11.8 CONDENSATE AND REACTOR FEEDWATER SYSTEMS

11.8.1 Power Generation Objective

The objective of the Condensate and Reactor Feedwater Systems is to provide feedwater to the reactor to maintain a constant reactor water level.

11.8.2 Power Generation Design Basis

The Condensate and Reactor Feedwater Systems shall provide adequate feedwater to the reactor vessel during power operation.

11.8.3 System Description

The Condensate and Reactor Feedwater Systems take suction from the main condensers and deliver demineralized water to the reactor vessel at an elevated temperature and pressure. Refer to Figures 11.8-1 sheets 1, 2, 3, 4, 5, and 6, 11.9-1a, 11.9-1b sheets 1, 2, and 3, 11.9-4, and 11.9-5 for system flow paths.

The Condensate and Reactor Feedwater System is designed to provide water to the reactor vessel under main turbine control valves wide-open conditions.

Feedwater heaters are designed in accordance with the Heat Exchange Institute (HEI) Standards for Closed Feedwater Heaters. Portions of the Condensate and Reactor Feedwater Systems are Class II systems, with associated piping designed in accordance with USAS B31.1, 1967. The Class II boundaries of the systems extend from the secondary containment boundary up to the half wall anchor in the steam vault (Reactor Feedwater). The major system components are described below.

11.8.3.1 Condensate and Reactor Feedwater Pumps

Three vertical, centrifugal, motor-driven condensate pumps; three horizontal, centrifugal, motor-driven condensate booster pumps; and three horizontal, centrifugal, single-stage reactor feedwater pumps with variable-speed steam turbines are provided for these systems. In the event one condensate pump or one condensate booster pump is out of service, approximately 90%-load (pre-uprate) or 84% (uprated, based on a flow of 14.15 Mlb/hr) can be carried. In the event one reactor feedwater pump is out of service, reactor power operation can be continued at 100% power by the remaining two reactor feedwater pumps. The feedwater pumps utilize water from the injection water system for sealing and cooling. A differential pressure indicator exists in the line between the duplex strainer and the feedwater pumps. This decreases the possibility of a loss of feedwater transient caused by inadequate cooling flow to the feedwater pump due to a clogged strainer.

11.8.3.2 Feedwater Heaters

Three parallel strings of heaters, each consisting of three low-pressure feedwater heaters and two high-pressure feedwater heaters, are provided. The feedwater heaters may be taken out of service in various combinations without plant interruption but at a reduced generator output. Analyses show that operation with final feedwater temperature reduced by up to 55 degrees Fahrenheit, at rated conditions, can be accommodated within the licensing basis.

The lowest-pressure heaters have separate drain coolers. All others have integral drain coolers. The two sets of lowest-pressure heaters, along with the separate drain coolers, are located horizontally in the condenser necks.

The remaining three sets of feedwater heaters are vertical. All heaters are of the two-pass, U-tube type. The separate drain coolers are of the one-pass, straight-tube type.

All tubes are stainless steel, rolled, and welded to the tube sheets. Stainless steel baffles are provided at entering steam and drain connections.

Condensate drainage from the drain coolers of each feedwater heater flows to the next lower-pressure heater by means of pressure differential between successive heaters. Condensate drainage exiting from the separate drain cooler of the lowest-pressure heater is returned to the condenser.

11.8.3.3 Condensate Filter/Demineralizer System

A complete full-flow demineralizing system is provided in the condensate system to ensure that required water quality to the reactor vessel is maintained. A description of this system is included in Subsection 11.7.

11.8.3.4 Steam Jet Air Ejector (SJAE) Inter-Condensers

Condensate leaving the condensate pumps is divided and directed through SJAE inter-condensers, offgas condenser, and the steam-packing exhauster. A description of the air removal equipment is included in Subsection 11.4.

11.8.3.5 Steam-Packing Exhauster

The steam-packing exhauster is arranged in parallel with the SJAE to minimize the pressure loss in the condensate system. Description of the exhauster system is included in Subsection 11.4.

