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DRAWINGS CITED IN THIS CHAPTER*

*The listed drawings are included as "General References" only; i.e., refer to the drawings to obtain additional detail or to obtain background information. These drawings are not part of the UFSAR. They are controlled by the Controlled Documents Program.

DRAWING*	SUBJECT
M-12	Diagram of Main Steam Piping Unit 2
M-13	Diagram of Extraction Steam Piping Unit 2
M-14	Diagram of Reactor Feed Piping Unit 2
M-15	Diagram of Condensate Piping Unit 2
M-16	Diagram of Condensate Booster Piping Unit 2
M-17	Diagram of Condensate Demineralizer Piping Unit 2
M-18	Diagram of Heater Drain Piping Unit 2
M-19	Diagram of Heater Miscellaneous Vent and Drain Piping Unit 2
M-36	Diagram of Circulating Water and Hypochlorite Piping
M-43-1, -2, -3	Diagram of Off-Gas Piping Unit 2
M-345	Diagram of Main Steam Piping Unit 3
M-347	Diagram of Reactor Feed Piping Unit 3
M-371-1	Diagram of Off-Gas Piping Unit 3

10.0 STEAM AND POWER CONVERSION SYSTEM

10.1 SUMMARY DESCRIPTION

The equipment and evaluations presented in this section are applicable to either unit. The steam and power conversion system is designed to produce electrical power from the steam generated by the nuclear reactor.

Steam from the reactor flows directly to the high-pressure steam element. The high-pressure element exhaust steam flows through the moisture separators before entering the regenerative low-pressure elements. The exhaust steam from the low-pressure elements is condensed by the main condenser where it is deaerated and collected in the condenser hotwell, along with condensed steam from miscellaneous drains from the turbine cycle. Heat removed by the condenser is transferred to the circulating water system. The heat is then rejected to the cooling lake and/or the Illinois River system. The condensate pumps take suction from the hotwell and pump the condensate to the steam jet air ejector condensers, turbine gland seal exhaust condensers, off-gas condensers, 100% condensation filtration system, and demineralizers. The purified condensate then flows to the suction of the condensate booster pumps. The condensate booster pumps increase the condensate pressure and discharge the condensate through the low-pressure feedwater heaters to the suction of the reactor feedwater pumps. Discharge from the reactor feedwater pumps passes through feedwater-regulating valves (which control pressure, flow, and ultimately level), and then through the high-pressure heaters to the reactor.

Extraction steam from the low-pressure elements is used for feedwater heating. The condensate from the moisture separator drains and condensed extraction steam is cascaded through the feedwater heaters to the main condenser.

Table 10.1-1 summarizes the design and performance characteristics of the major components of the power conversion system. The principal flow quantities and thermal qualities which define the heat balance are provided in Section 10.4.

Normally, the turbine uses all the steam generated by the reactor except for a small amount provided to process auxiliaries. Automatic pressure-controlled bypass valves can discharge excess steam directly to the condenser. The capacity of the bypass valves is sufficient to allow load rejections of up to 33.5% of rated steam flow without a turbine trip or reactor scram.

The steam and power conversion system is capable of accepting at least 103% of the turbine rated steam flow. The interface between the reactor protection system and the turbine and condenser instrumentation is described in Section 7.2. Features of the steam and power conversion system are described in more detail in Sections 10.2, 10.3, and 10.4.

Table 10.1-1

MAJOR COMPONENT DESIGN AND PERFORMANCE CHARACTERISTICS OF THE POWER CONVERSION SYSTEM

A.	Turbine Data		
	1.	Manufacturer	General Electric Company
		LP Rotor manufacturer	ALSTOM
	2.	Type	Tandem compound, six flow exhaust
	3.	Number of HP sections	1
	4.	Number of LP sections	3
B.	Gross generator nameplate		
	1.	Unit 3	1,068,000 (KVA) at 0.945 PF
	2.	Unit 2	1,068,000 (KVA) at 0.945 PF
C.	Final feedwater temperature		356°F(1)
D.	Supply steam rating		
	1.	Flow	11.8 x 10^6 lb/hr
	2.	Pressure	910 psig
	3.	Temperature	535.2°F
	4.	Moisture content	0.6%
E.	Turbine cycle arrangement		
	1.	Number of feedwater heating stages	4
	2.	Heater drain system	Cascading
	3.	Feedwater heater stages in condenser neck	1
F.	Type of condensate demineralizer		Ion exchange
G.	Main steam bypass capacity		33.5%
H.	Type of condensate filter		100% full-flow filter

(1) The values given for feedwater temperature and supply steam flowrate serve as nominal reference values at valve wide open (VWO) conditions, but are not limits.

