10.4.5 Circulating Water System

The circulating water system (CWS) supplies cooling water from the normal heat sink to the turbine condensers and auxiliary cooling water system (ACWS). After removing heat from the condensers and ACWS, the circulating water is returned to the normal heat sink.

10.4.5.1 Design Bases

The CWS performs no safety-related function and therefore has no nuclear safety-related design basis.

The CWS is designed to meet the following functional criteria:

- Supply cooling water from the normal heat sink to the turbine condensers and ACWS.
- Discharge heated water from the turbine condensers and ACWS to the normal heat sink.
- Cool the discharged heated water in the normal heat sink to an acceptable temperature.

10.4.5.2 System Description

10.4.5.2.1 General Description

The CWS is a non-safety related interface system that provides a continuous supply of cooling water to the turbine condensers and ACWS and rejects heat to the environment via the normal heat sink.

Table 3.2.2-1 provides the seismic design and other design classifications for components in the CWS. Section 3.2 describes how the guidance of RG 1.26 is implemented for the U.S. EPR.

The CWS consists of circulating water pumps, mechanical draft cooling towers, and associated piping, valves and instrumentation, as shown in Figure 10.4.5-1—Circulating Water System Flow Diagram. The design of the CWS outside of the turbine building is site-specific. A COL applicant that references the U.S. EPR design certification will provide the description of the site-specific portions of the CWS.

10.4.5.2.2 Component Description

Cooling Towers

[[The CWS has mechanical draft cooling towers, each with a basin and circulating water sump. Each sump houses a circulating water pump. The sumps are designed to

provide sufficient submergence of the pump suction. Trash racks or suction screens are provided to prevent the ingestion of debris.]]

Circulating Water Pumps

[[The circulating water pumps are constant speed, vertical shaft type. The pumps are designed to operate under normal plant operating load conditions. Each pump has its suction located in its own pump bay. The pumps are designed to permit reverse flow.]]

Cooling Tower Makeup System

[[The cooling tower makeup system is site-specific and will be designed to provide adequate makeup flow to the cooling tower basins.]]

Chemical Treatment System

[[Water treatment for the CWS is based on site makeup water chemistry, blowdown requirements, environmental regulations and system materials.]]

A COL applicant that references the U.S. EPR design certification will provide the specific chemicals used to support the chemical treatment system as determined by the site-specific water conditions.

Cooling Tower Blowdown System

[[The cooling tower blowdown system is site-specific, and along with the makeup system will be designed to maintain the concentration of dissolved solids in the CWS within acceptable limits.]]

Piping and Valves

The CWS is designed to withstand the maximum operating discharge pressure of the circulating water pumps. The CWS includes condenser water boxes and tube bundles, butterfly valves and expansion joints. A COL applicant that references the U.S. EPR design certification will provide the site-specific CWS piping design pressure.

[[A butterfly valve is installed downstream of each circulating water pump.]] Isolation valves are installed at the inlets of the low pressure condenser water box and outlets of the high pressure condenser water box. [[Each cooling tower riser also has a butterfly valve that serves to isolate the cooling tower cell during maintenance activities. The butterfly valves contained in the CWS are designed to operate under normal plant operating load conditions. Valve opening and closing times are chosen to reduce water hammer effects.]]

Vacuum Breaker

A vacuum breaker is installed at the outlet water box of the condenser. During transient operating conditions or shutdown of circulating water pumps, the valve opens and atmospheric air flows into the circulating water piping to prevent water hammer.

Condenser Tube Cleaning System

Deposits that form on condenser tubes are removed by the condenser tube cleaning system (CTCS). Continuous cleaning of internal tube surfaces is accomplished by a constant circulation of sponge rubber balls having a diameter slightly larger than the tube, and a density when wet similar to that of the circulating water.

These sponge rubber balls are injected into the cooling water inlet through two or more ball injection nozzles. The flow of water carries them into the water boxes, through the tubes and into the ball strainer at the condenser circulating water outlet. From there, they are drawn off by the ball strainer and pumped by the ball circulation pump through the ball collector and back to the cooling water inlet.

The ball strainer of the CTCS is installed in the return line from the condenser to the normal heat sink. The ball collector permits gathering of the sponge rubber balls when the condenser is in normal operation.

