9.2 Water Systems

9.2.1 Essential Service Water System

The function of the essential service water system (ESWS) is to remove heat from plant components which require cooling during normal operation, for safe shutdown of the reactor and following a design basis accident (DBA). This is accomplished by providing cooling water from the essential service water (ESW) cooling tower basins to the component cooling water system (CCWS) heat exchangers (HX), emergency diesel generator (EDG) HXs and ESW pump room coolers. The function of the ESW cooling towers is to dissipate heat rejected from the ESWS during all plant modes of operation.

Ultimate heat sink (UHS) components such as the mechanical draft cooling towers and site-specific basin support systems which include the ESW makeup system, ESW blowdown system and the ESW chemical treatment system are addressed in Section 9.2.5.

9.2.1.1 Design Bases

- ESWS structures, systems and components which provide essential cooling for safety-related equipment are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, and external missiles without loss of capability to perform their safety-related functions (GDC 2). Structures housing the system as well as the system components are capable of withstanding the effects of earthquakes. The seismic design of this system meets the guidance of RG 1.29 (Position C.1 for the safety-related portion, and Position C.2 for the non-safety-related portion). Refer to Section 3.2 for quality group classifications.

- Safety-related portions of the ESWS are designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. These shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping and discharging fluids, that may result from equipment failures and from external events (GDC 4).

- The ESWS does not share structures, systems or components important to safety with other nuclear power plant units unless it has been shown that such sharing does not significantly impair the ability to perform their safety-related functions; including, the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units (GDC 5).

- The ESWS functions to provide heat removal from the CCWS HXs, EDG HXs, and ESW pump room coolers during normal operation and accident conditions, and transfers that energy to the UHS (GDC 44).

- The ESWS is designed to permit appropriate periodic inspection of important components necessary to maintain the integrity and capability of the system (GDC 45).

- The ESWS is designed to permit appropriate periodic pressure and functional testing necessary to maintain structural and leak-tight integrity of its components, the operability and performance of the active components of the system, and the operability of the system as a whole. The ESWS is also designed to make sure the performance of the full operational sequence necessary to bring the system into operation for reactor shutdown is satisfactory. For loss of coolant accident (LOCA) conditions, operation of applicable portions of the protection system (PS) and the transfer between normal and emergency power sources is also provided (GDC 46).

The ESWS provides sufficient cooling water for removing heat from essential plant equipment and transferring the heat to the cooling towers over the full range of normal reactor operation. The ESWS flow capacity and supply capability are designed so that the temperatures in essential plant equipment remain within their specified limits.

The ESWS operates in conjunction with the CCWS and other reactor auxiliary components to provide a means to cool the reactor core and reactor coolant system (RCS) to achieve a safe shutdown. The safety-related ESWS divisions provide continued heat transfer from the fuel pool cooling system (FPCS) via the CCWS as long as any spent fuel assemblies are in the spent fuel storage pool located outside containment.

9.2.1.2 System Description

The ESWS consists of four separate, redundant, safety-related divisions, and one dedicated, non-safety-related division.

The ESWS cools the CCWS HX which acts as an intermediate loop isolating the ESWS from the RCS. The CCWS is monitored to detect radioactive contamination into and out of the system.

The ESWS takes suction from the UHS cooling tower basin and provides cooling water to the CCWS HX, EDG HXs, and the ESW pump room coolers. The heated water is then returned to the UHS cooling tower. The system is shown in Figure 9.2.1-1—Essential Service Water System Piping & Instrumentation Diagram. Safety and seismic design classification of the components is provided in Section 3.2.

Each safety-related ESWS division consists of one ESWS pump, a debris filter, piping, valves, controls and instrumentation.

Provisions are made to make sure there is a continuous flow of cooling water under normal and accident operating conditions. The four safety-related divisions of the

ESWS are powered by Class 1E electrical buses and are emergency powered by the EDGs.

The non-safety-related dedicated division contains a dedicated ESWS pump, debris filter, piping, valves, controls, and instrumentation. The non-safety related ESWS pumps cooling water from the division four UHS cooling tower basin to the dedicated CCWS HX and back to the division four UHS cooling tower during severe accidents (SA). The dedicated ESWS pump is powered by 1E electrical buses and is emergency powered by the station blackout diesel generators (SBODG).

