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SECTION 11 PLANT POWER CONVERSION SYSTEMS

11.1 Summary Description

Saturated steam generated in the reactor at approximately 1000 psig is supplied to the high pressure section of the turbine. Steam leaving the high pressure turbine is divided; the bulk of it passing through moisture separators prior to admission to the low pressure sections. A portion of the steam is extracted from the system and is condensed as it is cascaded through feedwater heaters enroute to the main condenser. Condensate pumps, taking suction from the condenser hot well, pump the condensate through the air ejector condensers, gland seal exhaust condensers and demineralizers through the low pressure heaters to the reactor feed pump suction. The reactor feed pumps discharge through the high pressure heaters to the reactor.

Normally, the turbine utilizes all the steam being generated by the reactor. However, automatic pressure-controlled bypass valves are supplied which can discharge excess steam directly to the condenser. The bypass system is sized to pass 11.5% of 2004 MWt reactor steam flow without a turbine trip or reactor scram (Reference 1). 01101248

11.2 Turbine-Generator System

11.2.1 Design Basis

The turbine-generator system converts the thermodynamic energy of the steam into electrical energy. The turbine-generator is designed using the following bases:

Turbine Rating	691,269 KW
Steam Conditions:	
Pressure	952 psia
Quality	0.5% moisture
Exhaust Pressure	1.5 in Hg abs.

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The steam conditions have been optimized to give high turbine efficiency consistent with long turbine blade life and realistically attainable BWR conditions. Moisture content of 0.5% represents the design point. However, there is no significant impact on turbine operation to a design limit of less than 1.0%.

11.2.2 Description

The turbine generator system consists of the turbine generator unit, condenser, and required subsystems as described below:

The turbine is a 691,269 KW, 1800 rpm, tandem-compound, four flow, non-reheat steam turbine with 38-inch last-stage buckets, designed for steam conditions of 952 psia with 0.5% moisture, while operating at 1.5 inches mercury absolute exhaust pressure and 0.0% makeup and while extracting for five stages of feedwater heating (see Figure 1.3-2). The turbine unit consists of one single-flow high pressure and two double-flow, low-pressure machines. Exhaust steam from the high-pressure turbine passes through moisture separators before entering the low-pressure units. The separators reduce the moisture content of the steam to less than 2 percent by weight. 01101248

The generator is a direct driven 60-cycle, 22,000 V, 1800 rpm, conductor-cooled, synchronous generator rated at 718,000 KVA at 0.954 power factor, 45 psig hydrogen pressure and 0.50 Short Circuit Ratio. The generator-exciter system is of Alterrex type rated at 1440 KW, 425 V.

The turbine controls include a speed governor, overspeed governor, steam admission valves, emergency stop valves, a pair of initial pressure regulators, bearing and seal oil pumps, turning gear and various instruments and protective devices.

The ability of the plant to follow system load is accomplished by adjusting the reactor power level either by regulating the reactor recirculating flow or by moving control rods. The turbine speed governor can override the initial pressure regulator, and the steam admission valves close when an increase in system frequency or a loss of generator load causes the speed of the turbine to increase. In the event that the reactor is delivering more steam than the admission valves will pass, the excess steam is bypassed directly to the main condenser by automatic pressure-controlled bypass valves.

11.2.3 Performance Analysis

The details of the turbine/generator performance analysis for the current fuel cycle are given in Sections 14 and 14A.

11.2.4 Tests and Inspections

Tests and inspections are conducted to assure functional performance as required for continued safe operation and to provide maximum protection for operating personnel. Among these tests is the periodic exercise of the turbine stop valves and the steam bypass valves. Other control valves not normally in motion are also periodically exercised. To minimize reactor perturbation while performing surveillance testing of the turbine stop valve, a crossover line connecting the four main steam lines upstream of the turbine stop valves was installed. This provides steam flow equalization when one turbine stop valve is closed.

In 1996 the internal components of the HP and both LP turbines were replaced. The new turbine rotors are monoblock designs which eliminate Stress Corrosion Cracking concerns in the rotor discs. The new equipment extends the intervals between routine turbine overhauls to ten years.

11.3 Main Condenser System

11.3.1 Condenser

11.3.1.1 Design Basis

When operating at 2004 MWt with 60°F cooling water and cleanliness correction factors of 86.7% (LP) and 73.3% (HP), the projected back pressures are 1.93 and 3.11 in. Hg, respectively (Reference 2). 01101248

The approximate heat load for the dual-pressure condenser is 4,505 MBtu/hr under 2004 MWt operating conditions (References 2 and 3). The effective heat transfer surface is approximately 399,000 square feet. Deaeration is provided to remove dissolved gases from condensate to an oxygen content of no more than 0.005 cc per liter with air inleakage not exceeding 15% of the air removal equipment capacities and non-condensible volumes not exceeding 141 cubic feet per minute.

The condenser can accommodate 11.5% of 2004 MWt reactor steam flow through the main turbine bypass without increasing back pressure beyond the turbine trip setpoint (Reference 1). 01101248

11.3.1.2 Description

The main condenser is a single pass dual-pressure, deaerating type with divided water boxes. One condenser shell is located beneath each of two low pressure turbine exhausts. Stainless steel tubes are rolled into Muntz Metal tube sheets. The condenser shell and bonnet-type water boxes are fabricated carbon steel. The condenser hotwell has a rectangular labyrinth to provide a 2-minute condensate retention time. This retention allows time for radioactive decay of short-lived isotopes from the time condensate enters the hotwell until it is removed by the condensate pumps. Deaeration of condensate is provided in the condenser for removal of air and noncondensible gases contained in the turbine steam.

