CHAPTER 10 - STEAM AND POWER CONVERSION SYSTEM

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10.1 SUMMARY DESCRIPTION

The Steam and Power Conversion System is designed to produce electrical energy through conversion of the thermal energy contained in the steam supplied from the reactor. The system then condenses the turbine exhaust steam into water, and returns the water to the reactor as heated feedwater. A major portion of the gaseous, dissolved, and particulate impurities in the water are removed in the system.

Steam is supplied from the reactor through two main steam lines to drive the Turbine Generator. Heat balances for the cycle, at reactor power levels of 1600 MWt and 1930 MWt, (in the valves-wide-open condition) are shown in Drawings GE798D807 and GE846D640, respectively. These drawings are applicable for rated power operation with the HP and IP feedwater heaters in operation.

The major components of the Steam and Power Conversion System Are: the main steam supply lines, the Turbine Generator, the moisture separators and reheaters, the Main Condenser, the condensate pumps, the Steam Jet Air Ejectors, the turbine bypass valves, the condensate demineralizers, the reactor feedwater pumps, the feedwater heaters and drain coolers, the Condensate Storage Tank, and the condensate transfer pumps. The heat rejected by the Main Condenser is removed in the Circulating Water System.

The design of the individual components of the Steam and Power Conversion System is based on proven conventional design, acceptable for use in large central power generating stations. The turbine plant auxiliary equipment is selected to provide the optimum operating economy with maximum safety and reliability. All auxiliary equipment is specified for a design capability corresponding to the turbine valves-wide-open condition. Adequate design margins are included, as required for wear and system surges, to provide dependable service.

The saturated steam produced by the boiling water reactor is passed through the high pressure stages of the turbine where the steam is expanded and is then exhausted to the moisture separators and then to the reheaters. The moisture separators remove the moisture content of the steam, and the first stage and second stage reheaters superheat the steam before it enters the low pressure stages, where the steam expands further. From the low pressure stages the steam is exhausted into the Main Condenser where it is condensed and deaerated, and then returned to the cycle as condensate.

Under normal operations, a small part of the main steam supply is continuously used by the Steam Jet Ai Ejectors (SJAEs), the steam seal regulator and the second stage reheaters. The condensate pumps take suction from the condenser hotwell and deliver the condensate to the low pressure drain coolers, and the low pressure and intermediate pressure feedwater heaters, via the condensate demineralizers. Condensate from the discharge of the condensate pumps is also used as a condensing medium in the SJAE condensers, and in the steam packing exhaust condenser. The Reactor Feedwater Pumps supply feedwater through one stage of high pressure feedwater heaters to the reactor. Steam for heating the feedwater and the first stage reheaters is supplied from turbine extractions. The feedwater heaters also provide the means of handling the moisture separated from the steam in the moisture separators, and the condensate from the first stage and second stage reheaters.

Normally, the turbine utilizes all the steam being generated by the reactor. However, under certain operating transients, excess steam is generated. An automatic pressure controlling Turbine Bypass System is provided to discharge excess steam up to 40 percent of the turbine steam flow at design power level directly to the main condenser. The Turbine Bypass System is designed to control pressure by dumping excess steam during startup, shutdown, and during power operation, when the reactor steam generation exceeds the transient turbine steam requirements.

The plant is designed to accommodate transients associated with the Turbine Generator. These transients are addressed in Section 10.2. The Main Steam Supply System is described in Section 10.3. Other features of the Steam and Power Conversion System are covered in Section 10.4.

The major components of the Steam and Power Conversion System are located in the Turbine Building, and are not safety related. Design features of the Steam and Power Conversion System components are presented in the applicable subsections which describe the major systems and components. The system components are shown on the general arrangement drawings in Section 1.2. The summary of major parameters is shown in Table 10.1-1.

TABLE 10.1-1
(Sheet 1 of 1)

STEAM AND POWER CONVERSION SYSTEM SUMMARY OF MAJOR PARAMETERS*

Parameter	Value		
1. Core Thermal Power, MW	1930		
2. Full Design Reactor Steam Flow, lb/hr	7.259×10^6		
3. Full Design Turbine Steam Flow, lb/hr	6.834×10^6		
4. Turbine Throttle Pressure, psia	965		
5. Design Exhaust Pressure, inches HgA	1.0		
6. Moisture Separator/Reheaters	Separator	1st Stage RH	2nd Stage RH
Quantity	4	2	2
Design Pressure, psia	165		

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* Component parameters based on 670 MW electrical load.

10.2 TURBINE GENERATOR

10.2.1 Design Bases

The Turbine Generator has been designed to produce electrical power from the steam generated in the reactor, and to discharge exhaust steam into the condenser.

The turbine nameplate rating is 640,700 kW, 1800 rpm, 15 stage, tandem compound, six flow, two stage (513°F) reheat steam turbine with 38 inch last stage buckets, designed for steam conditions of 950 psig saturated with 0.28 percent moisture, 1 inch mercury absolute exhaust pressure and 0 percent makeup while extracting for three stages of feedwater heating. The six flow design and speed of 1800 rpm were dictated by the pressure and temperature of the steam available from the reactor.

The generator is a direct driven, 60 cycle, 24,000 volt, 1800 rpm conductor cooled, synchronous generator rated at 687,500 kVA at 0.8 power factor, 45 psi hydrogen pressure and 0.58 Short Circuit Ratio (SCR). The turbine includes one double flow (high pressure) and three double flow (low pressure) elements. Exhaust steam from the high pressure element passes through moisture separators and reheaters before entering the three low pressure units. The separators are designed to reduce the moisture content of the steam to less than 1 percent by weight.

The turbine controls include speed governor, overspeed governor, steam control valves, main stop and bypass valves, combined intercept and reheat stop valves, and two initial pressure regulators: one electro hydraulic and the other mechanical.

The ability of the plant to follow system load is accomplished by adjusting the reactor power level, either by regulating the reactor recirculation flow or by moving the control rods. The turbine speed governor can override the initial pressure regulation, and close the steam admission valves 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. Other standard protective devices are included.

Control and bypass valves are provided to maintain constant reactor pressure. The Turbine Bypass System (TBS), with a rated capacity of 40 percent of the turbine rated steam flow is used during startup to control reactor pressure until the turbine can use all of the reactor steam. The system also limits transient pressure changes and resultant reactor flux disturbances after stop valve closure. Load rejections within the TBS capacity will cause the control valves to close and the bypass valves to open and dump steam to the condenser. A design transient mismatch of 5 percent rated flow should not be enough to cause a high flux scram. Load rejection beyond the TBS capacity will cause a high flux scram.

The Turbine Generator was not designed to seismic requirements and is not safety related. Applicable codes are listed in Section 3.2.

10.2.2 Description

10.2.2.1 Main Generator

The generator converts the mechanical energy of the turbine into electrical energy, which is fed to the main transmission lines, and is also used to satisfy in-house loads.

The unit is a direct driven 60 cycle, 24,000 volt, 1800 rpm, conductor cooled, synchronous generator rated at 687,500 kVA at 0.8 power factor, at 45 psig hydrogen pressure and 0.58 SCR. Output voltage is controlled by regulating the field applied to the main exciter which, in turn, changes the field applied to the rotor. Manual regulation is accomplished by regulating the generator field voltage with the static excitation system. Automatic regulation is accomplished by regulating the generator's terminal voltage with the static excitation system.

If a fault condition is sensed in the generator, the relays provided will trip a master lockout relay in the Control Room, which will initiate the following actions:

a. Activate the main turbine trip solenoid to prevent overspeed on loss of load.

b. Trip two 230 kV breakers to separate the fault from the system.

c. Trip the auxiliary transformer breakers (1A and 1B) to prevent backfeed of power from the buses into faulted generator.

d. Close breakers S1A and S1B to transfer buses to the startup transformers.

e. Deleted

f. Trip the generator field breaker to stop generation of power and thus limit interval damage to the generator.

g. Deleted

h. Activate an alarm in the Control Room.

10.2.2.2 Steam Turbine

10.2.2.2.1 General Description

The tandem compound, six flow steam turbine includes the high and low pressure turbine sections, four stop valves, four control valves, six combined reheat valves, the Turbine Bypass System including nine bypass valves, the necessary control and protective devices, operating and supervisory instrumentation, turning gear equipment, the Steam Seal System, the Exhaust Hood Spray System, and the lubrication system, including the Lubricating Oil Purification and Transfer System. Except for the Turbine Bypass System, and the dual pressure regulators the turbine is of conventional design for saturated steam conditions; it consists of a double flow high pressure section followed by three double flow low pressure sections, each served by a separate divided water box condenser.

Steam from each end of the double flow, high pressure element exits via two 36 inch lines (a total of four lines) into the four moisture separators (one per line). Downstream of the moisture separators, steam enters the first stage reheaters. There are two first stage reheaters which handle the flow from two of the four 36 inch lines which exit the high pressure element. The first stage reheater is heated by steam from the third stage extraction of the turbine. Steam from the first stage reheaters flows into the second stage reheaters. There are two second stage reheaters, which are heated with steam from the steam chest.

After being reheated, the steam from each second stage reheater is admitted to the center sections of the three low pressure turbines by way of three pairs of combined reheat intercept stop valves. After passing through the low pressure turbine the steam is then exhausted into the corresponding Main Condenser section immediately below.

Steam extracted from the 8th, 11th, and 13th stages of the low pressure elements of the turbine is applied to a separate string of feedwater heaters. The turbine is described as a 15 stage tandem compound 1800 rpm turbine. The high pressure element has 7 stages and each of the low pressure elements has 8 stages. Each of the four individual sections of the turbine is mounted on a single shaft connected to the generator. Major design characteristics of the turbine are given in Table 10.2-1.

10.2.2.2.2 Major Components

Main Stop Valves

Four main stop valves are provided, a hand wheel mechanism is provided to position the bypass valve internal to mainstop valve no. 2 to warm the turbine shell and chest. The control linkage for valve no. 2 also opens and closes the remaining three stop valves. The valve no. 2 operating linkage is interlocked with the control valve position to prevent closing of the three remaining stop valves with the control valves open. On a turbine trip, operating oil is dumped from the valve operating cylinders and the valves close quickly by spring force. Local and remote circuits are provided for testing each stop valve under load. Interlocks permit only one valve at a time to be tested, and prevent the start of a test unless all four valves are fully open.

