9.2.2 Component Cooling Water System

The component cooling water system (CCWS) is a closed loop cooling water system that, in conjunction with the essential service water system (ESWS) and the ultimate heat sink (UHS), removes heat generated from the plants safety-related and non-safety components connected to the CCWS. Heat transferred by these components to the CCWS is rejected to the ESWS via the component cooling water heat exchangers (HX).

The four safety-related trains of the CCWS cool the safety-related equipment, as required, during all phases of operation. Two non-safety-related branches of the CCWS cool the common users located inside the Fuel Building (FB), Reactor Building (RB), Radioactive Waste Processing Building (RWB), and Nuclear Auxiliary Building (NAB). The four independent safety-related trains provide enough capability that the loss of one train from a single component failure, with a second train down for maintenance, will not impair the ability of the CCWS to meet its safety-related functional requirements.

One additional non-safety-related train comprises the dedicated CCWS that cools the severe accident heat removal system (SAHRS).

The CCWS fluid serves as a barrier preventing radioactive fluid from the components it cools from leaking into the environment. It also serves as a barrier against the leakage of untreated service water into the containment or reactor systems.

9.2.2.1 Design Bases

The CCWS safety-related trains are:

- Protected from the effects of natural phenomena;
  - Earthquakes, tornadoes, hurricanes, floods, and external missiles.
  - Designed to function following such events (GDC 2).
- Designed to the Seismic Category assigned by RG 1.29 (Seismic Category I) and therefore will remain functional after a safe shutdown earthquake (SSE) (GDC 2).
- Designed to remain functional in spite of the postulated hazards of internal missiles, pipe whipping and discharging fluids (GDC 4).
- Not shared among nuclear power units (GDC 5).
- Designed to remain functional despite a single active component failure coincident with the loss of either the offsite or onsite power source (GDC 44).
- Designed to permit appropriate periodic inspection of important components to provide for integrity and capability of the system (GDC 45).

- Designed to permit appropriate periodic pressure and functional testing to make sure of (1) the structural and leak-tight integrity of its components, (2) the operability and the performance of the active components of the system, and (3) the operability of the system as a whole and, under conditions as close to the design as practical, the performance of the full operational sequence that brings the system into operation for reactor shutdown and for loss of coolant accidents (LOCA), including operation of applicable portions of the protection system and the transfer between normal and emergency power sources (GDC 46).
- Designed to permit isolation of lines that penetrate the primary containment to maximize containment isolation integrity (GDC 57).
- Designed to provide acceptable performance for all environments anticipated under normal, testing, and design basis conditions in compliance with the requirements of 10 CFR 50.49.
- Supplied by highly reliable and diverse power and control systems in conformance with the guidance of RG 1.32.
- Provides cooling to the thermal barrier of the reactor coolant pump (RCP) seals during all plant operating modes when the RCPs are running. (Thermal barrier cooling does not isolate due to an accident signal.)

The non-safety-related dedicated CCWS train is available on demand, in the unlikely event of a severe accident, to cool the SAHRS.

9.2.2.2 System Description

9.2.2.2.1 General Description

The CCWS design complies with applicable industry codes and standards, and regulatory requirements, commensurate with the function of each of the safety-related components.
As such, the CCWS components are fabricated, installed, and maintained in compliance with:

- ASME Boiler and Pressure Vessel (BPV) Code Section III, (Reference 1) Class 2 and 3 components.
- ASME Power Piping Code B31.1 (Reference 2).
- ASME BPV Code Section VIII, (Reference 3) non-safety-related components.
- Electrical redundancy and separation as specified in IEEE Std 603 (Reference 4).
- Seismic Category I and important-to-safety components as defined in RG 1.29.
- Environmental qualification as specified in 10 CFR 50.49.

The CCWS is a four train system configured to allow sharing of operational and safety-related users among the trains during normal operation, while always maintaining train separation with rapid isolation capability of the non-safety-related users in the event of an accident. The trains form pairs; trains 1 and 2 form one pair, and trains 3 and 4 the other pair. During normal operation, one or both trains in each associated pair can be in operation to cool the two common sets of users. Depending on the system user requirements, heat loads, and flow rates, and depending on the existing plant operating condition, the CCWS may have two, three, or all four trains in operation. System design parameters and flow requirements are listed in Table 9.2.2-1—CCWS Design Parameters and Table 9.2.2-2—CCWS User Flow Requirements.

Trains may be added or dropped as necessary to maintain the CCWS HX outlet temperature above the minimum required and below the maximum allowed and maintain the individual CCWS pump steady-state operating flow between the minimum required and the maximum allowed values. Idle CCWS trains are available and isolated from the common headers to provide safety injection system (SIS) availability if necessary. Maintenance on a CCWS train during power operation is possible.

During normal operation and design basis events, the CCWS provides the cooling function for the safety injection system/residual heat removal system (SIS/RHRS) and the safety chilled water system (SCWS) of divisions 2 and 3. The CCWS also transfers decay heat from the fuel pool cooling system (FPCS) whenever fuel is stored in the spent fuel pool. The CCWS additionally cools the thermal barriers of the RCP seals during all plant operating modes when the RCPs are running. Upon receipt of a containment isolation signal, the CCWS responds to protect the integrity of the containment pressure boundary.

To meet single-failure criteria for the RCP thermal barrier cooling function, the load is required to be cooled by a common header which is capable of being connected to two operable CCW trains A single failure of a train initiates an automatic system response to transfer the common header to the remaining train.

The CCWS flow rate is automatically controlled for those users which have been determined to have a limited operating temperature range for support of stable operation, while less temperature-sensitive users remain at a fixed flow resistance during all operating conditions. These fixed flow rates are adjusted once during plant commissioning with the system in its most demanding flow configuration (system flow balancing), and is reaffirmed regularly throughout the plant life by periodic surveillance, to make sure there is adequate required user flow for all operating conditions. It is not expected that the CCWS flow balance will require adjustment after the initial flow balance has been established.

