9.5.5 Diesel Generator Cooling Water System

The diesel generator cooling water system (DGCWS) provides the necessary cooling for the engine and turbocharger for the EDGs. The DGCWS system dissipates heat from the crankcase, cylinder heads, turbochargers, governor oil, generator bearings, combustion charge air, and lubricating oil resulting in reduced engine operating temperatures. Preheating bypass circuits are provided to establish quick starting times and short load acceptance times to minimize cold start wear. The system is composed of coolant preheater, preheating circulation pump, temperature regulating valves, cooling water pumps, heat exchangers, and an expansion tank. Each EDG has a separate, independent DGCWS, as shown in Figure 9.5.5-1—Emergency Diesel Generator Cooling Water System.

9.5.5.1 Design Basis

The safety-related portion of the DGCWS is required to function following a design basis accident (DBA) and to achieve and maintain the plant in a safe shutdown condition.

- The DGCWS is protected from the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC 2).
- The safety-related portion of the DGCWS remains functional after an SSE and performs its intended function following the postulated hazards of fire, internal missiles, or pipe break (GDC 3 and 4).
- The DGCWS components designated as safety related are not shared by the individual EDGs (GDC 5).
- Safety functions can be performed, assuming a single active component failure coincident with the LOOP (GDC 17).
- The active components are capable of being tested during plant operation. Provisions are made to allow for inservice inspection of components (GDC 45 and 46).
- The safety-related portion of DGCWS is designed and fabricated to codes consistent with the quality group classification assigned by RG 1.26 and the seismic category assigned by RG 1.29. The power supply and control functions are in accordance with RG 1.32.
- The capability to isolate components, systems, or piping is provided, when required, so that the system safety function is not compromised. This includes the isolation of components to deal with leakage or malfunctions and the isolation of non-safety-related portions of the system (GDC 44).
- The DGCWS safety-related primary design function is to provide the necessary cooling to dissipate heat from the diesel engine coolant and lubricating oil to

maintain temperatures within normal operating limits during emergency operation. The engine cooling system relies on the essential service water system (ESWS) for its heat sink.

- The DGCWS non-safety related function is to maintain the engine coolant at a set temperature during standby to provide optimal condition and reduce stress on the mechanical portions of the engine during emergency starts.

9.5.5.2 System Description

9.5.5.2.1 General Description

The DGCWS is located in the EPGB of each division and consists of a coolant preheater, preheat circulation pump, temperature regulating valves, cooling water pumps, heat exchangers, and an expansion tank.

Each cooling system is subdivided into safety-related and non-safety-related portions. The non-safety-related portion is provided for preheating. The safety-related portion is equipped with heat exchangers cooled by the ESWS and is active during engine operation.

The system is comprised of two subsystems, jacket water cooling and intercooler cooling, which are connected to a common expansion tank. The expansion tank is located in the EPGB at an elevation higher than the rest of the DGCWS cooling system to make sure air is removed from the system by vents from various portions and components of the system. The tank allows for expansion of the coolant due to temperature variations experienced during system operation.

The materials of the cooling system components, the water quality, and the flow rate are coordinated to minimize corrosion or deposits. The engine coolant water chemistry is controlled using vendor recommended chemicals. Corrosion inhibitor, biocide, and antifreeze may be added to the cooling water to prevent internal corrosion and organic fouling of the cooling system.

The layout of the piping and main components (i.e., expansion tank, heat exchangers, pumps, and valves) provides the space required to permit routine inspections, cleaning, and maintenance.

9.5.5.2.2 Component Description

The major components of the DGCWS are described in the following paragraphs. Table 3.2.2-1 provides the seismic design and other design classifications for components in the DGCWS.

Jacket Water Coolant Preheater

The jacket water coolant preheater heats the coolant while the DGCWS system is in standby operation. The preheater is switched on and off as a function of the coolant temperature during standby operation. During DGCWS system startup, the preheater is switched off when the preheat circulation pump is switched off.

Jacket Water Preheat Circulation Pump

The jacket water preheat circulation pump is an electrically driven pump that supplies preheated coolant to the engine crankcase, cylinder heads, and turbochargers while the DGCWS system is in standby operation. The preheat circulation pump is switched off when the engine reaches a rotational speed where the engine-driven cooling water pump can take over.

Jacket Water Temperature Regulating Valve

The jacket water temperature regulating valve is a three-way temperature controlled valve that controls the coolant temperature by directing coolant to the jacket water heat exchanger, as required, to maintain coolant temperature at the desired operating level.

Jacket Water Cooling Water Pump

The jacket water cooling water pump is an engine-driven pump that supplies coolant to the engine crankcase, cylinder heads, turbochargers, and the jacket water heat exchanger while the DGCWS system is in normal operation.

Jacket Water Heat Exchanger

The jacket water heat exchanger has the capacity to cool the system to the required temperature for engine operation at 110 percent. The jacket water heat exchanger is cooled by the ESWS.