Control Valves and Bypass Valves

The four control valves and nine bypass valves are operated by the turbine pressure regulators, through interconnecting linkage, to maintain constant reactor pressure. The Turbine Bypass System, with a rated capacity of 40 percent of the rated steam flow, is used during startup to control reactor pressure until the turbine can use all of the reactor steam. The system also limits transient pressure changes and resultant reactor flux disturbances after stop valve closure. Load rejections within the bypass system capacity will cause the control valves to close and the bypass valves to open and dump steam to the condenser. The design transient mismatch of 5 percent rated flow under these conditions should not be enough to cause a high flux scram.

Load rejections beyond the bypass system capacity will cause an anticipatory trip, but the bypass system will normally limit the pressure rise to keep the safety valves from opening. A stop valve trip is so fast that it may cause a high flux scram below 40 percent rated load because the bypass valves cannot open fast enough. The bypass valves will open in response to the pressure rise when the stop valves close. They will regulate the reactor pressure after the scram until decay heat decreases and the pressure returns to the operating point.
The number of control valves was determined by the speed and load regulation requirements of the turbine; the number of bypass valves by the requirement that the transient steam flow

mismatch as the bypass valves operate must not exceed 5 percent. The control valves and bypass valves are opened and closed by hydraulic servos. The control valves open and close together. The bypass valves operate in sequence and are positioned by a camshaft that provides sequential operation and a linear relationship between valve position and steam flow.

For Cycle 24 only, analysis was performed to support operation with 1 turbine bypass valve out-of-service which results in reduced steam flow capacity. (Chapter 15, References 36 and 37)

Local and remote test circuits are provided for testing each bypass valve under load. Interlocks permit only one valve at a time to be tested. During each test cycle, each valve strokes fully open from its closed position during the start of the cycle and then returns to its original closed position. Stroke time during the test cycle is set to give the pressure regulator time to follow.

Combined Reheat Valves

There are six combined reheat valves, one in each of the two reheat steam lines to each of the three low pressure sections. Each valve consists of an intercept valve, positioned by a hydraulic servo linked to the speed regulation controls, and a normally open stop valve that closes only during a trip. Its operation is similar to that of the main stop valves. Local and remote test circuits are interlocked so that only one stop valve and associated intercept valve can be closed at a time. During operation under load all combined reheat valves must be open before a test stroke can start.

Reheat Relief Valves

There are six relief valves provided to protect the reheaters and the low pressure piping from overpressure conditions. These valves are located between the reheater assembly and the low pressure turbine elements admission and are set to maintain pressure, in that portion of the system, below 250 psig.

Turning Gear and Lift Pumps

A motor operated turning gear is arranged for both remote manual start and automatic operation. The turning gear will automatically start when the turbine has tripped, the turbine speed decreases to a preset value, the turning gear is disengaged, and bearing oil header pressure is above a preset value.

Steam Seal System

The Steam Seal System consists of the steam seal regulator and the steam packing exhauster. It is designed to handle the steam flows resulting from twice the normal packing clearances. This system is described in Subsection 10.4.3.

10.2.2.2.3 Turbine Control and Instrumentation

The objectives of the Turbine Control System are as follows:

a. To regulate the flow of steam to the turbine at a rate consistent with reactor power through the proper positioning of the control and bypass valves.

b. To monitor critical parameters and (through the Turbine Generator Protection System), control the flow of steam as necessary to protect the turbine and condenser.

c. To send signals to the Reactor Protection System, when the flow of steam is interrupted, in anticipation of the resultant pressure flux spike.

Speed and Load Control

Turbine speed and load are controlled entirely by the quantity of steam admitted through the control valves and intercept valves.

The conventional turbine control elements (speed governor, speed-load control, and load limit control), the two pressure regulators, and the bypass valve opening jack operate the control valve relay through two pilot valves in series. This arrangement allows the turbine to be brought up to speed in the conventional manner, using the load limit control to position the control valves. Meanwhile, the active pressure regulator operates the bypass valves to hold reactor pressure constant. As soon as the turbine is loaded to the point where it can use all of the reactor steam, control is shifted to the pressure regulator by setting the speed load and load limit controls above 100 percent rated speed or load. With speed governor pilot out of range, the pressure regulator pilot alone operates the control valve relay.

Governor Runback

The governor motor control circuit is interlocked with the generator Stator Cooling Water System (Subsection 9.2.1.6) to decrease the load automatically to about 25% power on high coolant temperature or low coolant inlet flow. In the governor runback mode stator current is reduced to below the stator “No-Flow” capability (approximately 25 percent of rated generator load). If after a three minute time delay the stator current is still more than the stator “No-Flow” capability, a turbine trip occurs.

10.2.2.2.4 Turbine Generator Protection System

The Turbine Generator Protection System consists of an assembly of various trip and protection devices which are installed on or associated with the Turbine Generator.

The Turbine Control System provides the necessary signals to the protection system. Hydraulic operating oil is used to open four main stop valves, the four control valves, the nine bypass valves, the six reheat stop valves, the six intercept valves, and the trip cylinders on six low pressure extraction check valves. When the trip oil pressure is removed, all valves except bypass valves (bypass valves go open) close to prevent the flow of steam to the turbine. Removal of trip oil pressure is commonly referred to as turbine trip.

Analysis was performed to support operation of either a single Turbine Stop Valve, or a single Turbine Control Valve out-of-service, or one Turbine Bypass Valve, or two Turbine Bypass Valves out-of-service (Chapter 15, References 26 and 35).

There are generally two types of valve trip events which can occur at the OCNGS. The first will trip closed the main stop valves, reheat stop valves, main control valves, intercept valves, and extraction check valves and opens the bypass valves to provide a flowpath of reactor steam through the bypass valve assembly to the Main Condenser of up to 40 percent of reactor thermal power. The second type of valve trip will close the bypass valves on low condenser vacuum, thereby protecting against an overpressurization of the Main Condenser. Bypass trip oil is used to actuate the bypass valve trip, independent of the turbine trip oil, via the bypass valve relay.

The Reactor Protection System (RPS) will scram the reactor upon sensing >10% main stop valve closure if reactor power is greater than approximately 40% thermal power.

For Cycle 24 only, analysis was performed to support operation with 1 turbine bypass valve out-of-service which results in reduced steam flow capacity. (Chapter 15, References 36 and 37)

The RPS also constantly monitors piston pressure in the acceleration relay which is actuated by loss of turbine trip oil pressure or by action of the acceleration relay. Upon detection of a loss of pressure if reactor power is greater than approximately 40% thermal power, the Reactor Protection System will scram the reactor in anticipation of turbine trip.

In addition, loss of condenser vacuum in any condenser A, B, or C (as sensed by either trip system described above) will cause the RPS to scram the reactor if reactor pressure is >600 psig.

Protective Controls and Instrumentation

A backup overspeed trip and other remote trips (solenoid trips) operate through a vacuum trip, which dumps operating oil to the load limit trip piston, main stop valves, acceleration relay pilot valve, and extraction relay dump valve. The stop valves close immediately, as do the check valves in the extraction lines. A load limit trip piston and an acceleration relay pilot valve act to close the control valves immediately, and also to open the bypass valves in advance of an overpressure signal from the pressure regulator. The bypass valves are tripped separately by a second vacuum trip at approximately 10 inches Hg vacuum to prevent condenser overpressure. As long as circulating water flows through the condensers, the bypass valves should not trip closed after a stop valve trip.

On loss of auxiliary power, the Circulating Water System pumps stop and condenser vacuum decreases. The stop valves trip closed at approximately 22 inches Hg vacuum, and the bypass valves discharge at full rated capacity for about 6 seconds. Flow then decays to about 10 percent of the bypass valve capacity within 30 seconds after the stop valves trip closed. Total discharge during this 30 second period is about 12,000 pounds. This amount can be condensed before the bypass valves trip on low vacuum, even if there is no circulating water flow. Thus by the time the bypass valves trip, they have already closed down to 10 percent of their rated flow. Following a 10 inches Hg vacuum trip, they close immediately to prevent rupture of the pressure relief diaphragms in the turbine low pressure shells. Reactor pressure buildup following valve closure would not be enough to open the safety valves.

Turbine Trip Summary

Inputs which trip the main stop valves, the reheat stop valves, control valves, intercept valves, and extraction check valves are discussed in the following paragraphs.

Turbine Overspeed

There are two separate devices which will trip the turbine on overspeed conditions. At about 110 percent the overspeed governor actuates. At about 112 percent speed the backup overspeed trip will operate.

Loss of Vacuum

Normally the Main Condenser is maintained at about 29 inches (mercury) vacuum. Should the vacuum decrease to approximately 22 inches in any of the three condenser sections, a turbine trip will occur to protect the low pressure turbines' last stage buckets from damage due to the unusual stimuli suffered during low vacuum operation.

Thrust Bearing Wear Detector

If the turbine shaft moves a preset amount from its normal position, a Control Room annunciator alarms.

High Water Level in Reactor Vessel

If the water level in the vessel exceeds the height of the top of the steam separators (175" TAF), the turbine trips to protect against water damage to the turbine blades.

High Water Level in Moisture Separator Reheater

Should any of the four moisture separators become flooded, the turbine trips to protect the blades in the low pressure turbines from water damage.

High Temperature at Exhaust Hood

The High Temperature trip is Deleted. Should the temperature at the low pressure turbine exhaust hoods exceed 175°F, an alarm is sounded. High temperatures can occur during low steam flow conditions. The exhaust hood sprays are used to minimize exhaust hood temperatures.

Turbine Control Valve Closure

Should the turbine control valves close to the 20 percent rated load, turbine trip will occur to protect the turbine reheaters against rapid cooldown from further rapid load reduction. During a normal, controlled shutdown, this trip is prevented by depressing a reset switch when a warning alarm alerts the Control Room of decreasing power.

Reheater Protection During Light Load

During startup or load reduction, when the load is below approximately 20 percent of rated load, the turbine will trip if the reheat stop check valves for the second stage reheaters are not closed. This is to protect the reheaters from high differential temperature between tube and shell sides.

