Type 630[3]
	SA-240 Type 304[1, 2]
	SA-240 Type 304L[1]
	SA-240 Type 316[1, 2]
	SA-240 Type 316L[1]
	SA-193 Grade B8[1]
	SA-194 Grade 8[1]
Austenitic stainless steel welding material	SFA 5.4 E308[2], E309[2], E316[2]
	SFA 5.4 E308L[2], E309L[2], E316L[2]
	SFA 5.9 ER308[2], ER309[2], ER316[2]
	SFA 5.9 ER308L, ER309L, ER316L
	SFA 5.22 E308[2], E309[2], E316[2]
	SFA 5.22 E308L[2], E309L[2], E316L[2]

Notes:

1. Solution annealed and rapidly cooled.
2. Carbon not exceeding 0.03wt%.
3. Quenched and tempered.
4. Piping is seamless.
5. For cast austenitic stainless steel components that will experience service temperatures greater than 482°F, the delta ferrite content is limited to less than or equal to 20% for low molybdenum content statically cast materials, less than or

equal to 14% for high molybdenum content statically cast materials, and less than or equal to 20% for high molybdenum content centrifugally cast materials. Low molybdenum content is defined as 0.5 wt% maximum and high molybdenum content is defined as 2.0 to 3.0 wt%.