XI - POWER CONVERSION SYSTEMS

PAGE

XI - POWER CONVERSION SYSTEMS (Cont'd)

LIST OF FIGURES

(At end of Section XI)

XI - POWER CONVERSION SYSTEMS

1.0 SUMMARY DESCRIPTION

The power conversion systems are designed to produce electrical energy through conversion of a portion of thermal energy contained in the steam supplied from the reactor, condense the turbine exhaust steam into water, and return the water to the reactor as heated feedwater, with a major portion of its gaseous, dissolved, and particulate impurities removed. An overall schematic of the power conversion systems is provided in the Heat Balance, Siemens Energy Drawing DPPPG6002043800 B008247-980500 Sheet 5.

The major components of the power conversion system are: turbine-generator, main condenser, condensate pumps, air ejector, Turbine Gland Seal system, Turbine Bypass system, condensate filter-demineralizers, condensate booster pumps, feedwater heaters, reactor feed pumps, and Condensate Storage system. The heat rejected to the Main Condenser is removed by the circulating water system.

The saturated steam produced by the boiling water reactor is passed through the high pressure turbine where the steam is expanded and then exhausted through the moisture separators. Moisture is removed in the moisture separators and the steam is then passed through the low pressure turbines where the steam is again expanded. From the low pressure turbines, the steam is exhausted into the condenser where the steam is condensed and deaerated, and then returned to the cycle as condensate. A portion of the main steam supply is continuously used by the steam jet air ejectors. During startup and at lower power levels a portion of main steam is used by the reactor feed pump drive turbine and the turbine gland seal system. The condensate pumps, taking suction from the condenser hotwell, deliver the condensate through the air ejector condensers, turbine gland seal condenser, and the condensate demineralizer to the condensate booster pumps which pump the condensate through five stages of feedwater heaters to the reactor feed pumps. The reactor feed pumps supply feedwater to the reactor. Normally, the turbine utilizes all the steam being generated by the reactor, however, an automatic pressure-controlled steam bypass system is provided to discharge excess steam up to 25% of the design flow directly to the condenser.

The power conversion systems are designed for the turbine-generator maximum capacity based on the full power operation of the LP Turbines at rated thermal power.

2.0 TURBINE-GENERATOR

2.1 Power Generation Objective

The objective of the Turbine-Generator is to receive steam from the boiling water reactor, economically convert a portion of the thermal energy contained in the steam to electric energy and provide extraction steam and moisture for feedwater heating.

2.2 Power Generation Design Basis

The Turbine-Generator and the associated systems, and their control characteristics, are integrated with the features of the reactor and associated nuclear systems to obtain an efficient and safe power generating unit.

2.3 Description

The Turbine-Generator consists of the following components: turbine, generator, exciter, controls, and required subsystems.

The turbine is an 1,800 rpm tandem-compound, non-reheat unit with 46-inch last stage blades. It consists of a double flow high pressure turbine and two double flow low pressure turbines. There are eleven stages in the high pressure turbine and nine stages in each low pressure turbine. Exhaust steam from the high pressure turbine passes through moisture separators before entering the two low pressure turbines. The separators reduce the moisture content of the steam to close to zero percent.

The generator is a direct-coupled, three-phase, 60 Hertz, 22,000 volt, hydrogen inner-cooled armature-winding, synchronous generator rated at 983,000 kVa, a short circuit ratio of 0.60 and a maximum hydrogen pressure of 60 psig. The exciter system is a rotating rectifier brushless type, 1,800 rpm, rated at 4,000 kW at 500 volts.

The turbine utilizes a Digital Electro-Hydraulic (DEH) control system consisting of solid state governing devices, governor, startup control devices, emergency devices for turbine and plant protection (overspeed governor, master trip, vacuum trip, motoring protection, thrust bearing wear trip, low bearing oil pressure trip) and special control and test devices. The system operates the main stop valves, governor valves, bypass valves, reheat stop and interceptor valves, and other protective devices. Turbine governor functions and turbine control is covered more fully under Control and Instrumentation, USAR Section VII-11, "Pressure Regulator and Turbine-Generator Control".

