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).

A COL applicant that references the U.S. EPR design certification will provide a description of materials that will be used for the UHS 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 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. The site-specific UHS systems are shown in Figure 9.2.5-2—[[Conceptual Site-Specific UHS Systems]].

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.

UHS cooling tower fill is constructed of ceramic tile, supported on reinforced concrete beams. Spray piping and nozzles are fabricated of corrosion resistant materials (e.g., stainless steel, bronze). UHS cooling tower internals are seismically designed and supported to withstand a safe shutdown earthquake (SSE). Passive failures of the cooling tower spray or fill systems are considered extremely unlikely due to their materials of construction, supporting systems and Seismic Category I design.

To prevent the entrainment of debris from the UHS cooling tower, each cell of the UHS cooling tower includes a debris screen located between the cooling tower internals and the ESW pump.

To account for potential interference effects of the cooling towers, an inlet wet bulb correction factor is used. As part of addressing Item 2.0-1 of Table 1.8-2, the COL applicant that references the U.S. EPR design certification will evaluate their site-specific conditions of orientation (with respect to wind direction), location, wind velocity, and direction to determine a wet bulb correction factor to account for interference effects.

To account for potential recirculation effects of the cooling towers, an inlet wet bulb correction factor is used. As part of addressing Item 2.0-1 of Table 1.8-2, the COL applicant that references the U.S. EPR design certification will evaluate their site-specific location to determine a wet bulb correlation factor to account for recirculation effects.

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).

Inservice testing of valves will 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, Subsection ISTC (Reference 2).

9.2.5.3.3 Cooling Tower Basin

The 72-hour basin water volume is the minimum water volume that must be present in a basin to accommodate system water inventory losses experienced in the basin due to ultimate heat sink (UHS) tower operation under the worst case environmental conditions, and with the highest essential service water (ESW) heat load for a 72-hour period, without incurring pump damage during operation.

UHS tower blowdown is automatically secured during the initial 72-hour post-accident period through system instrumentation and control design features, so the only significant system water inventory losses are due to evaporation, tower drift, and valve seat leakage and seepage.

Meteorological conditions resulting in the maximum evaporative and drift loss of water for the UHS over a 72-hour period are presented in Table 9.2.5-3—Design Values for Maximum Evaporation and Drift Loss of Water from the UHS[1].

Meteorological conditions for the U.S. EPR that result in minimum cooling tower cooling that are the worst combination of controlling parameters (wet bulb and dry bulb), including diurnal variations for the first 24 hours of a DBA LOCA, are presented in Table 9.2.5-4 and do not result in a maximum ESWS supply temperature from the UHS basin exceeding 95°F.

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. Cooling tower fans operating in the reverse direction during normal operation are considered operable at the onset of a design basis accident (DBA). Upon receipt of a safety injection (SI) signal, any fans operating in the reverse direction are secured and brought to a complete stop before re-energizing to operate at full speed in the forward direction. Upon receipt of an SI signal, fans in the operating and standby trains are automatically set to full fan speed to dissipate the maximum heat load to the environment. 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.

Based on the increase in heat removal during a DBA, a temperature of less than or equal to 90°F is maintained in the UHS basin during normal operation, so that the cooling tower basin temperature does not exceed 95°F.

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 aboveground piping and components are protected by the 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. The normal and emergency blowdown isolation valves provide automatic isolation of the ESWS from downstream non-safety-related blowdown piping under DBA conditions to prevent loss of ESW inventory. The ESW emergency makeup water system also provides isolation of the normal makeup water system from the tower basins under DBA conditions to prevent loss of ESW inventory.

The heat load after 72 hours post-DBA is lower than the peak heat load due to a reduction in the decay heat from the reactor. Consequently, the makeup flow rate required after 72 hours is lower than the peak condition. Since the UHS basin contains at least 72 hours of water inventory for the DBA, in combination with the worst ambient evaporation conditions, the UHS emergency makeup is not required to start until after 72 hours. At that point, the makeup requirements are diminished. The minimum makeup supply rate is based on the maximum evaporation rate over a 72 hour period post-DBA and considers such losses as drift, seepage and valve seat leakage.

COL applicants that reference the U.S. EPR will verify that the makeup water supply is sufficient for the ambient conditions corresponding to their plant location. Refer to Table 1.8-2, Item number 2.3-10.