Stator Cooling Failure

Turbine load runback is initiated by either high outlet water temperature or low inlet water flow in the stator cooling water system. If either or both of these conditions is sensed, the turbine runback circuit is initiated, causing the turbine load to be reduced to the stator "no-flow" load condition (approximately 25 percent of rated generator load). A timer is also started, which will cause the turbine to trip if the "no-flow" load, as sensed by a current relay, is not reached within approximately three minutes.

Generator Lockout Relay

The generator protective devices will activate generator lockout relays which in turn will trip the turbine master trip solenoid and actuate the vacuum trip. Loss of DC power supply to any protection relay or lockout relay is annunciated.

Two independent microprocessor based Digital Protection Relay Systems (DPRS "A" as primary, and DPRS "B" as backup) are integral part of the turbine generator protection system. Output of DPRS "B" has been disabled, it is no longer a backup.

Generator protection functions provided by DPRS's include: sequential tripping, antimotoring (reverse power), turbine steam cutoff, under-frequency, three phase accidental energization, loss of field, negative sequence (unbalance current), stator ground, over-excitation, pole slip, rotor ground, potential transformer monitoring, and protection during generator shutdowns and startups.

Generator Synchronization Protection

When the generator is synchronized to the grid, it is desirable to prevent breaker closing out of phase. The synchronization protection provided by DPRS "A" ensures that by allowing generator breaker closure only when the generator's and the grid's phase angles, voltages and frequencies are within allowable limits. This protection will not cause a turbine trip.

Main Transformer Lockout Relay

A turbine trip will result if Sudden Pressure is detected in the Main Transformers.

Auxiliary Transformer Lockout Relay

A trip of the turbine results if a fault is detected within the auxiliary transformer circuit, such as a ground on either secondary of this transformer or a current mismatch between the primary and secondaries of the transformer.

Auxiliary Trip Lockout Relay

A turbine trip will occur upon the detection of a current flow mismatch in the overall generator-transformers-transmission lines circuitry.

Bypass Valve Trip

Should the vacuum in the Main Condenser continue to decrease following a trip of the control valves, the bypass valves will be tripped thereby preventing the admission of steam into the condenser. This trip will occur when the condenser vacuum approaches 10 inches of mercury. The bypass valve trip is independent, and has no mechanical or electrical relation to, the turbine trip. The purpose of the bypass valve trip is to protect the condenser from overpressurization.

Other Trips

In addition to the above described trips, the following may occur:

a. Trip of the turbine on loss of the turbine oil pressure.

b. The turbine may be tripped manually from the Control Room or from the front standard.

c. Bypass valves can be tripped manually from the Control Room.

10.2.2.2.5 Supervisory Instrumentation

Recording instruments are provided in the Control Room to record the following:

a. Shaft Eccentricity

b. Shaft Speed

c. Control Valve Position

d. Shaft Vibration

e. Shell and Differential Expansion

f. Shell Temperature

g. Bypass Valve Position Cam Position

10.2.2.2.6 Turbine Lubricating Oil System

The Lubricating Oil System consists of an oil reservoir, vapor extractor, two full capacity oil coolers, a shaft driven main pump, two ac motor driven auxiliary oil pumps, one dc motor driven emergency bearing oil pump, one ac motor driven turning gear oil pump, and one oil driven booster pump.

The shaft driven main oil pump is supplied with oil by the oil driven booster pump in the oil tank. Oil discharged from the main pump is piped to an operating oil header, from which feed lines supply operating oil to the governing and control mechanism. This header also carries oil back to the tank, where it drives the oil turbine that powers the booster pump. As the oil passes through the turbine, its pressure is reduced and regulated, oil at this reduced pressure is passed through the oil coolers and on to turbine bearings.

The two auxiliary oil pumps supply operating oil during startup or in an emergency when the main oil pump fails to develop enough pressure. They take suction from the tank and discharge into the operating oil header. The two pump circuits are controlled in parallel from the Control Room. There is a separate alarm for each pump.

Since the auxiliary pump has a lower discharge pressure than the main oil pump, its flow will automatically decrease as the main oil pump reaches its normal operating characteristics. To prevent cycling, the pump control circuit is arranged so that the pump will not shut down automatically, it must be turned off from the Control Room. The pump will start automatically when the operating oil header pressure decreases to a preset value, either automatically upon trip due to a dip in header pressure as the valves trip closed, or on decrease in speed as the main pump discharge pressure drops. Once the pump has started, it runs until it is shut down manually.

The turning gear oil pump supplies bearing oil during turning gear operation or in an emergency if the main and auxiliary oil pumps fail. The pump discharges into the bearing oil header downstream of the main oil pump. The turning gear oil pump starts automatically when operating oil pressure drops to a preset value. During a normal shutdown, the pump cuts in to supply bearing oil pressure as soon as the auxiliary oil pump shuts down. Once started, the pump runs until shut down from the Control Room.

The emergency bearing oil pump is dc motor driven from the station 125 volt dc system. It cuts in automatically on low discharge pressure of either the auxiliary oil pumps or the turning gear oil pump. Pump conditions are annunciated in the Control Room.

10.2.2.2.7 Lubricating Oil Purification and Transfer System

The Oil Purification and Transfer System consists of one turbine oil conditioner, one circulating oil pump, one lubrication oil transfer pump, one dirty oil storage tank, and associated piping, valves, and accessories.
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The turbine oil conditioner, located in the Turbine Building basement at El. 0'-0", receives oil from the main oil tank overflow (El. 11'-6") through an oil sight glass. Water and sludge are removed in a precipitation compartment, and water is ejected to the Turbine Building drain sump. Oil is drawn from the bottom of the precipitation compartment by the circulating oil pump, forced through one full capacity polishing filter, and returned to the main oil tank. A vent fan exhausts the air above the conditioner oil compartments to prevent condensation of atmospheric moisture.

The 15,000 gallon dirty oil storage tank is sized to contain all of the lubricating oil in the system, so that the system can be drained completely for maintenance. The transfer pump and manually valved lines are used to transfer oil between the main oil tank and the dirty oil storage tank.

10.2.2.3 Reheat Steam System

10.2.2.3.1 Purpose

The Reheat Steam System dries the steam leaving the turbine high pressure casing and adds about 150°F of superheat (at design flow) before the steam is applied to the low pressure stages. The system uses chevron type moisture separators to reduce the moisture content to 1 percent maximum, followed by two-stage, steam-to-steam reheaters. Heating steam is extracted at two points from the steam chest downstream of the stop valves, and from the turbine third stage.

10.2.2.3.2 General Description

Following exhaust from the last stage of the high pressure turbine, the steam is low in temperature and contains a large amount of moisture. For these reasons, there are four chevron type moisture separators, one in each of the four 36 inch turbine cold reheat lines. The moisture separators are arranged in pairs on opposite sides of the Turbine Building basement.

Each moisture separator pair delivers dry steam to one of the two 1st stage reheaters. Steam leaves each 1st Stage Reheater via 4 36" lines and is delivered to one of two second stage reheaters. Steam leaves each second stage reheater via four 36 inch lines. These are manifolded, and a 54 inch header (reducing to 48 inch and 36 inch lines) supplies the three 36 inch combined reheat valves on the inlet sides of the three low pressure turbines. Heating steam to the first stage reheaters is provided by extracting steam from the third stage of the high pressure section of the turbine. The second stage reheaters receive heating steam directly from the steam chest. The combined effect of these two stages of reheating is to add about 150°F of superheat to the steam exhausted from the high pressure section of the turbine. The third stage extraction steam and the steam chest supplied steam, which was used to provide for reheating of the high pressure exhaust steam, condenses and is collected by a system of drain tanks. The moisture removed from the reheat steam by the moisture separators is also collected by this system of drain tanks. The shell-and-tube reheaters are pitched 1/8 inch per foot so that the tubes will drain dry after shutdown.

10.2.2.4 Turbine Extraction System

Extraction steam is a term applied to any steam removed from the turbine during its flow through the 15 stage (combined) high and low pressure sections. Once extracted, such steam does not return to the normal path of flow through the turbine, but flows into the Main Condenser.

Third Stage Extraction

This steam is directed through ten inch lines to the first stage steam reheaters. The reheaters add additional heat to the steam after its use in the high pressure element and before its use in the three low-pressure elements of the turbine.

Eighth Stage Extraction

Steam is extracted from the eighth stage and is provided, through 14 inch lines, to the high pressure feedwater heaters. This steam serves to aid in the heating of the feedwater prior to its return to the reactor vessel.

Eleventh Stage Extraction

This steam is directed to each of the intermediate pressure feedwater heaters through 24 inch headers. These intermediate pressure heaters also aid in the heating of feedwater.

Thirteenth Stage Extraction

Low pressure feedwater heaters and low pressure drain coolers receive thirteenth stage extraction steam through four 24-inch lines inside the condenser. The low pressure heaters drain to the low pressure coolers, both of which are mounted in the neck of the condensers, and both add heat to the returning feedwater.

Fourteenth Stage Extraction

Since the later stages of the turbine contain large amounts of moisture, moisture removal provisions are provided. At the 14th stage this moisture is extracted and discharged directly to the condenser. This piping is contained entirely within the turbine condenser housing, and is directed by internal piping within the condenser neck. Piping is provided with restricting orifices.

Fifteenth Stage Exhaust

The fifteenth and final stage of the turbine exhausts directly into the main condensers.

10.2.2.4.1 Description

The system consists of the extraction steam lines from each of the turbine low pressure stages to the three parallel strings of three feedwater heaters each. The system also includes the vent lines from flash tanks 1-1 and 1-2, which discharge in parallel to the high pressure heaters. The 14th-stage turbine extraction lines are internal to the turbine.

The low pressure heaters and separate drain cooler sections (Table 10.2-2) are mounted in the neck of each condenser section. Each heater receives thirteenth stage extraction steam through four 24 inch lines inside the condenser. Each heater is provided with a 12 inch line and an air operated control valve (normally controlled by the heater level controller to open on high heater level) which bypasses the drain cooler upon high water level. The bypass is connected to the Main Condenser. The control valve is also interlocked to open on turbine trip and heater bank isolation.

The intermediate pressure (IP) heaters (Table 10.2-3) are located on the mezzanine floor adjacent to each turbine low pressure section. Each is supplied with eleventh stage extraction steam through a 24 inch line with a motor operated isolation valve and an air operated reverse flow check valve. When the isolation valve is closed, the supply line drains to the condenser through an 8 inch line, a 6 inch air operated bypass valve, and a restriction orifice.

