5.0 REACTOR COOLANT SYSTEM AND CONNECTED SYSTEMS

5.1 SUMMARY DESCRIPTION

The reactor is a pressurized water reactor (PWR) with two coolant loops. The Reactor Coolant System (RCS) circulates coolant (borated water) in a closed cycle, removing heat from the reactor core and internals and transferring it to a secondary (steam generating) system. In a pressurized water reactor, the steam generators provide the interface between the Reactor Coolant (primary) System and the Main Steam (secondary) System. The steam generators are vertical U-tube heat exchangers in which heat is transferred from the reactor coolant to the Main Steam System. Reactor coolant is prevented from mixing with the secondary steam by the steam generator tubes and the steam generator tube sheet. This makes the RCS a closed system which forms a barrier to the release of radioactive materials from the core of the reactor to the containment.

The arrangement of the RCS is shown in Figures 5.1-1 and 2. The major components of the system are the reactor vessel; two parallel heat transfer loops, each containing one steam generator and two reactor coolant pumps; a pressurizer connected to one of the reactor vessel outlet pipes; and associated piping. All components are located inside the containment. Effluent discharges from the pressurizer safety valves are condensed and cooled in the quench tank.

→(EC-8458, R307)
The major impacts to the RCS due to steam generator replacement were evaluated. An increase in RCS volume of approximately 4%, an increase in heat transfer capability, and a slight change in normal RCS flow rate are expected. The potential impact to specific RCS functional requirements and design bases were addressed in detail, and based on those evaluations the evaluated RCS functional and performance requirements are met following steam generator replacement.
←(EC-8458, R307)

Table 5.1-1 shows the principal pressures, temperatures and flowrates of the RCS under normal steady-state, full-power operating conditions. Instrumentation provided for operation and control of the system is described in Chapter 7.

System pressure is controlled by the pressurizer, where steam and water are maintained in thermal equilibrium. Steam is formed by energizing immersion heaters in the pressurizer, or is condensed by the pressurizer spray to limit pressure variations caused by contraction or expansion of the reactor coolant.

The average temperature of the reactor coolant varies with power level and the fluid expands or contracts, changing the pressurizer water level.

The charging pumps and letdown control valves in the Chemical and Volume Control System (CVCS) are used to maintain the programmed pressurizer water level. A continuous but variable letdown purification flow is maintained to keep the RCS chemistry within prescribed limits. Two charging nozzles and a letdown nozzle are provided on the reactor coolant piping for this operation. The charging flow is also used to alter the boron concentration or correct the chemistry of the reactor coolant.

Other reactor coolant loop penetrations are the pressurizer surge line in one reactor vessel outlet pipe; the four safety injection inlet nozzles, one in each reactor vessel inlet pipe; one outlet nozzle to the Shutdown Cooling System in each reactor vessel outlet pipe; two pressurizer spray nozzles; vent and drain connections; and sample connections and instrument connections.

Overpressure protection for the reactor coolant pressure boundary is provided by two spring-loaded ASME Code safety valves connected to the top of the pressurizer. These valves discharge to the quench tank, where the steam is released under water to be condensed and cooled. If the steam discharge exceeds the capacity of the quench tank, it is relieved to the containment atmosphere through a rupture disc.

Overpressure protection for the secondary side of the steam generators is provided by 12 spring-loaded ASME Code safety valves located in the Main Steam System upstream of the main steam isolation valves.

Components and piping in the RCS are insulated with a material compatible with the temperatures involved to reduce heat losses and protect personnel from high temperatures. All insulation material used has a low soluble chloride and other halide content to minimize the possibility of stress corrosion of stainless steel.

Principal parameters of the RCS are listed in Table 5.1-2. Table 5.1-3 lists RCS volumes.

Shielding requirements of the surrounding concrete structures are described in Section 12.3. Reactor Coolant System shielding permits limited personnel access to the containment building during power operation. The reactor vessel sits in a thick walled concrete well. This and other shielding reduces the dose rate within the containment and outside the shield wall during full power operation to acceptable levels.