Rupture diaphragms are provided on the turbine exhaust hoods for over-pressure protection of them, as well as the condenser shells.

The Turbine-Generator is provided with supervisory instrumentation in the Main Control Room.

2.4 Turbine Missile Analysis[1]

The Turbine-Generator at CNS has two low pressure turbines, with each low pressure turbine containing six discs shrunk on a shaft with three discs per flow. The low pressure turbine casing is designed to prevent rupture due to disc failure at 120% design overspeed conditions. See USAR

Section VII-11.3.3 for discussion of main turbine overspeed protection. The summary of the analysis with regards to the 120% rated overspeed protection is as follows:

> A process of interaction between missile analysis resulting from a hypothetical turbine rotor burst-type failure of low pressure shrunk-on disks of 1800 rpm turbines designed for nuclear power plant applications and turbine casing is considered.
>
> The analysis covers the case of low pressure disk failure at 120% of rated and burst speed.
>
> The initial missile energy at the moment of rotor burst and the energy dissipation as the missile crashes through the inner and outer turbine casings are compared. A fragment that becomes a missile at 120% of rated speed or less will not have enough energy to escape the turbine casing.
>
> The turbine structure is designed to withstand missile effects for normal operation, i.e., the inner and outer casing are designed to resist disk missile impact at more than 120% of rated speed.

2.5 Power Generation Evaluation

The following abnormal operational transient analyses have been made for a component failure in the Turbine-Generator system and are included in USAR Chapter XIV, "Station Safety Analysis" and USAR Appendix G, "Nuclear Safety Operational Analysis":

1. Generator trip (turbine control valve fast closure)
2. Turbine trip (turbine stop valve closure)
   a. Turbine trip from high power with bypass
   b. Turbine trip from high power without bypass
3. Pressure regulator malfunction
4. Closure of the main steam isolation valves
   a. All valves
   b. One valve
5. Loss of main condenser vacuum.

2.6 Inspection and Testing

The Turbine-Generator is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Oil Analysis (see USAR Section K-2.1.28), and Water Chemistry Control - BWR (see USAR Section K-2.1.39). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

3.0 MAIN CONDENSER

3.1 Safety Objective

The safety objective of the Main Condenser is to provide the capability to limit the release of fission products in the event of a postulated design basis Loss-of-Coolant Accident so that offsite doses will not exceed the guideline values set forth in 10CFR50.67 or in the event of a Control Rod Drop Accident so that offsite doses will not exceed the guideline values set forth in 10CFR100, and Control Room occupant doses will not exceed GDC 19 limits.

3.2 Safety Design Basis

The Main Condenser provides MSIV leakage holdup and the resulting iodine partitioning and plateout within the condenser so that offsite doses for a LOCA do not exceed the guideline values set forth in 10CFR50.67, offsite doses for a CRDA do not exceed the guideline values set forth in 10CFR100, and Control Room occupant doses for a CRDA will not exceed GDC 19 limits.

3.3 Power Generation Objective

The objective of the Main Condenser is to provide a heat sink for the turbine exhaust steam, turbine bypass steam and other flows. It also provides deaeration and storage capacity for the condensate, which is reused after a period of radioactive decay (approximately two minutes).

3.4 Power Generation Design Basis

The Main Condenser is designed for the following conditions:[12]

1.	Condenser Duty	5.6×10^9 Btu/hr
2.	Circulating Water Inlet Temperature	67.1°F
3.	Cleanliness Factor	90%
4.	Number of Passes	1
5.	Circulating Water Velocity	7.5 ft/sec.
6.	Pressure (Single)	2.0 in Hg Abs.

3.5 Description

During normal operation, steam from the low pressure turbine is exhausted directly downward into the condenser shells through exhaust openings in the bottom of the turbine casings. The condenser serves as a heat sink for several other flows such as the reactor feed pump drive turbine exhaust, cascading heater drains, air ejector inter-condenser drain, gland seal condenser drain, feedwater heater shell operating vents, and condensate pump suction vents.

During abnormal conditions the condenser is designed to receive (not all simultaneously) flow from turbine bypass steam, feedwater heater high level dump(s), and relief valve discharges (crossover steam line, feedwater heater shells, steam seal regulator, various steam supply lines).