For the accident analysis it is assumed that one CCWS train is unavailable due to maintenance or other activity and a second train fails to perform its function, leaving only two trains available for the event. Upon receipt of a safety injection and containment isolation Stage 1 actuation, the reactor protection system starts the CCWS pumps and opens the low head safety injection/residual heat removal (LHSI/RHR) isolation valves (CCWS flow to the LHSI/RHR HXs and LHSI pump coolers in trains 2 and 3) of the trains not initially in operation. The non-safety-related common users outside of the RB and the containment ventilation and reactor coolant drain tank (RCDT) cooler inside the RB are isolated. A subsequent containment isolation Stage 2 signal isolates the RCP and CVCS loads inside the RB except for the RCP seals thermal barrier coolers.

For the analysis, the accident is assumed to occur with coincident loss of offsite power (LOOP). The loss of one train is assumed to occur due to single failure, the most limiting of which is loss of one electrical division. This loss also results in the incidental loss of the associated emergency core cooling system (ECCS) and ESWS trains. This sequence is detailed in Chapter 15. Throughout accident mitigation and recovery, one of the remaining available CCWS trains cools the LHSI/RHR HX and the other provides additional cooling to the remaining safety loads, with both CCWS trains cooled by their associated ESWS trains.

Leaks in the CCWS, either in or out, will be apparent from various indications, and must be promptly isolated for repair or other corrective action. For instance, leakage of reactor coolant into the CCWS from an RHR HX tube, RCP seal thermal barrier, or other source is identified by increased activity in the CCWS fluid as detected by a continuous monitor or routine sampling, and is also indicated by an unexpected increasing level in the surge tank. The RCP thermal barrier leakage is detected by indication of a high outlet flow from the barrier or an elevated return temperature (or both) which results in an automatic isolation of the CCWS flow through the barrier. The operational pressure gradient of the cooling chain makes in-leakage of service water unlikely. Out-leakage from the system is indicated by an unexpected decrease in surge tank level, indicated by a noticeable increase in automatic makeup flow, visible leakage in the accessible areas or change in reactor coolant chemistry identified during routine sampling. For significant out-leakage from the CCWS, a rapid drop of the CCW level in the corresponding surge tank would trigger automatic inhibition of common users transfer of that train on sufficiently low level, and subsequent isolation of the common header upon reaching the low level isolation setpoint. This conserves the system capacity to cool the safety-related SIS users directly associated with the CCWS train. The system configuration also enables all such leaks to be readily isolated to prevent release of radioactive fluid, excessive dilution or chemical contamination of the reactor coolant.

The four separate, independently powered safety cooling trains of the CCWS, combined with high standards for system design, installation and maintenance, provides assurance that the system will fulfill its safety-related function under the most demanding postulated conditions in spite of its most limiting credible single failure.

During severe accidents, containment heat is removed by the dedicated cooling chain, consisting of the SAHRS, dedicated CCWS, and dedicated ESWS. This dedicated CCWS train is normally in standby operation and is manually started if needed. In case of loss of the dedicated CCWS or ESWS division, the SAHRS cooling chain is lost. This condition is outside the DBA.

Each physically separated CCWS safety-related train includes:

- A main system pump fitted with a recirculation line and pump motor cooling line.
- An HX, cooled by ESWS, with a parallel flow bypass line with control valve to maintain CCW minimum temperature during cold weather and low-load operation.
- A concrete, steel lined surge tank connected to the pump suction line with sufficient capacity to compensate for CCWS normal leaks or component draining.
- A sampling line with continuous radiation monitor.
- A chemical additive supply line.
- Isolation valves to separate the safety-related train from the common load set.

Each CCWS safety-related train supplies cooling to its respective CCWS and medium head safety injection (MHSI) pumps and motors and associated LHSI/RHR HXs, and trains 2 and 3 cool their respective LHSI pumps and motors. The LHSI pumps and motors of trains 1 and 4 are cooled by the SCWS.

The SCWS chillers for divisions 2 and 3 are supplied by CCWS trains 1 or 2, and 3 or 4, respectively. This enables continuous availability of the safety chillers during testing or maintenance activity and allows for equitable distribution of operating time for each of the CCWS safety-related trains. The CCWS safety-related trains are shown in Figure 9.2.2-1—Component Cooling Water System Trains 1 through 4.

The non-safety-related operational loads are supplied by two separate isolable headers designated common 1 and common 2. Common 1 may be aligned for service from either safety-related trains 1 or 2, and common 2 may be aligned to safety-related trains 3 or 4. Each common header branches into subheaders further designated “a” and “b” (i.e., common 1.a, 1.b, 2.a, and 2.b). Headers 1.a and 2.a, which cool FPCS trains 1 and 2, respectively, are separate from the other operational loads to provide continued cooling of the spent fuel. Headers 1.b and 2.b cool the remaining operational CCWS loads. Each of the common b-loops is isolable from the associated safety train by two fast-acting hydraulic valves, one installed in each train supply line and the other in the return line.

Common 1.b cools RB CCWS loads through two branches. One branch cools RCP 1, RCP 2, and CVCS high pressure (HP) cooler 1. The other branch cools heating ventilation and air conditioning (HVAC) coolers 1, 2, 3, and 4 and the RCDT cooler. Common 1.b also cools CVCS charging pump 1 and sampling system coolers in the FB, and the first chiller of both OCWS subsystems in the NAB.

Common 2.b cools RCP 3, RCP 4, and CVCS HP cooler 2 in the RB; CVCS charging pump 2 and sampling system coolers in the FB; and the second chiller of both OCWS subsystem, liquid, waste, coolant treatment, and boron recycle system users in the NAB and RWB.

To maintain CCWS train separation for the RCP thermal barrier cooling, an interlocking function is required. Either CCWS Common 1b or 2b headers can provide cooling to the thermal barriers. To maintain strict separation, the containment isolation valves on the RCP thermal barrier cooling path on the supply and return side of CCWS Common 1b cannot be opened unless the CIVs on both the supply and return side of Common 2b are closed, and vice-versa. If one CCWS train is inoperable, RCP thermal barrier cooling will be aligned to the CCWS common header with two operable CCWS trains.

