

9.2.8 Safety Chilled Water System

The safety chilled water system (SCWS) supplies refrigerated chilled water to the safety-related heating, ventilation and air conditioning (HVAC) systems and the low head safety injection system (LHSI) pumps and motors in Safeguard Buildings (SB) 1 and 4. The SCWS consists of four separate and independent divisions, numbered 1 to 4.

9.2.8.1 Design Bases

The SCWS provides chilled water as a heat sink to the safety-related HVAC systems, which in turn provides an acceptable environment for safety-related equipment and main control room (MCR) habitability in the event of a design basis accident (DBA) (GDC 44). The SCWS is classified as a safety-related system and has safety-related design functions. The system is designed Seismic Category I. Safety-related systems are required to function following a DBA and are required to achieve and maintain a safe shutdown condition.

- Each SCWS division is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, and floods (GDC 2).
- Each division remains functional and performs its intended functions for all postulated environmental conditions or dynamic effects, such as pipe breaks (GDC 4).
- Safety functions are performed assuming a single active component failure coincident with the loss of offsite power (GDC 44).
- The SCWS is not shared with any other plant unit (GDC 5).
- Active components of the SCWS divisions are capable of being periodically tested and required inspections can be performed during plant operation (GDC 45 and GDC 46).

The SCWS divisions use design and fabrication codes consistent with the safety classification and seismic design criteria provided in Section 3.2. The quality group classification meets the requirements of RG 1.26. The seismic design of the system components meets the guidance of RG 1.29. The power and control functions are designed in accordance with RG 1.32.

The SCWS operates continuously as described for the safety-related function when the plant is in normal conditions of startup, shutdown, power operation, and outages.

9.2.8.2 System Description

9.2.8.2.1 General Description

The SCWS consists of four separate, physically separated independent divisions, numbered 1 to 4. Each is located in one of the four SBs. Each SCWS division is a closed loop system that supplies chilled cooling water for specified area HVAC air handling units (AHU) and, where required, process systems cooling. Each division consists of a refrigeration chiller unit, two pumps, expansion tank, user loads, and the associated piping and controls.

The SCWS provides chilled water to the HVAC cooling coils of the main control room (MCR), the electrical division rooms (SBVSE) in the SBs, SB controlled-area ventilation system (SBVS), Fuel Building (FB) ventilation system (FBVS), and the low head safety injection system (LHSI) pump motors in SB Divisions 1 and 4.

System design parameters are listed on Table 9.2.8-1—Safety Chill Water Design Parameters. The SCWS flow diagram is shown in Figure 9.2.8-1—Safety Chilled Water System.

9.2.8.2.2 Component Description

The general description of the component design features for the SCWS is provided below. Refer to Section 3.2 for details of the seismic and system quality group classification of the SCWS.

Chilled Water Pumps

Two 100 percent SCWS pumps, with one in standby, in each of the four divisions circulates chilled water between the HVAC users and the evaporator of the chiller refrigeration unit in each division.

Air-Cooled Chiller Refrigeration Unit

SCWS, Divisions 1 and 4, each contain one 100 percent air-cooled chiller refrigeration unit that functions to refrigerate chilled water to its design basis temperature of 41°F for supply to the HVAC users. These chillers are located in dedicated rooms of the SBs. Each chiller contains a condenser, compressor, evaporator, and associated piping and controls. Environmentally safe refrigerants are used in these chillers.

Water-Cooled Chiller Refrigeration Unit

SCWS, Divisions 2 and 3, each contain one 100 percent water-cooled chiller refrigeration unit that functions to refrigerate chilled water to its design bases temperature of 41°F for supply to the HVAC users. These chillers are located in dedicated rooms of the SBs. Each chiller contains a condenser, compressor,

evaporator, and associated piping and controls. Environmentally safe refrigerants are used in these chillers.

Diaphragm Expansion Tank

Each SCWS division contains a diaphragm expansion tank with a nitrogen fill connection in each of the SBs. These tanks are provided with overpressure protection.

Cooling Coils

Multiple HVAC cooling coils in each division receive chilled water for heat removal from selected HVAC users.

Safety Valves

A safety valve located in each SCWS division protects the chilled water closed loop against high pressure.

Chiller Bypass Valve

The chiller bypass valve installed in the closed loop of each SWCS division varies flow returning to the chiller to prevent freezing at the evaporator coil.

9.2.8.3 System Operation

9.2.8.3.1 Normal Operation

All four SCWS divisions supply chilled water to plant components when the plant is in power operation under normal conditions. Each of the four SBs is supplied by one of four divisions of the SCWS. Each SCWS division is designed with a closed single pumping loop and one refrigeration unit for chilled water production. Chilled water production and chilled water distribution are grouped together to form a single closed system.

Each of the four divisions has one SCWS pump in service and one in standby, to circulate the chilled water in a closed loop between the HVAC users and the evaporator of the refrigeration unit. The chilled water distribution circuit operates with a variable flow rate that is governed by the position of the control valves associated with supplied user loads. A regulated chilled water bypass line is provided between the refrigeration–evaporator outlet line and the return line to prevent freezing. A diaphragm expansion tank is used for equalization of pressure and volumetric expansion and helps maintain the requisite static system pressure. A safety valve on the connecting line prevents the line design pressure from being exceeded.

A manually operated make up demineralized water supply is used when water loss resulting from operational measures (e.g., venting and draining) is indicated by an expansion tank pressure instrument.

The SCWS is treated with hydrazine in low concentration for corrosion control. Monitoring of the water chemistry is provided by means of local sampling at the central chilled water station.