There are other periodic flows into the condenser such as condensate and reactor feed pump startup vents, reactor feed pump minimum recirculation flow, feedwater lines startup flushing, turbine equipment clean drains, low point drains, extraction steam spills, makeup, and condensate.

The Main Condenser is a single pass, horizontal tube unit, cooled by river water. It consists of two shells, one for each low pressure turbine exhaust. Each half capacity condenser has one feedwater heater located in its neck. It has an effective condensing surface area of 465,000 sq. ft., utilizing 7/8 in. O.D., 22 BWG, 40 ft. long stainless steel tubes. The design circulating water flow rate is 631,000 gpm.

Each condenser shell has divided waterboxes, which permits isolation of the circulating water on one-half shell while the other half remains in operation. The arrangement of circulating water piping allows backwashing of the condenser to remove possible debris accumulated on the inlet tubesheets.

The hotwell storage capacity is sufficient for two minutes storage plus three minutes retention or a total of five minutes at rated flow. The condenser is located beneath the low pressure cylinders of the main turbine. Condenser tubes are located transversely to the turbine generator axis.

Tapered wooden wedges have been installed between condenser tubes in regions of high steam velocity.[3] These wedges reduce the chances of a tube failure caused by vibration induced by high steam velocities. The wedges, in effect, increase the number of tube supports for the selected locations and change the natural vibration frequency of the tubes.

With this arrangement there are two considerations for satisfactory plant operation: (1) chemical and physical compatibility and, (2) the possibility of a wedge coming loose and damaging the condensate pumps.

With regard to the former consideration wood has no chemical and physical properties that would contaminate the condensate supply system.

When the wedges are properly installed, they should not work their way out. If, however, a wedge were to break loose, it would float and remain in the hotwell. If the wedge would work itself to the condensate suction line, the screen would prevent the wedge from being sucked into the pumps' impellers.

To accommodate thermal expansion a rubber belt expansion joint is provided for each condenser neck. Equalizing connections between the two condenser shells are provided for both the steam space and hotwell.

To provide for detecting tube sheet leakage of the circulating water into the condenser, collecting troughs are located at the tube sheet below the tubes. The troughs are monitored by conductivity elements in order to detect in-leakage of the river water.

The Main Condenser is equipped with deaerating type hotwells to provide deaeration of the condensate leaving the condenser. It is designed to maintain an oxygen content of 0.005 cc per liter or less. The noncondensible gases are concentrated in the air cooling section of the condenser, and removed by the steam jet air ejectors. To permit a two minute decay period of the condensed steam, the condenser hotwells are equipped with the necessary baffles.

3.6 Safety Evaluation

Main Steam piping directs MSIV leakage from the MSIVs to the Main Condenser. This allows crediting the dose consequence mitigation assumptions described in Section XIV-6.2.7 and XIV-6.3.8.3.2 for a Control Rod Drop Accident or Loss-of-Coolant Accident (LOCA). The Main Condenser is a Class II SSC. As part of the licensing of the LOCA dose calculations, the NRC has required that the Main Condenser be evaluated as capable of withstanding the seismic loadings of a postulated Safe Shutdown Earthquake. Details of the evaluation that established the Main Condenser seismic ruggedness are described in Section XII-2.3.5.3.

3.7 Inspection and Testing

The Main Condenser is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. There are no aging effects that required management by USAR Appendix K Aging Management Programs. There are no Time-Limited Aging Analyses that are applicable.

4.0 MAIN CONDENSER GAS REMOVAL AND TURBINE SEALING SYSTEMS

4.1 Power Generation Objective

The objective of the Main Condenser Gas Removal system is to remove all noncondensible gases from the condenser.

The objective of the Turbine Sealing system is to prevent air leakage into, or steam leakage out of the turbine.

4.2 Power Generation Design Basis

4.2.1 Main Condenser Gas Removal System

The Main Condenser Gas Removal system is designed to remove all noncondensible gases from the condenser including air in-leakage and disassociation products originating in the reactor, and exhaust them to the off-gas system. The size of the gas removal system is determined by taking into consideration potential air in-leakage, the oxygen and hydrogen formed by disassociation of water in the reactor, and the water vapor contained in the gas mixture.