The non-safety-related CCWS loads in the NAB and RWB can be quickly isolated from the rest of the CCWS by fast-closing hydraulic valves, as required. The non-safety-related common branches of the CCWS trains are shown in Figure 9.2.2-2—Component Cooling Water System Common Loop 1, and Figure 9.2.2-3—Component Cooling Water System Common Loop 2.

The design of the Component Cooling Water System (CCWS) minimizes and withstands adverse transients (i.e., water hammer) and meets functional performance requirements for all operating modes including postulated DBA consistent with the guidance for water hammer prevention and mitigation found in NUREG-0927 (Reference 6).

The CCW system design minimizes the potential for dynamic flow instabilities by avoiding high line velocities and specifying valve opening and closing speeds that are low enough to prevent damaging pressure increases.

Vents are provided for venting components and piping at high points in liquid filled systems that can become normally idle and in which voids could occur. These vents are located for ease of operation and testing on a periodic basis.

Consideration has been made to avoid voiding, which can occur following pump shutdown or during standby by placing the pumps and CCWS users at an elevation below the water level of the surge tanks. Means are provided for a slow and controlled fill of those portions of the CCW system where voiding could occur after pump shutdown or during standby.

The design incorporates controls and instrumentation to support operating and maintenance procedures to provide adequate measures to avoid water hammer.

One non-safety-related train comprises the dedicated CCWS. This train cools the SAHRS train, is supplied demineralized makeup water by the dedicated CCWS injection pump, is cooled by its assigned dedicated ESWS train, and is provided backup power from its assigned station blackout diesel generator (SBODG). The dedicated CCWS train consists of one main pump, one dedicated ESWS-cooled HX, one surge tank connected to the suction line to keep the system filled and maintain adequate head to prevent in-leakage of radioactive fluids from the SAHRS HX, a connection to the demineralized water system with an injection pump for inventory makeup, a chemical additive supply connection, and associated piping, fittings, and valves. The dedicated CCWS surge tank is charged by nitrogen over pressurization, which allows compressible compensation for fluid expansion and contraction and helps provide that any potential coolant leakage is into rather than out of the SAHRS. The dedicated CCWS train is shown in Figure 9.2.2-4—Component Cooling Water System Dedicated CCWS Trains.

In general, butterfly valves are used in the CCWS for isolation service (open or closed), not for throttling. In those applications where a butterfly valve is used in the CCWS and is subject to substantial throttling service for extended periods, design provisions will prevent consequential pipe wall thinning immediately downstream of the valves. Such design provisions include the use of erosion resistant materials, the use of thick wall pipe, and provision of straight pipe lengths immediately downstream of the affected valves.

All components and piping are carbon steel, except the demineralized feedwater line, which is stainless steel, and the CCWS HX tubes and dedicated CCWS HX tubes which are of a suitable corrosion resistant metal.

9.2.2.2.2 Component Description

Refer to Section 3.2 for details of the seismic and system quality group classification of the CCWS, CCW structures, and CCW components.

CCWS Pumps

The CCWS pumps are part of the safety-related cooling trains.

The four pumps are centrifugal type. The pump motor is cooled by an air-water cooler supplied by CCWS itself. The pump and motor are horizontally mounted on a common base plate. The pump and motor bearings are oil lubricated and are air cooled.

Motor heaters are provided on the motors and are energized when the pump is not in operation to prevent the formation of condensation.

During normal operating conditions, two of the four pumps are operating.

Dedicated CCWS Pump

The dedicated CCWS pump is non-safety-related and is in standby during normal plant operation.

The pump is centrifugal type. The pump motor is cooled by an air-water cooler supplied by the CCWS itself. The pump and motor are horizontally mounted on a common base plate. The pump and motor bearings are oil lubricated and are air cooled.

A motor heater is provided on the motor and is energized when the pump is not in operation to prevent the formation of condensation.

Dedicated CCWS Makeup Pump

The water supply pump is a positive displacement piston type to increase the head of the demineralized water distribution system (DWDS) supply to adjust the level of the pressurized surge tanks. To prevent flow pulses and to limit system vibration a pulsation damper is installed just downstream of the piston pump.

CCWS Heat Exchangers

The CCWS HXs are horizontal tube and shell type HXs. The CCW is circulated on the shell side and the ESWS supplies cooling water on the tube side.

Dedicated CCWS Heat Exchanger

The dedicated CCWS HX is a horizontal tube and shell type HX. CCWS circulates on the shell side and the ESWS supplies cooling water on the tube side.

CCWS Surge Tanks

The CCWS surge tanks are concrete structures with a steel liner. Each tank is connected to the suction side of its respective train CCWS pump.

Each surge tank has sufficient storage capacity to compensate for normal system leaks or component draining. Makeup water is supplied from the DWDS.

An additional makeup source of water to each surge tank originates from the seismically qualified (Seismic II) portion of the fire water distribution system inside the Nuclear Island. This makeup source provides sufficient post seismic event surge tank capacity to accommodate system leakage for seven days. Emergency makeup to the surge tanks is a manual operation performed by inserting a spool piece between valves AA141 and AA142. The manual valves AA141 and AA142 are then opened to provide the emergency makeup.

Dedicated CCWS Surge Tank

The dedicated CCWS surge tank is connected to the dedicated CCWS pump suction line.

The surge tank makeup is provided from the DWDS and nitrogen overpressure is provided to prevent a leak of radioactive fluids into the dedicated CCWS from the SAHRS.

The surge tank is provided with overpressure protection.

Common Header Switchover Valves

The common header switchover valves are fast-acting, hydraulically operated valves. Actuation of the valves is provided by a hydraulic circuit. A normally closed pilot valve blocks the hydraulic fluid path to the reservoir and the associated hydraulic pump generates the motive force to compress the valve actuator spring to open the valve. Closure of the valve is accomplished by energizing the pilot valve to bleed off the hydraulic fluid pressure, while the actuator spring closes the valve.