10.2 TURBINE-GENERATOR

10.2.1 Design Bases

The turbine-generator system converts the thermodynamic energy of steam into electrical energy. The turbine-generator was designed to the following specifications:

Steam Conditions:

Throttle Pressure	910 psig
Quality	Saturated with 0.6% moisture
Exhaust Pressure	1.5 in.Hg abs.

The inlet pressure of the turbine is dictated by the choice of the optimum reactor pressure. As limited by the interfacing equipment, saturated steam quality is maintained as high as possible to minimize blade erosion, and exhaust pressure is maintained as low as possible for maximum turbine efficiency.

There are no industry codes related to the design, manufacture, or installation of the turbine rotor. The turbine and all components, including the turbine rotor, were designed in accordance with the manufacturer's standards.[1]

10.2.2 Description

The turbine-generator system consists of the turbine, generator, exciter, controls, and required subsystems.

The turbine is an 1800 rpm, tandem-compound, six-flow, nonreheat steam turbine. The turbine is designed for saturated steam conditions of 910 psig with 0.6% moisture, 1.5 inches mercury absolute exhaust pressure, and 0% makeup while extracting steam for four stages of feedwater heating (see Drawings M-12, Sheet 2 and M-13). The turbine unit consists of one double-flow, high-pressure element, and three double-flow, low-pressure elements. Exhaust steam from the high-pressure element passes through moisture separators before entering the three low-pressure elements. The low-pressure elements have 47-inch last stage buckets in which operation at a maximum backpressure of 7.5 inches mercury is permitted. The separators reduce the moisture content of the steam to less than 1% by weight.

The Unit 2 generator is directly driven from the turbine shaft and rated at 1,068,000 kVA at 0.945 power factor and a 0.50 short circuit ratio. It is a synchronous generator with a 60 Hz, 18,000 V output at 1800 rpm. The generator armature and stator are cooled by hydrogen which is rated at 60 psig. Stator internals are water cooled. Generator excitation is provided by an Alterrex exciter rated at 2398 KVA at a 0.95 power factor and 427 VAC. The ac output of the exciter is rectified to dc before feeding the main generator field. The main generator field is rated at 3762 A, and 506 Vdc.

The Unit 3 generator is directly driven from the turbine shaft and is rated at 1,068,000 kVA at a 0.945 power factor and 0.52 short circuit ratio. It is a synchronous generator with a 60-Hz, 18,000 V output at 1800 rpm. The generator armature and stator are cooled by hydrogen. The design operating pressure for the generator hydrogen system is 60 psig. Stator internals are water cooled. Generator-excitation is provided by an Alterrex exciter rated at 1910 kVA at a 0.97 power factor and 375 Vac. The ac output of the exciter is rectified to dc before feeding the main generator field. The main generator field is rated at 3910 A and 468 Vdc.

Turbine steam flow is controlled by a set of four hydraulically operated turbine control valves on the high-pressure element main steam supply as shown in Drawing M-12, Sheet 2. Four hydraulically operated main steam stop valves provide isolation of the main steam supply to the turbine. High-pressure element exhaust steam is routed to four moisture separators prior to entering the low-pressure elements. Steam flow from the moisture separators to the low-pressure elements is controlled by the combined intermediate valves (CIVs). Each CIV includes an intercept valve and an intermediate stop valve. The intercept valves throttle to control flow from the moisture separators during turbine overspeed conditions and the intermediate stop valves provide isolation between the moisture separators and the low-pressure elements (similar to the turbine control valves and main steam stop valves on the main steam supply).