11.3.2 Main Condenser Gas Removal System

11.3.2.1 Design Basis

The main condenser gas removal system evacuates gases from the turbine and main condenser during startup and maintains the main condenser essentially free of gases during operation. This system will handle all noncondensible gases which may enter the turbine through its seals, the condensate feedwater and steam systems, or may be generated by dissociation of water in the reactor. The turbine sealing system is of the conventional type to prevent leakage of air into or steam out of the turbine during startup and operation.

11.3.2.2 Description

Steam Jet Air Ejector

Section 15 Drawings NH-36034, NH-36035, and NH-36035-2 are P&IDs of the gas removal system. The main condenser gas removal system includes two one-half capacity steam jet air ejector units with an inter-condensing second stage. Standby steam jets are provided for each unit. The air ejectors remove gases and vapors from the main condensers using main steam, reduced in pressure, as the driving medium and deliver steam-diluted noncondensible gases to the recombiner system. The inter-condensers use condensate as their cooling medium. Condensed vapors from the inter-condensers, which may contain dissolved gases, are returned to the main condenser.

Mechanical Vacuum Pump

A mechanical vacuum pump removes gases from the main condenser when adequate steam pressure is not available to establish vacuum conditions using the steam jet air ejectors. The discharge from this pump is routed to the gland-seal off-gas holdup systems.

Turbine Sealing System

The turbine sealing system provides steam to the seals on the turbine glands at a pressure slightly above atmospheric. It collects and condenses sealing steam and discharges air leakage to the gland seal off-gas holdup system. The steam packing exhauster uses condensate from the discharge of the condensate pump as its condensing medium. Condensed vapors are returned to the main condenser.

Off-gas System

The off-gas system collects gases that are potentially contaminated for hold-up decay and eventual discharge to the off-gas stack. The design holdup time is a minimum of 50 hours for the steam jet air ejector gases and 1.75 minutes for the mechanical vacuum pump and gland steam seal gases, to allow decay of the short-lived radioactive isotopes before the gases are discharged to the environment through the off-gas stack. The gaseous radwaste system is discussed in Section 9.3.

11.3.2.3 Performance Analysis

The gas removal system is designed to prevent leakage of radioactive gases into the turbine and condenser areas and to process and release these gases through the elevated release point so that the resulting off-site doses will be as low as reasonably achievable (ALARA).

The Mechanical Vacuum Pump (MVP) will isolate under the following signals:

1. High Main Steam Radiation. This prevents a significant increase in elevated release rates and mitigates the consequences of the design basis Control Rod Drop Accident (see USAR Section 14.7.1).

2. Primary Containment Isolation Logic. MVP operation causes reduced SGTS flow.

The SJAE system will automatically terminate main condenser off-gas flow to the recombiner system if low steam pressure is sensed at the 2nd stage SJAE steam supply. This automatic action prevents undiluted off-gas from reaching the recombiner system.

The isolation logic for the MVP and SJAE system has a seal-in feature that requires operator action to reset the logic. The manual reset forces the operator to evaluate plant conditions before returning the off-gas system to normal operation.

11.4 Main Turbine Bypass System

11.4.1 Design Basis

The turbine bypass system valves are designed to pass 11.5% of 2004 MWt reactor steam directly to the condenser (Reference 1). 01101248

11.4.2 Description

The turbine bypass valves are provided to protect against reactor vessel over pressures by bypassing steam directly to the condenser. The valves are fast response modulating type valves used in conjunction with pressure reducing orifices. The bypass valves are controlled by reactor pressure and perform three basic functions. The most stringent function is to reduce the rate of rise of reactor pressure when the turbine admission or stop valves are moved rapidly in the closing direction. To perform this function, the bypass valves need about the same speed of response as the turbine admission valves. The second function of the valve is to control reactor pressure during startup of the turbine. This allows the reactor power level to be held constant while the turbine steam flow is varied as the turbine is brought up to speed under the control of its speed governor. The third function of the valve is to control reactor pressure after the turbine has been tripped. It is used to discharge the decay heat to the condenser and to control the rate of cooling of the reactor system.

11.4.3 Performance Analysis

The effects of malfunctions of the main bypass system valves and the effects of such failures on other components have been evaluated as mentioned in Section 11.2.3.

11.5 Circulating Water System

11.5.1 Design Basis

The purpose of the Circulating Water System is to remove the heat from the main condenser that is rejected by the turbine or turbine bypass system over the full range of operating loads.

The system is designed to:

a. Regulate circulating water flows and temperatures to produce condenser back pressures consistent with plant economy.

b. Conform to governmental regulations with respect to limitations placed on (1) river temperature rise due to plant operation, and (2) percentage of river water flow diverted to plant.

c. Limit condenser tube flow velocity to 7 feet per second to minimize erosion based on original admiralty brass tube material.

d. Inject Sodium Hypochlorite/Sodium Bromide into the circulating water to minimize marine growth and bacteria in the system.

e. Prevent pump cavitation and minimize the effect of pressure surges by means of automatic controls.

f. Provide for make-up water during operation of the cooling towers.

11.5.2 Description

The Circulating Water System has been designed for open cycle, once through cooling towers, closed cycle with cooling towers, and for variations of these modes, i.e., partial recirculation. The P&ID for the circulating water system is shown in Drawings NH-36489 and NH-36489-2, Section 15.