The valves provide the physical train separation for the support of the common cooling loads. They are used to transfer cooling of the common users during normal plant operation or in the event of a failure during a design basis event.

The valves are interlocked so that two trains may not be simultaneously connected to the same common header. The stroke time of these fast-acting valves is sufficient to minimize the interruption of cooling to the CCWS loads.

To provide reliability of the switchover function, an uninterruptible power supply (UPS) is provided to the hydraulic actuation pilot valves. A failure of the electrical distribution system does not inhibit the transfer of the common header to the non-faulted train.

LHSI Heat Exchanger Isolation Valves

These valves are motor-operated valves. The valves are normally closed to prevent dilution of the LHSI fluid and may be opened when necessary to provide an adequate flow path to support long term pump operation. The valves automatically open when the train associated LHSI system is placed into service.

LHSI Pump Seal Fluid Cooler Isolation Valves

These valves are motor-operated valves. The valves are normally closed to prevent dilution of the LHSI fluid and automatically open when the train associated LHSI system is placed into service.

Containment Isolation Valves

The CCWS containment isolation valves are motor-operated valves. The normally open valves provide the means for containment isolation to maintain the integrity of the containment penetrations and thus prevent the release of potentially radioactive material during a design based accident. The containment isolation valves for non-safety-related loads are automatically closed by containment isolation actuation signals. The containment isolation valves for the RCP thermal barrier coolers are not provided with a containment isolation signal but may be remote manually closed from the control room if required.

9.2.2.3 System Operation

9.2.2.3.1 Normal System Operation

The safety-related CCWS is a four train concept which allows sharing of operational and safety users during normal operation and to separate them in case of design and beyond design based accidents. Each physically separated train consists of a main pump, motor cooler, an HX, surge tank, sample piping with permanently installed radiation monitor, a chemical addition tank and pairs of common header isolation valves. Each train also supplies cooling to the associated MHSI pump motor cooler and the LHSI HX. The CCWS trains 2 and 3 also provide cooling to the LHSI pump motor and seal water coolers.

During normal operations, one or two trains can be in operation in each pair of associated trains (trains 1 and 2 or trains 3 and 4) to cool the two common sets of users (common 1.b (2.b), with or without common 1.a (2.a)). Each of the common headers may be split so that one of the two associated trains is supplying the common 1.a (2.a) header and the other is supplying the common 1.b (2.b) header to enhance cooling efficacy of the cooling chain.

The common 1.a header provides cooling to the first FPCS train and the common 2.a header provides cooling to the second FPCS train. These are separated from the other operational loads (1.b and 2.b) that the CCWS supplies to maintain FPCS cooling capacity during maintenance or plant outages.

Each train in operation:

- Cools the fluid in a closed loop through the CCWS exchanger.
- Provides recirculation in the surge tank for CCW mixing.
- Cools the main auxiliary pumps coolers (SIS and CCWS pumps).
- Is continuously sampled for radioactivity leakage into the CCWS using the permanently installed radiation monitor.

For each of common headers (1 and 2), the associated safety-related trains are isolated from each other by the four switchover isolation valves located on the supply and return side of each common header sub-loop (a and b).

Depending on the system user requirements, heat loads and flow rates, and depending upon the current plant operation, the CCWS can be configured with two, three or four trains in operation.

The following criterion drives CCWS operation with two, three or four trains:

- CCW temperature at the outlet of CCWS HX must be above the minimum required and below the maximum allowed.
- CCWS pump steady state operating flow must be between the minimum required and the maximum allowable.

For some users, the CCWS flow rate will be controlled automatically, while the others stay at fixed flow resistance during all operating conditions. Flow rates through CCWS users are adjusted once during plant commissioning with the most penalizing configuration (system flow balancing). After this, the minimum required user flow rate is always maintained whatever the plant operating condition. The system flow balance is reaffirmed regularly throughout the plant life during periodic surveillances. The expected cooling flow rate through system users, with fixed flow resistance, can reach approximately 140 percent of the required flow. Manual adjustments of flow balancing devices generally are not required during the normal plant operating cycle.

To make sure that the CCWS pump operates within the allowable range, system operation is limited. The allowed system configurations for a train are as follows:

- One train supplies only its associated SIS users (train-related LHSI HX and LHSI/ MHSI pumps).
- One train supplies the common 1.a (2.a) header (common FPCS and FBVS loads) and associated LHSI users.
- One train supplies only the common 1.b (2.b) header (main common user group).
- One train supplies the common 1.b (2.b) header and associated LHIS users.

- One train supplies the common 1.a and 1.b (2.a and 2.b) headers.
- One train supplies the common 1.a and 1.b (2.a and 2.b) headers and its LHSI users without the maximum flow rate through the CVCS and FPCS HXs.

For pump protection, the following configurations for an operating train are not permitted:

- One train cannot be isolated from the common headers and also from the LHSI/ RHR HX.
- One train cannot supply only the common 1.a (2.a) header.
- One train cannot supply the common 1.a and 1.b (2.a and 2.b) header and its LHSI users with the maximum flow rate through the CVCS and FPCS HXs.

Forbidden configurations lead to operations with abnormal flow rate and are subject to automatic system protection.

CCWS leakage (e.g., valve packing and pump seals) is compensated for by a makeup of demineralized water to the CCWS surge tanks. This makeup is controlled by the automatic opening and closing of the DWDS supply isolation valve. This isolation valve is a motor-operated safety-related valve that is part of the CCWS.

Depending upon the ESWS temperature, the CCWS temperature could be too low. The HX bypass control valve is positioned in order to maintain a CCWS HX outlet temperature greater than the minimum allowable.

Hot Shutdown

After the reactor is shut down, the RCS is cooled by the steam generators down to a temperature of 250°F. During the beginning of this state, CCWS has the same configuration as in power operation. At the end of this state, four CCWS trains will be in operation.

Two CCWS trains are in operation, aligned and ready to remove residual heat from the RCS via the associated LHSI trains as soon as they are placed in RHR operation.

The remaining two CCWS trains continue to cool the two common headers, and are ready to provide their SIS functions if necessary.