4.2.2 Turbine Sealing System

The Turbine Sealing system is designed to provide the means of automatically sealing with steam the turbine shaft glands and the valve stems (main stop, governor, interceptor, and bypass valves).

4.3 Description

4.3.1 Main Condenser Gas Removal System

The Main Condenser Gas Removal system includes two steam jet air ejector units complete with inter- and after-condensers to remove air and noncondensible gases from the Main Condenser. Mechanical vacuum pumps are provided for startup and shutdown. (See Burns and Roe Drawing 2009).

4.3.1.1 Steam Jet Air Ejectors

Each Steam Jet Air Ejector (SJAE) is a full-capacity, two-stage twin-element unit with an automatic steam pressure reducing station. Each SJAE element (four total) is capable of handling one of the two Main Condenser shells. Piping and valving are arranged so that one SJAE unit with both first stages and both second stages working can evacuate both Main Condenser shells. Alternatively, both SJAE units each with one first stage and one second stage element working can evacuate both shells. Another option is to place one first stage from each SJAE unit in service with all four second stages in service.

The air ejector uses main steam reduced in pressure from 950 psig to 300 psig as the driving medium.

Air in-leakage and noncondensible gases, as well as entrained water vapor, are removed from the condenser by the first stage jets. The gas-vapor mixture is then discharged and condensed in the inter-condenser. The resulting condensate is drained back to the Main Condenser. The second stage ejector removes the resulting noncondensible gases and water vapor from the inter-condenser, discharging them into the after-condenser. The after-condenser drain is also drained back to the Main Condenser. Manways have been installed on each waterbox of the SJAE to allow checking for and, if necessary, repair of tube leaks in the SJAE condensers.[4]

The noncondensible gases and entrained vapor from the after-condenser are then exhausted to the Off-Gas system. The air ejector exhaust is metered, sampled, and monitored prior to entering the off-gas holdup piping. USAR Section VII-12, "Process Radiation Monitoring", contains a detailed description of the Air Ejector Off-Gas Radiation Monitor and USAR Section IX-4.3.1.2, contains a detailed description of the system response to the Air Ejector Off-Gas Radiation Monitor.

4.3.1.2 Mechanical Vacuum Pumps

Two mechanical vacuum pumps are provided to remove air and noncondensible gases from the main condenser during startup and shutdown when adequate steam pressure is not available to operate the Steam Jet Air Ejector and the volume of air and gases exceeds the capacity of the air ejector. The discharge of the mechanical vacuum pump is routed to the gland seal holdup system, in view of the fact that the average gaseous activity is expected to be low under such circumstances of startup and shutdown.

The mechanical vacuum pump discharge is also isolated by automatically tripping the mechanical vacuum pump inlet and outlet valves upon sensing a main steam high radiation signal (see USAR Section VII-12, "Process Radiation Monitoring").

4.3.2 Turbine Sealing System

The Turbine Sealing system consists of the steam seal pressure regulator, steam seal header, gland seal condenser, two full-capacity exhaust blowers and the associated piping and valves. The steam seal pressure regulator maintains the steam seal header at constant pressure.

On pressure packings (high pressure turbine and valve stems) sealing steam leakage is extracted. On sub-atmospheric glands (low pressure turbines) steam sealing is supplied from the steam seal header. The outer ends of all glands are routed to the gland seal condenser, which is maintained at a slight vacuum by the exhaust blowers. During planned operation one blower is operating while the other is in standby. The exhaust blowers deliver air and noncondensible gases to the gland seal holdup system. The gland seal condenser is cooled by main condensate flow after it passes through the air ejector condensers.

The Main Turbine Sealing Steam system also supplies regulated sealing steam to, and receives leakoff steam from the reactor feed pump seals.

A cross-connection exists between the House Heating Steam system and the Main Steam system which is capable of providing gland sealing steam to the main turbine[5] depending upon the availability of the Auxiliary Steam Boilers. Inadvertent release of radioactivity is precluded by two normally closed isolation valves, with the zone between these valves vented to the condenser.