9.2.1.3 Component Description

9.2.1.3.1 Safety-Related Essential Service Water Pumps

Each of the four safety-related cooling divisions contains one 100 percent capacity pump. During normal operating conditions, two of the four divisions are operating. The required flow rate of each ESWS pump is defined by the heat to be removed from the system loads. Design parameters are listed in Table 9.2.1-1. The pumps are designed to fulfill the corresponding minimal required design mass flow rate under the following conditions:

- Minimal water level without cavitation.
- Head losses in the cooling water inlet piping according to full power plant operation.
- Fluctuations in the supplied electrical frequency.
- Increased pipe roughness due to aging and fouling.
- Fouled debris filters.
- Maximum pressure drop through the system HXs.

Determination of the discharge head of the pumps is based on the dynamic pressure losses, the minimum/maximum water levels of the water source, and the head losses of the mechanical equipment of the associated ESWS at full load operation.

The pump motors are air cooled. To remove heat losses, an air recirculation system is installed for each division. In addition, anti-condensation heaters on the motors are switched on as soon as the pumps cease operation.

9.2.1.3.2 Dedicated Essential Service Water Pump

The 100 percent capacity dedicated ESW pump is normally in standby mode.

This non-safety-related pump is manually started only in response to certain postulated SA conditions; it is not credited for response to any DBA.

The required flow rate of the dedicated ESWS pump is defined by the heat to be removed from the dedicated CCWS HX. Design parameters are listed in Table 9.2.1-2. The pump is designed to fulfill the corresponding minimal required design mass flow rate under the following conditions:

- Minimal water level.
- Fluctuations in the supplied electrical frequency.
- Increased pipe roughness due to aging and fouling.
- Fouled debris filter.

The pump motor is air cooled. In addition, an anti-condensation heater on the motor is switched on as soon as the pump ceases operation.

9.2.1.3.3 Debris Filters -Safety Divisions

The debris filters remove all debris particles from the cooling water that would obstruct the system user HXs.

The debris filters are designed as an automatic backwash type. With increasing fouling, the differential pressure across the filter segments increases until reaching a preset operational point. The pressure relief backwash process of the filter is initiated by either the signal of the differential pressure measuring system, a timer after the start of the ESW pump or via a manual operator initiation.

The discharge and disposal of the collected debris must be treated in accordance with federal and state regulations relevant to site location.

9.2.1.3.4 Debris Filter -Dedicated Division

The debris filter removes all debris particles from the cooling water that would obstruct the dedicated CCWS HX.

The debris filter is designed as an automatic backwash type. With increasing fouling, the differential pressure across the filter segments increases until reaching a preset operational point. The pressure relief backwash process of the filter is initiated by either the signal of the differential pressure measuring system, a timer after the start of the dedicated ESW pump or via a manual operator initiation.

The discharge and disposal of the collected debris must be treated in accordance with federal and state regulations relevant to the site location.

9.2.1.3.5 Piping, Valves, and Fittings

System materials must be selected that are suitable to the site location, ESW fluid properties and site installation. System materials that come into contact with one another must be chosen so as to minimize galvanic corrosion. All safety-related piping, valves, and fittings are in accordance with ASME Code Section III, Class 3 (Reference 1).

A COL applicant that references the U.S. EPR design certification will provide a description of materials that will be used for the essential service water system (ESWS) at their site location, including the basis for determining that the materials being used are appropriate for the site location and for the fluid properties that apply.

The general protection concept in case of pipe failures in the ESWS with regard to flooding is based on the principle of restricting the consequences to the affected division. In case of significant leakage from an ESWS train in a Safeguard Building (SB), the associated motor-driven ESWS pump discharge isolation valve is automatically closed and the ESWS pump is tripped. Another ESWS train is also put into operation. The detection and isolation signaling is done by safety-related means. One-out-of-two logic from two nuclear island drain and vent system (NIDVS) sump level instruments in the non-controlled areas of the SBs provide a MAX alarm in the MCR and isolate the affected ESWS train. No operator action is required to isolate the ESWS in a large flooding event.

Primary overpressure protection on the ESWS side of the CCWS HXs is provided by thermal relief valves.

Secondary overpressure protection on the ESWS side of the CCWS HXs is provided by manual opening of the valve (located upstream of the relief valve) before isolation of the particular HX.

To make sure the performance of the safety-related functions, all manually operated valves in the main lines of the safety-related ESWS divisions are mechanically locked in the proper position.

In-service testing of valves shall be performed as described in Section 3.9.6.3. Leakage rates for boundary isolation valves that require testing are based on ASME OM Code, 2004 Edition, Subsection ISTC.

A maximum valve leakage criterion will be specified for the safety-related check valves which will be no less stringent than the API-598 metal seated check valve criterion. A hydraulic transient analysis will be performed to confirm the integrity of ESW piping to withstand the effects of water hammer.