The system for open cycle operation consists essentially of a river intake structure with two half-capacity circulating water pumps, piping river water through the condenser to a discharge structure where the water enters an approximately 1000 foot long canal that returns the water to the river downstream from the intake.

Two induced draft cooling towers are used during closed cycle operation. Two half-capacity cooling tower pumps are located in the Discharge Structure and pump water from the Discharge Structure to the top of the cooling tower. Cooled effluent returns by gravity to the Intake Structure from the cooling tower basins. Blowdown overflows the side weirs of the basins and is piped to the discharge canal. Make-up water is added at the Intake Structure. The cooling tower system is described more fully in Section 11.6.

Design river level at the intake is at an elevation of 904 feet above MSL and centerlines of the circulating water pumps and the cooling tower pumps are, respectively, 903.5 feet and 903 feet. The system is designed to utilize syphon recovery in pumping through the condenser, the top tube of which is at elevation 929 feet 7 inches.

River water is turned through an angle of 81° to approach the plant along a channel excavated to elevation 898 feet. It enters the Intake Structure through a trash rack before dividing into two separate streams to the circulating water pump chambers. Each stream passes through two parallel automatically-operated traveling screens, the service water pump bay and two parallel motor-operated sluice gates before reaching a circulating water pump. The center dividing wall permits dewatering of either pump bay. A normally closed gate in the wall can be manually opened during normal operation if a traveling screen is out of service for maintenance. Taking suction from the service pump bay are two 14,000 gpm make-up pumps and pumps for the station cooling, screen wash, and fire protection.

Equipment at the intake structure delivers Sodium Hypochlorite/Sodium Bromide to the service water pump bay, and the circulating water pump forebay. Refer to Section 12 for details of the Intake Structure and to Section 10.3 for a description of the service systems.

The two circulating water pumps are each driven by 1,250 hp synchronous motors (See Table 11.5-1). Each pump has a 78-in. diameter motor-operated butterfly valve at its discharge with a 20-second operating time.

The discharge from the circulating water pumps passes in series through each shell of a twin shell, single-pass dual pressure condenser with divided water boxes (See Section 11.3 for condenser details).

Normally two pumps are delivering water through the twin 90-in. diameter lines to the first shell (low-pressure condenser) but a cross-connection at the pumps permits single pump operation.

There are 90-in. diameter motor-operated butterfly valves in the two supply lines to the low-pressure condenser and 78-in. diameter motor-operated valves in the two discharge lines from the high-pressure condenser. Each valve has an operating time of 60 seconds. The valves are used to isolate half of the circulating water side of the condenser for inspection and maintenance. When both circulating water pumps are running, these isolation valves are opened, but if only one pump is in use, the condenser discharge valves are automatically positioned to limit the flow as required to prevent pump cavitation.

The condenser outlet lines drop below the turbine building slab and are wye-connected beyond the building to a 108-in. steel pipe which runs approximately 600 feet to the discharge structure.

The combined flow diverges into parallel paths through the Discharge Structure and, during open-cycle operation, through two motor-operated sluice gates for return to the river via the discharge canal.

A 36-in. de-icing line runs from the condenser discharge line to the intake structure apron. When temperatures approach the freezing point, relatively warm condenser effluent can be delivered through this line to the intake structure to keep the area ice free. Steam is also available at the intake structure from 1″ hose connections.

General experience in this area indicates that the ice on lakes will normally range between 24 and 30 inches thick. Experience also indicates that the ice on the lakes in this area will get to a maximum of about 40 inches thick during an extremely cold winter with light snow cover.

The ice thickness on the river was measured at three locations near the intake structure in February 1968 and measured 27 to 28 inches. In 1969, the ice thickness was also measured and found to range between 0 to 20 inches. The lesser thickness in 1969 can be attributed to the high 1969 river flows and above average snow-cover on the ice.

River ice cover is less than lake ice cover due to the erosive action of river flow. However, based on a lake maximum ice thickness of 40 inches at the Monticello intake canal it would leave at least 2.5 feet of open water available to supply the plant since the bottom of the intake canal is at elevation 898 feet msl which is 6 feet below the design low flow stage of 904 feet msl (200 cfs). Since the canal has a bottom width of 62 feet there is more than adequate area available to supply the necessary water for the engineered safeguards of the plant.

11.5.3 Performance Analysis

The approximate heat load of the condenser at 2004 MWt load is 4,505 MBtu/hr. At this load and assuming 60°F circulating water at the average summer flow rate of 249,585 gpm, the projected backpressure is 1.93 in. Hg in the low pressure condenser and 3.11 in. Hg in the high pressure condenser (References 2 and 3). 01101248

Open-cycle operation will normally be used. The operating diagram of open-cycle cooling tower operation is shown in Figure 11.5-2a. Cooling towers are used when river flow is low or to meet the regulations on river temperature rise. Cooling tower operation may be in a closed cycle, a partial recirculation cycle, or a “helper” cycle where no water is recirculated, but part or all of the condenser effluent is discharged through the cooling towers before return to the river. Diagrams of these cycles are shown on Figures 11.5-2b through 11.5-2d. Automatic positioning of the pump discharge valves and condenser discharge valves, and sequencing with pump start-up or trip, is provided as required to prevent cavitation and minimize water hammer.

Circulating water can be automatically chlorinated/brominated at preset intervals.