Vacuum Priming System

A vacuum priming system is used for a site-specific application where the highest tubes in the condenser tube bundle cannot be filled with water by means of gravity. The connections to the vacuum priming system are at the condenser water boxes. The air from the circulating water is discharged via the vacuum priming system to the water and air separator and from there to the atmosphere.

If a vacuum priming system is required, a COL applicant that references the U.S. EPR design certification will provide the site-specific information.

Vents and Drains

The CWS piping and condenser water boxes include high-point vents and low-point drains at appropriate locations for use during filling and draining of the system.

10.4.5.2.3 System Operation

Normal Operation

During normal plant operation, circulating water is routed from the individual cooling tower basins into the respective circulating water sumps. The circulating water pumps

discharge the circulating water into a common header, and from there into separate supply lines to the condenser water boxes. Downstream of the condenser water boxes in the outdoor area, the circulating water is routed back to the cooling towers through two separate return lines.

As unit load is decreased, and at lower-than-design wet bulb temperatures, individual cooling tower fans can be switched off. Individual circulating water pumps can be turned off and their associated butterfly valve closed. One circulating water pump and cooling tower must remain in operation as long as there is demand for heat removal capability from the condensers.

Abnormal Operation

If there is a loss of one circulating water pump the total flow of cooling water is reduced, resulting in an increased temperature rise across the condenser. The turbine backpressure will also increase, resulting in a decrease in power output. If more than one circulating water pump fails, these effects on performance increase. If all circulating water pumps fail, heat removal is provided by the main steam relief trains described in Section 10.3.

Flooding protection is included in the design so that large leaks from circulating water piping do not result in the loss of all circulating water pumps. The layout of the CWS design is such that a malfunction of any component or piping does not adversely affect the safe operation of the plant or any safety-related system.

In the case of loss of one cooling tower, the temperature drop across the circulating water in the cooling tower will increase. This will increase the outlet temperature from the condenser halves. The turbine backpressure will also increase, resulting in a decrease in power output. If more than one cooling tower fails, these effects on performance increase. If all cooling towers fail, heat removal is provided by the main steam relief trains described in Section 10.3.

Loss of offsite power results in the loss of the non-emergency AC power supply. The effect is the same as the loss of all circulating water pumps.

If one condenser path is closed due to leakage in the condenser, the affected line is isolated. The circulating water flow rate is reduced, resulting in a decrease in power output.

If both condenser paths are closed due to leakage in the condenser, the effect is the same as the loss of all circulating water pumps.

10.4.5.3 Safety Evaluation

The CWS has no safety-related function and is not credited for mitigation of design basis accidents and has no safe shutdown functions. The CWS is not located in an area that contains any safety-related components and is not required to operate during or after an accident.

The design of the CWS satisfies GDC 4, as it relates to the CWS including design provisions to accommodate the effects of discharging water that may result from a failure of a component or piping in the CWS. Flooding control is described in Section 3.4.

- [[Means are provided to prevent or detect and control flooding of safety-related areas so that the intended safety function of a system or component will not be diminished due to leakage from the CWS.]]

- [[Malfunction or failure of a component or piping in the CWS, including an expansion joint, will not produce unacceptable adverse effects on the functional performance capabilities of safety-related systems or components.]]

A COL applicant that references the U.S. EPR design certification will provide information to address the potential for flooding of safety-related equipment due to failures of the site-specific CWS.

10.4.5.4 Inspection and Testing Requirements

The CWS is inspected and tested as part of the initial plant test program described in Section 14.2 (test abstracts #069 and #223). Components of the CWS are accessible for inspection during normal plant operation. The circulating water pumps meet the performance testing requirements in standards of the Hydraulic Institute (Reference 1).

10.4.5.5 Instrumentation Requirements

[[Pressure is measured at the discharge of each circulating water pump. Temperature is measured at the condenser inlet and outlet for each tube bundle.]] The circulating water is also monitored for pH and conductivity. [[Permanent flowmeters measure individual circulating pump flow and total flow to the turbine condenser. Access ports allow temporary flowmeters to be installed in the main circulating water piping. Cooling tower basin level is monitored and used to control makeup flow. Blowdown is manually adjusted as required to maintain desired water chemistry.]]

10.4.5.6 References

1. ANSI/HI Pump Standards, Hydraulic Institute, 2002.

Next File