The high pressure (HP) heaters (Table 10.2-3) are located on the mezzanine floor adjacent to each turbine low pressure section. Each receives eighth stage extraction steam through a 14 inch line with a valving and bypass arrangement like the one used for the IP heaters. Vents from the two flash tanks discharge to the three heaters in parallel at each HP feedwater heater steam inlet through normally open MOV valves controlled from the feedpump room at LIR #3.

10.2.2.4.2 Drain Tanks and Feedwater Heaters

A simplified flow diagram of the reheater and moisture separator drains is shown in Drawing BR 2007. Drains are collected in six drain tanks (one for each pair of moisture separators and one for each reheater). These tanks are located in the Turbine Building basement below the main steam lines.

Moisture from the separators and reheaters is drained to these tanks by gravity and steam pressure. The levels in the drain tanks is maintained at a desired level by controlling the normal air operated drain valves to the main flash tanks. These flash tanks are located on the heater bay floor above the feed pump room. The steam pressure on top of the drain tanks is sufficient to force this water upward to the main flash tanks. Should the level in any of the drain tanks rise to an undesired high level that tank's air operated alternate drain valve opens to provide additional drain capacity to the auxiliary flash tank. The 300 gpm drain pump for this tank is normally running. The 2000 gpm drain pump will be operated either automatically or manually to maintain level in the auxiliary flash tank.

Should conditions develop that inhibit the drain capacity from the moisture separators, the water would back up into the separators and eventually be carried by the steam flow to the low pressure turbines. This would damage the turbine blades. In order to protect against such an occurrence, level switches are installed on the moisture separators. Upon reaching a high level in any of the moisture separators, the high level switch will alarm and open the alternate drain valves for both moisture separator drain tanks. Upon sensing an extreme high water level in the separators these level switches will generate a signal to trip the turbine thus protecting the low pressure units from moisture carryover damage.

After reaching the main flash tanks through the normal drain path, the condensed steam is still quite high in temperature. Instead of wasting the heat a system reclaims this heat by using it to preheat the reactor feedwater.

The main flash tanks are vented and drained to each of the three high pressure feedwater heaters. The vent line is normally open to each of the high pressure heaters and the air operated drain valves are positioned to control a desired level in the main flash tanks.

The high pressure (HP) heaters are shell and tube type heat exchangers with reactor feedwater flowing through the tube side and the cascading drains on the shell side. Eighth stage extraction steam is supplied to the shell of each HP heater. The shell side is vented to the condenser. The level of the high pressure heater shell side is controlled by positioning its normal air operated drain valves. Should the moisture reach higher levels, the air operated alternate drain valve is opened to drain the excess directly to the condenser.

The intermediate pressure (IP) feedwater heater operates in a similar manner. Eleventh stage extraction steam is supplied to the shell of each IP heater. It is vented to the condenser. Its normal drain is to the low pressure feedwater heater with an alternate drain to the condenser.

The extraction lines to both the high and intermediate pressure heaters have motor operated isolation valves and air operated non return valves. The non return valves shut automatically upon a very high level condition in the associated heater. This prevents water from flooding back into the turbine. When the isolation valve or non return valve is shut a moisture removal drain valve opens to maintain moisture removal provisions within the turbine. This air operated drain valve opens directly to the condenser.

Thirteenth stage extraction steam is supplied to the shell of each low pressure (LP) heater. The low pressure feedwater heater is vented directly to the condenser. This low pressure heater has no normal drain valve in its normal drain path to the low pressure drain cooler. It does, however, have an alternate air operated drain to the condenser which is used whenever a high level condition is sensed.

The low pressure drain cooler receives the cascading drains from the low pressure heater. Its air operated drain valve is positioned by the level sensed in the low pressure heater (therefore, the low pressure drain cooler is normally flooded up into the low pressure heater). There is no extraction steam vent on the low pressure cooler as it is normally flooded.

The low pressure heaters and drain coolers are contained within the necks of each of the three sections of the Main Condenser. The high and intermediate pressure heaters are located on the heater bay floor above the feed pump room in the Turbine Building.

10.2.3 Turbine Disk Integrity

This section has been deleted based on GPUN evaluations of turbine missile consequences as described in Section 3.5.1.3.

10.2.4 Evaluation

The design and construction of components for the Turbine Generator are in accordance with well established codes and standards.

During normal and accident conditions, restricted areas and shielding around selected components in the system will protect plant personnel from exposures above established limits (Section 3.8).

Materials selection in the system, combined with the operation of the full flow condensate demineralizer, minimize the effects of crud deposition on critical components in the reactor system.

The performance of the Turbine Generator and the effects of failures of components on the rest of the plant has been evaluated in detail.

The transient analyses for the Turbine Generator are included in Chapter 15. The following transients have been analyzed.

a. Loss of Electrical Load

b. Turbine Trips (1930 MWT and 1025 MWT)

c. Loss of Main Condenser Vacuum

d. Inadvertent Opening of a Turbine Bypass Valve

e. Loss of Feedwater

f. One Feedwater Pump Trip and Restart

g. Excess Feedwater Flow

TABLE 10.2-1
(Sheet 1 of 1)

STEAM TURBINE DESIGN CHARACTERISTICS

Type	Tandem compound, six-flow, reheat, condensing
Nameplate Rating	640,700 kW
Design Operating Conditions	
Steam pressure	950 psig
Steam temperature	540°F
Moisture content	0.28 percent
Speed	1800 rpm
Backpressure	1.0" Hga
Reheat steam temperature	513°F
Extraction Stages	3rd, 8th, 11th, 13th, 14th
Tripping Speeds	
Emergency Governor Trip	1980 ±18 rpm (1962 - 1998)
Backup overspeed trip (percent rated speed)	
Operating	Approximately 112 percent
Test	Approximately 109 percent
Pressure Regulators	
Type	Mechanical (force-restored) and electrohydraulic
Adjustment Range	150 - 1050 psig (mechanical) 950 -1050 psig (electrical)
Adjustment rate (approx)	1 psi/sec
Deadband	Less than 1 psi (less than 0.05 percent change in rated power output)
Bypass Valve System	
Number of valves	9
Maximum capacity	40 percent of rated steam flow

TABLE 10.2-2
(Sheet 1 of 1)

LOW PRESSURE HEATERS AND DRAIN COOLERS

	LP Heaters	Drain Coolers
Design Pressure, psig		
Shell side	50	50
Tube side	400	400
Design Vacuum, inches HG Absolute		
Shell side	1.49	1.49
Test Pressure, psig		
Shell side	75	75
Tube side	600	600
Design Temperature, °F		
Shell side	300	300
Tube side	300	300

TABLE 10.2-3
(Sheet 1 of 1)

INTERMEDIATE AND HIGH PRESSURE HEATERS

	IP Heaters	HP Heater
Manufacturer	Struthers Wells Corp	
Design Pressure, psig		
Shell side	50	100
Tube side	400	1950
Design Vacuum, inches HG Absolute		
Shell side	1.49	1.49
Test Pressure, psig		
Shell side	75	150
Tube side	600	3000
Design Temperature, °F		
Shell side	300	430
Tube side	300	375

10.3 MAIN STEAM SUPPLY SYSTEM

10.3.1 Design Bases

The Main Steam Supply System is designed to convey the maximum design flow of 7,259,000 lb/hr of steam generated in the reactor from the Containment (downstream of the second Main Steam Isolation Valve) to the following:

a. The Turbine Generator (Section 10.2)

b. The Turbine Gland Seal System (Subsection 10.4.3)

c. The Steam Jet Air Ejectors (Subsection 10.4.2)

d. The Crossaround Steam Reheaters (Section 10.2)

e. The Turbine Bypass System (Subsection 10.4.4)

f. The Condenser Deaerating Steam System (Subsection 10.4.2)
The Deaerating Steam System was isolated from the 20 inch bypass steam header and the Main Condensers and abandoned in place under BA 403060.

The Main Steam Supply System is designed in accordance with the Code for Pressure Piping, ASA B31.1 (1955). The design conditions are 1250 psig and 575°F.

10.3.2 Description

The main steam piping extends from the primary containment to various locations inside the Turbine Building. The system starts at the outboard Main Steam Isolation Valves (MSIV); these are described in Subsection 5.4.5. The system consists of two 24 inch headers which run independently to a common 30 inch header located in the Turbine Building. One of the 24 inch headers receives the Isolation Condenser System Vent lines discharge. At the 30 inch header, main steam conditions are approximately 950 psig and 540°F. Four 18 inch lines connect the 30 inch header to the four turbine stop valves.

A 20 inch line connects the 30 inch main steam header with a nine valve bypass assembly for the Turbine Bypass System. In the vicinity of the bypass valve assembly, the 20 inch line divides into two 16 inch branches which supply the nine valve assembly from two opposite ends for better flow distribution.

The Main Steam Supply System feeds the Auxiliary Steam System which in turn supplies steam to the three Steam Jet Air Ejectors (SJAEs) associated with the Main Condenser (Subsection 10.4.2). Main steam is supplied to the Auxiliary Steam System through a 2 1/2 inch pipeline from the 30 inch main steam header through a pressure reducing station.

The steam to the turbine gland steam seal regulator is supplied through a 5 inch branch off the 20 inch bypass pipe.

Each of two eight inch lines transfer steam from the steam chest (between the Turbine Stop Valves and Control Valves) to each of two second stage reheaters.

10.3.3 Evaluation

The quality group and seismic classification of the Main Steam Supply System are provided in Section 3.2. The analysis of main steam line breaks outside containment is presented in Section 3.7.

The main steam header is provided with instrumentation which closes the Main Steam Isolation Valves on a low pressure signal to protect against fast reactor vessel depressurization due to main steam line breaks or a stuck open turbine bypass valve. Setpoints are provided in the Technical Specifications.

10.3.4 Inspection and Testing Requirements

The main steam piping was hydrostatically tested at the end of its construction, in accordance with ANSI B31.1. The system is subjected to periodic inspections as established in the Oyster Creek Inservice Inspection Program.