Table 11.5-1 Circulating Water Pump

Number of units	2
Pumps	
Type	Dry pit, mixed flow
Rated flow and head	140,000 gpm at 27.8 ft. TDH[1]
Rated speed	225 rpm
Bhp at rating	1,115 bhp
Shut-off head	53.4 feet
Shut-off load	1,425 bhp
Motor	
Type	GE type TS-V brushless synchronous
Voltage, phase, and cycle	4,000 v, 3-phase, 60 Hz
Rated continuous load	1,250 hp
Rated speed	225 rpm
Power factor	1.0
Service factor	1.0
Starting torque	40% rated
Pull-in torque	125% rated
Pull-out torque	150% rated

1. Head was decreased due to a 1984 main condenser tube placement modification, resulting in higher circulating water flows.

11.6 Cooling Tower System

11.6.1 Design Basis

The cooling tower system is designed to remove the heat rejected to the circulating water system over the range of expected operating loads and to provide sufficient operating flexibility to return either part or all of the cooled water to the circulating water pump basin for recirculation or to return either part or all of the cooled water directly to the river via the discharge canal.

11.6.2 Description

Circulating water from the main condenser and the plant's service water heat exchangers flows through parallel chambers at the discharge structure where it is directed by vaned scoops to the suction of two parallel half-capacity cooling tower pumps.

The two cooling tower pumps are each rated 145,000 gpm (circulating water plus service water) at 57.5 feet TDH, and driven by 2,500 hp synchronous motors, as noted in Table 11.6-1. The pump motor is designed for a maximum reverse speed of 150% rated speed for protection in the event that a tripped pump has an open discharge valve when the other pump continues to run. Each pump discharges through a 66 inch diameter motor-operated butterfly valve with a 20-second operating time. Opening (and closing) of the valve is automatically synchronized with pump start (or trip) as described in Section 7.9.

A single underground steel pipe conveys the water from both pumps to two cooling towers. The pipe is 108 inches in diameter and approximately 200 feet long to the first tower, and 78 inches in diameter and 300 feet long from the first to the second tower. Each tower has two 60-inch diameter risers with a manually operated butterfly valve at grade.

As indicated in Table 11.6-2 each tower is a 9-cell, induced-draft, cross-flow tower with one 26 foot diameter fan per cell. The fans are driven by 200 hp, 1,800 rpm motors. Control equipment for the fans is located in a small fan control house adjacent to each tower and there is a hand switch in the main control room to shut down the fans.

Water flows by gravity from each tower basin through an 84 inch diameter steel pipe with a motor-operated control gate. The lines combine in a single 108 inch diameter pipe for conveying water to the intake structure where the flow diverges to parallel circulating water pump basins. The distance from the far tower to the intake structure is approximately 1,150 feet.

Two 14,000 gpm make-up pumps located at the intake structure are arranged for discharging make-up water to the circulating water pump basins as required during cooling tower operation.

Blowdown and overflow from the tower basins flows across a series of parallel weirs to the inlet of corrugated metal pipes for conveyance to the discharge canal leading to the river. The weirs permit measurement of the rate of overflow. Discharge at the canal is through a structure designed to prevent erosion of the canal banks. A final overflow weir structure is located at the end of the discharge canal. The weir structure permits the normal outflow of cooling water while preventing fish from entering the canal. The weir is an earth fill dike with a vertical sheet-pile overflow. Provision is also made for draining the tower basins through these discharge lines by manual operation of a tower gate.

Concrete isolation gates permit continued operation if one cooling tower pump is out of service for repairs.

11.6.3 Performance Analysis

At a design wet bulb temperature of 73°F, each tower is rated to reduce the temperature of 145,000 gpm of water from an inlet temperature of 116.9°F to an outlet temperature of 90°F.

Closed cycle operation with full cooling tower capacity is required only during conditions of low river flow and/or high river temperature. For this condition, the river is isolated by closing control gates at the inlet and discharge structures, and the control gates in the recirculation lines from the cooling tower basins are open. Flow through the system is stabilized by operating one circulating water pump with one cooling tower pump or both pairs of pumps. For interlocks between the pumps, refer to Section 7.9.

During periods when the river flow is insufficient for compliance with governmental restrictions, it may be necessary to operate the cooling towers in order to meet thermal restrictions on river use. In this case, the system is operated on helper cycle by closing the recirculation gates and returning water from the cooling tower basins directly to the river via the basin overflow weirs.

In the event of low river flow and a cooling tower discharge temperature higher than the upstream river temperature, the recirculation gates may be partially opened to allow only enough recirculation to satisfy the appropriate requirement.

Table 11.6-1 Cooling Tower Pump

Number of units	2
Pump	
Type	Dry pit, mixed flow
Rated flow and head	145,000 gpm at 57.5 feet TDH
Rated Speed	277 rpm
Bhp at rating	2,340 bhp
Shut-off head	97.5 feet
Shut-off load	2,720 bhp
Motor	
Type	GE type TS-V brushless synchronous
Voltage, phase, and cycles	4,000 v, 3-phase, 60 Hz
Rated continuous load	2,500 hp
Rated speed	277 rpm
Power factor	1.0
Service factor	1.0
Starting torque	40% rated
Pull-in torque	120% rated
Pull-out torque	150% rated
Maximum speed (reverse)	150% rated

Table 11.6-2 Cooling Tower

Number of towers	2
Type	Crossflow
Cells per tower	9
Tower size, L x W x H overall	270 ft x 59 ft x 61 ft
Height, curb to stack/stack	47 ft/14 ft
Static pumping head above curb	42.7 ft
Rated performance	
Water flow, total for two towers	290,000 gpm
Water temperature, entering/leaving	116.9°F/90°F
Heat transfer	3,900 x 10^6 Btu/hr
Wet bulb temperature	73°F
Fans	
Number per cell	1
Number of blades/diameter	9/26 ft
Fan speed/TIP speed	146 rpm/11,925 fpm
Capacity per fan	1,316,939 SCFM
Fan bhp	193.5 bhp
Motor hp/speed	200 hp/1,800 rpm
Fan blade material	Fiberglass reinforced, vinyl ester resin