4.4 Inspection and Testing

The Turbine Sealing system is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Flow-Accelerated Corrosion (see USAR Section K-2.1.18), and Water Chemistry Control - BWR (see USAR Section K-2.1.39). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

5.0 TURBINE BYPASS SYSTEM

5.1 Power Generation Objective

The objective of the Turbine Bypass system is to dissipate the energy of main steam generated by the reactor, which cannot be utilized by the turbine.

5.2 Power Generation Design Basis

1. The Turbine Bypass system is designed to control reactor pressure: (1) during reactor heatup to rated pressure, (2) while the turbine is brought up to speed and synchronized, (3) during power operation when the reactor steam generation exceeds the transient turbine steam requirements and limitations, and (4) when cooling down the reactor.

2. The Turbine Bypass system capacity is based on 25% of the turbine design flow.

5.3 Description

The Turbine Bypass system consists of three automatically operated regulating valves mounted on a valve discharge manifold. Each valve is connected to a branch from the main steam line manifold upstream of the turbine main stop valves. The bypass valve outlet manifold is piped to the main condenser. (See Burns and Roe Drawing 2002, Sheets 1 and 2).

The basic operation of the Turbine Bypass system is that it receives from the turbine control system (initial pressure regulator) a signal to open the bypass valves whenever the actual steam pressure exceeds the preset steam pressure by a small margin. This occurs whenever the amount of steam generated by the reactor cannot be entirely absorbed by the turbine.

The bypass valves will be tripped closed whenever the vacuum in the main condenser falls below approximately seven in. Hg vacuum (see USAR Chapter VII, Control and Instrumentation). Also the bypass valves will fail closed upon loss of motive oil pressure.

5.4 Power Generation Evaluation

The effects of malfunctions of the Turbine Bypass system and the effects of such failure on other components are evaluated in USAR Chapter XIV, Station Safety Analysis.

6.0 CIRCULATING WATER SYSTEM

6.1 Power Generation Objective

The objective of the Circulating Water system is to provide the Main Condenser with a continuous supply of cooling water for removing the heat rejected by the turbine exhaust and turbine bypass steam as well as from other incidentals over the full range of operating loads.

6.2 Power Generation Design Bases

1. Provide the required river water flow to the condenser.

2. Provide debris removal from the river water used.

3. Provide condenser backwash for the inlet tube-sheet cleaning.

4. Provide river water to the screen wash pumps.

5. Conduct Service Water system returns back to the river.

6.3 Description

The Circulating Water system uses water taken from the Missouri River. Water passes through trash racks and then through traveling screens. A major portion of the flow is directed to the Circulating Water pumps, which deliver water to the main condenser. A smaller portion of Missouri River water is used by the Service Water pumps discussed in USAR Section X-8. The discharge from the condenser and from the Service Water system is returned via the discharge channel to the river. (See Burns and Roe Drawing 2006, Sheets 1 through 4).

A trash rack is installed in front of the traveling screens to retain pieces of debris larger than three inches. The traveling screens will retain particles 1/8 x 1/2 inches and larger for the Circulating Water system and 5 mm and larger for the Service Water system.

A guide wall and an array of submerged flow turning vanes has been installed east of the Intake Structure in order to streamline the river flow in front of the Intake Structure and reduce the amount of silt and sand entering the structure. Additional details of the guide wall are provided in USAR Section XII-2.2.7.2.

The system has four sets of two each traveling water screens in parallel, each set to remove debris for each Circulating Water pump plus one screen serving the Service Water bay. Debris is removed from the screens by the spray wash assembly. The spray wash assembly and/or the traveling screens may be turned off for short periods of time (≤ 7 days) so that maintenance may be performed. The Intake Structure (see USAR Chapter XII) is divided into five bays, one for each of the Circulating Water pumps and one for the four Service Water pumps. Water can also be fed to the Service Water bay from the adjacent Circulating Water pump bay. A water jet sparger system is provided in the Circulating Water pump bays to clear light particles and keep smaller particles in suspension. Additional details of the sparger system are provided in USAR Section X-8. There are four Circulating Water pumps, with a rated head of 35 feet and a rated flow of 159,000 gpm each for a total of 636,000 gpm, of which 5,000 gpm is designated for miscellaneous losses. The pumps are vertical, mixed flow, wet pit type. The pump drivers are brushless synchronous motors rated 1,750 Hp, 277 rpm, 4,160 volts, 3-phase, 60 Hertz.

