11.6 CONDENSER CIRCULATING WATER SYSTEM

11.6.1 Power Generation Objective

The power generation objective of the Condenser Circulating Water System is to provide an efficient means of rejecting waste heat from the power generation cycle into the ambient surroundings, while meeting all applicable thermal criteria. A secondary purpose is to provide water for the Raw Cooling Water System and to dilute and disperse low-level radioactive liquid waste from the radwaste treatment facilities. It also provides a discharge path to station sumps and sewage treatment plant.

11.6.2 Power Generation Design Basis

a. The Condenser Circulating Water System shall provide flow to the condensers to remove the heat produced during power operation and maintain the condenser shell pressure at an economical level.

b. The Condenser Circulating Water System shall allow the plant to operate within the applicable State water-quality standards with a minimum of load reduction.

c. The Condenser Circulating Water System provides the source of water for the Raw Cooling Water System for each unit.

d. The Condenser Circulating Water System shall be capable of providing adequate flow to the condensers under shutdown conditions without the normal offsite power supply.

e. The Condenser Circulating Water System shall provide for the dilution and dispersion of radioactive liquid wastes from the plant.

f. The Condenser Circulating Water System shall provide for a discharge path to the station sumps and sewage treatment plant.

11.6.3 System Description

The flow diagram for this system is shown in Figures 11.6-1, 11.6-2, 11.6-3 sheets 1, 2, 3, 4, and 5, 11.6-4, 11.6-5, and 11.6-6.

The Condenser Circulating Water System is designed to provide a flow of approximately 675,000 gpm to the condenser during open cycle operation, and a flow of approximately 25,000 gpm to Raw Cooling Water System of each unit.

This was the minimum number of pumps which could supply the total flow and yet remain in an economical size within manufacturer's capability. Head losses are held to a minimum by designing the system to maintain the most practical velocities and smoothness of flow commensurate with construction and operating costs.

The intake pumping station is located at the land end of the intake channel, which has a bottom EL. 523 ft above sea level.

On the reservoir end of the intake channel is located gate structure No. 3, which consists of three motor-operated wheel gates which are capable of acting as a skimmer wall by blocking the intake channel down to EL. 527.

The nine circulating water pumps are vertical, nonpullout-type, single-stage, mixed-flow, wet-pit-type. Suction for these pumps is provided to EL. 532. Each group of three pumps, operating in parallel, supplies the condenser cooling water requirements for full power requirements of a generating unit. Each pump is installed in a separate suction well with entering water strained by trash racks and traveling screens, operating in parallel. Each pump discharge is equipped with motor-operated butterfly valves. The discharges of the three pumps are brought together in a steel trifurcation transition to a single tunnel. The water is channeled to the condenser by this tunnel.

A debris filter is installed in the 78" inlet pipe of the CCW piping into the 3A1, 1C2, and 2C2 condenser water box. The debris filter is provided with a backwash line that permits manual or automatic operation of the backwash system. The backwash line bypasses the condenser and discharges directly into the 3A1 water box outlet piping for Unit 3, the 1C2 water box outlet piping for Unit 1, and the 2C2 water box outlet piping for Unit 2.

Normally, filling and operating of the condensers are accomplished by (1) venting, (2) evacuation of the condenser water box by a vacuum system, and (3) operation of one or more circulating water pumps. Each unit at BFN has one main condenser. Each main condenser has three subsections, one each for each LP turbine. Each subsection has two parallel cooling water paths, making a total of six parallel paths for each unit's main condenser. The three cooling sections of the three condensers can be operated fully flooded by only one pump. The discharge from the condensers passes to the discharge tunnel and then to the warm water channel going to the cooling towers or to the discharge diffusers in the reservoir or a combination of these discharge paths.

Gate 1A is provided to allow the discharge from the condenser to pass out through the diffusers in the reservoir and to divert the water to the warm water channel by way of the vacuum loop. Gate 1A consists of three motor-operated wheel gates, with one gate in the discharge conduit from each unit. The gates are controlled to operate independently of one another.

The vacuum loop is a high point in each tunnel which carries water to the warm water channel while operating under vacuum at the normal design flow. The discharge of the tunnel at the warm water channel is submerged under all normal operating conditions. When gate 1A is closed, water is pumped over the high point at a reduced flow rate. The air which is displaced by the water is vented through vent valves. When all air can be vented, a vacuum is established and one circulating water pump may be stopped. The flow through the vacuum loop then stabilizes. The vacuum is maintained by a vacuum priming system.