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11.7 Condensate Demineralizer System

11.7.1 Design Basis

The design basis of the condensate demineralizer system is as follows:

a. To remove dissolved and suspended solids from the reactor feedwater to maintain a high reactor feedwater quality. High quality water minimizes the possibility of scaling deposits and solids buildup in the reactor which could affect fuel performance and accessibility to reactor primary system components, and reduces the capacity required for the reactor cleanup demineralizer system.

b. To protect the reactor water-steam system from entry of foreign materials, such as could occur due to main condenser leaks.

c. To provide final polishing of make-up water entering the reactor feedwater loop.

d. To maintain high water-purity water rejected to condensate storage and transfer system.

11.7.2 Description

The condensate system pumps take suction from the main condenser hotwell and discharge through the steam jet air ejector condensers and gland seal steam condenser to the full flow condensate demineralizer system to insure a supply of high purity water to the reactor. The condensate demineralizer P&ID is shown in Drawings NH-36038 and NH-36038-2, Section 15.

The condensate demineralizer system consists of five demineralizer vessels operating in parallel and sized for full condensate flow at reactor rated conditions. In addition to demineralizer vessels, the condensate demineralizer system includes the associated piping, valving, instrumentation and controls for proper operation and protection against malfunction. Instrumentation includes automatic flow balancing control to maintain equal flow through each on-stream unit.

The condensate demineralizer system is controlled from local panels and designed for computer based control initiation. Valves, pumps, and instrumentation are remotely operated. Integrated flow and conductivity monitors are provided for each demineralizer to indicate when a unit is exhausted. Suitable alarms are provided.

The demineralizer vessels are located in shielded cells. Wastes from an exhausted unit are transferred to the radwaste system for disposal.

A bypass line, with an automatic flow control valve around the demineralizer, is provided to maintain system flow in case the demineralizers in service are insufficient to maintain the required flow. The condensate demineralizer system pressure drop controls the system bypass valve. The effluent is monitored to assure that water quality is within acceptable limits. When the limiting conductivity is approached, an alarm is actuated to alert the operator to take appropriate action.

11.7.3 Performance Analysis

The condensate demineralizer system is sized to process the peak condensate impurity concentrations, which may occur for periods up to about a week during plant startup, as well as handle lower concentrations during extended full power operation.

Radioactive impurities in the condensate requiring removal occur from:

a. Corrosion products from main steam line, turbine, main condenser, condensate and feedwater systems and the steam side of feedwater heaters;

b. Corrosion product and solid fission product carry-over from the reactor in the steam;

c. Fission products occurring in the condensate as volatized iodine and radioactive daughters of fission gases, if fuel leaks are present.

While the radioactivity effects from the above sources do not measurably affect the capacity of the resins, concentration of radioactive material requires shielding which is provided for the condensate demineralizer equipment.

11.8 Condensate and Reactor Feedwater Systems

11.8.1 Design Basis

The condensate and reactor feedwater systems provide feedwater to the reactor to maintain a constant reactor water level.

11.8.2 Description

The condensate and reactor feedwater systems take condensate from the main condenser and deliver it to the reactor at an elevated temperature and pressure. Condensate is pumped through the steam jet air ejector inter-condenser, and the steam packing exhauster by two motor driven vertical pumps each rated at one-half the total required capacity. After leaving the steam packing exhauster, it passes through the full flow condensate demineralizer system. Demineralizer effluent is then split into two parallel streams, each with three stages of feedwater heating. Feedwater, at the required suction head, then flows to the suction of the reactor feed pumps. The reactor feed pumps are also each rated at one-half the total required capacity. The flow from each of the two centrifugal motor-driven, reactor feedwater pumps goes through the fourth and fifth stages of feedwater heating and then to the reactor as shown on the P&ID, Drawings NH-36036 and NH-36037, Section 15.

11.8.2.1 Condensate Pumps

Two half capacity, centrifugal, motor-driven, vertical condensate pumps are provided in the condensate system. The condensate pumps provide the required head to pump condensate through the steam jet air ejector condensers, gland seal steam condenser, condensate polishing demineralizer, overcome flow and static resistance, and provide excess over the suction pressure requirements of the reactor feed pumps.

11.8.2.2 Reactor Feedwater Heaters

Two parallel strings of heaters, each consisting of five reactor feedwater heaters, are provided. Three heaters are located before the reactor feedwater pumps, and two heaters are located after the reactor feedwater pumps. The high pressure, high intermediate pressure, and intermediate pressure feedwater heaters have chrome-moly alloy steel shells and carbon steel heads. The low intermediate pressure and low pressure feedwater heaters have stainless steel and alloy steel shells and heads. All the feedwater heaters have stainless steel tubes. The two lowest pressure heaters have separate drain coolers while all others have integral drain coolers.

11.8.2.3 Reactor Feedwater Pumps

Two horizontal motor driven reactor feedwater pumps are provided in the reactor feedwater system. Recirculation control valves are provided in the pump discharge lines to permit recirculation of feedwater to the main condenser to assure minimum flow through the feedwater pumps. The feedwater pumps will automatically trip on high water level following transients. The automatic feature decreases the possibility of main steam line flooding following transients.