10.3.5 Main Steam Piping Materials

Main steam piping is seamless carbon steel. Compliance with the requirements of Regulatory Guides 1.31, 1.37 and 1.50 during fabrication and installation is discussed in Section 1.8

10.4 OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEMS

10.4.1 Main Condensers

10.4.1.1 Design Bases

The primary function of the Main Condenser is to provide a means of transferring residual heat in the turbine exhaust (or turbine bypass steam) along with other flows to the Circulating Water System, thereby condensing the steam to water, to be returned to the reactor as feedwater. It also provides sufficient delay time of condensate to allow for decay of entrained radioactive isotopes.

The Main Condenser is designed:

a. To maintain a pressure of 1.49 inches Hga with the turbine operating at rated capacity, with 60°F cooling water and 85 percent tube cleanliness.

b. To accept a turbine bypass steam flow of up to 40 percent of rated steam flow without exceeding the turbine exhaust pressure and temperature limitations.

c. To receive, in addition to the main turbine exhaust, vents and drains from the regenerative feedwater heating system and from various other components and systems of the heat cycle. The total thermal capacity of the three condenser shells is about 4.47×10^9 Btu/hr.

d. To provide time for radioactive isotope decay by retaining sufficient water in the hotwell for a 3 minute flow through time, without makeup and with turbine throttle valves wide open.

The Codes and Standards which are applicable to the condenser design include:

a. Standards for Steam Surface Condensers by the Heat Exchange Institute

b. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

10.4.1.2 Description

The Main Condenser consists of three single pass shells, with divided waterboxes, one each for the three low pressure (LP) cylinders of the main turbine. Each shell is rigidly supported on a concrete foundation and is connected to the corresponding LP turbine cylinder casing by means of an expansion joint. Major condenser parameters are listed in Table 10.4-1.

Equalizing connections between condenser shells limit the pressure differential between adjacent shells. These connections also allow use of one single vacuum breaker for all three shells.

The divided waterboxes, each provided with inlet and outlet circulating water valves, permit individual operation, removal from service of one half shell for maintenance, or backwashing of either half shell.

The hotwell is divided along the axis of the tubes. Each half of the hotwell is provided with horizontal and vertical baffles to ensure the minimum retention time of three minutes for any particle of condensate from the time it enters the hotwell until it is removed by the condensate pumps. This three minute period assures decay of radioactive nitrogen isotopes to an equivalent dose rate of 1 mR/hr or less by the time the condensate enters the condensate piping.

Makeup from the Condensate Storage Tank (Subsection 10.4.7.2) is evenly divided between the operating condenser shells. At each condenser, a 6 inch line supplies make up to a spray nozzle at the elevation of the drain coolers. Makeup thus enters the steam space to ensure deaeration before it mixes with condensate in the hotwell.

During normal operation, steam from the LP turbine cylinders is exhausted directly downward, through exhaust openings in the turbine casings into the condenser shells. During abnormal conditions, the Main Condenser receives, although not simultaneously, flows from the Turbine Bypass System, feedwater heater drains, and relief valve discharges from various steam lines. There are also other intermittent flows into the Main Condenser, such as condensate and reactor feedwater pumps minimum recirculation flows.

The condenser shells and turbine casings are protected by relief diaphragms which will open up in the event of failure of a turbine bypass valve to close on loss of condenser vacuum. The steam released from a ruptured diaphragm is discharged to the stack through the ventilating system.

Prior to initial plant startup the Main Condenser shell tubes and waterboxes were hydrostatically tested to verify their integrity. Access manholes are provided on the inlet and outlet waterboxes for inspection of the tube sheets and tubes.

The protection of the reactor from chloride intrusion due to condenser tube leakage is provided by the Condensate Demineralizer System and by the Conductivity Monitoring System associated with the Main Condenser.

Leakage into the condensate from the Circulating Water System is detected by monitoring conductivity cells in the condenser shells. Individual indications are provided on a common local panel with a common alarm to the Control Room. After a leak has been identified from a local inspection of the monitors, the alarming monitor would be locally cut out, freeing the Control Room circuit to accept another alarm.

Hotwell level is monitored and alarms are provided for both low and high level. Hotwell level control is described in Subsection 10.4.7.2. Local temperature indication is also provided. Condenser vacuum is indicated locally and in the Control Room. Vacuum pressure monitors provide alarm and trip signals to the Main Turbine and for the turbine bypass valves for loss of vacuum.

10.4.1.3 Safety Evaluation

Due to the location of the condenser in the Turbine Building any flooding resulting from circulating water side or steam side condenser failure will not affect the operation of any safety related equipment.

In case of a diaphragm rupture on the steam side of any condenser shell, or turbine casing, the operator must initiate closure of the turbine stop and bypass valves or Main Steam Isolation Valves (MSIVs). Should the operator fail to take action, the reactor would automatically scram on low water level and consequently close the MSIVs. The consequences of this action in terms of radioactive release are much less severe than those of a steam line break.

Plant response to a loss of condenser vacuum is discussed in Chapter 15.

10.4.2 Main Condenser Air Extraction System

10.4.2.1 Design Bases

The Air Extraction System removes noncondensibles from the condenser shells and conveys them to the Offgas System. During startup it serves to establish a vacuum in the Main Condenser until sufficient steam flow is available.

The noncondensibles to be removed are air inleakage, hydrogen from hydrogen water chemistry control, and gaseous hydrogen and oxygen formed by radiolytic decomposition of the reactor coolant. The latter are the major constituent of the noncondensibles, amounting to more than twice the volume of inleakage. These gases, although for the most part not radioactive, may be present in explosive concentrations. The principal radioactive noncondensibles are short lived isotopes of nitrogen and oxygen, and to a lesser extent radioactive noble gases from leaking fuel assemblies.

Piping and instrumentation lines have been designed to eliminate all sources of ignition, such as hot spots or sparks from static electricity, and to withstand both shockwave forces and static pressure, if an explosion does occur.

10.4.2.2 Description

The AES consists of three Steam Jet Air Ejectors (SJAEs), one per condenser shell (Table 10.4-2), one mechanical vacuum pump, and associated filters, piping and valves (Drawing BR 2008). The vacuum pump is intended only for air removal when no motive steam is available to the SJAEs. This motive steam is provided via a 2 1/2 inch line from the 30 inch main steam header through a pressure reducing station and is designated as the Auxiliary Steam System.

There are two 10 inch air extraction lines from each condenser shell, which join a 14 inch header to the associated air ejector. The three SJAEs are twin element, two stage units complete with intercondensers and aftercondensers. Condensate pump discharge from the main condenser hotwell is used as the heat sink in the SJAE condensers. Steam which is condensed in the SJAE stream is discharged back to the Main Condenser via the drain tanks and pumps. From the air ejectors, the noncondensible gases pass to the Offgas System (Section 11.3) and hence to the stack. If necessary, noncondensible gases are subjected to treatment to reduce radioactivity levels.

The mechanical vacuum pump has dual inlets and one outlet, all three provided with air operated isolation valves downstream of the separator. The pump discharges through a moisture separator to the 30 inch extraction holdup line from the steam packing exhausters (Subsection 10.4.3). Seal water makeup is obtained from the Demineralized Water Transfer System and cooling is achieved by the Turbine Building Closed Cooling Water System.

The ejectors and the vacuum pump are located in separate shielded rooms in the Turbine Building basement, which are not normally entered during normal plant operation.

The Deaerating Steam System was isolated from the 20 inch bypass steam header and the Main Condensers and abandoned in place under BA 403060.

The AES is equipped with flow meters, gas monitoring and sampling stations, and pressure and temperature switches. Differential pressure transmitters are provided for the offgas discharge line absolute filters which alarm in the Control Room. Temperature and pressure for the mechanical vacuum pump are indicated locally.

Air valves at the ejector first and second stages are interlocked with the steam admission valves and controlled by a common switch for each ejector in the Control Room. Isolating valves at the condensers are controlled from one local switch or from a switch in the Control Room. These valves are interlocked with the process monitoring system to trip closed immediately on overpressure or overtemperature resulting from an explosion. Two solenoid pilot valves in series provide fail safe actuation for the isolation valves. The monitoring logic is two channel, with the high level signal required to close the valves. Each channel has a bypass switch in the Control Room to bypass the isolation signal if the pressure and temperature switches do not reset.

The mechanical vacuum pump discharge valve is interlocked to open whenever the pump operates. The inlet valves are controlled by one switch from the Control Room. These valves are interlocked with the pump motor starting circuit and with the transfer valves to each of the Main Condenser air extraction headers. The transfer valves are controlled by switches in the Control Room.

The mechanical vacuum pump is provided with a power operated isolation valve on its discharge line.

10.4.2.3 Safety Evaluation

The mechanical vacuum pump is not protected against explosion, nor are there any provisions for filtering its discharge. Therefore, the mechanical pump is not to be used when the reactor is operating above 5 percent of rated power.

The radiological aspects of gaseous waste disposal are discussed in Section 11.3. A high high radiation signal from the upstream end of the 30 minute holdup pipe, in the Offgas System, initiates a 15 minute timer. If the radiation level has not dropped below the setpoint at timer timeout, the system isolation valves will automatically close, causing a turbine trip on loss of condenser vacuum.

10.4.3 Steam Seal System

10.4.3.1 Design Bases

The Steam Seal System is designed to prevent escape of steam to the atmosphere and entrance of air into the turbine through the shaft seals of the main turbine during all phases of turbine operation, including startup, shutdown and turning gear operation.

10.4.3.2 Description

The Steam Seal System comprises the steam seal regulator and the steam packing exhauster. The exhauster is located in the SJAE room.

The gland packings between turbine shaft and casings are of the labyrinth type. Each packing consists of a series of annular chambers around the shaft, separated by stationary annular partitions having very small clearance from the rotating shaft. The outboard chambers of all packing casings are connected to an exhaust header maintained at a slightly sub-atmospheric pressure, while the inboard chamber is connected to the steam seal header. Steam seal header pressure is regulated by the steam seal regulator to maintain pressure at the packing casings greater than 2 psig. Steam seal header pressure is normally between 4 and 7 psig (or as required) to establish proper sealing of the turbine shafts as they penetrate their casings. The steam for the regulator is supplied through a 5 inch line off the 20 inch bypass header. When the exhaust pressure of the high pressure turbine is high enough (typically around 50% of full pressure) steam will flow along the packing and into the steam seal header and the outboard chamber of the HP turbine packing casings. When the exhaust pressure of the high pressure turbine is too low to supply the necessary sealing steam, steam will be supplied to the HP turbine from the steam seal header. In all cases, a mixture of steam, air and other noncondensible gases flow from the outboard chamber of the seal to the exhaust header, which conveys the mixture to the steam packing exhauster. Condensed steam is returned via drain transfer tanks to the Main Condenser while the air and other noncondensible gases are extracted by means of the exhauster fans and are sent to the Offgas System via a buried holdup pipe. Two full capacity exhauster fans are provided. The cooling medium for the exhauster is condensate derived from the piping downstream of the SJAE condensers.

