TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

6.2 COOLING WATER SYSTEMS

Learning Objectives:

1. State the purposes of the following AP1000 Cooling Water Systems:

    a. Component Cooling Water System (CCS),
    b. Service Water System (SWS),
    c. Spent Fuel Cooling System,
    d. Turbine Building Closed Cooling Water System, and
    e. Condenser Circulating Water System.

2. Describe the major differences between the AP1000 and current operating Westinghouse plants Cooling Water Systems.

6.2.1 Component Cooling Water System (CCS)

The component cooling water system is a nonsafety-related, closed-loop cooling system that transfers heat from various plant components to the service water system cooling tower. It operates during normal phases of plant operation including power operation, normal cooldown, and refueling. The system includes two component cooling water pumps, two component cooling water heat exchangers, one component cooling water surge tank and associated valves, piping, and instrumentation.

The component cooling water system provides a reliable supply of cooling water to the various plant components listed in Table 6.2-2. A simplified sketch of the component cooling water system is included as Figure 6.2-1.

The AP1000 component cooling water system provides a barrier to the release of radioactivity between the plant components being cooled that handle radioactive fluid and the environment. The component cooling water system also provides a barrier against leakage of service water into primary containment and reactor systems.

The component cooling water system, in conjunction with the normal residual heat removal system removes both residual and sensible heat from the core and the reactor coolant system and reduces the temperature of the reactor coolant system during the second phase of cooldown.

The first phase of plant cooldown is accomplished by transferring heat from the reactor coolant system via the steam generators to the main steam systems.

During fuel shuffling (partial core off-load) or a full core off-load, cooling water flow is provided to spent fuel pool heat exchangers to cool the spent fuel pool. For a full core off-load cooling water is also supplied to a normal residual heat removal heat exchanger as part of spent fuel pool cooling.

The CCS components are arranged into two mechanical trains. Each train includes one component cooling water pump and one component cooling water heat exchanger. The two trains of equipment take suction from a single return header. The surge tank is connected to the return header. Each pump discharges directly to its respective heat exchanger. A bypass line around each heat exchanger containing a throttle valve prevents overcooling the component cooling water. The discharge of each heat exchanger is to the common supply header.

The component cooling water heat exchangers are plate type heat exchangers. Component cooling water circulates through one side of the heat exchanger while service water circulates through the other side. Component cooling water in the heat exchanger is maintained at a higher pressure than the service water to prevent leakage of service water into the system.

Component cooling water is distributed to the cooled components by the single supply/return header. Components are grouped in branch lines according to plant arrangement, with one branch line cooling the components inside containment. Loads inside containment are remotely isolated (1) in response to a safety injection signal, which also trips the reactor coolant pumps, and (2) in response to a high bearing water temperature trip signal from one of the reactor coolant pumps. Individual components, except the reactor coolant pumps, can be isolated locally to permit maintenance while the remaining components are supplied with cooling water.

The component cooling water surge tank accommodates thermal expansion and contraction. It also accommodates leakage into or out of the component cooling water system until the leak is isolated. Water makeup to the surge tank is provided automatically on a low surge tank level signal by the demineralized water transfer and storage system. A line routed from the pump discharge header to the surge tank includes a mixing tank to add chemicals into the system to inhibit corrosion.

Failure of the component cooling water system or its components will not affect the ability of safety-related systems to perform their intended safety functions. The component cooling water system serves no safety-related function except for containment isolation and therefore has no nuclear safety design basis except for containment isolation.

During normal plant operation, one component cooling water system mechanical train of equipment is operating. The operating train is aligned to provide component cooling for the loads identified in Table 6.2-2. The other train is aligned to automatically start in case of a failure of the operating component cooling water pump.

The component cooling water pumps are automatically loaded on the standby diesel generators in the event of a loss of normal ac power. The component cooling water system therefore continues to provide cooling of required components if normal ac power is lost.

6.2.2 Service Water System (SWS)

The service water system (SWS) is a nonsafety-related system that supplies cooling water to remove heat from the nonsafety-related component cooling water system (CCS) heat exchangers in the turbine building.

The system consists of two 100-percent-capacity service water pumps, automatic backwash strainers, a two-cell cooling tower with a divided basin, and associated piping, valves, controls, and instrumentation.

The service water pumps, located in the turbine building, take suction from piping which connects to the basin of the service water cooling tower. Service water is pumped through strainers to the component cooling water heat exchangers for removal of heat. In the standard AP1000 design heated service water from the heat exchangers then returns through piping to a mechanical draft cooling tower where the system heat is rejected to the atmosphere. Cool water, collected in the tower basin, flows through fixed screens to the pump suction piping for recirculation through the system. Use of a cooling tower is dependent on the site chosen for the plant (i.e., salt water versus fresh water makeup).