11.8.2.4 Reactor Feedwater Controls

The reactor feedwater control system is described in Section 7.7, "Turbine-Generator System Instrumentation and Control".

11.8.2.5 Ultrasonic Flow Measurement System

The generating capacity of MNGP is affected by fouling of the Feedwater Venturi Nozzles (FE-4382A/B) over the course of each fuel cycle. The nozzle fouling causes an erroneously high feedwater flow to be calculated. When input to the plant process computer, this feedwater flow result causes an erroneously high reactor power level to be calculated. Over the course of the fuel cycle, although the plant is operated at 100% calculated power, less power is actually generated. MNGP has installed the CROSSFLOW Ultrasonic Flow Meter (UFM) as a means to account for fouling of the feedwater nozzles.

The major operative components of the CROSSFLOW ultrasonic flow monitoring system used to measure feedwater flow include transducers externally-mounted on feedwater lines FW2A-143-DE and FW2B-143-DE, and an electronics cabinet mounted in the Computer Room, which contains a multiplexer, a signal conditioning unit (SCU) and a signal processing unit (SPU).

As the ultrasonic signal passes through the fluid, it is modulated by the flow turbulence (eddies) in the fluid. These eddies also modulate a second ultrasonic signal further downstream in the same way. The only difference between the two modulated signals is the displacement in time that it took for the eddies to travel between the transducer sets.

The CROSSFLOW system calculates a correction factor for the flow through each feedwater nozzle based on the eddy displacement time. The correction factor is sent to the plant computer to correct the feedwater flow rate used in the thermal power calculation. The venturi is still the primary flow measurement instrument used in the thermal power calculation. The CROSSFLOW system will indicate the degree of nozzle losses due to fouling, such that control room operators can appropriately adjust reactor power to account for the error.

11.8.3 Performance Analysis

NSPM performed an analysis to predict combined condensate and feedwater system performance for normal operation and for transients including single feedwater pump trip, feedwater control system failure and single condensate pump trip. The analysis showed that the loss of a condensate pump at high power levels could result in the loss of both reactor feedwater pumps from low suction pressure. NSPM committed that "*Prior to EPU implementation NSPM will revise operating procedures for condensate/feedwater (CFW) transient events, to take prudent actions to recover CFW flow, and place the reactor in a safe and stable condition*" (References 4 and 5). In Reference 7 the NRC noted in the discussion of SRP 14.2.1 that MNGP is equipped with motor driven reactor feedwater (FW) pumps that allows prompt restoration of FW system flow. Therefore, the revised operating procedures for transient FW system events to direct prudent actions for recovering FW system flow and placing the reactor in a safe and stable condition are acceptable to mitigate the slight increase in potential for loss of the FW system. 01101248

NSPM also committed *"to evaluating the changes in condensate and feed pump area heat load to confirm temperatures remain within design limits prior to EPU implementation. If necessary, modifications to the HVAC system for this area will be implemented to maintain these areas within the design limits."* In the condensate pump area the increased heat load was determined to require additional cooling. NSPM completed a modification to support the increased condensate pump area heat load. For the feedwater pump area the heat load with the replaced feedwater pumps was acceptable and no modification was required. (References 4 and 6)

11.9 References

1. Monticello calculation 09-239, Revision 0A, “Turbine Bypass Valve Capacity for EPU”.

2. Sargent & Lundy Evaluation No. 2007-01440, Revision 0, “Heat Rejection Systems Study for EPU Conditions”, March 7, 2007 (located in EC13638).

3. NMC EPU Project Task Report T0605, Revision 0, “Task T0605: Main Condenser/Circulating Water/Normal Heat Sink Performance and Discharge Limits”, (located in EC11813).

4. NSPM letter L-MT-13-92 (K D Fili) to NRC, “Monticello Extended Power Uprate (EPU): Completion of EPU Commitments, Proposed License Conditions and Revised Power Ascension Test Plan (TAC MD9990)”, dated September 30, 2013. 01101248

5. Engineering Change 21448, Revision 0, "Combined Condensate and Feedwater System Performance Following a Trip of a Feedwater Pump or a Trip of a Condensate Pump".

6. Engineering Change 16307, Revision 0, "EPU - Condensate Pump HVAC".

7. NRC (T A Beltz) letter to NSPM (K D Fili), "Monticello Nuclear Generating Plant - Issuance of Amendment No. 176 to Renewed Facility Operating License Regarding Extended Power Uprate (TAC No. MD9990)", dated December 9, 2013.

FIGURES

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Figure 11.5-2a Cooling Tower Open Cycle Operating Diagram