Intercooler Temperature Regulating Valve

The intercooler temperature regulating valve is a three-way temperature controlled valve that controls the coolant temperature by directing coolant to the intercooler heat exchanger as required to maintain coolant temperature at the desired operating level.

Intercooler Cooling Water Pump

The intercooler cooling water pump is an engine-driven pump that supplies coolant to the turbocharger charge air intercoolers, governor oil cooler, generator bearing cooler, and the intercooler heat exchanger while the DGCWS system is in normal operation.

Intercooler Water Heat Exchanger

The intercooler water heat exchanger has the capacity to cool the intercooler system to the required temperature for engine operation at 110 percent. The intercooler heat exchanger is cooled by the ESWS.

Cooling System Expansion Tank

The expansion tank compensates for differences in coolant volume due to thermal expansion. The tank is located at the highest point of the DGCWS cooling system, and the tank level is monitored and alarmed. The tank provides sufficient reserve capacity for operation of the EDG at continuous rating for at least seven days with normal anticipated minor water loss. The expansion tank is equipped with an auto fill connection from the demineralized water distribution system and a manual fill port.

9.5.5.3 System Operation

9.5.5.3.1 Normal Operation

The DGCWS supports the EDGs and is required when the EDGs are running. During normal engine operation, the coolant preheater and preheat circulation pump is off. The coolant is circulated at that time by the engine-driven jacket water cooling water pump. The jacket water temperature regulating valve controls flow of the coolant to the jacket water heat exchanger to maintain the desired coolant temperature. Heat is dissipated from the crankcase, cylinder heads, and turbochargers to maintain the engine temperatures within normal operating limits. Additionally, the engine-driven intercooler cooling water pump circulates water through the turbocharger intercooler heat exchangers, governor oil heat exchanger, and generator bearing oil heat exchanger. The intercooler temperature regulating valve controls the flow of the coolant to the intercooler heat exchanger, which cools combustion air before it enters the engine cylinders to improve the efficiency of the engine.

Operating procedures require loading of the engine up to a minimum of 50 percent of full load for 30 minutes after four hours of continuous no-load operation or light load (<30%) operation or as recommended by the manufacturer.

9.5.5.3.2 Abnormal Operation

Failure of the engine preheat system activates a temperature alarm to alert the operator so that corrective action can be taken. In this event, the engine may be started from the MCR to maintain it in a warm condition until the problem can be corrected.

During EDG operation, the equipment is monitored by local operators that routinely observe the equipment for abnormal operating conditions, including leaks. The system is also monitored for expansion tank level and system temperature alarms. The

system is equipped with isolation valves on all branch lines so that a leak in those lines is isolated without affecting the operability of the DGCWS. Normal makeup to the system is provided by the demineralized water distribution system. The expansion tank also has provisions for alternate fill. A leak in the DGCWS is made up from the system expansion tank. The leak results in a low level in the DGCWS expansion tank, which provides an expansion tank low level alarm and actuates the demineralized water system fill valve. In the event the demineralized water distribution system is unavailable or unable to maintain adequate makeup, the operator manually fills the system from an alternate source. If a leak is greater than that which can be maintained through normal or alternate fill provisions, the EDG is shut down by the operators or it will trip on very-high water temperature, once the water loss reduces the capability of the DGCWS to properly cool the engine. The very-high temperature trip shuts down the engine to prevent overheating and potentially catastrophic engine failure.

9.5.5.4 Safety Evaluation

- The cooling system is located in the EPGB and meets the same safety objectives as the diesel engine itself. The cooling water heat exchangers are installed in the EPGB and are structurally protected against environmental impacts.

- The EPGB is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other similar natural phenomena. Sections 3.3, 3.4, 3.5, 3.7(B), and 3.8 provide the bases for the adequacy of the structural design of the EPGBs.

- The safety-related portion of the DGCWS is designed to remain functional after an SSE. Sections 3.7(B).2 and 3.9B) provide the design loading conditions that were considered. There are no high- or moderate-pressure lines in the EPGB whose failure can affect the function of more than one DGCWS. Sections 3.5, 3.6, and 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.

- The DGCWS for each diesel engine is independent of any other diesel engine's DGCWS. This precludes the sharing of any safety-related systems and components that could prevent those systems or components from performing required safety functions.

- The four-division design of the DGCWS provides redundancy. No single failure will compromise the EDG safety functions. Vital power can be supplied from either onsite or offsite power systems, as described in Chapter 8. This meets the recommendation of NUREG/CR-0660 (Reference 1).

- The DGCWS is initially tested with the program described in Chapter 14. Periodic inservice functional testing is carried out in accordance with Section 9.5.5.5.

- The power supplies and control functions necessary for safe function of the DGCWS are Class IE, as described in Chapters 7 and 8.

9.5.5.5 Inspection and Testing Requirements

9.5.5.5.1 Normal Testing

Preoperational testing is described in Chapter 14 and Section 14.2, tests #104, 105, and 106.

The DGCWS is tested periodically along with the complete EDG system. This test demonstrates the performance, structural, and leak tight integrity of each system component.