In general, butterfly valves are used in the ESWS for isolation (open or closed) service and not for throttling. In those applications where a butterfly valve is used in the ESWS and is subject to substantial throttling service for extended periods of time, design provisions are considered to prevent consequential pipe wall thinning immediately downstream of these valves. Such design provisions include the use of erosion resistant materials, the use of thick wall pipe and installing straight pipe lengths immediately downstream of the affected valves.

9.2.1.4 Operation

9.2.1.4.1 Normal Operating Conditions

Safety-Related Divisions

The ESWS supply is vital for all phases of plant operation and is designed to provide cooling water both during power operation and shutdown of the plant. During normal plant operation, two of four pumps are in operation with the remaining divisions in standby. The pumps are switched over periodically, thus changing the operational divisions.

The four divisions are filled and vented prior to operation. Under normal system operating conditions on a per division basis, the ESWS pump is in operation, the debris filter is functioning and all the valves in the main line are open. If the differential pressure across the debris filter reaches the predefined setpoint, automatic filter cleaning is initiated.

During standby, the divisions not in operation are aligned for normal operation (manual valves in the main line are open) and the system is filled and vented. The debris filter is in standby and ready to start. The system can be started manually from the main control room or automatically. In all cases, only the start signal needs to be actuated; preparatory measures are not necessary. The stopping of a particular division is performed manually.

Four ESWS divisions are normally running to achieve cold shutdown in the minimum time. Only two divisions are required to achieve cold shutdown.

During refueling, when the core is almost discharged to the Fuel Building (FB), two or three ESWS divisions are in operation. During this phase, maintenance can be performed on one division. When the core is totally offloaded and in the FB, only two ESWS divisions are required to be in operation.

Non-Safety-Related Division

The dedicated ESW division is not in use during normal plant operation. The ESW side of the dedicated CCWS HX is separated from the rest of the system. The ESW inlet and outlet isolation valves are closed and this section is filled with demineralized

water to prevent corrosion. The rest of the system is filled with site specific ESW fluid.

The dedicated ESW cooling chain is activated in case of an SA. This requires closing the ESW isolation valve downstream of CCW HX #4, manually opening the dedicated ESW isolation valves upstream and downstream of the dedicated CCW HX, and manually starting the dedicated ESW pump.

9.2.1.4.2 Abnormal Operating Conditions

Non-LOCA Design Basis Event During Power Operation

The ESWS operates as described for normal operating conditions, supplying the operating CCWS divisions as required.

Loss of Offsite Power

In case of loss of offsite power (LOOP), at least three of the safety-related ESWS divisions are available assuming one division is not available due to preventive maintenance. The four ESWS pumps belonging to the four safety-related divisions have power supplied by the EDGs.

In case of LOOP, the dedicated ESWS division is available but in standby condition. Power is supplied by the EDG. The dedicated ESWS division is also capable of being powered by the SBODGs so that the function is available even in case of LOOP with simultaneous loss of all EDGs.

If one safety-related ESWS pump fails during normal operation, a switchover to the other ESWS division is carried out. This switchover is done automatically for the entire cooling chain.

A spurious closure of the isolation valve in a safety-related ESWS division has the same consequences as the failure of the respective pump for that division.

A failure of the cleaning function of the debris filter in a safety-related division is monitored by the elevated differential pressure or function alarm. In this case, the operator initiates a division switchover.

9.2.1.5 Safety Evaluation

The ESWS pump buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other natural phenomena. Section 3.3, Section 3.4, Section 3.5, Section 3.7 and Section 3.8 provide the basis for the adequacy of the structural design of these structures.

The ESWS is designed to remain functional after a safe shutdown earthquake (SSE). Section 3.7 and Section 3.9 provide the design loading conditions that are considered. Section 3.5, Section 3.6 and Section 9.5.1 provide the hazards analyses to verify that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

The four division design of the ESWS provides complete redundancy; therefore a single failure will not compromise the ESWS system safety-related functions. Each division of ESWS is independent of any other division and does not share components with other divisions or with other nuclear power plant units.

Considering a single failure and preventative maintenance, two ESW divisions may be lost, but the ability to achieve the safe shutdown state under DBA conditions can be reached by the remaining two ESWS divisions. In case of LOOP the four ESW pumps have power supplied by their respective division EDGs.