At the rated circulating water flow of 631,000 gpm through the condenser and at design power on the turbine-generator, the temperature rise through the condenser is approximately 17.8°F.

The condenser tubes can be cleaned by backflushing. This is accomplished by sequentially operating the inlet water box valves, the crossover and outlet valves and backwash valves so that the water will then flow in the normal direction through one side of each condenser shell, crossover and flow in the reversed direction through the other side, and discharge through the backwash connection to the discharge tunnel. The second side of each shell would be backwashed in a similar manner. Both condenser shells are only backwashed simultaneously if the REACTOR MODE switch is not in RUN.

Connections are provided to allow chemical injection into the Circulating Water System.

6.4 Inspection and Testing

The Circulating Water system is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), One-Time Inspection (see USAR Section K-2.1.29), and Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31). There are no Time-Limited Aging Analyses that are applicable.

7.0 CONDENSATE DEMINERALIZER SYSTEM

7.1 Power Generation Objective

The objective of the Condensate Demineralizer system is to maintain the required purity of feedwater to the reactor.

7.2 Power Generation Design Basis

The Condensate Demineralizer system is designed to remove the following contaminants from the feedwater:

1. Corrosion products that result from the corrosion and erosion that occurs in the main steam, turbine extraction, feedwater heater shells and drains.

2. Suspended and dissolved solids which may be introduced by small leakages of circulating water into the condenser.

3. Fission products which may be released by failed fuel elements.

4. Solids carried in by the makeup water.

7.3 Description

To assure the specified conditions and to produce the best feedwater quality attainable, a full flow Powdex condensate filter demineralizer system is provided. (See Burns and Roe Drawing 2035, Sheets 1 through 4).

The Condensate Demineralizer system consists of seven Powdex filter demineralizers and an external precoat system. In addition, the condensate demineralizer system includes the associated piping, valving, instrumentation, and controls for proper operation and protection against malfunction. Piping is furnished in accordance with ANSI B31.1.0. The design pressure of the condensate side of the system is 200 psig.

The demineralizer system is controlled from local panels and designed for pushbutton control initiation; valves and pumps are remotely operated. Integrated flow and conductivity monitors are provided for each demineralizer to indicate when its resin is exhausted. Suitable alarms and differential pressure indicators are provided and system influent and effluent conductivity is monitored. The Condensate Demineralizer system is sized to process condensate impurity concentration during planned operations and peak contamination periods.

Each filter demineralizer contains filter elements, upon which a layer of Powdex resins is coated to a thickness of about ¼ inch. The Powdex resin is a finely ground mixture of anion and cation resins which forms a floc-type coating on the elements. Due to its consistency, the resin coating provides mechanical filtration for particulates and ion exchange for impurities in solution.

The resin coating is maintained on the filter elements by virtue of condensate flow, which is directed from the outside towards the center of the elements. In order to maintain this coating, adequate flow is ensured by 1) balancing the number of filter demineralizer units in service so that equal flow through each unit is provided, and 2) employing a holding pump on out-of-service units when unit flow drops below 800 gpm.

Resin is determined to be exhausted based on either high filter demineralizer unit differential pressure (indicative of high particulate loading) or on high effluent conductivity (evidence of depletion of the ion exchange capability). Upon evidence of exhaustion, the unit is removed from service. The spent resin is then backwashed and a new Powdex resin coating is applied.

Certain expected radioactive material originating from corrosion product and fission product carryover from the reactor will be removed by the demineralizers. Backwash from the filter demineralizers is sent to the Radwaste system for disposal [see USAR Chapter IX, Radioactive Waste (Radwaste) Systems].

7.4 Inspection and Testing

The Condensate Demineralizer system is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Flow-Accelerated Corrosion (see USAR Section K-2.1.18), and Water Chemistry Control - BWR (see USAR Section K-2.1.39). There are no Time-Limited Aging Analyses that are applicable.