A small portion of the service water flow is normally diverted to the circulating water system. This blowdown is used to control levels of solids concentration in the SWS. An alternate blowdown flow path is provided to the waste water system (WWS).

The service water system is arranged into two trains of components and piping. Each train includes one service water pump, one strainer, and one cooling tower cell. Each train provides 100-percent-capacity cooling water in the quantities and operating conditions listed in Table 6.2-3. Cross-connections between the trains upstream and downstream of the component cooling water system heat exchangers allows either service water pump to supply either heat exchanger, and allows either heat exchanger to discharge to either cooling tower cell.

Temperatures in the system are moderate, and the pressure of the service water system fluid is kept above saturation at all locations. This, along with other design features of the system arrangement and control of valves, minimizes the potential for thermodynamic or transient water hammer.

Service water system materials are compatible with the cooling water chemistry and the chemicals used for the control of long-term corrosion and organic fouling. The turbine island chemical feed system equipment injects the required chemicals into the service water system. This injection maintains a noncorrosive, nonscale forming condition and limits biological film formation. Chemicals are injected into service water pump discharge piping located in the turbine building.

In the event of loss of normal ac power, the service water pumps and cooling tower fans, along with the associated motor operated valves, are automatically loaded onto their associated diesel buses. This includes isolation of cooling tower blowdown, which minimizes draindown of the system while both pumps are off.

6.2.3 Spent Fuel Cooling System

The AP1000 spent fuel pool cooling system is a nonsafety-related system designed to remove decay heat from the fuel pool and to circulate water through demineralizers to maintain fuel pool water purity. The safety-related function of cooling and shielding the fuel in the spent fuel pool is performed by the water in the pool.

The spent fuel pool cooling system consists of two mechanical trains of equipment. Each train includes one spent fuel pool pump, one spent fuel pool heat exchanger, one spent fuel pool demineralizer and one spent fuel pool filter. The two trains of equipment share common suction and discharge headers. In addition, the spent fuel pool cooling system includes the piping, valves, and instrumentation necessary for system operation.

The spent fuel pool cooling system is designed such that either train of equipment can be operated to perform any of the functions required of the spent fuel pool cooling system independently of the other train. One train is continuously cooling and purifying the spent fuel pool while the other train is available for water transfers, in-containment refueling water storage tank purification, or aligned as a backup to the operating train of equipment.

For fuel shuffling (partial core off-load), CCS cooling water flow is provided to both spent fuel pool heat exchangers to maintain the spent fuel pool water temperature below 120°F. With a full core off-load and 10 years accumulation of spent fuel in the pool, both spent fuel pool heat exchangers and one normal residual heat removal heat exchanger maintain the spent fuel pool water temperature below 120°F.

The spent fuel pool cooling system removes radioactive corrosion products and fission ions to maintain low in-containment refueling water storage tank activity levels during normal plant operation prior to a scheduled refueling. The spent fuel pool cooling system is designed to maintain the water in the in-containment refueling water storage tank consistent with activity requirements of the water in the refueling cavity during a refueling.

The AP1000 reactor cavity seal ring is part of the fuel handling system and is a permanent welded seal ring used to provide the seal between the vessel flange and the refueling cavity floor. The reactor cavity seal ring does not use pneumatic seals and is not subject to a gross failure due to loss of a seal. Leakage is not expected with this design. Leakage past or through the seal would not significantly affect the water level in the refueling canal and would be detected as an increase in water level in the containment sump. Water level in the sump is a key parameter in reactor coolant leak detection.

The spent fuel pool cooling system pumps can be manually loaded on the respective onsite standby diesel generator in the event of a loss of offsite power. The spent fuel pool cooling system is capable of providing spent fuel pool cooling following this event.

Following a loss of ac power (off-site power and both standby diesel generators are unavailable), the heat capacity of the water in the pool is such that cooling of the fuel is maintained. Spent fuel pool makeup for long term station blackout can be provided through seismically qualified safety-related makeup connections from the passive containment cooling system.

6.2.4 Turbine Building Closed Cooling Water System

The turbine building closed cooling water system (TCS) provides chemically treated, demineralized cooling water for the removal of heat from nonsafety-related heat exchangers in the turbine building and rejects the heat to the circulating water system.

The system consists of two 100-percent capacity pumps, three 50-percent capacity heat exchangers (connected in parallel), one surge tank, one chemical addition tank, and associated piping, valves, controls, and instrumentation. Heat is removed from the turbine building closed cooling water system by the circulating water system via the heat exchangers.