During SAs, containment heat is removed by the dedicated cooling chain consisting of the severe accident heat removal system (SAHRS), dedicated CCWS, and dedicated ESWS. This cooling chain is manually actuated. In case of loss of the dedicated ESWS division, the SAHRS cooling chain is lost. This condition is outside the DBA.

In the event of an LOCA during power operations, the engineered safety features system (ESFS) (refer to Section 7.3) initiates a safety injection and containment isolation phase 1 signal. The ESWS divisions previously not in operation are automatically started by the PS.

9.2.1.6 Inspection and Testing Requirements

The ESWS is initially tested with the program given in Section 14.2, Test # 48.

The installation and design of the ESWS provides accessibility for the performance of periodic inservice inspection and testing. Periodic inspection and testing of all safety-related equipment verifies its structural and leak tight integrity and its availability and ability to fulfill its functions. Inservice inspection and testing requirements are in accordance with Section XI of the ASME BPV Code and the ASME OM Code.

U.S. EPR FSAR Tier 2, Section 3.9 and Section 6.6 outline the inservice testing and inspection requirements. Refer to U.S. EPR FSAR Tier 2, Section 16.0, Surveillance Requirement (SR) 3.7.8 for surveillance requirements that verify continued operability of the ESWS.

9.2.1.7 Instrumentation Requirements

Instrumentation is provided in order to control, monitor and maintain the safety-related and non-safety-related functions of the ESWS.

9.2.1.7.1 System Monitoring

The ESWS system is monitored for the following parameters:

- Fluid flow rate and pressure downstream of the ESWS pumps and the dedicated ESWS pump.
- Differential pressure at the ESWS and the dedicated ESWS debris filters, CCWS HXs, and Essential Service Water Pump Building Ventilation System (SAQ) room cooler.
- Fluid flow from the CCWS and EDG HXs.
- Temperature of the ESWS and the dedicated ESWS pump discharge.
- Temperature at the outlet of the HXs.

9.2.1.7.2 System Alarms

- High temperature ESW and dedicated ESW.
- ESW and dedicated ESW pump abnormal.
- Low flow across the CCWS and dedicated CCWS HX.
- High ΔP across the CCWS, dedicated CCWS HX, and SAQ room cooler.
- Low temperature ESW.
- Table 9.2.1-3—Alarm Summary provides additional information.

9.2.1.8 References

1. ASME Boiler and Pressure Vessel Code, Section III: "Rules for Construction of Nuclear Facility Components," Class 3 Components, The American Society of Mechanical Engineers, 2004.

Table 9.2.1-1—Essential Service Water Design Parameters

Essential Service Water Pump 30PEB10/20/30/40 AP001	
Description	Technical Data
Number	4
Type	Wet Pit Vertical Turbine
Normal Flow Rate	19,340 gpm
Required Pump Head at Normal Flow Rate	185 ft/H_2O

Table 9.2.1-2—Dedicated Essential Service Water Design Parameters

Dedicated Essential Service Water Pump 30PEB80 AP001	
Description	Technical Data
Number	1
Type	Wet Pit Vertical Turbine
Normal Flow Rate	2737 gpm
Required Pump Head at Normal Flow Rate	150 ft/H_2O

Table 9.2.1-3—Alarm Summary

Alarm Name	Division	Setpoint Name
CCW Hx differential pressure Hi	1/2/3/4	Max 1
CCW Hx Lo flow	1/2/3/4	Min 1
EDG coolers Lo flow	1/2/3/4	Min 1
SAQ room cooler differential pressure ESW side	1/2/3/4	Max 1
ESW temperature Hi	1/2/3/4	Max 1
ESW temperature Hi – Hi	1/2/3/4	Max 2
ESW temperature Low	1/2/3/4	Min 1
ESW debris filter differential pressure Hi	1/2/3/4	Max 1
ESW debris filter differential pressure Hi - Hi	1/2/3/4	Max 2
ESW pump abnormal	1/2/3/4	Min1 / Max 1
Dedicated CCW Hx differential pressure Hi	Dedicated	Max 1
Dedicated CCW Hx Lo flow	Dedicated	Min 1
Dedicated ESW temperature Hi	Dedicated	Max 1
Dedicated ESW temperature Hi - Hi	Dedicated	Max 2
Dedicated ESW pump abnormal	Dedicated	Min 1 / Max 1
Cooling tower basin water level Hi - Hi	1/2/3/4	Max 2
Cooling tower basin water level Hi	1/2/3/4	Max 1
Cooling tower basin water level Lo	1/2/3/4	Min 1
Cooling tower basin water level Lo - Lo	1/2/3/4	Min 2

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