Water is pumped to the seven cooling towers by pumps located in seven pumping stations located along the warm water channel. Each pumping station for Cooling Towers 1 through 6 have two 137,500 gpm pumps at a design head of 75 feet. The pumping station for Cooling Tower 7 has four 102,500 gpm pumps at a design head of 83.5 feet.

The twelve cooling tower supply pumps for Cooling Towers 1 though 6 are 440 rpm, mixed-flow, vertical, wet-pit, and non-pullout type above the deck discharge. The pumps are direct-connected to 3100 hp, solid-shaft electric motors. The pumps for Cooling Tower 7 are 509 rpm, mixed-flow, vertical, wet-pit, pullout-type, below the deck discharge. The pumps are direct connected to 2700 hp, solid-shaft electric motors. Each pump is installed in a separate concrete pumping pit which has long approach walls to reduce flow turbulence and to prevent vortices.

Cooling Towers 1 through 7 are mechanical-induced-draft, cross flow cooling towers.

Cooling Towers 1 through 7 fans are electrically driven by minimum 200 horsepower, 1800 rpm, totally enclosed fan cooled motors.

Standpipes are located on the top of each tower's distribution header to provide a vent to the atmosphere in the event of a sudden reverse flow of the water due to the loss of pump flow.

Tower cool-water basins are reinforced concrete structure, and framing is of wood or fiberglass reinforced plastic (FRP); the exterior is of corrugated sheathing, and the heat exchanger fill is polyvinyl chloride.

The discharge from the cooling tower cold water basins flows into an open channel, over a discharge control structure, and then through gate 1 back to the reservoir through the diffuser. The design of the cold water channel, discharge control structure, and gates 1 and 2 is described in paragraph 12.2.7.

The Condenser Circulating Water System provides for a diffuser discharge system which injects the waste heat into the reservoir in such a way so as to maximize the area of the mixing zone.

The diffusers are extensions of the discharge tunnels, made of corrugated metal pipe laid on the bottom of the reservoir. They have a series of nozzles on the downstream side to inject the condenser discharge water into the main flow of the reservoir. For details of the diffuser system, see paragraph 12.2.7.5. The Condenser Circulating Water System is a combined system capable of operation in open or helper modes, or any combination thereof.

In the open mode, water is drawn into the circulating water pumping station forebay from the reservoir, pumped through the main condenser, passed through gate 1A, and discharged back into the reservoir through the diffusers. Gate 3 is open to allow water to flow into the pumping station forebay, gate 1A is open to allow water to flow back to the reservoir from the plant, gate 2 is closed, and gate 1 is open to allow rainfall in the cooling tower area to run off. Additionally, gate 1 can be opened to assist in CCW pump back pressure control. The vacuum loop in the tunnels to the cooling towers is vented to the atmosphere.

In the helper mode, water is drawn into the circulating water pumping station forebay from the reservoir, pumped through the main condenser, diverted through the vacuum loop into the warm water channel going to the cooling towers, and pumped out of the warm water channel through the cooling towers by the lift pumps. The discharge from the cooling towers flows into the cold water channel, over the discharge control structure, and is then diverted through gate 1 (gate 2 is closed) and is discharged back to the reservoir through the discharge diffusers. Gate 1A may be throttled to assist in warm water channel level control.

The Condenser Circulating Water System is designed so that one of the nine circulating water pumps can furnish adequate flow to the condensers of all three units under shutdown conditions and without normal offsite power supply. Two standby diesel-generators are operated in parallel to start the single pump required for this condition.

One pump cannot be operated alone without its discharge being throttled to produce a head on the pump sufficient to provide a downthrust on the pump. To operate a pump without downthrust will damage the Kingsbury-type thrust bearing in the pump motor.

Practically all of the head in the system is friction, with the exception of the loss through the diffuser nozzles. The entire Condenser Circulating Water System is below siphon-break limitations. A vacuum system operating continuously keeps all passages of the open mode system full.

The pumping station also houses the traveling screen wash pumps, motor-driven fire pumps and strainers, residual heat removal service water pumps, emergency equipment cooling water pumps and strainers, and associated electrical equipment.