The pumps take suction from a single return header. Either of the two pumps can operate in conjunction with any two of the three heat exchangers. Discharge flows from the heat exchangers combine into a single supply header. Branch lines then distribute the cooling water to the various coolers in the turbine building. The flow rates to the individual coolers are controlled either by flow restricting orifices or by control valves, according to the requirements of the cooled systems. Individual coolers can be locally isolated, where required, to permit maintenance of the cooler while supplying the remaining components with cooling water. A bypass line with a manual valve is provided around the turbine building closed cooling water system heat exchangers to help avoid overcooling of components during startup/low-load conditions or cold weather operation.

The system is kept full of demineralized water by a surge tank which is located at the highest point in the system. The surge tank connects to the system return header upstream of the pumps. The surge tank accommodates thermal expansion and contraction of cooling water resulting from temperature changes in the system. It also accommodates minor leakage into or out of the system. Water makeup to the surge tank, for initial system filling or to accommodate leakage from the system, is provided by the demineralized water transfer and storage system. The surge tank is vented to the atmosphere.

The turbine building closed cooling water pumps are provided ac power from the 6900-V switchgear bus. The pumps are not required during a loss of normal ac power.

6.2.5 Condenser Circulating Water System

The circulating water system supplies cooling water to remove heat from the main condensers, the turbine building closed cooling water system (TCS) heat exchangers, and the condenser vacuum pump seal water heat exchangers under varying conditions of power plant loading and design weather conditions.

The circulating water system and cooling tower are subject to site specific modification or optimization.

The circulating water system consists of three 33-1/3-percent-capacity circulating water pumps, one hyperbolic natural draft cooling tower, and associated piping, valves, and instrumentation.

Makeup water to the CWS is provided by the raw water system (RWS). In addition, water chemistry is controlled by the turbine island chemical feed system (CFS).

Table 6.2-1

NOMINAL COMPONENT DATA - COMPONENT COOLING WATER SYSTEM

CCS Pumps (all data is per pump)	
Quantity	2
Type	Horizontal centrifugal
Minimum capacity (gpm, each) to support shutdown cooling and spent fuel pool cooling	8300
Design capacity (gpm, each)	9500
Design total differential head (ft)	250
Minimum flow rate to support shutdown cooling (gpm)	2685
Minimum flow rate to support spent fuel cooling (gpm)	1200
CCS Heat Exchangers (all data is per exchanger)	
Quantity	2
Type	Plate
Design duty end of cooldown (MBtu/hr)	44.1
Minimum UA (MBtu/hr/°F) to support shutdown cooling and spent fuel pool cooling	14.0
Design UA (MBtu/hr/°F)	15.5
CCS side Design flow rate (gpm)	9629
Service water side Design flow rate (gpm)	10,500
Plate material	Austenitic stainless steel
Seismic design	Non-seismic

Table 6.2-2

PLANT COMPONENTS COOLED BY COMPONENT COOLING WATER SYSTEM

Component	System
RCP 1A	RCS
RCP 1B	RCS
RCP 2A	RCS
RCP 2B	RCS
RCP 1A Variable Frequency Drive	RCS
RCP 1B Variable Frequency Drive	RCS
RCP 2A Variable Frequency Drive	RCS
RCP 2B Variable Frequency Drive	RCS
Letdown HX	CVCS
RCDT HX	WLS
RHR HX	RNS
RHR HX	RNS
RHR Pump A	RNS
RHR Pump B	RNS
SFP HX A	SFS
SFP HX B	SFS
Chiller A	VWS
Chiller B	VWS
Sample HX	PSS
Miniflow HX	CVS
Miniflow HX	CVS
Air Compressor A	CAS
Air Compressor B	CAS
Air Compressor C	CAS
Air Compressor D	CAS
Cond Pump A Oil Cooler	CDS
Cond Pump B Oil Cooler	CDS
Cond Pump C Oil Cooler	CDS

Table 6.2-3

NOMINAL SERVICE WATER FLOWS AND HEAT LOADS AT DIFFERENT OPERATING MODES

	CCS Pumps and Heat Exchangers	SWS Pumps and Cooling Tower Cells (Number Normally is Service)	Flow (gpm)	Heat Transferred (Btu/hr)
Normal Operation (Full Load)	1	1	10,500	$103 x 10^6$
Cooldown	2	2	21,000	$346 x 10^6$ ($173 x 10^6$ per cell)
Refueling (Full Core Offload)	1	1	10,500	$74.9 x 10^6$
Plant Startup	2	2	21,000	$75.8 x 10^6$
Minimum to Support Shutdown Cooling and Spent Fuel Cooling	1	1	10,000	$170 x 10^6$