8.0 CONDENSATE AND FEEDWATER SYSTEM

8.1 Power Generation Objective

The objective of the Condensate and Feedwater system is to provide a dependable supply of feedwater to the reactor, to provide feedwater heating, and to maintain high quality feedwater.

8.2 Power Generation Design Bases

1. Provide the required flow to the reactor with sufficient margin under normal and anticipated transient conditions.

2. Provide feedwater at the required feedwater temperature to the reactor.

3. Provide a startup recirculation line from the reactor feed pump suction lines to the condenser hotwell for the purpose of minimizing corrosion product input to the reactor during startup conditions.

8.3 Description

Three one-third capacity motor-driven, condensate pumps take the condensate from the condenser hotwells and pump it through the air ejector condensers, gland seal condenser, and condensate demineralizers. Demineralizer effluent is then pumped by three one-third capacity motor-driven condensate booster pumps into two parallel streams, each with five stages of feedwater heaters. Common bypass lines around the first two heaters, the third and fourth, and the fifth heater are provided. Two one-half capacity turbine-driven reactor feed pumps then deliver the feedwater through parallel 18" lines to four 12" (see Burns and Roe Drawing 2004, Sheets 1 through 3) reactor feedwater inlets.

8.3.1 Condensate and Condensate Booster Pumps

Each condensate pump is a multi-stage vertical, canned suction type, centrifugal unit. The pumps are installed at an elevation that permits full capacity operation at any level in the condenser hotwell, including extreme low level. The pumps provide the maximum design flow, plus design margins at the required pressure including static head, friction loss, and the required suction head of the condensate booster pumps. The pumps are rated at 7,500 gpm and 320 ft. total head at 1,187 rpm when pumping 101.2°F condensate. The motors are rated each 800 Hp, 1,180 rpm, 4,160 V, 3-phase, 60 Hz and are induction, open drip-proof units with vertical shafts.

Each condensate booster pump is a single stage horizontal centrifugal unit. The pumps provide the maximum design flow, plus design margins, at the required pressure including static head, friction loss, and the required suction head of the reactor feed pumps. The pumps are rated at 7,500 gpm and 960 ft. total head at 3,580 rpm when pumping 103°F condensate. The motors are rated each 2,500 Hp, 3,580 rpm, 4,160 V, 3-phase, 60 Hz and are induction, open drip-proof units.

8.3.2 Feedwater Heaters

The five feedwater heaters of each train are U-tube units with integral drain coolers. Feedwater flow is tubeside, and the temperature rise through each train is approximately 260°F at design flow.

All heaters have stainless steel tubes and welded tube to tubesheet joints.

A description of the abnormal operational transient resulting from a loss of feedwater heating is in USAR Section XIV-5, "Analyses of Abnormal Operational Transients".

8.3.3 Reactor Feed Pumps

Each reactor feed pump is a single-stage, horizontal, centrifugal unit. The pumps operate in series with the condensate and condensate booster pumps and provide the maximum design flow plus design margins at the required pressure at the reactor inlet nozzles. The pumps are rated at 12,800 gpm and 2,500 ft. total head at 5,500 rpm when pumping 370°F water. The drive turbines are rated at 8,320 Hp at 5,500 rpm.

The motive steam for the reactor feed pump drive turbines is normally supplied by low pressure extraction steam from the "A" and "B" moisture separators.

The feedwater control system is described in USAR Section VII-10.

8.3.4 Reactor Feed Pumps Turbine Missile Analysis[1]

The reactor feed pumps are located in a shielded room in the basement of the Turbine Building. This room is composed of reinforced concrete walls of the following thicknesses: 30" along the west and south walls, 28" along the east wall, and 48" along the north wall with a 36" reinforced concrete floor slab as the room's ceiling.

Although it is extremely unlikely, it can be hypothesized that the protective devices and turbine rotor could fail, thereby generating missiles. In this event, a low trajectory missile would have to penetrate a 30" shield wall plus a 24" Turbine Building exterior wall before reaching the east basement wall of the Reactor Building which is approximately 36" thick. For potential high trajectory missiles, the missile would have to penetrate a 36" mezzanine floor slab plus a 48" operating floor slab, or a 42" wall in the Turbine Building before reaching the Reactor Building.

