Westinghouse Technology Systems Manual

Section 14.1

Generic Component Cooling Water System

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14.1 COMPONENT COOLING WATER SYSTEM

Learning Objectives:

1. State the purposes of the Component Cooling Water (CCW) System.

2. List the loads served by the CCW system.

3. Explain how the design of the CCW system prevents the release of radioactivity to the environment.

4. Describe both methods of detecting leakage into the CCW system.

5. Describe how the CCW system is protected against leakage in the thermal barrier heat exchangers.

14.1.1 Introduction

The purposes of the component cooling water (CCW) system are:

1. To remove heat from systems and components which may contain radioactive water,

2. To transfer the heat to the essential service water system, and

3. To act as a barrier between radioactive systems and the environment.

The CCW system is used during all phases of plant operation, including shutdown and post accident. This system is sometimes referred to as a buffer system. It operates at a lower pressure than the radioactive systems which it cools and at a lower pressure than the system cooling it (essential service water [ESW] - section 14.2). The entire system is safety related and meets all seismic qualifications.

14.1.2 System Description

The component cooling water system (Figure 14.1-1) consists of two safety-related cooling loops and a third service loop for nonsafety loads. The system is Seismic Category I, and power supplies are Class 1E. The two safety-related loops are independent and redundant. Each loop or train consists of two pumps, a heat exchanger, and a surge tank. The loops could be cross-connected, but for reliability they are operated independently. Each of the pumps is a 100% capacity pump.

The entire CCW system is of the closed-cycle type, with fluid continuously circulated through the system by the CCW pumps. Heat is removed from the system by the flow of essential service water through the tube side of the CCW heat exchangers. The closed cycle design assures a monitored intermediate barrier between the components handling reactor coolant system fluids and the ESW system. The closed cycle also permits use of a corrosion inhibitor in the system to protect the system water passages from corrosion. During normal operations, the service water (SW) system supplies the heat exchangers with cooling water, and during accident conditions, ESW from the ultimate heat sink is used as the cooling medium.

Emergency makeup water can be supplied directly to the pump suction header from the ESW System. Two valves, in series, supply each loop. HV-12 and -14 supply loop B, and HV-11 and -13 supply loop A.

14.1.2.1 Safety-Related Loops

The outputs from the CCW heat exchangers are directed to the safety loops. The loads in these loops consist of:

- Safety injection pump oil coolers,
- Centrifugal charging pump oil coolers,
- Spent fuel pool heat exchangers,
- Residual heat removal (RHR) pump seal coolers,
- Residual heat removal heat exchangers, and
- Post-accident sampling station coolers.

Only one safety loop supplies the post-accident sampling station. This is done with manual valves. The flow then goes through two motor-operated valves, HV-72 and HV-73. Flow returns to the loop through HV-74 and HV-75. All four valves close on a safety injection actuation signal, and a surge tank low-low level closes one supply and one return valve.

All safety loads are supplied during normal operations, except the RHR heat exchangers. The heat exchangers are supplied by opening HV-101 and HV-102 from the main control board.

14.1.2.2 Service Loop

The service loop (Figure 14.1-2) supplies nonsafety loads and is connected to only one of the safety loops. The supply valves are HV-53 for loop A and HV-54 for loop B. The return valves are HV-15 and HV-16 for loops A and B, respectively. Cross-connecting the loops will generate an alarm. There are three load groups supplied by the service loop:

- Reactor containment loads,
- Auxiliary building loads, and
- Radwaste building loads.

The reactor containment loads are the heat exchangers on the reactor coolant pumps and motors, excess letdown heat exchanger, and reactor coolant drain tank heat exchanger. The supply header is common for all these loads, but the thermal barrier heat exchangers have a separate return header.

All penetrations close on a containment phase B isolation signal. One of the containment isolation valves on the thermal barrier heat exchanger return header closes on a high flow signal to protect the system from overpressure if a leak occurs in the heat exchanger. Upstream of the penetration, each reactor coolant pump has its own return valve which closes on high flow, but the setpoint is lower than that of the common valve. With this convention, a leak in one heat exchanger may not affect the other pumps.

The auxiliary building loads are the letdown heat exchanger, the seal water heat exchanger, and the positive displacement charging pump cooler. These loads may be individually isolated by local manual valves.