The exhauster has a design capacity of 6600 lb/hr of steam and 2740 lb/hr of air at 200°F with a condensate flow of 14,500 gpm at 80°F and 350 psig.

At startup, prior to opening the turbine throttle valve, the entire turbine space is at condenser pressure and steam must be supplied to all packings. In this case main steam is furnished to the steam seal header through the steam seal regulator or reglator bypass valve.. During turbine operation the high pressure turbine will be under pressure but the last stages of the low pressure turbine will still be under vacuum. In this case the steam leakoff from the high pressure turbine packings to the steam seal header will normally be sufficient to feed the packings of the low pressure turbines and no addition of main steam is required.

A steam seal regulator monitor annunciates low pressure in the system in the Control Room, exhauster fan trip is also annunciated in the Control Room. The fans and motor operated valves for the system are operated from separate switches in the Control Room. To provide the minimum vacuum that will prevent steam from leaking past the packing and into the turbine room, the outlet valve of the operating fan is manually adjusted.

10.4.3.3 Safety Evaluation

The Steam Seal System is subject to radioactive contamination from the reactor steam and the radioactive noncondensible gases carried by the steam. These gases are separated from the steam in the steam packing exhauster and are conveyed to the Offgas System. A complete discussion of the radiological aspect of gaseous radwaste disposal is provided in Section 11.4.

The steam seal header is provided with a condenser dump valve for normal discharge of excess leakoff steam from the high pressure turbine and with relief valves to protect the system against accidental overpressure due to failure of the normal pressure regulating system.

10.4.4 Turbine Bypass System

10.4.4.1 Design Bases

The Turbine Bypass System is designed to control reactor pressure by diverting, directly to the Main Condenser, steam generated in the reactor which cannot be utilized by the turbine:

a. During reactor heatup to rated pressure.

b. While the turbine is brought up to speed and synchronized.

c. During power operation when the reactor steam generation exceeds turbine steam requirements and limitations. Under these conditions a transient mismatch of 5 percent rated flow will not cause a high flux scram.

d. When cooling down the reactor.

The Turbine Bypass System capacity is 40 percent of rated reactor steam flow.

For Cycle 24 only, analysis was performed to support operation with 1 turbine bypass valve out-of-service which results in reduced steam flow capacity. (Chapter 15, References 36 and 37)

Analysis was performed to support operation with one Turbine Bypass Valve, or two Turbine Bypass Valves out-of-service, which results in lower available bypass capacity. (Chapter 15, References 26 and 35)

10.4.4.2 Description

A 20 inch line connects the 30 inch main steam header with the nine valve bypass valve assembly (Drawing BR 2002). In the vicinity of the bypass valve assembly, the 20 inch line divides into two 16 inch branches, which supply the bypass valve assembly from two different sides for better flow distribution.

Nine independent bypass lines connect the valves to the three condenser shells (three lines per shell). These bypass lines are six inches in diameter and provided with pressure reducing assemblies.

A compound control mechanism is provided to operate the turbine control valves and bypass valves in proper coordination for control of reactor pressure and turbine load (or speed during startup) to set valves for a given reactor control rod configuration.

The bypass valves are opened and closed in sequence by hydraulic servos. The pilot valve for each valve in the group is positioned by a camshaft that provides sequential operation and a linear relationship between valve position and steam flow. The operating cylinder for each valve receives oil from the pilot valve and operates the valve through a linkage system.

It should be noted that a turbine trip action caused by either the emergency trip valve or vacuum trip No. 1 will not trip the bypass valves. The only trip device closing the bypass valves is vacuum trip No. 2 which will only be actuated at an extremely poor condenser vacuum. Vacuum trip conditions are discussed in Section 10.2. With this scheme, as long as condenser vacuum is such that the pressure relief diaphragms in the turbine low pressure shells do not rupture, the bypass valves are retained in service to dispose of reactor steam and limit the reactor pressure surge following turbine trip and prevent opening of the safety valves.

Load rejections beyond the bypass system capacity will cause a high-flux scram, but the bypass system will normally limit the pressure rise to keep the safety valves from opening. In the event of a stop valve trip, closure of the valves is so fast that the bypass valves will not open fast enough to prevent a high flux scram even below 40 percent rated load power operation. The bypass valves will nevertheless open and will regulate reactor pressure after the scram until decay heat decreases.

Local and remote test circuits are provided for testing each bypass valve under load. Interlocks permit only one valve at a time to be tested. Other testing and inspection requirements of the Turbine Bypass System are given in the plant procedures.

The position of the first two bypass valves, as well as bypass valve open and closed indicators, are provided in the Control Room.

10.4.4.3 Safety Evaluation

The evaluation of failure of the Turbine Bypass System is discussed in the accident analyses of Chapter 15.

10.4.5 Circulating Water System

10.4.5.1 Design Bases

The Circulating Water System is designed to supply a continuous flow of Barnegat Bay water through the plant to remove the waste heat released by the power cycle in the Main Condenser. It also provides an alternate, and/or supplementary supply of cooling water to the Turbine Building Closed Cooling Water heat exchangers.

The dilution plant portion of the system minimizes the adverse effects of hot discharge water on aquatic life in the discharge canal and Barnegat Bay to meet the conditions of the Oyster Creek New Jersey Pollutant Discharge Elimination System (NJPDES) Permit.

10.4.5.2 Description

The Circulating Water System comprises the intake canal from Barnegat Bay to the plant, the Main Condenser Circulating Water System, the dilution plant, the chlorination plant and the discharge canal to Barnegat Bay.

Intake and Discharge Canals

Circulating, cooling and dilution water are drawn from a 140 foot wide canal which has been dredged to a depth of 10'-0" below mean sea level. The water is discharged through a 100 foot wide discharge canal, with the same bottom elevation as the intake canal.

The intake canal was dredged along the Forked River bed for about one mile from Barnegat Bay and then up the South Branch of the Forked River to a point north of the OCNGS and immediately east of U.S. Route 9. West and south of that point, an entirely artificial canal was excavated for approximately 2000 feet to the intake structures at the station.

An artificial canal was excavated from the discharge structure to the South for approximately 2000 feet to meet the Oyster Creek stream. The Oyster Creek stream bed was widened and deepened by dredging for approximately 700 feet east to Route 9. East of Route 9 the creek was straightened as well as widened and deepened approximately 2600 feet to the bay.

Intake Structures

The main features of the intake structure are shown in Drawing 3E-168-02-001. The structure is divided in two sections, each of which contains a three segment trash rack and three traveling water screens, a chamber for two emergency service water pumps, one service water pump, one new radwaste service water pump and one high pressure screen wash pump, and a separate chamber for each of two circulating water pumps, also the north side contains two low pressure screen wash pumps. The sectional arrangement of the screens and pumps allows the use of stop logs to permit maintenance of equipment without interruption of circulating and service water flow. The total water flow through the intake structure can be as high as 475,500 gpm during normal plant operation.

Deicing recirculation is provided during cold weather operation. The deicing recirculation flow is taken from the discharge tunnel and returned to the intake pump structure (See Figure 10.4-3). A recirculation tunnel provides the heated water which is introduced into the intake structure via sluice gates installed in the tunnel upstream of the trash racks and travelling screens. If sufficient recirculation flow is not available, an alternate portable system is temporarily installed to pump water from the discharge tunnel to the intake structure.

The six traveling screens are served by a low pressure screen wash system and a high pressure screen wash system, which automatically clean the screens. The low pressure system is intended to gently remove collected fish from the screens. The high pressure system thoroughly removes all the remaining debris accumulated on the screens and in the debris troughs.

The description of the systems which draw cooling water from the intake structure, other than the Circulating Water System, is presented in Section 9.2.

Main Condenser Cooling Water System

The Main Condenser Cooling Water System, which is designated as the Circulating Water System (CWS), consists of four circulating water pumps, the intake and discharge tunnels, the connections to the Main Condenser and the connection to the Turbine Building Closed Cooling Water (TBCCW) heat exchangers (Section 9.2).

The four motor driven circulating water pumps each have a design capacity of 115,000 gpm at 28.5 ft head. Under normal operation, the four pumps deliver a total of 460,000 gpm. Of this total, 450,000 gpm is supplied to the Main Condenser, and 10,000 gpm are diverted to the TBCCW heat exchangers. The pumps discharge into 78 inch lines which direct the flow to a 10'-6" square tunnel (Figure 10.4-3) and hence to the Turbine Building west wall. Circulating

water enters and leaves the three condenser shells through 72 inch lines. On the discharge side of the Main Condenser, the 72 inch lines join into a 10'-6" square tunnel which leads the water to the discharge canal. The tunnel itself serves as a seal well, since its roof is below minimum water level in the discharge canal. The 60 inch deicing recirculation tunnel runs below the water level back to the intake structure.
Valving and crossover and discharge lines are provided for periodic backwashing of the condenser which is necessary to prevent accumulation of organic growth.

Vacuum Priming System

This system is no longer in service.

Chlorination System

The chlorination system is designed to operate year-round, and inject sodium hypochlorite to various points in the circulating water, service water and emergency service water systems. The purpose of the system is to eliminate or reduce biofouling while maintaining residual chlorine concentration at the discharge canal within Federal/State regulations. The sodium hypochlorite is typically stored in one 8850 gallon plastic storage tank. The system is located within the chlorination building and adjacent pad with the exception of the piping routed below grade and in the turbine building. An injection system is installed which delivers sodium hypochlorite to the main circulating and service water headers.. A programmable controller routes the solution to the selected points by the opening and closing of air operated valves. The New Radwaste Service Water (NRWSW) System uses an independent gaseous chlorine system to minimize biofouling (refer to Section 9.2.1.2).