9.2.8.3.2 Abnormal Operation

In the event of a DBA, with one SCWS safety-related train down for maintenance, and in case of failure of a second SCWS safety-related train (e.g., refrigeration units or pumps), the back up is provided by the two remaining SCWS 100 percent trains of the corresponding divisions.

The SCWS is powered from the emergency diesel generators (EDG) and continues to function during a DBA. Divisions 1 and 4 of the SCWS provide a heat sink to Division 1 and 4 HVAC systems in the event of a severe accident or station blackout (SBO). Divisions 1 and 4 are powered from motor control centers that are re-powered by the station blackout diesels during an SBO event.

9.2.8.4 Safety Evaluation

- The SCWS is designed as Seismic Category I as described in Section 3.2 to operate in all plant modes of operation including design basis events. The SCWS divisions are located in SBs 1 to 4, respectively. The SBs are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other natural phenomena. Section 3.3, Section 3.4, Section 3.5, Section 3.7(B), and Section 3.8 provide the bases for the adequacy of the structural design of these buildings.
- The SCWS is designed to remain functional after a safe shutdown earthquake. Section 3.7(B).2 and Section 3.9(B) provide the design loading conditions that were considered. Section 3.5, Section 3.6, and Section 9.5.1 provide the hazards analyses to make sure that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.
- A four train design of the SCWS fulfills the single failure criteria. Redundant safety systems (one per SB) are strictly separated within the SBs into four divisions. This divisional separation is provided for electrical and mechanical safety systems. The four divisions of safety-related systems are consistent with an N+2 safety concept. The four SCWS trains are backed up by the EDGs. Two of these trains, in Divisions 1 and 4, are also backed up by the SBO diesels.
- Structures, systems and components important to safety in the SCWS are not shared with any other co-located nuclear reactor units.

- Preoperational testing of the SCWS is performed as described in Chapter 14.0. Periodic inservice functional testing is done in accordance with Section 9.2.8.5.
- Section 6.6 provides the ASME Boiler and Pressure Vessel (BPV) Code, Section XI (Reference 1) requirements that are appropriate for the SCWS.
- Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system. Table 9.5.4-1 shows that the components meet the design and fabrication codes given in Section 3.2. All the power supplies and control functions necessary for safe function of the SCWS are Class IE, as described in Chapter 7 and Chapter 8.
- Cooling diversity is created between the load heat sinks of Divisions 1 and 4, and Divisions 2 and 3. Division 1 and 4 chillers are air cooled, and Division 2 and 3 chillers are water cooled by the component cooling water system (CCWS).

9.2.8.5 Inspection and Testing Requirements

Prior to initial plant startup, a comprehensive performance test will be performed to verify that the design performance of the system and individual components is attained. Refer to Section 14.2, Test #052, for initial plant testing of the SCWS.

After the plant is brought into operation, periodic tests and inspections of the SCWS components and subsystems are performed to verify proper operation. Scheduled tests and inspections are necessary to verify system operability.

9.2.8.6 Instrumentation Requirements

The SCWS system is controlled by the safety automation system (SAS). The normal indication, manual control, and alarm functions are provided by the process information and control system (PICS).

System pressure is monitored with the aid of two pressure measurements. The two measurements are combined in one measuring point. If the pressure falls below a set limit, an alarm is issued for operators to check nitrogen charge or provide makeup with demineralized water.

If the pressure falls below a second set limit, one of the following measures is initiated automatically:

- Chilled water system “Protection OFF” alarms.
- Refrigeration unit shuts down.
- Chilled water circulating pump shuts down.

A humidity sensor is installed in the nitrogen region of the diaphragm expansion tank. This sensor issues an alarm indicating a leaky diaphragm if humidity exceeds a set limit.

To provide a constant water flow through the evaporator for the refrigeration unit, a controlled bypass is implemented between chilled water feed and chilled water return by means of a control valve. The controlled variable is differential pressure across the chiller evaporator.

The chilled water system is deactivated by a “Protection OFF” command in the case of the following faults:

- Pump failure.
- High differential pressure.
- Minimum pressure limit for the system.
- Emergency power condition–under-voltage shutdown.

9.2.8.7

References

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

Table 9.2.8-1—Safety Chill Water Design Parameters

Description	Technical Data
QKA 10/40 Evaporator Refrigeration capacity	3.3034 E+06 Btu/hr (275 Tons)
QTA 10/40 Condensing capacity	4.4046 E+06 Btu/hr
QKA 10/40 Condenser Air Flow	167047 ft ³ /min
QKA 10/40 Required Evaporator Chilled Water Flow	736 gpm
QKA 10/40 Required Evaporator Chilled Water Outlet Temperature	41°F
QKA 10/40 Chilled Water Pump AP-107 Required Operating Flow	825 gpm
QKA 10/40 Chilled Water Pump AP-107 Required Operating Head	269 ft
QKA 10/40 Chilled Water Pump AP-107 Shutoff Head	338 ft
QKA 20/30 Evaporator Refrigeration capacity	2.9951 E+06 Btu/hr (250 Tons)
QKA 20/30 Condensing capacity	4.1227 E+06 Btu/hr (344 Tons)
QKA 20/30 Required Evaporator Chilled Water Flow	665 gpm
QKA 20/30 Required Evaporator Chilled Water Outlet Temperature	41°F
QKA 20/30 Chilled Water Pump AP-107 Required Operating Flow	745 gpm
QKA 20/30 Chilled Water Pump AP-107 Required Operating Head	270 ft
QKA 20/30 Chilled Water Pump AP-107 Shutoff Head	309 ft