The radwaste building loads include waste gas compressors, evaporator coolers, and hydrogen recombiners. A safety injection actuation signal closes all supply and return valves. Low-low level in a surge tank or high flow in the radwaste supply header closes supply and return valves.

14.1.3 Component Descriptions

14.1.3.1 Pumps

There are four 100% capacity CCW pumps, two in each loop. Pumps A and C supply the A loop, and pumps B and D supply the B loop. The pumps are single-stage, centrifugal, horizontally mounted pumps with a capacity of 11,025 gpm at 82 psig discharge pressure.

The motors are 700-hp induction motors powered from 4160-Vac vital distribution busses. Pumps A and C are powered from one train, while pumps B and D are powered from the other. During normal operation, one pump in each loop is running, with the backup pump in automatic. After a four-second delay, the standby pump starts on low discharge pressure. A safety injection actuation signal sends a start signal to the A and B pumps after five seconds and to pump C or D at ten seconds if the associated pump did not start.

14.1.3.2 Heat Exchangers

The CCW heat exchangers are on the discharge sides of the pumps. They are rated at 77.2×10^6 BTU/hr, enough capacity for all loads, including RHR loads during plant cooldowns. CCW flows through the shell side, and essential service water flows in the tubes.

Temperature of CCW is controlled by bypassing some flow around the heat exchangers using TV-29 and TV-30. These valves will close on a safety injection actuation signal.

14.1.3.3 Surge Tanks

Each loop has a surge tank which serves as an expansion volume for temperature changes or leakage into or out of the system. It also provides net positive suction head for the pumps. The tanks are vented to the atmosphere, and the vent valves close on high radiation in the heat exchanger bypass lines. A relief valve set at 150 psig protects each tank from overpressure, and a vacuum breaker protects against a collapse. The CCW system is a closed system, and chemicals are added to inhibit corrosion. Makeup water is provided by the demineralized water system. Level transmitters start and stop automatic makeup and provide indication of leakage in or out of the system.

14.1.4 System Features and Interrelationships

14.1.4.1 Safety Injection Actuation Signal

A safety injection actuation signal starts pumps A and B. Pump C and D starts only if its associated pump does not start. Also, heat exchanger bypass valves close so all flow goes through the heat exchangers. Also, radwaste building loads and the post-accident sampling station are isolated from the CCW system.

14.1.4.2 Phase B Containment Isolation Signal

All service loop loads supplied the component cooling water system, located inside the containment structure, are isolated on a phase B containment isolation signal.

14.1.4.3 Cooldown

Two trains of CCW are needed to cool the plant to cold shutdown in 20 hours. One train could achieve cold shutdown, but more time is required. Two pumps may be required in the train supplying the service loop because of the RHR heat exchanger load.

14.1.4.4 Leak Detection

The CCW system is operated at low pressure so that any leakage in a heat exchanger would leak into the CCW system and cause a rise in surge tank level. If the leakage is radioactive, it would be detected by the radiation elements in the heat exchanger bypass lines.

14.1.5 PRA Insights

The component cooling water system of some plants is a major contributor to core damage frequency (79% at Zion, and 31% at Sequoyah). This is due to its role in reactor coolant pump (RCP) seal cooling and cooling of equipment in the emergency core cooling systems (ECCSs). RCP seal cooling is provided by the thermal barrier heat exchanger and the normal charging seal injection. Both of these methods are dependent on CCW for pump seal cooling.

A loss of CCW would result in a failure of the RCP seal and produce a seal loss-of-coolant accident (LOCA). The charging pumps and safety Injection pumps are needed to supply injection to the core to makeup for the loss of inventory. Without CCW, they would fail due to overheating. The resultant unrecoverable inventory from the reactor coolant system would lead to core damage. Probable causes of failure of the CCW system are as follows:

1. Human error - At those sites such as Zion and Sequoyah where the CCW system is shared between units, failure to manually align the standby train after failure of the operating loop.

2. Loss of CCW pumps - The pumps fail to start, or fail to continue to run after starting, due to some common-mode failure, such as loss of power.

3. Valve failure - Local fault of the heat exchanger outlet or bypass valves, or on some designs, a local fault of the header isolation valve to the ECCS pump coolers.

4. Piping failure - At Zion, the most significant failure is a rupture of the CCW piping. A review of the Probabilistic Safety Study identified 30 pipe sections whose failure would lead to a loss of CCW.