Cool Down Procedure

Cooling by Two CCWS trains—RCS Temperature < 250°F

Two LHSI trains are operating in the residual heat removal (RHR) mode and are removing residual heat from the RCS to the heat sink. The associated CCWS trains cool the LHSI/RHR HXs. The other two trains cool the common 1 header (trains 1 or 2) and common 2 header (trains 3 or 4).

This configuration is the same as for Hot Shutdown.

During the plant cooldown and before depressurization of the RCS, it is necessary to purify the RCS fluid. The two CVCS charging pumps are running and the two CVCS HP coolers are supplied by the CCWS.

Cooling by Four CCWS trains—RCS Temperature <212°F

The two CCWS trains cooling the common headers are connected to their corresponding LHSI/RHR trains. Within these two trains, heat to be removed from the LHSI/RHR HX is controlled by throttling the LHSI/RHR HX bypass to limit the CCWS HX outlet temperature to the maximum allowable.

The FPCS HX is cooled by either the common 1 or 2 header. Flow through the second FPCS HX could be secured to increase the efficiency in that connected CCWS train.

Configurations discussed above consider the availability of the four CCWS/LHSI trains. When only three trains are used for the RHR operation, a delay in the cooldown process will occur, depending on the ESWS temperature.

Refueling

At the beginning of the core unloading process, the CCWS is supporting core cooling for the fuel in the reactor vessel and cooling the FPCS also, at the minimum flow. At the end of the core unloading process, the CCWS is only supporting the cooling of the spent fuel pool (SFP) with cooling provided to both FPCS HXs at the maximum rate. Cooling of the common headers is maintained during core unloading.

CCWS is not analyzed to simultaneously cool a LHSI HX, the Common 1.b (2.b) header, and the Common 1.a (2.a) header with maximum cooling to the FPCS HX.

It is expected that both FPCS HXs are in operation, with the first FPCS HX cooled by a CCWS train at the maximum required flow and the second FPCS HX cooled at the minimum flow. The CCWS train supplying cooling to the FPCS HX at the maximum rate must not also be connected to common 1.b (2.b) header.

During the core unloading process, the CCWS flow rate through the second FPCS HX can be increased from the control room by opening the motor-operated flow control valve on the outlet of the FPCS HX. The CCWS flow rate through the FPCS HXs depends on the ESWS temperatures and actual decay heat load.

As the fuel is transferred from the RCS to the SFP, the required cooling to the RHR system decreases and the required cooling to the FPCS increases. To maintain the

CCWS pump within its normal operating range, the cooling to the LHSI HX must be isolated for the CCWS train also connected to the second FPCS HX, prior to increasing flow from the minimum value. Another possibility is to transfer the cooling of the second FPCS HX to a train not also cooling the common 1.b (2.b) header.

Core Unloaded

When the core is completely unloaded into the SFP, the two CCWS trains not supplying the common 1.a and 2.a headers cool both FPCS HXs at the maximum flow rate, and other required common 1.b or 2.b users for this mode. Two CCWS trains can be out for maintenance if they do not supply the same common header (1 or 2 and 3 or 4).

Abnormal System Operation

Large Loss of Water

<u>CCWS Safety-Related Trains</u>

A large water loss occurring in a CCWS train leads to a significant loss of system fluid and consequently to a drop of the CCW level in the corresponding surge tank.

The following leakage detection sequence is initiated when the surge tank level is less than the MIN2 setpoint:

1. The non-safety-related piping, located in the NAB and RWB, is isolated by fast-closing valves if there is a difference between the measured flow rate at the inlet and outlet of each branch. This is an indication of a leak, localized on the branch.

2. If the surge tank level drops below the MIN3 setpoint, the leak may be located in safety-related piping on the common header. The common headers are then isolated by closing of the switchover valves of the faulted train. The goal of this actuation is to provide availability of the train for its SIS users.

3. If the surge tank level continues to decrease below the MIN4 setpoint after the switchover valves are closed, the leak is located on the corresponding train. After reaching level MIN4, the associated CCWS train pump is tripped.

<u>Dedicated Trains</u>

In case of a pipe break, the dedicated CCWS surge tank pressure will decrease and the makeup pump will automatically start to maintain the pressure. If the water leak is greater than the capacity of the makeup pump to replace, a low level is reached in the tank, at which point the tank is automatically isolated to prevent nitrogen injection into the pump suction piping. The train pumps are correspondingly tripped and the train is unavailable.

Loss of one ESWS Train

CCWS Safety-Related Trains

In case of loss of one ESWS or CCWS train, an automatic switchover is performed to allow the cooling of the common headers using the available train. In case of a loss of an ESWS train, the corresponding CCWS train can be kept in operation supplying its safety users (SIS users) so long as the CCWS operating temperature is lower than 100.4°F, the maximum operating temperature for safety users.

Dedicated Train

The dedicated CCWS train is cooled by the dedicated ESWS train. In case of a loss of the dedicated ESWS train, the associated dedicated CCWS train is also lost.

Loss of a CCWS train

CCWS Safety-Related Trains

In case of loss of one CCWS train, a switchover is done to allow the cooling of the common a or b headers (or both) with the available train.

Dedicated Train

In case of a loss of the dedicated CCWS train, the entire SAHRS cooling chain is lost.

Active Failure

CCWS Safety-Related Trains

In case of loss of a CCWS pump, a switchover is done to allow for cooling of the common a or b headers (or both) with the available train.

Dedicated Train

In the event of the loss of the dedicated CCWS pump, the train is lost. If the makeup pump is lost, water makeup from the DWDS is also lost. With a water leak within the dedicated CCWS train, a low level will eventually be reached in the tank and the tank will be automatically isolated. The main dedicated CCWS pump is then tripped, leaving the train unavailable.