5.1.1 SCHEMATIC FLOW DIAGRAM

The principal pressures, temperatures, and flow rates at major components are listed in Table 5.1-1. These parameters are referenced to Figure 5.1-3, the piping and instrument diagram, by numbered locations. Instrumentation provided for operation and control of the RCS is described in Chapter 7 and is indicated on Figure 5.1-3.

5.1.2 PIPING AND INSTRUMENT DIAGRAM

Figure 5.1-3 is the piping and instrument diagram of the RCS. The entire system is located within the containment. Fluid systems which are connected to the Reactor Coolant System and which include the limits of the reactor coolant pressure boundary as defined in 10CFR50.2 (v), are identified and the appropriate piping and instrument diagrams in other sections are referenced. Figure 5.1-4 is the piping and instrument diagram for the reactor coolant pump seals.

5.1.3 ELEVATION DRAWING

Major components of the RCS are surrounded by concrete structures, which provide support plus shielding and missile protection. Elevation drawings, illustrating principal dimensions of the RCS in relationship to the surrounding concrete structures, are provided on Figures 1.2-17 through 1.2-22.

TABLE 5.1-1 Revision 307 (07/13)

PROCESS DATA POINT TABULATION

→(DRN 03-2059, R14)

Parameter	Pressurizer	S.G. 1-A Midpoint	Pump 1-B Outlet	Reactor Vessel Midpoint	Pump 1-A Outlet	S.G. 2-A Midpoint	Pump 2-A Outlet	Pump 2-B Outlet
Data Point Figure 5.1-3	1	2	3	4	5	6	7	8
Pressure, psig	2,250	2,232.0	2,306.4	2,282.1	2,306.4	2,232.0	2,306.4	2,306.4
→(EC-8458, R307) Temperature, °F	652.7	572.5	543	572.5	543	572.5	543	543
Mass Flowrate lbm/hr (x 10^6)	-	81.8	40.9	163.5	40.9	81.8	40.9	40.9
Volumetric Flow-rate, gpm (x 10^4)	-	21.5	10.8	43.1	10.8	21.5	10.8	10.8

←(DRN 03-2059, R14; EC-8458, R307)

TABLE 5.1-2 Revision 307 (07/13)

→(DRN 03-2059, R14)

PARAMETERS OF REACTOR COOLANT SYSTEM

Parameter	Value
Rated Thermal Power, Mwt (core only)	3,716
Thermal Power Btu/hr (including heat addition from RCPs)	1.274×10^{10}
Design Pressure, psia	2,500
Design Temperature (except pressurizer and surge line), °F	650
Pressurizer and Surge Line Design Temperature, °F	700
→(EC-8458, R307) Coolant Flow Rate, Operating, lbm/hr ←(EC-8458, R307)	163.5×10^6
Cold Leg Temperature, Operating, °F	543
→(EC-8458, R307) Average Temperature, Operating, °F	572.5
Hot Leg Temperature, Operating, °F ←(DRN 03-2059, R14; EC-8458, R307)	602
Normal Operating Pressure, psia	2,250
→(EC-8458, R307) System Water Volume, $ft.^3$ (without pressurizer) ←(EC-8458, R307)	10,485
Pressurizer Water Volume, $ft.^3$ (full power)	800
Pressurizer Steam Volume, $ft.^3$ (full power)	700

TABLE 5.1-3 Revision 307 (07/13)

NOMINAL REACTOR COOLANT SYSTEM VOLUMES

Component	Volume (ft.^{3})
→(EC-8458, R307) Reactor Vessel (including nozzles)	4,811
Steam Generators (including nozzles) ←(EC-8458, R307)	2,051 each
Reactor Coolant Pumps	112 each
→(EC-8458, R307) Pressurizer	1,519
Piping	
Hot Leg ←(EC-8458, R307)	145 each
Cold Leg	198 each
→(EC-8458, R307) Surge Line ←(EC-8458, R307)	39