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.

The installation and design of the UHS provides accessibility for the performance of periodic inservice inspection and testing. Periodic inspection and testing of safety-related equipment verifies its structural and leaktight 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.

Section 3.9 and Section 6.6 outline the inservice testing and inspection requirements. Refer to Section 16.0, Surveillance Requirements (SR) 3.7.19 for surveillance requirements that verify continued operability of the UHS.

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.

2. ASME OM Code, “Code for Operation and Maintenance of Nuclear Power Plants,” Subsection ISTC, The American Society of Mechanical Engineers, 2004 edition.

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	0.0685	≤ 95°F	Normal Operations Shutdown/ Cooldown and DBA
ESW pump room cooler for 34 UQB	0.314	0.0347	≤ 95°F	Severe Accident - ESW flow supplied by dedicated ESW pump

Table 9.2.5-2—Ultimate Heat Sink Design Parameters

Cooling Tower Cells 31/32/33/34 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)
Design Inlet Wet Bulb Temperature	81°F (non-coincident, 0% exceedance value)[1]
Maximum Drift Loss (Percent of Water Flow)	< 0.005%
Maximum Evaporation Loss at Design Conditions (total both cells)	571 gpm
Number of Cells	2 Cell/Tower
Basin Water Volume (Min)	≥295,120 ft^3
Basin Water Level (Min)	23.75 ft
Required Cooling Tower Emergency Makeup Flow, 72 hours, post-DBA	300 gpm

Note:

1. COL applicant to determine wet bulb temperature correction factor to account for potential interference and recirculation effects. (Refer to COL Item 2.0-1 in Table 1.8-2).

Table 9.2.5-3—Design Values for Maximum Evaporation and Drift Loss of Water from the UHS[1]

Time (hr)	Wet Bulb Temp (°F)	Dry Bulb Temp (°F)		Time (hr)	Wet Bulb Temp (°F)	Dry Bulb Temp (°F)		Time (hr)	Wet Bulb Temp (°F)	Dry Bulb Temp (°F)
1	69.87	84		25	70.49	86		49	74.14	91
2	68.69	82		26	71.03	86		50	72.99	87
3	66.82	78		27	71.03	86		51	70.96	84
4	67.02	77		28	71.03	86		52	69.33	84
5	69.04	78		29	71.03	86		53	68.90	81
6	68.48	78		30	70.02	81		54	69.46	81
7	68.14	77		31	68.24	79		55	69.13	80
8	67.10	74		32	68.25	79		56	69.69	80
9	67.10	74		33	68.13	77		57	67.70	79
10	67.80	76		34	68.13	77		58	67.70	79
11	67.23	76		35	69.70	80		59	68.58	80
12	69.79	82		36	71.79	83		60	71.53	84
13	70.98	84		37	72.98	85		61	72.40	85
14	72.71	86		38	75.02	88		62	73	87
15	74.15	89		39	76.71	92		63	73.29	88
16	74.71	93		40	77.49	95		64	73.58	89
17	74.98	94		41	78.24	98		65	73.58	89
18	75.82	93		42	78.72	100		66	73.33	92
19	74.98	98		43	78.48	99		67	73.08	93
20	74.20	97		44	77.91	99		68	73.36	94
21	74.19	97		45	77.91	99		69	74.42	94
22	74.16	95		46	77.10	98		70	74.14	93
23	74.15	93		47	76.85	97		71	74.68	93
24	72.22	90		48	75.24	93		72	73.28	88

Note:

1. Only 72 hours of temperature data are provided because 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 of the required 30-day period.

Table 9.2.5-4—Design Values for Minimum Water Cooling in the UHS

Time (hr)	Wet Bulb Temp (°F)	Dry Bulb Temp (°F)
1	75.8	82
2	76.1	83
3	76.1	83
4	77.3	85
5	79.7	89
6	80.8	91
7	82.0	93
8	84.6	99
9	85.3	99
10	85.3	99
11	84.2	100
12	84.2	100
13	84.6	99
14	83.9	99
15	83.9	99
16	82.6	96
17	82.6	93
18	82.1	91
19	82.1	91
20	81.9	90
21	80.7	88
22	80.7	88
23	79.5	86
24	79.5	86

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