CCWS Protection Against RCS Dilution

Tube Rupture Inside RHR Heat Exchanger

When the LHSI is not operating in the RHR mode, an HX failure causes a leak from the CCWS to the SIS. The following protections have been designed to avoid RCS dilution:

- When a LHSI pump is not in operation, the isolation valve upstream and a check valve downstream of the RHRS HX prevents any leakage from the CCWS to the RHRS. When the isolation of the LHSI HX is not possible, flow being used for pump protection, an alarm informs the operator of the potential risk. The operator can sample directly the content of the water boxes of the HX via a dedicated sampling line.
- Before connecting an LHSI train for the first time to the RCS in the RHR mode, the relevant LHSI pump is started on its minimum flow line through the in-containment refuelling water storage tank. This second line of defense permits detection of the failed HX.
- When a LHSI pump is started on its minimum flow line or on the closed loop, a faulty HX causes leakage into the CCWS. This leakage is detected by the train radiation monitor or an uncontrolled level rise in the CCWS surge tank.
- Provisions are required to minimize the risk of CCWS leakage during maintenance on the LHSI trains. The component boundary can be verified via a pressure test on the CCWS side or a pressure test of the RHR/LHSI.

Failure of a LHSI Pump Seal Fluid Cooler

When a LHSI pump is not in operation, the isolation valve upstream and a check valve downstream of the seal cooler prevent any leakage from the CCWS to the RHRS.

Tube Rupture Inside Thermal Barrier

The possibility of diluting the RCS via a faulty RCP thermal barrier exists only when the RCS is in a low pressure state.

After a predetermined time delay (≈15 minutes), which allows for RCP coast down and when the RCS pressure is low, the CCWS will be automatically isolated from the RCP thermal barrier via the CCW inlet and outlet isolation valves.

Tube Rupture Inside a CVCS HP Cooler

A leak from the CVCS into the CCWS will be detected by radiation monitors on the CCWS return lines from each of the CVCS HP coolers. A high radiation alarm from either of these monitors will trigger automatic isolation of the affected CVCS HP cooler via motor-operated valves in the CVCS.

RCS Cooldown with Less Than 3 Trains

If less than three trains of the plant cooling chain (RHR, CCW, ESW) are available, stabilization of the RCS temperature is achievable. If the RCS must be cooled to cold shutdown conditions, it may be necessary to remove non-essential CCWS user loads from operation.
This may be necessary only during peak summer conditions, and an excessive

throttling (bypassing) of the LHSI HX to limit the CCWS temperatures late in the cooldown process is an indication of the need to do so.

Accident Operating Conditions

Safeguard Building LOCA or LOCA Coupled With Unavailability of Two CCWS/SIS Trains

This accident condition postulates the unavailability of one CCWS train due to a single failure with another train in maintenance. Upon receipt of a safety injection and containment isolation stage 1 actuation, the reactor protection system (RPS) starts the CCWS trains not in operation by:

- Opening the LHSI/RHR isolation valves of the train not initially in operation.
- Isolation of the non-safety-related common users outside the RB.
- Isolation of the containment ventilation and RCDT loads inside the RB (containment isolation stage 1).
- Starting of the CCWS pumps not initially in operation.

Upon actuation of a containment isolation stage 2 signal issued from the RPS, the RCP and CVCS loads inside the RB are isolated (not including the RCP thermal barriers).

Loss of Offsite Power

CCWS Safety-Related Trains

In case of LOOP, the four CCWS trains are still available for operation. The four CCWS pumps belonging to the four trains receive emergency power supplied by the main emergency diesel generators (EDG). Previously operating CCWS trains return to operation according to the EDG load sequencing and standby trains remain in idle unless other start orders are received during the EDG load sequencing.

Beyond Design Basis Events (Dedicated CCWS)

CCWS Safety-Related Trains

The CCWS trains are kept in operation unless they are unavailable due to a failure. If they are unavailable (e.g., a severe accident), the dedicated CCWS train can be used. When the CCWS trains are unavailable during SBO, RCP seal cooling is not available. To mitigate leakage from RCP seal failure during this event, the RCPs are supplied with a standstill seal, an alternative to seal cooling, which limits seal leakage to 0.5 gpm.

<u>Dedicated Train</u>

The dedicated CCWS train provides for removal of the heat from the SAHRS during accidents with the potential to result in core melt. It is also actuated in case of beyond design basis scenarios such as failure of the LHSI during small break loss of coolant accident (SBLOCA) and loss of LHSI or MHSI.

9.2.2.4 Safety Evaluation

The CCWS safety-related components and piping are installed in a physically hardened building (divisions 2 and 3) and separate buildings (divisions 1 and 4) 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(B), and Section 3.8 provide the bases for the adequacy of the structural design of these structures.

The CCWS is designed to remain functional after an SSE. Section 3.7(B).2 and Section 3.9(B) provide the design loading conditions that were considered. Section 3.5 and Section 3.6 provide the hazards analyses to verify safe shutdown, as outlined in Section 7.4, can be achieved and maintained.

Because only a single division of the CCWS is lost in the event of the postulated hazards of internal missiles, pipe whipping, and discharging fluids, the system safety-related functions are not prevented.

The four division design of the CCWS provides complete redundancy; therefore, no single failure will compromise the CCWS system safety-related functions. Each division of the CCWS is independent of any other division. The common 1 and common 2 non-safety-related users can be isolated from the safety-related portion of the CCWS by automatic isolation valves without compromising the safety-related function of the system.

The CCWS is powered from emergency powered distribution busses. Each electrical division is functionally independent and physically separated so that a single failure in one division will not affect another division. In case of a LOOP, each safety-related division is powered by a separate EDG.

The four safety-related divisions of the CCWS are not shared with other units. An accident in one unit will not impair the ability of the CCWS in another unit from conducting an orderly shutdown and cooldown of the remaining units.

Considering a single failure and preventative maintenance, one CCWS division may be out of service for maintenance and a second division lost to a single failure, but the ability to reach a safe shutdown state can be achieved by the remaining two CCWS divisions coincident with LOOP.

The CCWS is initially tested following the program given in Chapter 14. Periodic inservice functional testing is done in accordance with Section 9.2.2.5.

In the event of an LOCA during power operations, the RPS (refer to Section 7.3) initiates a safety injection and containment isolation phase 1 signal. The CCWS divisions previously not in operation are automatically started by the process. Containment isolation is detailed in Section 6.2.4.