11.8.3.6 Offgas Condenser

The offgas condenser is also arranged in parallel with the SJAE. A description of the offgas condenser is included in Subsection 9.5. To further minimize the pressure loss, a butterfly valve is provided to permit part of the condensate to bypass the parallel heat exchangers when flow is adequate to satisfy all performance requirements of the heat exchangers. The condensate side of the offgas condensers is equipped with flow measuring devices. A pressure tap is located at each end of the piping, leading from the condenser to other process systems. These pressure taps are connected to differential pressure indicators which constitute the flow measuring devices. These devices are strategically placed to avoid areas of moisture concentration whenever possible.

11.8.3.7 Feedwater Control

Feedwater flow is normally controlled by varying the speed of the reactor feedwater pump turbine drives. However, during startup, feedwater flow is controlled by startup level control valves (see Subsection 7.10).

11.8.3.8 Condensate and Reactor Feedwater System Minimum Flow Bypasses

The condensate system is provided with minimum flow bypass valves located downstream of the condensate booster pumps. The bypass valves receive their operating signal from a flow device located in the condensate pump discharge line. The purpose of this bypass is to protect the condensate system pumps, and to provide cooling water (condensate) flow to the SJAE condensers, offgas condenser, and steam-packing exhauster at all times.

The reactor feedwater system has a minimum flow bypass line located downstream of each feedwater pump to permit direct recirculation of condensate to the main condensers. The bypass control valve in each line opens on a low-flow signal from a flow-measuring device located downstream of each pump and thereby protects the pumps from damage due to insufficient flow.

11.8.3.9 Condensate Oxygen Injection System

The condensate system is provided with means to inject oxygen gas into the condensate in order to minimize corrosion in the condensate and feedwater system piping. A program of feedwater dissolved oxygen control minimizes corrosion product input into the reactor, thereby decreasing radiolytic activation products, pipe wall thinning, plate-out, and fouling of heat transfer surfaces. The non-safety, non-seismic oxygen injection system is located in the turbine building in an area where no safety-related equipment is located. (See Figures 11.9-1a, 11.9-4, and 11.9-5).

The Unit 2 and Unit 3 injection system consists of supply tanks with regulators supplying oxygen gas to a flow control panel equipped with a manual flow regulator,

flow indicator, pressure indicator and manual isolation valves. In addition, a tubing connection from the oxygen tank farm piping is connected downstream of the flow regulator to provide a continuous oxygen supply to the condensate pumps. The injection tubing connects to each of the three condensate pumps' suction. The manually operated injection system design provides features to limit excess oxygen flow into the condensate/feedwater system. An excess flow check valve protects against excess gas flow due to regulator failure or injection tube break. The tubing and panel are protected from over pressure with a relief valve, and check valves prevent backflow of condensate into the oxygen injection system.

The Unit 1 injection consists of manual isolation valves. A tubing connection from the oxygen tank farm piping provides a continuous oxygen supply to the condensate pumps. The injection tubing connects to each of the three condensate pumps' suction. The manually operated injection system design provides features to limit excess oxygen flow into the condensate/feedwater system. Check valves prevent backflow of condensate into the oxygen injection system.

11.8.3.10 Zinc Injection Skid

The Feedwater System is provided with a passive Zinc Injection System. The system consists of a simple recirculation loop around the feedwater pumps which injects (dissolves) small amounts of zinc oxide into the reactor feedwater. The presence of trace quantities of zinc reduces occupational radiation exposure to plant personnel by promoting the formation of a thin oxide layer on stainless steel piping and components. This thin oxide layer results in reduced soluble Co-60 buildup and is a primary factor in reducing shutdown dose rates on piping and components (see Figures 11.8-1 sheets 1, 3, and 5).

11.8.4 Inspection and Testing

Test and inspection of system components and equipment are conducted to ensure functional performance as required for continued safe operation, and to provide maximum protection for operating personnel.

The initial factory acceptance testing of the condensate and reactor feedwater pumps, and the shell and tube sides of the feedwater heaters, consists of hydrostatic testing at 1-1/2 times the design pressure.

Condensate and reactor feedwater pumps received shop tests verifying pump head, capacity, efficiency, and BHP requirements over the entire flow range. Certified pump curves are on record and final pump data have been incorporated into system design.