The screen wash system can be operated in manual or automatic modes. Differential pressure across each pair of traveling screens is monitored by an air bubbler system. When operating the system in the automatic mode, the screen wash pump is started when a preset pressure differential is reached across any of the three pairs of screens. When a pressure of 70 psi is established at the screen wash nozzles, the screen motors are automatically started and the screens are washed. In either manual or automatic mode the pump and screens run until manually stopped.

Water supply to the RHR service water pumps passes through these screens; however, the pumps take suction from their own pit, separate from the Condenser Circulating Water pumps.

The traveling screens are not designed to operate under loss-of-power conditions. Since the ratio of flow for normal operations to that for loss of normal auxiliary power conditions is about 100:1 (33:1 with loss of Wheeler Dam), adequate flow to the RHR service water pumps is assured without automatic cleaning of the screens.

11.6.4 Power Generation and Safety Evaluation

The intake pumping station is a watertight structure below the top deck which is at EL. 565.

The design of the intake channel and pumping station structure is described in paragraph 12.2.7. The Condenser Circulating Water pumps and valves are not designed to Class I design considerations. The circulating water pump motors and traveling screens are the only parts exposed above grade. The pumps have been analyzed and determined to be stable under tornado wind conditions. They are subject to individual missile damage, but there is virtually no possibility of all nine pump motors being damaged simultaneously by missiles.

One circulating water pump has more than adequate capacity to dissipate the shutdown heat for the three units. A cross-tie with electric-operated butterfly valves is provided between the three circulating water tunnels so that any one pump in emergency, can supply water to all units. As previously stated, throttling of the pump is required to prevent its operating at too-low head conditions. If the units happen to be operating in the helper mode during a power blackout, gate 1A must be manually cranked partially open within 4 hours. This is necessary to avoid the overflow of water out of the warm water channel, due to the single circulating water pump delivering water to the warm water channel with all tower lift pumps off.

The design of gate structures 1, 1A, 2, and 3 is described in paragraph 12.2.7. None of the gates, with the exception of gates in structure 2, in the system has Class I design considerations. The vacuum priming system on the vacuum loop does not have Class I design considerations, but a vacuum breaking system with the remote manual control to break vacuum on the vacuum loop is a redundant, seismic Class I engineered safeguard. The vacuum must be broken by the operator upon loss of the downstream dam to prevent backflow of warm water from the tower warm water channel through the plant to the pumping station forebay.

The Condenser Circulating Water System would be susceptible to backflow to the pumping station forebay, until the operator breaks the siphon at the vacuum loop, if all the main condenser circulating water pumps were to stop with the level in the warm water channel above the forebay level. Therefore, whenever the CCW system is operating with a vacuum in the vacuum loop, the operator shall maintain the warm water channel level below the level of the forebay.

Whenever the level in the warm water channel exceeds the forebay level, the operator is alerted by redundant warm water channel indicator and a forebay/warm water channel differential level indicator in the control room. The control room indicators, level sensors, and control room instrumentation power supply are all designed to seismic Class I criteria. The cabling between the control room and the sensors is not seismically designed. However, the control room indicators give an indication of adverse differential water level or an indication of instrument malfunction, if the cables are short-circuited or open-circuited, respectively. In addition, both of these conditions are alarmed in the control room.

Neither operation of the mechanical draft cooling towers nor of the cooling tower lift pumps serves any safety-related function.

11.6.5 Inspection and Testing

Components of the system which are in continuous service during normal plant operation require no additional periodic testing. Gates, cooling towers, and other nonsafety-related components which operate intermittently are inspected and tested periodically for operability. All safety-related features such as the vacuum breaking system are also inspected and tested periodically to verify their operability.

11.6.6 Operational Requirements

In addition to the condenser cooling requirements, the Condenser Circulating Water System supplies water to the plant raw cooling water pumps.

In the event of complete outage of the circulating water pumps, at least one raw cooling water pump per unit can still be supplied from the condenser intake tunnels. In the event of complete failure of the Condenser Circulating Water System, the essential systems are provided with backup supply from the RHR service water pumps feeding through the EECW system.

11.6.7 Radioactive Waste Discharge

Operation of the radioactive system discharge, in conjunction with the Condenser Circulating Water System, is described in paragraph 9.2.5.