Remote manual isolation of the RCP thermal barrier coolers is provided to isolate the thermal barrier in the event of a leak in the HX.

9.2.2.5 Inspection and Testing Requirements

Preliminary operational testing of the CCWS is conducted with the system cold and aligned for normal power. An accident signal is initiated, and the breakers on the lines supplying offsite power are tripped so that operation of the EDGs is tested in conjunction with the CCWS. System testing provides the following verifications of system performance:

- Satisfactory generation and transmission of the accident signal.
- Proper operation of the EDGs, including sequential load pickup.
- Within specification valve operating times.
- Within specification pump starting times.
- Within specification pump delivery rates.

Refer to Section 14.2, Test # 046, for initial plant testing of the CCWS.

The installation and design of the CCWS provides accessibility for the performance of periodic testing and inservice inspection with limited personnel exposure. Periodic testing of all safety-related equipment verifies its availability and ability to fulfill its functions. Inservice testing and inspection requirements are in accordance with the ASME BPV Code, Section XI (Reference 5).

Section 3.9 and Section 6.6 outline the inservice testing and inspections. Refer to technical specifications in Chapter 16 (SR 3.7.7) for surveillance requirements that provide for the continued operability of the CCWS.

9.2.2.6 Instrumentation Requirements

The CCWS trains are monitored and controlled from the main control room (MCR) through the process information and control system (PICS), which provides the normal indication, manual control, alarm functions, and the safety information and control system (SICS). These systems process and display information provided through the safety automation system (SAS) from the protection system (PS), which actuates the CCWS function as required by plant process safety parameters, and the process automation system (PAS), which monitors less critical process information.

Upon receipt of a safety injection signal, automatically initiated by the PS, the four CCWS trains start supplying all MHSI pump motor coolers and LHSI pump and motor coolers (except the train 1 and 4 LHSI pumps and motor coolers, which are cooled by SCWS), and the four LHSI HXs. The non-safety-related users outside of the RB are isolated. The progression of this sequence is:

1. The CCWS pumps start.
2. The LHSI HX isolation valves open.
3. The trains 2 and 3 LHSI pump seal cooler isolation valves open.
4. The isolation valves for non-safety-related users outside the RB are closed

This sequence optimizes the CCWS to cool the SIS pumps and the LHSI HXs. The simultaneous operation of the LHSI HX isolation valves (opening) and of the non-safety-related isolation valves (closing) maintains the pump operation in a safe range. There is no automatic order from the protection system to configure HX bypass control valves.

Upon receipt of a containment isolation stage 1 signal, automatically initiated by the PS, the containment HVAC and RCDT users in the RB are isolated. This achieves containment isolation and maximizes the CCW flow rate through the LHSI HX in the event of a coincident safety injection signal.

Upon receipt of a containment isolation stage 2 signal, automatically initiated by the PS, the RCP and CVCS loads inside the RB (except the RCP thermal barriers) isolate.

9.2.2.6.1 Control Features and Interlocks

The following control features and interlocks provide CCW, interfacing, and ancillary systems and equipment protection during normal operation:

- Each pump is interlocked with its associated LHSI/RHR HX supply valve so that when the pump is stopped the supply valve closes, following a delay to allow for pump coast down. This action prevents potential leakage of the CCW into the SIS train.
- In the event of a pump low-flow condition, the associated LHSI HX isolation valve opens automatically to provide a minimum flow path for CCWS pump protection. In the event of a pump high-flow condition, the FPCS HX outlet flow control valve is closed to its minimum opening mechanical stop position to reduce the CCWS flow rate and to maintain normal pump operation.

- The CCWS surge tanks are instrumented with level indication and graduated level control and equipment protection setpoints designated from lowest to highest level (MIN4, MIN3, MIN2, MIN1, MAX1, MAX2, MAX3, and MAX4). A CCWS train can operate continuously so long as the water level in its surge tank is maintained between MIN1 and MAX1.

- Small CCWS leakage is made up with demineralized water via operation of the DWDS supply isolation valve. When the surge tank water level falls to the MIN1 level, the DWDS supply isolation valve automatically opens. When the surge tank water level rises to MAX1, the DWDS supply isolation valve automatically closes.

- In the event of a more significant leak which causes the surge tank level to fall to MIN2, switchover of the common users to another train is inhibited to avoid transferring the leak. The non-safety-related branches isolate in the event of a flow mismatch between the inlet and outlet of the users supply and return lines. If the surge tank level continues to fall to MIN3, the switchover valves close to isolate the common headers and switchover of the header to another train is prohibited. This action maintains the availability of the train with the faulty piping for cooling of its MHSI and LHSI users. If the surge tank level subsequently falls to MIN4, the CCWS pump is tripped, the DWDS supply isolation valve closes to prevent feeding demineralized water through the leak, the switchover is inhibited in order to lock the system in its configuration, and an alarm is relayed to the operator in the MCR.

- In the event of failure or significant leakage of a switchover valve seat, a water transfer can occur from the pressure differential between two associated CCWS trains. If the water transfer leads to a MAX2 level signal on one of the two associated trains and MIN3 on the other, the common users are automatically isolated from the safety-related trains to conserve the safety-related function of both trains.

- Additional leakage detection is provided through segmented differential flow measurements and radiation detection. A high flow indication above a threshold value indicates a fault of a thermal barrier, which initiates automatic isolation of CCWS flow from the thermal barrier HX. Detection of increasing radiation in the CCW from the CVCS HP coolers indicates leakage and prompts the isolation of both fluids (CCWS and CVCS). Leakage of reactor coolant into the CCWS from such users as the LHSI HXs is also indicated by increasing radiation in the CCW and prompts isolation of the user. Only the thermal barrier and HP cooler leaks result in an automatic isolation of the failed user. The other leaks trigger MCR alarms and require operator action for isolation.