PRA studies (Reactor Risk Reference Document NuReg-1150) on importance measures have shown that the CCW system can be a major contributor to both risk reduction and risk achievement (Sequoyah - risk reduction factor of 450, risk achievement factor of 120-630).

14.1.6 Summary

The CCW system is a closed-loop, low pressure system designed to transfer heat from radioactive systems to the environment. This system acts as a barrier between systems that may contain radioactive or potentially radioactive fluids and the environment. It provides these functions during normal plant operations, post-accident operations, and plant cooldowns. The component cooling water system is a safety system with two separate redundant trains, designed to be operational during all phases of plant operation.

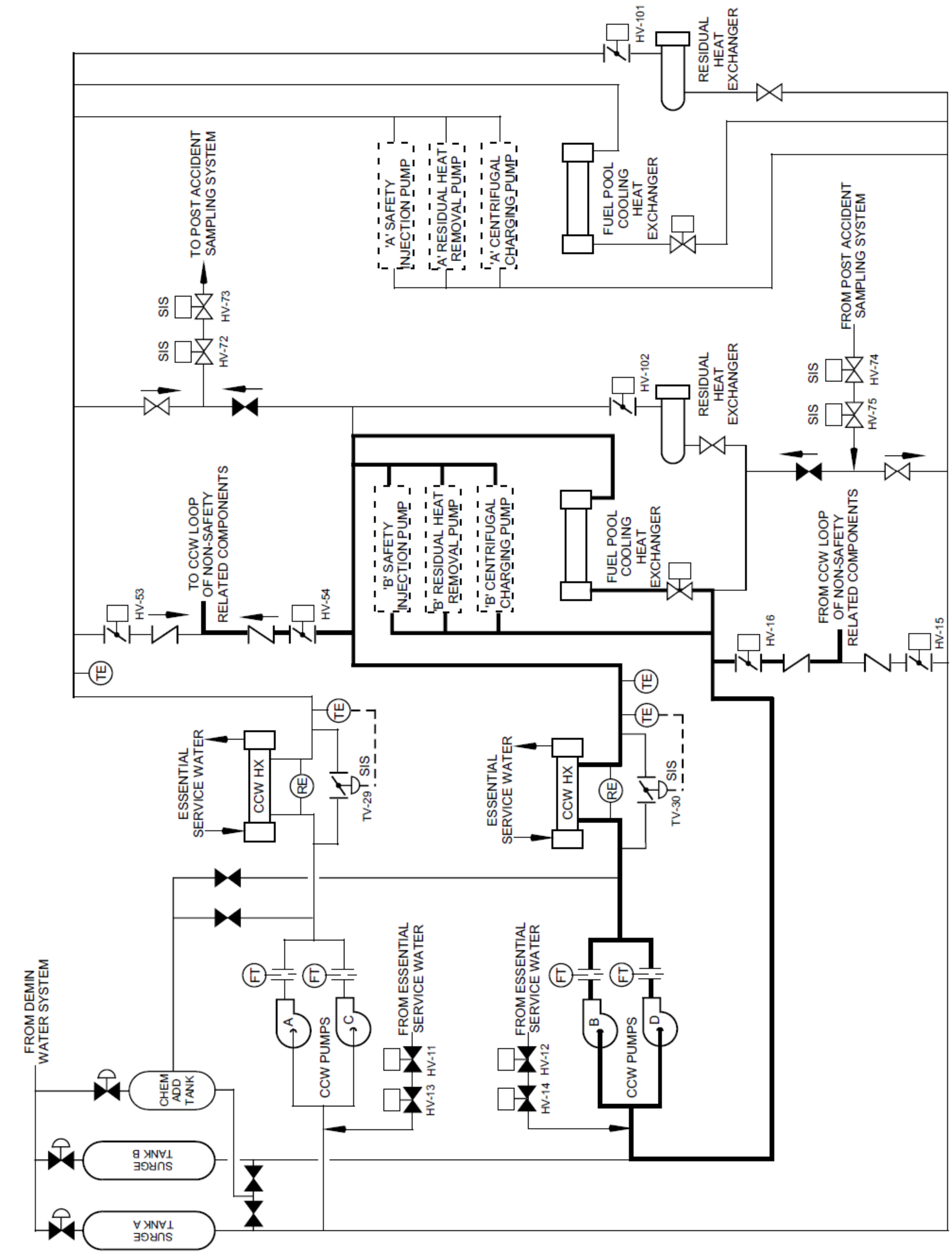

Figure 14.1-1 Component Cooling Water

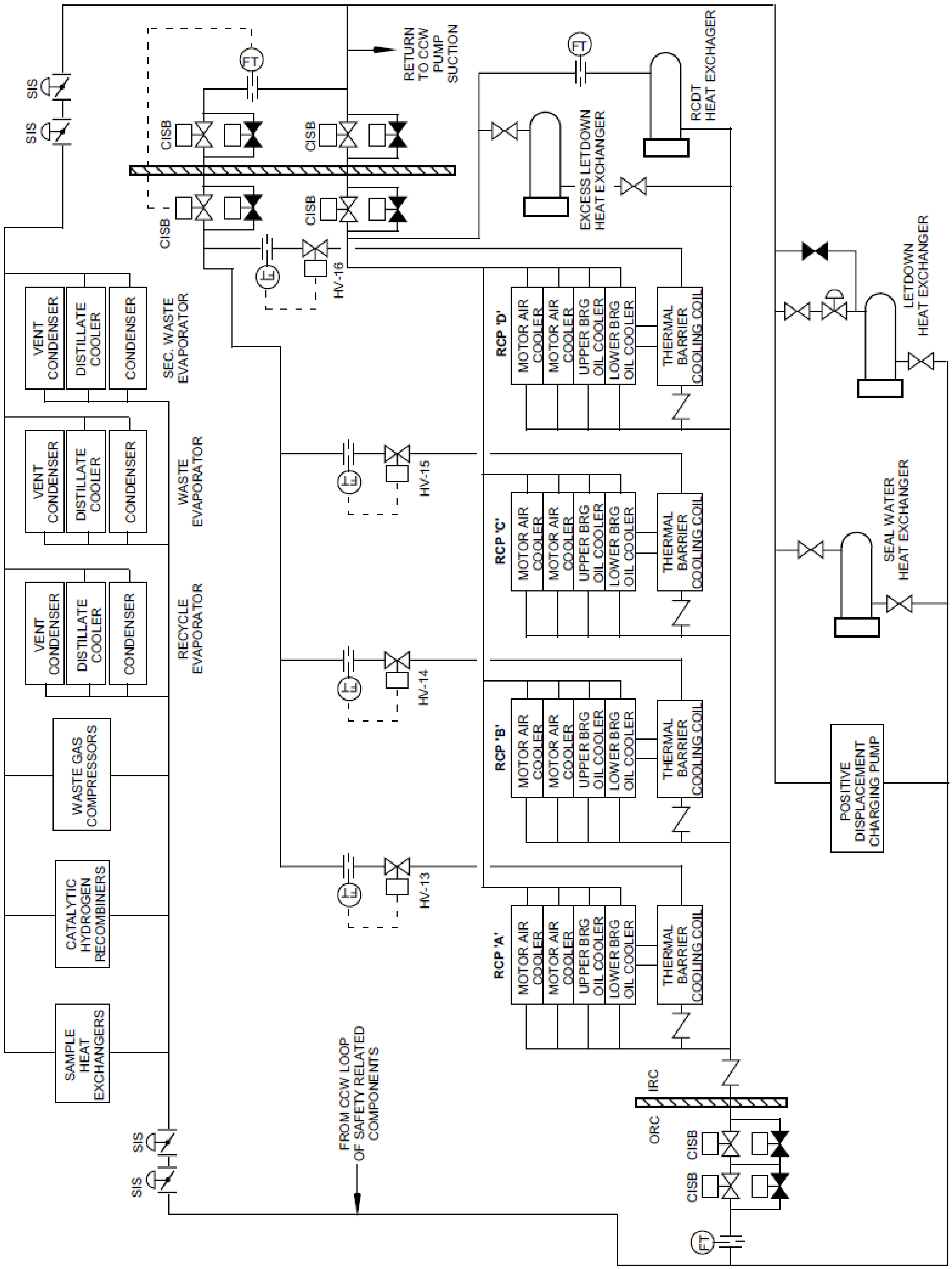

Figure 14.1-2 Component Cooling Service Loop