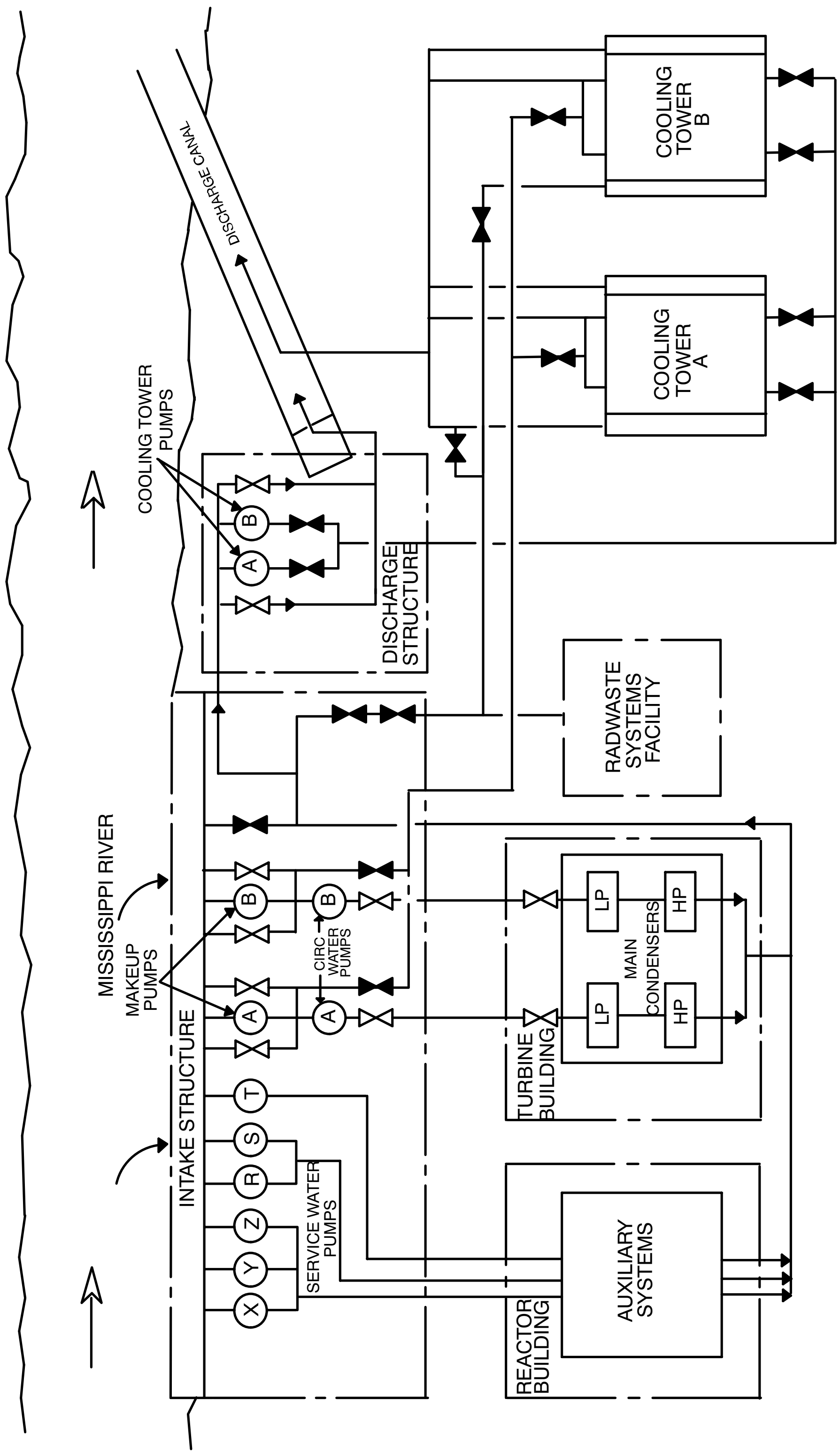

Figure 11.5-2b Cooling Tower Closed Cycle Operating Diagram

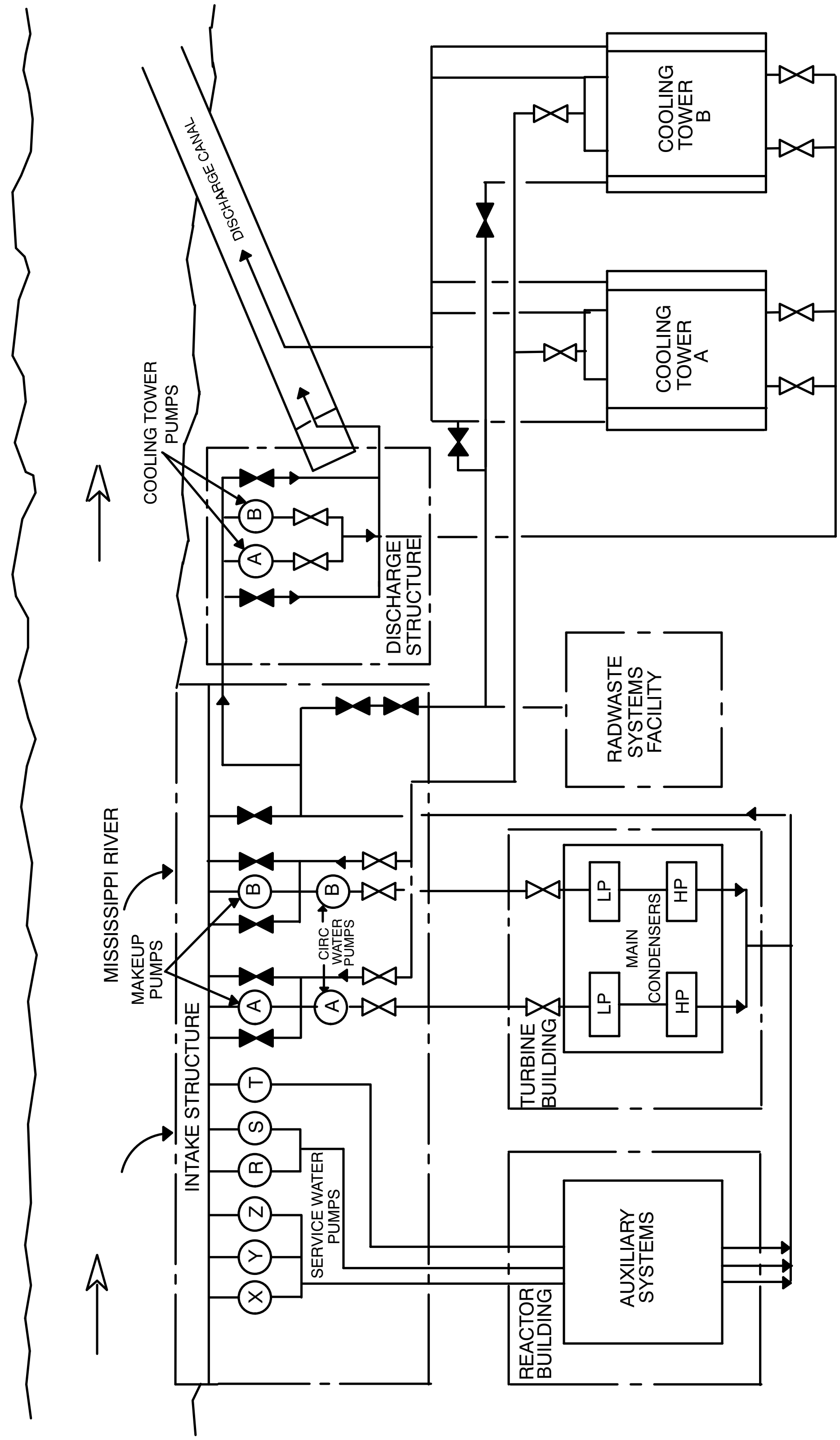