- To limit the loss of flow to users in either of the common .b subheaders (1.b or 2.b) occurring as a result of loss of a CCWS pump, loss of an ESWS train, or inadequate cooling flow to the affected users due to inadvertent closure of a CCWS valve or failure of a manual switchover sequence, an automatic partial switchover of the affected loop occurs. Either of these conditions will generate a signal to close the affected train switchover valves and open its LHSI HX isolation valve, and open the oncoming train common .b subheader switchover valve and start its CCWS pump. The oncoming train common .a subheader switchover valve may then be opened, and the HX bypass valve positioned, manually. Automatic switchover of the common .a subheader is not necessary since the inertia of the SFP allows adequate time for manual actuation. These actions provide adequate continued cooling flow to the affected common .b subheader users in the event of failure of a train supplying either of the common .b sub-headers (1.b or 2.b), or either of the common 1 or 2 headers (1.a and 1.b, or 2.a and 2.b).

- The CCWS switchover valves are interlocked to provide train separation of the redundant CCWS Divisions and to make sure that a fault affects no more than one train. The switchover valve connected to the initial safety-related CCWS train must close before the switchover valve from the opposite train begins to open in order to maintain train separation. If the switchover valves on the initial train fail to close or the switchover valves on the oncoming train fail to open, which may occur if the oncoming train switchover sequence is inhibited due to low surge tank level, the alignment is automatically switched back to its initial configuration. Refer to Section 7.6.1.2.3 for a more detailed description.

- Normally, the CCWS HX bypass control valve is manually positioned to maintain a normal CCWS outlet temperature slightly greater than the minimum allowable. An alarm in the MCR alerts the operator if the outlet temperature approaches the low temperature limit (decreasing temperature). If the outlet temperature continues to decrease, the CCWS HX bypass control valve automatically throttles open to maintain a CCWS user minimum cooling water inlet temperature greater than the minimum allowable. During warmer operating periods, the HX bypass control valve normally remains closed. In the event of a CCWS HX high outlet temperature condition combined with a bypass valve open signal, which indicates the bypass valve has failed open, the bypass valve automatically closes.

- The non-safety-related dedicated CCWS train is monitored and manually controlled from the PICS or SICS. Indications available from the PICS and SICS include dedicated CCWS main loop flow rate and pressure; dedicated CCWS HX inlet and outlet temperature; dedicated CCWS surge tank pressure, temperature and water level and position indication for critical valves.

- The dedicated CCWS main pump is started manually from the PICS or SICS. The dedicated CCWS main pump trips in the event of surge tank low level, associated dedicated ESWS pump not running or high temperature of the dedicated CCWS pump or pump motor. Manual override of the dedicated CCWS pump protective trips, to preserve cooling for the SAHRS pump, is also available at the PICS and SICS. The PICS and SICS also include controls for the dedicated CCWS surge tanks nitrogen injection and outlet isolation valves.

- Dedicated CCWS surge tank level is maintained automatically. When the surge tank level falls to the low level makeup setpoint (decreasing), the dedicated CCWS makeup valve opens and the dedicated CCWS injection pump starts. The makeup valve closes and the injection pump stops when the surge tank level reaches the high level setpoint (increasing). If the surge tank level falls to the low level isolation setpoint, the surge tank outlet isolation valve closes.

  – The injection pump trips in the event of:

- Low suction pressure.
- Injection pump safety valve opening.
- Dedicated CCWS suction piping safety valve opening.
- Dedicated CCWS makeup valve closure
- Dedicated CCWS surge tank isolation valve closure.

- The pressurized nitrogen bubble in the dedicated CCWS surge tank is maintained manually from the PICS or SICS. The surge tank is protected against over pressurization by a safety valve connected to the gas space, which automatically opens if the surge tank outlet isolation valve closes or if the dedicated CCWS suction piping safety valve fails to open upon reaching its trip setpoint. The surge tank outlet isolation valve is usually open but may be closed in the event of a large pipe break to prevent the injection of the pressurizing nitrogen into the dedicated CCWS piping.

9.2.2.7 References

1. ASME Boiler and Pressure Vessel Code, Section III: "Rules for Construction of Nuclear Facility Components," Class 2 and 3 Components, The American Society of Mechanical Engineers, 2004.

2. ANSI/ASME B31.1-2004, "Power Piping," The American Society of Mechanical Engineers, 2004.

3. ASME Boiler and Pressure Vessel Code, Section VIII: "Rules for Construction of Pressure Vessels," The American Society of Mechanical Engineers, 2004.

4. IEEE Std 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 1991.

5. ASME Boiler and Pressure Vessel Code, Section XI: "Rules for Inservice Inspection of Nuclear Power Plant Components," The American Society of Mechanical Engineers, 2004.

6. NUREG-0927, Serkiz, A.W., Technical Report, "Evaluation of Water-Hammer Experience in Nuclear Power Plants," U.S. Nuclear Regulatory Commission, May 1983.

Table 9.2.2-1—CCWS Design Parameters

Description	Technical Data
Component Cooling Water Pump (KAA10/20/30/40 AP001	
Number	4
Type	Centrifugal Pump
Flow rate max.	17,768 gpm
Pump head min (at max flow rate)	199.7 ft
Dedicated Component Cooling Water Pump (KAA80 AP001)	
Number	1
Type	Centrifugal Pump
Flow Rate	2678 gpm
Pump Head	180 ft
Component Cooling Water Surge Tank KAA10/20/30/40 BB001)	
Number	4
Volume	950 ft^3
Dedicated Component Cooling Water Surge Tank (KAA80 BB001)	
Number	1
Volume	75 ft^3
Component Cooling Water HX (KAA10/20/30/40 AC001)	
Number	4
Heat Load (DBA)	291.3×10^6 Btu/hr

Table 9.2.2-2—CCWS User Flow Requirements

Component	KKS	Required Flow (10^6 lb/hr)
FPCS Heat Exchanger	30FAK10/20 AC001	0.8818
RCP Thermal Barrier	N/A	0.0198
LHSI Heat Exchanger	30JNG10/20/30/40 AC001	2.1906
SCWS Chiller	30QKA20/30 AC002	0.3730

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