9.2.5 Ultimate Heat Sink

The function of the ultimate heat sink (UHS) is to dissipate heat rejected from the essential service water system (ESWS) during normal operations and post accident shutdown conditions. System interface heat loads are listed on Table 9.2.5-1. The UHS for the U.S. EPR is sized to provide adequate cooling capacity as required by RG 1.27.

9.2.5.1 Design Basis

UHS structures, systems and components which provide 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.

The UHS is 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 UHS 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 UHS functions to provide heat removal from the ESWS during normal operation and accident conditions, and transfers that energy to the environment (GDC 44).

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

The UHS is designed to permit operational functional testing of safety-related components to ensure system operability (GDC 46).

The UHS operates in conjunction with the ESWS and component cooling water system (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 UHS operates for a nominal 30 days following a loss of coolant accident (LOCA) without requiring any makeup water to the source or demonstrates that replenishment or use of an alternate or additional water supply can be effected to ensure continuous capability of the sink to perform its safety-related functions.

9.2.5.2 System Description

The UHS consists of four separate, redundant, safety-related divisions. Also included is one dedicated non-safety-related division which is located in division 4. Each safety-related UHS division consists of one mechanical draft cooling tower with two fans, piping, valves, controls and instrumentation. System design parameters are listed on Table 9.2.5-2. The system is shown in Figure 9.2.5-1—Ultimate Heat Sink Piping and Instrumentation Diagram.

A COL applicant that references the U.S. EPR design certification will provide site-specific information for the UHS support systems such as makeup water, blowdown and chemical treatment (to control biofouling).

The UHS contains isolation valves at the cooling towers to isolate the safety related portions of the system from the non-safety-related basin support systems provided by the COL applicant.

9.2.5.3 Component Description

9.2.5.3.1 Mechanical Draft Cooling Towers

The cooling towers are rectangular mechanical-induced draft-type towers. Each tower consists of two cells in a back-to-back arrangement. The two cells of the cooling tower in a particular division share a single cooling tower basin and each cell is capable of transferring fifty percent of the design basis heat loads for one division from the ESWS to the environment under worst-case ambient conditions. The division four cooling tower shares use with the dedicated ESW train and can transfer severe accident (SA) heat loads to the environment under worst-case ambient conditions.

The cooling tower fill design and arrangement maximize contact time between water droplets and air inside the tower. The tower fill spacing is chosen to minimize the buildup of biofilm and provide for ease of cleaning, maintenance, and inspection.

Each cooling tower basin is sized to provide for a minimum 72-hour supply of cooling water to the associated ESW division under design basis accident (DBA) conditions assuming loss of normal makeup water capability.

9.2.5.3.2 Piping, Valves, and Fittings

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

9.2.5.4 System Operation

The safety related ESWS pumps cooling water from the cooling tower basin to supply ESWS loads and back to the mechanical draft cooling tower. The four safety-related divisions of the UHS are powered by Class 1E electrical buses and are emergency powered by the emergency diesel generators (EDG).

The non-safety-related dedicated ESWS pumps cooling water from the division four cooling tower basin to the dedicated system heat load and back to the division four mechanical draft cooling tower during SA and beyond DBAs.

The cooling tower fans are driven with multi-speed drives that are capable of fan operation in the reverse direction. Consistent with vendor recommendations, the fan may be operated in the reverse direction for short periods to minimize ice buildup at the air inlets. The cooling tower bypass piping provides a means for diverting ESW return flow directly to the tower basin under low load/low ambient temperature conditions to maintain ESW cold water temperature within established limits and to protect against freezing.

9.2.5.5 Safety Evaluation

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

Considering preventative maintenance and a single failure, two UHS divisions may be lost, but the ability to achieve the safe shutdown state under DBA conditions can be reached by the remaining two UHS divisions. In case of LOOP the four UHS cooling towers have power supplied by their respective division EDGs. Isolation valves can isolate non-safety-related portions of the system if necessary without compromising the safety-related function of the system.

The cooling towers must operate for a nominal 30 days following a LOCA without requiring any makeup water to the source or it must be demonstrated that replenishment or use of an alternate or additional water supply can provide continuous capability of the heat sink to perform its safety-related functions. The tower basin contains a minimum 72-hour supply of water. After the initial 72 hours, the site specific makeup water system will provide sufficient flow rates of makeup water to compensate for system volume losses for the remaining 27 days.

9.2.5.6 Inspection and Testing Requirements

Prior to initial plant startup, a comprehensive preoperational test is performed to demonstrate the ability of the ESWS and UHS to supply cooling water as designed under normal and emergency conditions. The UHS is tested as described in Chapter 14.2, Test # 49.

After the plant is brought into operation, periodic inspections and tests of the ESWS and UHS components and subsystems are performed to verify proper operation. Scheduled inspections and tests are necessary to verify system operability.

9.2.5.7 Instrumentation Applications

Instrumentation is provided in order to control, monitor and maintain the safety-related functions of the UHS. Indications of the process variables measured by the instrumentation are provided to the operator in the main control room.

9.2.5.7.1 System Monitoring

- Cooling tower basin water level.
- Cooling tower water temperature.

9.2.5.7.2 System Alarms

- Cooling tower water temperature low.
- Cooling tower basin water level low.
- Cooling tower basin water level high.

9.2.5.8 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 9.2.5-1—Ultimate Heat Sink System Interface

Component	Max Heat Load MBTU/hr	Total Required ESW Flow (10^6 lb_m/hr)	Required ESW Temperature	Comments
CCWS heat exchanger	128.1	7.540 min	≤92°F	Normal Operation
	120.1	7.540 min	≤90°F	Spring/Fall Outage Cooldown
	291.3	7.540 min	≤95°F	DBA
Dedicated CCWS heat exchanger	48.64	1.205 min	≤95°F	Severe Accident
EDG heat exchanger	22.0	1.06	≤95°F	
ESW pump room cooler for 31/32/ 33/34 UQB	0.619	137.6 gpm	≤ 95°F	Normal Operations Shutdown/ Cooldown and DBA
ESW pump room cooler for 34 UQB	0.314	69.8 gpm	≤ 95°F	Severe Accident - ESW flow supplied by dedicated ESW pump

Table 9.2.5-2—Ultimate Heat Sink Design Parameters

Cooling Tower Cells 31/32/3/34 URB	
Description	**Technical Data**
Cooling Tower Type	Mechanical Induced Draft
Design Water Flow (total both cells)	19,200 gpm
Design Cold (Outlet) Water Temperature	≤95°F (max, DBA)
Ambient Wet Bulb/Summer/Design Inlet WBT	81°F (includes 1°F correction for interference)
Maximum Drift Loss (Percent of Water Flow)	< 0.005%
Evaporation Loss at Design Conditions (total both cells)	571 gpm
Number of Cells	2 Cell/Tower
Basin Water Volume (Min)	337,987 ft^3
Basin Water Level (Min)	27.2 ft

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