The DGCWS supports test runs of the EDGs on a periodic schedule defined by the plant Technical Specifications. The engine is manually started from the MCR and increased to rated speed in two steps. The engine accelerates to idle speed (≈ 60 percent of rated speed) and is maintained there for a short time to achieve proper warming, then is increased to rated speed.

9.5.5.5.2 LOOP Testing

The DGCWS also supports test runs to simulate a LOOP. This test is an auto-actuation, whereby the diesel starts, accelerates to rated speed, and is under the control of the safety-related control system for automatic load sequencing. This test is normally run during a plant outage.

9.5.5.6 Instrumentation Requirements

Each EDG is provided with sufficient instrumentation to monitor the operation of the cooling water system. Alarms are separately annunciated on the local EDG engine control panel, which also signals a general diesel trouble alarm in the MCR. The DGCWS is provided with the indicators and alarms as shown in Table 9.5.5-1—DGCWS Indicators and Alarms.

Instrumentation and controls for the DGCWS are designed to provide the following safety-related functions:

- Emergency protections – The diesel control will monitor ESWS pressure and will alarm when a minimum pressure is reached, at which point the operability of the EDG could be affected. The EDG will trip on a complete loss of ESWS cooling water. The alarm and trip will be delayed for two minutes during LOOP condition to enable the ESW pump to re-establish flow.

- The diesel control will alarm on high jacket water temperature and will trip on high-high jacket water temperature in all EDG operating modes.

- The instrumentation and controls for the DGCWS are designed to provide the following non-safety-related functions:

- Standby heating – The engine is kept warm during standby by a heater and a circulation pump located in the jacket water system. The temperature of the system is monitored and the heater is controlled to maintain a preset temperature. The pump and heater stop when the engine is started.

- Monitoring of cooling systems – The level in the surge tank and the temperature in the cooling system (i.e., diesel engine inlet and outlet) are continuously monitored. An alarm is received for jacket water high temperature or low level.

- Normal protections – During periodic tests, the engine is stopped in case of low-low level or high temperature cooling water.

9.5.5.7 References

1. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," University of Dayton Research Institute for the U.S. NRC; UDR-TR-79; February 1979.

Table 9.5.5-1—DGCWS Indicators and Alarms
Sheet 1 of 2

Component	Indication / Alarm
Water expansion tank level	Monitoring w/alarm and control
Jacket water temperature-engine-Out	Monitoring w/alarm, NT, ET and control
Jacket water pressure-engine-Out	Monitoring w/alarm
Jacket water temperature HX-In	Monitoring w/alarm
Jacket water HX pressure-In	Monitoring w/alarm
Jacket water temperature HX-Out	Monitoring w/alarm
Jacket water pressure HX-Out	Monitoring w/alarm
Jacket water Pump temperature-In	Monitoring w/alarm
Jacket water pump pressure –In	Monitoring w/alarm
Jacket water pump temperature out / engine temperature-In	Monitoring w/alarm
Jacket water pump pressure out / engine pressure-In	Monitoring w/alarm
Keep-warm pump temperature-In	Monitoring w/alarm
Keep-warm pump pressure-In	Monitoring w/alarm
Keep-warm pump temperature out /keep-warm heater temperature-In	Monitoring w/alarm
Keep-warm pump pressure out / keep-warm heater pressure-In	Monitoring w/alarm
keep-warm heater temperature-Out	Monitoring w/alarm
Keep-warm heater pressure-Out	Monitoring w/alarm
Governor oil cooler water temperature-Out	Monitoring w/alarm
Governor oil cooler water pressure-Out	Monitoring w/alarm
Intercooler A water temperature-Out	Monitoring w/alarm
Intercooler A water pressure-Out	Monitoring w/alarm
Intercooler B water temperature-Out	Monitoring w/alarm
Intercooler B water pressure-Out	Monitoring w/alarm
Intercooler water header temperature-Out	Monitoring w/alarm and control
Intercooler water pressure-Out	Monitoring w/alarm
Intercooler HX water temperature-In	Monitoring w/alarm
Intercooler HX water pressure-In	Monitoring w/alarm
Intercooler HX water temperature-Out	Monitoring w/alarm
Intercooler HX water pressure-Out	Monitoring w/alarm
Intercooler water pump temperature-In	Monitoring w/alarm
Intercooler water pump pressure-In	Monitoring w/alarm

Table 9.5.5-1—DGCWS Indicators and Alarms
Sheet 2 of 2

Component	Indication / Alarm
Intercooler water pump temperature-Out / Intercooler A&B and Governor cooler temperature-In	Monitoring w/alarm
Intercooler water pump pressure-Out / Intercooler A&B and Governor cooler pressure-In	Monitoring w/alarm
Generator bearing Cooler water temperature-In	Monitoring w/alarm
Generator bearing Cooler water pressure-In	Monitoring w/alarm
Generator bearing Cooler water temperature-Out	Monitoring w/alarm
Generator bearing Cooler water pressure-Out	Monitoring w/alarm