Dilution Plant

The dilution plant intake structure, on the west side of the intake canal, is divided into three sections or bays, each having two trash racks and one dilution pump. Each pump has a design capacity of 260,000 gpm, and under normal operation these deliver up to 520,000 gpm of dilution water directly to the discharge canal. Normally one or two pumps are operating with the remaining pump(s) held in reserve.

Pump control switches are provided in the Control Room. Instrumentation and alarms are provided to monitor operation of the system as required by the conditions of the NJPDES Permit.

The controls of each dilution pump are interlocked such that placing the control switch in the START position initiates auxiliary lube oil system for the operation of the pump(s). Lube oil cooling and seal water are manually lined up if isolated to the desired pump(s) prior to initiation of the pump start signal. If, after a two (2) minute time delay, support system flows and pressures are normal the dilution pump starts.

The dilution pumps will trip because of various pump or motor protective functions. In addition a reactor scram may cause a pump trip. The auto-bypass control switch position determines the response of the pumps to a reactor scram. In the auto position the pumps will trip on a scram signal, in the bypass position a scram signal will not affect the operation of the pumps. The position of this switch is generally determined by environmental considerations.

10.4.5.3 Safety Evaluation

The CWS is protected against entry of foreign material by the bar racks and the traveling screens.
Protection against accumulation of ice in the intake is provided by the water recirculation system which is activated when needed by opening the sluice gates or temporarily installing and utilizing a portable pump and piping system.

Although the circulating water intake structure was originally designated as a Class II structure it is expected to be capable of withstanding Class I lateral earthquake loadings which is desirable since the structure houses the Emergency Service Water System pumps. This is due to its functional arrangement resulting in a compartmentalized concrete box with longitudinal and transverse walls, and also because, since the structure is entirely below grade, seismic accelerations are not magnified by building deflections.

The evaluation of the Ultimate Heat Sink is presented in Subsection 9.2.5. The system parameters are monitored in accordance with the Technical Specifications.

10.4.6 Condensate Demineralizer System

10.4.6.1 Design Bases

The Condensate Demineralizer System is designed to insure the required level of purity for the condensate water supplied to the reactor. The system removes corrosion products from the Main Turbine, Main Condenser and the tube side of the feedwater heaters, protects the reactor from accidental condenser tube leaks, and removes condensate impurities which may enter the cycle with the makeup water.

The system is sized to process rated load condensate flow.

10.4.6.2 Description

The Condensate Demineralizer System consists of seven mixed bed demineralizer units (including one spare), one recycle pump, and the required piping, valves, instrumentation and controls.

The operating demineralizers can treat the total condensate flow of 15,300 gpm.

The demineralizer tanks are rubber lined carbon steel, sized for an operating flow rate of 50 gpm per ft^2 of bed surface area.

Demineralizer resins are no longer chemically regenerated and reused. The resins are cleaned using the J. O. Backwash process. Chemically exhausted resins are processed in the radwaste system and disposed of. Wastes from the J. O. Backwash process are routed to the chemical waste/floor drain collector tanks.

Main flow valves are manually operated. Depleted resin is either transferred to demineralizers in Radwaste for further depletion or to the spent resin storage tanks. Resins from the spent resin storage tanks are processed in the Waste Solidification System on a periodic basis.

The Condensate Demineralizer System is controlled from a local panel. Integrated flow and conductivity monitors are provided for each demineralizer to indicate when changeout is required. Suitable alarms and pressure drop recorders are provided in the Control Room.

10.4.6.3 Safety Evaluation

The demineralizer vessels are located in shielded areas. Valves, pumps and instrumentation are outside this area but are located nearby. Piping carrying condensate or demineralized condensate does not require shielding.

10.4.7 Condensate and Feedwater Systems

10.4.7.1 Design Bases

The Condensate and Feedwater Systems returns the turbine seal, exhaust deaeration and/or bypass steam, which has been condensed (Subsection 10.4.1) and deaerated (Subsection 10.4.6) to the reactor through a purification system and a regenerative feedwater cycle. A feedwater temperature of about 315°F is reached at the outlet of the high pressure feedwater heaters when the unit is operating at rated power.

Analysis for the end-of-cycle 16 was performed to justify the removal of the HP and IP heaters and allow for operation at rated power at reduce feedwater temperatures. Any future operation in this configuration will require a cycle specific analysis and evaluaton.

The system also supplies, by means of the Condensate Transfer System, a varying quantity of condensate for demineralizer backwash, flushing and resin transport, decontamination, and radwaste processing. The system provides condensate to the Control Rod Drive System and to the low pressure turbine hood sprays, assists the Emergency Core Cooling System (Section 6.3) during accident conditions to maintain reactor water level, and acts as a reservoir of makeup water for various plant users.

10.4.7.2 Description

The Condensate and Feedwater System is shown in Drawing BR 2003, the Condensate Transfer System is shown on Drawing BR 2004. The system starts at the Main Condenser hotwell, and terminates at the Reactor Vessel, it is subdivided into the Condensate System which extends from the Main Condenser to the Reactor Feedwater Pumps, the Feedwater System which extends from the Reactor Feedwater Pump Suction to the Reactor Vessel; and the Condensate Transfer System which includes the Condensate Storage Tank, the Condensate Transfer Pumps and piping and valves.

Condensate System

Two lines from each of the three condenser hotwells discharge into a common 30 inch condensate supply header. The header also receives returned condensate from radwaste processing, the Spent Fuel Pool and the cleanup system. Three one third capacity condensate pumps (Table 10.4-3) take suction from the condensate supply header and discharge into a common 24 inch header which branches to provide cooling flow to the three intercondensers and the three after condensers of the SJAE units. These six condensers are arranged in parallel. Manually operated isolation valves are provided on the suction and discharge lines for each condensate pump, a check valve is provided on each condensate pump discharge line.

The three sets of condensers for the SJAE units are provided with motor operated isolation valves at their intake and discharge lines. The flow recombines downstream of the SJAE condensers, passes through the steam packing exhauster and normally enters the condensate pre-filters. The Condensate Pre-Filter System is designed to reduce feedwater iron concentrations consistent with EPRI Guidelines in EPRI Report BWRVIP-130, "BWR Water Chemistry Guidelines – 2004 Revision." This reduction results in improved reactor water chemistry. Following the pre-filters the flow enters the condensate demineralizers. Upstream of the demineralizers, a branch line is provided for demineralizer backwash. Downstream of the demineralizers, one branch line is provided to the Reactor Feedwater Pump Seals, a second branch line is provided to the low pressure turbine exhaust hood sprays, and a branch line to the CRD System.

Hotwell level is maintained automatically by a level control system. Makeup water is added to the hotwell directly from the Condensate Storage tank through control valves when hotwell level begins to drop below the level setting. If level continues to drop, increasing makeup water is added until level recovers or the control valves reach their full flow position. Conversly, water is rejected from the hotwell through control valves when level rises above the level setting. If level continues to rise, water is rejected at an increasing rate until level recovers or the control valves reach their full flow position. Water from the hotwell is rejected from the Condensate system downstream of the Condensate Demineralizers.

During low feedwater flow demand conditions with Turbine steam seals in operation, a minimum flow through the Condensate system of 2400 gpm is maintained for cooling of the Steam Packing Exhauster. When the Steam Packing Exhauster is not required, Condensate system minimum flows can be limited to lower flow rates based on pump minimum flow requirements.

After leaving the condensate demineralizers, the condensate flows through three parallel strings of feedwater heaters. Under normal operating conditions, one third of the condensate stream flows through each feedwater string. Each string consists of a drain cooler, a low pressure heater and an intermediate pressure heater. At the point of discharge from the intermediate pressure heaters, the line becomes part of the Feedwater System.

Feedwater System

Each of the three one third capacity Reactor Feedwater Pumps (Table 10.4-4) takes suction from one of the intermediate pressure feedwater heaters, and discharges through one of three high pressure feedwater heaters into a common header which separates into two lines prior to penetrating the containment vessel. Each line contains two check valves (one inside containment and one outside) and a manually operated isolation valve inside containment. The lines penetrating the reactor vessel supply a feedwater sparger which distributes the feedwater into the downcomer outside the core shroud (Section 5.2).based upon an Ops/Chemistry Department specified operating point, determined to assure IGSCC crack growth mitigation. The hydrogen injection system is automatically tripped upon high area hydrogen concentration, or manually isolated by operator action from either the local control panel or in the Main Control Room.

The feedwater flow, downstream of the Reactor Feedwater Pumps, is controlled by the Reactor Level Control System which modulates a flow control valve in response to deviations of the reactor water level from a setpoint. The feedwater demand signal is fed through three control stations so that the total demand can be shared by the three heater strings in any desired proportion.

There is no cross connection between the pumps so if a pump is shutdown, the entire associated heater string is shutdown. Each pump is provided with a recirculation line which discharges to the Main Condenser through a minimum flow valve.

A manual isolation valve is installed in each recirculation line downstream of the minimum flow valves to provide positive isolation between the Feedwater System and the Main Condenser for maintenance purposes.

Three 10 inch, diaphragmoperated flow regulating valves are installed, one each, on the discharge lines of the three feedwater pumps downsream of the recirculation lines. The automatic control system modulates these valves to maintain the desired reactor water level. The excess water discharging from the pump is returned to the condenser through the minimum flow recirculation line.

During startup, when much smaller flow rates are required, two smaller flow control valves, paralleling the feedwater flow control valves of two of the feedwater trains, are used to maintain the desired flow.

A permanent automatic Reactor Overfill Protection System (ROPS) as required by USNRC Generic Letter 89-19, Request for Action Related to Resolution of Unresolved Safety Issue A-47, "Safety Implication of Control Systems in LWR Nuclear Power Plants" pursuant to 10 CFR 50.54(f) dated September 20, 1989, is provided at OCNGS to minimize the potential of Main Steam Line Breaks (MSLB) caused by steam line flooding. It is designed to trip all three (3) feedwater pumps on high reactor level provided feedwater flow is not low and normal/bypass selector switch located on control room panel 4F is not in bypass position. This system is discussed in detail in Section 7.7.1.6.

Condensate Transfer System

The Condensate Transfer System consists of a 525,000 gallon Condensate Storage Tank (CST), two full capacity condensate transfer pumps, and the associated piping and valves. A line from the Demineralized Water Transfer System is included as part of the Condensate Transfer System, since it constitutes the source of makeup to the Condensate System.