Figure 11.5-2c Cooling Tower Helper Cycle Operating Diagram

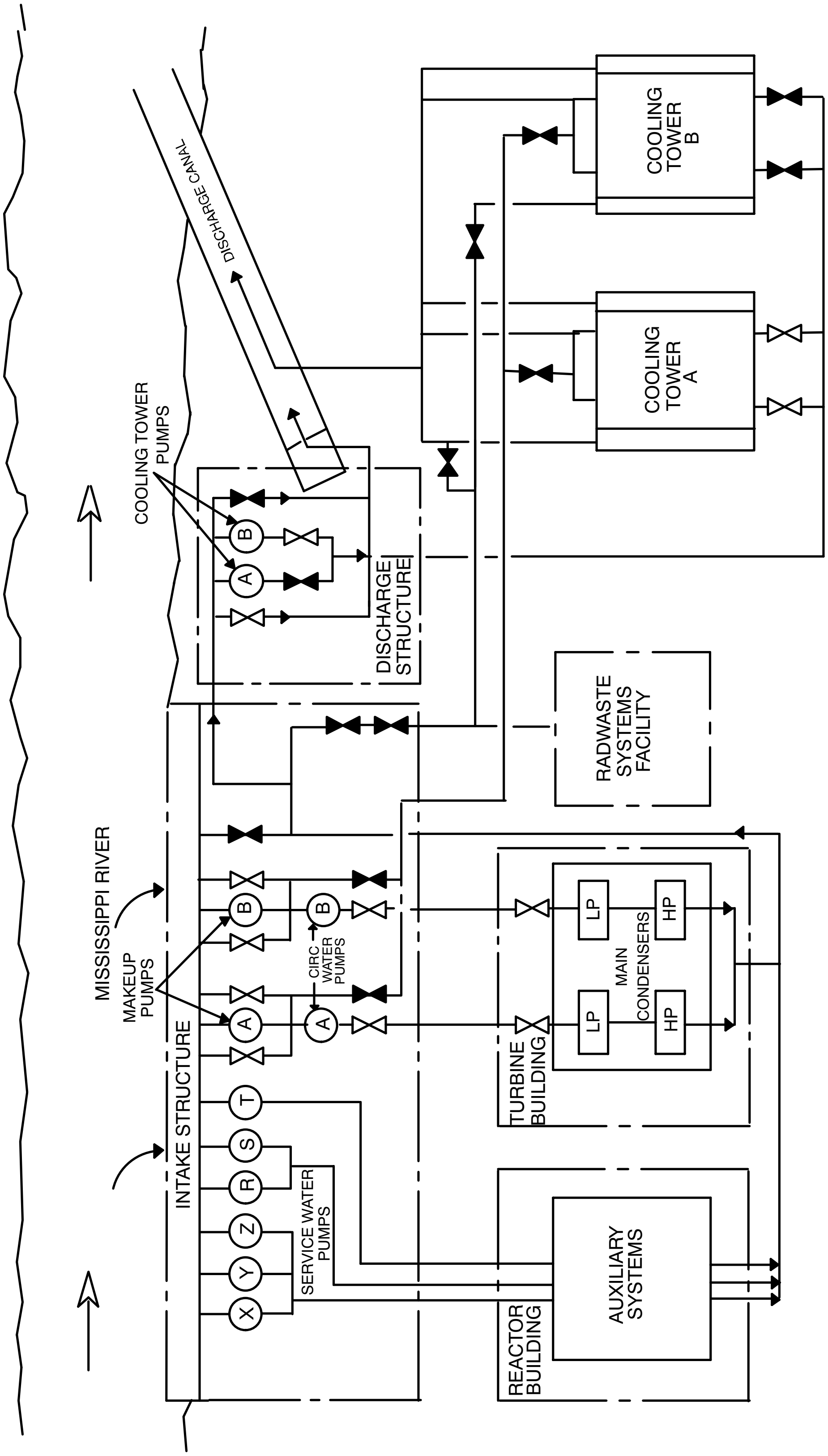

Figure 11.5-2d Cooling Tower Partial Closed Cycle Operating Diagram