In consideration of the massive concrete structures surrounding the reactor feed pumps, it is concluded that it is impossible for a missile generated from these pumps to do any damage to the Reactor Building resulting in a hazardous release of fission products.

8.4 Inspection and Testing

The Condensate system is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Flow-Accelerated Corrosion (see USAR Section K-2.1.18), Oil Analysis (see USAR Section K-2.1.28), and Water Chemistry Control - BWR (see USAR Section K-2.1.39). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).}

The Feedwater system is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Flow-Accelerated Corrosion (see USAR Section K-2.1.18), and Water Chemistry Control - BWR (see USAR Section K-2.1.39). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

9.0 CONDENSATE STORAGE SYSTEM

9.1 Power Generation Objective

The power generation objective is to provide condensate for system makeup needs, and to take system "reject" surges.

9.2 Power Generation Design Basis

The Condensate Storage system provides station system makeup, receives system reject flow, and provides condensate for any continuous service needs and intermittent batch type services. The total stored design quantity is based on the demand requirements during refueling for filling the dryer separator pool and the reactor well and, for coping with a Station Blackout special event.

9.3 Description

One 450,000-gallon (1A) and one 700,000-gallon (1B) capacity Condensate Storage Tank (CST) supply the various station requirements as shown on Burns and Roe Drawing 2004, Sheets 1 through 3. They can receive demineralized makeup water from the water treatment plant (USAR Section X-11) or reprocessed water from the radwaste system (USAR Section IX-2). The tanks are constructed of coated carbon steel with electric heaters for anti-freeze protection. The 700,000-gallon tank is complete with a steel retaining wall. The purpose of the retaining wall is to prevent spillage from a tank rupture or overflow of radioactive water onto the surrounding site and into the Missouri River.[6]

The suctions to the Core Spray and Residual Heat Removal pumps (only RHR Pump A and RHR Pump D) can also be lined up to CST 1A. (See USAR Section VI-4.3 and Section VI-4.4.)

Two 50,000 gallon Emergency Condensate Storage Tanks (ECST) located in the basement of the Control Building provide water for the HPCI system (see USAR Section VI-4.1) and the RCIC system (see USAR Section IV-7). These tanks are supplied by the main CSTs.

The ECSTs have adequate inventory for reactor coolant makeup via the HPCI and RCIC systems during a four hour Station Blackout coping duration.[8][9][10][11] During this special event, 69,348 gallons are needed for heat removal (which includes 15,840 gallons for recirculation pump seal leakage and maximum allowable RCS leakage by Technical Specifications). During a Station Blackout, the normal Condensate Storage Tanks can be aligned to fill and maintain ECST level.[8][9][10][11][13] The Station Blackout special event is described in USAR Section XIV-5.

9.4 Inspection and Testing

The Condensate Storage system is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Selective Leaching (see USAR Section K-2.1.34), and Water Chemistry Control - BWR (see USAR Section K-2.1.39). There are no Time-Limited Aging Analyses that are applicable.

10.0 REFERENCES FOR CHAPTER XI

1. Siemens Technical Report S32M7 10409, Dated 12/10/2004.

2. Deleted.

3. MDC 76-106.

4. MDC 76-19.

5. Letter Davis (Burns & Roe) to Pratt (GE) dated January 2, 1975. 17523 0391.

6. MDC 84-095.

7. Deleted.

8. NRC Safety Evaluation of the CNS Response to the Station Blackout Rule dated August 22, 1991.

9. NRC Supplemental Safety Evaluation of the CNS Response to the Station Blackout Rule dated June 30, 1992.

10. NRC Supplemental Safety Evaluation and Closeout of Staff Review of the CNS Response to the Station Blackout Rule dated November 19, 1992.

11. Enercon Services Report NPP1-PR-01, "Station Blackout Coping Assessment for Cooper Nuclear Station," Rev. 2, June 1993.

12. Cooper Nuclear Station "Condenser and Auxiliaries", Contract No. E-68-4, Including Addendum 1, 2, and 3.

13. NEDC 89-1886.