The 12 inch diameter aluminum condensate transfer supply line for the Core Spray System pumps and Control Rod Drive System pumps is routed above grade from the CST, into a trench towards the Turbine Building and is then routed approximately five feet below grade towards an existing penetration near the northwest corner of the Turbine Building The 10 inch diameter aluminum condensate transfer lines are routed above grade from the CST and into the Condensate Transfer/Demineralized Water Transfer (CT/DWT) Pump House. These 10 inch diameter lines connect to the existing Feedwater System and Fire Protection Water System tie-in points which are located within the pump house. Similarly, the 6" diameter aluminum condensate transfer suction line is routed above grade from the CST and into the CT/DWT Pump House. This 6 inch diameter line connects to the existing suction header of the Condensate Transfer Pumps which is also located within the pump house. The 6 inch diameter aluminum condensate transfer discharge line is routed approximately seven feet below grade from the CT/DWT Pump House towards an existing penetration at the west wall of the Turbine Building Valves are installed on the CST nozzles and will isolate the CST in the event of a water leak in the aluminum piping. Other CST supply/return lines (carbon steel) are routed below grade. All below grade piping is externally coated to prevent corrosion.

Condensate Transfer System piping was designed for 200 psig and 100°F, as per ANSI B31.1.The Condensate Transfer Pumps, with local instrumentation, isolation and check valves, minimum flow bypass lines and a rotameter with valves for in-service testing of the pumps are located near the Chlorination Building. Automatic and manual valves on the makeup line from the Demineralized Water Transfer System are located in the vicinity of the pumps. Overflow and drain lines are provided to the tank. The Condensate Storage Tank also supplies makeup to the Isolation Condensers.

Feedwater Control

The primary function of the feedwater level controller is to maintain the desired water level in the reactor vessel. The control is achieved by sensing plant parameters which affect reactor vessel water level control such as:

a. Reactor vessel water level

b. Steam flow out of the reactor vessel

c. Feedwater flow into the reactor vessel

d. Reactor Vessel Pressure

e. Feedwater return temperature

The desired reactor vessel level is selected by the operator in the Control Room and compared to the actual level signal. The level controller opens or closes the feedwater regulating valves to maintain the desired level.

10.4.7.3 Safety Evaluation

During all periods of power generation and reactor operation, the Main Condenser is the principal heat sink for reactor power and the Feedwater and Condensate Systems are the only means of maintaining the reactor water level. Therefore, the Condensate and Feedwater Systems are essential for power operation. All condensate and reactor feedwater pumps are normally running and all major components are in service at full power.

Alarms are set at anticipating conductivity levels to allow time for shutting off the flow of circulating water to a leaking condenser section before the leakage exceeds the capability of the condensate demineralizer to remove undesirable substances. In case of loss of one condensate or feedwater pump at approximately 80 percent load or below, it is possible, by means of operator action to reduce reactor power to match the reduced flow capability before the reactor scrams on low water level.

The reactor feedwater pumps are protected by low suction pressure trip, low lube oil pressure trip and motor overcurrent trip. To prevent the effects of spurious pump trips due to suction pressure fluctuations, pressure relays switches PSL-101, -102, and -103 are provided with time delays.

The time delay will maintain feed pump protection against cavitation while increasing the reliability of plant operation. The pumps must be restarted manually after a trip.

The feedwater control system also protects against reactor feedwater pump runout by limiting flow through the feedwater regulating valves to a preselected setpoint. To assist the operator in determining which pump is experiencing runout, individual feedwater pump status indicating lights are provided in the Control Room. In addition, to detect a steam leak, if the steam flow from the turbine steam chest does not match the steam flow leaving the reactor, an alarm is sounded. To prevent spurious actuation, a time delay circuit has been incorporated to this control function.

The HWC System has no safety function. The system is not required for safe shutdown of the reactor and is not required to mitigate the consequences of a postulated accident. Hydrogen gas piping is provided with excess flow protection, isolation valves and check valves to preclude line ruptures or other hazards in accordance with NRC approved guidelines. (See Section 2.2.3.2).

The ROPS has no safety function. The system is not required for safe shutdown of the reactor and is not required to mitigate the consequences of a postulated accident. The purpose of the ROPS is to minimize the potential for Main Steam Line Break (MSLB). It is designed to trip all three feedwater pumps when high water level condition occurs in the reactor vessel.

10.4.7.4 Inspection and Testing

The Condensate and Feedwater System piping was hydrostatically tested prior to initial plant startup. Condensate grab samples can be obtained downstream of each condensate pump. Inservice testing of the Condensate Transfer Pumps is performed periodically.

10.4.8 Heating and Process Steam System

10.4.8.1 Design Basis

The primary purpose of this system is to supply energy to the facility’s operations of:

a. Processing liquid radioactive waste by evaporation
b. Providing building space heat throughout the plant
c. Providing oxygen-free boiler feedwater to prevent corrosion

A steam generating capacity of approximately 39,000 lbs/hr total at 75 psig is available from two fuel-oil fired boilers in a vapor cycle.

The design pressure/temperature for the Heating and Process Steam System is 150 psig/350°F.

The chemical and physical properties of both boilers meet the requirements of material specifications of the ASME B&PV Code. Their design, materials, construction, and workmanship conform to Section I, Power Boilers, of the ASME B&PV Code.

Boiler External Pipe is designed to ASME B&PV Code Section I provisions. The remainder of the steam piping and fittings are designed to ASA/ANSI/ASME B31.1 Class C, Seismic Class II.

The cleanliness class of all associated piping and equipment is Class D as defined by ANSI N45.2.1.

The boilers are subject to the applicable provisions of Federal New Source Performance Standards (NSPS) for Small Industrial Generating Units, 40 CFR Part 60 Subparts A and Dc. Air Pollution Control Permits and Certifications to Operate are established by New Jersey Air Pollution Control (NJAPC) regulations, which are codified in New Jersey's Administrative Code Chapter 7, Subsection 27.

The Deaerator and other pressure vessels are designed and constructed to Section VIII of the ASME B&PV Code.

10.4.8.2 Description

The Heating and Process Steam System is designed with the capacity to provide facility space heating and steam for operating a Radwaste Concentrator for the evaporative processing of liquid radioactive waste.

Energy input to the steam cycle comes from combusting #2 Fuel Oil in a boiler. The boilers are fire-tube boilers.

The general description of the Heating and Process Steam cycle consists of:

a. the energy liberated from combusting #2 fuel oil heats water maintained at constant pressure to the saturation temperature where vaporization occurs. Here the "working fluid" is brought from the lower to the upper temperature limit of the cycle.

b. the expansion of the fluid to the lower temperature and pressure limits of the cycle

c. the complete condensation of the fluid by the emission of energy at the lower temperature and pressure, constituting the rejection of unavailable energy to the receiver, and

d. the return of the condensed fluid to the upper pressure by reversible adiabatic compression.

These processes take place successively in the boiler(s), heating elements and radwaste concentrator, the condensate return traps and tanks, deaerator and feed pump(s).

During normal operation steam is supplied by either or both auxiliary boilers (depending on steam requirement) to heating and process loads. A common header joins the steam outlets from each boiler allowing it to be directed to where the need exists.

Condensate from the plant space heating is returned to the boiler condensate storage tank by gravity or by the pumps associated with the condensate returns units in the Turbine Building Basement and Radwaste small pump room.

Steam supplied for processing liquid radwaste is used in a Radwaste Concentrator. The concentrator components using this steam are the Preheater and the Evaporator. Steam condensate from the concentrator(s) is gravity drained through traps to the Radwaste small pump room drain collection tank.

Steam at a pressure above atmospheric, is supplied to a direct-contact heater to deareate boiler feedwater, lowering the oxygen content of the feedwater to the boilers.

Makeup is provided from the Demineralized Water Transfer System. Boiler blowdowns, used to remediate water chemistry, is directed to an overboard discharge, or sump 1-2.

10.4.8.3 Safety Evaluation

The Heating and Process Steam System is not safety related.

TABLE 10.4-1
(Sheet 1 of 1)

MAIN CONDENSER PARAMETERS

Type	Three shell, divided water box, deaerating
Design Parameters, (per shell)	
Capacity, Btu/hr	1,490,000,000
Back Pressure in. Hga	1.49
Tube Surface, sq ft	141,000
Cooling Water Requirements at 60°F, gpm	150,000
Cooling Water Design Temperature Rise, °F	19.87
Hotwell Capacity, gallons	15,000
Holdup Time, Minutes	3

TABLE 10.4-2
(Sheet 1 of 1)

STEAM JET AIR EJECTORS

Type	Two stage, twin element
Performance	
Capacity per Element	266 total lb mixture per hr. including 157.2 lb noncondensibles
Steam Conditions at Nozzle	100 psig, dry and saturated; 1.7 psig maximum back pressure
Steam Consumption per Element	2290 lb/hr

TABLE 10.4-3
(Sheet 1 of 1)

CONDENSATE PUMPS

Design and Operating Conditions	
Capacity at Design Point, gpm	5,000
TDH, ft. H_2O	660
Bhp at design point	977
Overall efficiency at design point, percent	84
NPSH required at design point, ft	(-) 2.5
Shutoff heat, ft.	780
Maximum hp	1100
Minimum required flow, gpm	500
Casing design pressure, psi	375
Motor	
Manufacturer	General Electric Co.
Hp	1000
Power Requirements	4160 volt, 3 phase
Power Source	
1A	4160 volt, switchgear 1A
1B, 1C	4160 volt, switchgear 1B

TABLE 10.4-4
(Sheet 1 of 1)

REACTOR FEEDWATER PUMPS

Pumps		
Capacity, gpm	5000	
TDH, ft	2800	
Speed, rpm	3570	
Required NPSH above first-stage impeller, ft	89	
Shutoff head, ft	3340	
Minimum flow, gpm	1000	
Power required at design capacity and head, BHP	3995	

Motors	Main Drive	Auxiliary Oil Pump
Capacity, hp	4000	1/4
Voltage	4000	440
Rated Speed		1725
Power Source		
1A	4160-volt switchgear 1A	MCC 1A13
1B	4160-volt switchgear 1B	MCC 1B13
1C	4160-volt switchgear 1B	MCC 1B13

Lubrication System
Shaft-driven IMO pump with motor-driven auxiliary oil pump, reservoir, filters, coolers, and required piping and instrumentation.