Turbine controls include a speed control unit, a load control unit, a bypass control unit, a flow control unit, and a pressure control unit. An electrohydraulic control (EHC) system integrates the electronic control circuits with the hydraulic system. The EHC system positions the turbine control and bypass valves to control reactor pressure and consequently generator load and turbine speed and is driven by a triple modular redundant pressure controller. Refer to Section 7.7 for a description of the turbine control system.

The unit follows system load by adjusting the reactor power level. Power level can be adjusted by regulating the reactor recirculating flow or by moving control rods.

The turbine speed governor can override the pressure regulator and close the turbine control valves and intercept 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 turbine control valves will pass, up to 33.5% of rated steam flow can be routed directly to the main condenser via a set of nine bypass valves. The bypass valves are controlled by the EHC system as part of the overall reactor pressure control scheme. The turbine-generator load controls are designed for a 20 MWe gross per second maximum rate of change of power demand.

The EHC system oil is supplied through numerous interconnected or interacting subsystems. Some of these are the fluid actuator supply (FAS), fluid actuator supply trip controlled (FASTC), and fluid jet supply (FJS) subsystems.

The FAS subsystem supplies the actuators for the main and intermediate stop valves, and the actuators for the bypass valves. FAS supplies the servo unit for No. 2 main steam stop valve via a ported manifold block between the servo unit and the control pac on the valve. FAS also supplies the FASTC subsystem through an orifice and relay trip valve. The FASTC subsystem supplies the actuators for the intercept and control valves. In addition, FASTC supplies the FJS to the servo units on the turbine control valves and No. 1, No. 3, and No. 5 intercept valves via a ported manifold block between the servo unit and the control pac. The FJS line connects to FAS line that is feeding the manifold to supply both FAS and FJS ports internally.

Both Units 2 and 3 have the ability to isolate the EHC fluid supply used for the FASTC subsystem, the main stop valves, the control valves and the intercept valves while allowing both FAS and FJS fluid to the bypass valves. This allows the reactor remain operational via the bypass valve operation below 40% of rated steam flow while the other subsystems of the EHC fluid have been isolated.

Loss of EHC system oil will cause the following actuations:

> A generator load rejection scram will occur on decreasing FASTC subsystem oil pressure at a setpoint greater than or equal to 460 psig (nominally set at less than 600 psig), via pressure switches tied to the load rejection scram logic. The area under the control valve disk dump valve is one-fourth of the area above the disk dump valve. The FASTC subsystem oil (1600 psig) acts beneath the disk dump, such that when the oil pressure below the disk dump drops to approximately 400 psig, the disk dump valve opens and the control valve fast closes. The pressure switches, one for each control valve, monitor the FASTC subsystem oil pressure to the disk dump valve and provide a signal to the reactor protection system, thus anticipating the turbine trip. This scram is further discussed in Section 7.2.

If a load rejection occurs, the turbine control valves and the intercept valves throttle to limit turbine overspeed. A load rejection typically also results in a generator lockout, which is an input signal for a turbine trip. Due to the large quantity of energy in the turbine and moisture separator fluid, steam flow to the low-pressure elements could continue after the turbine control valves are fully closed. The intercept valves provide overspeed protection by throttling intercept valves No. 1, 3, and 5 to control this steam flow at 105% of rated speed.

Intercept valves No. 1, 3 and 5 are positioning valves (one for each LP element) with each valve operated through a servo motor positioned by the output from a servo valve. A fast acting solenoid valve is installed on each intercept valve to close the valve on loss of load. Intercept valves No. 2, 4 and 6 are slaved to valves No. 1, 3 and 5, respectively. They are either full open or closed. This is done by a test solenoid valve actuated by limit switches on its respective positioning valve. This intercept valve also has a fast acting valve for rapid closing. The nonpositioning intercept valve will open when its companion positioning valve is open. The nonpositioning valve will close when the positioning intercept valve is lowered below half-stroke.

Nonreturn valves in the extraction steam lines to the B, C, and D feedwater heaters prevent steam from the feedwater heater fluid from flowing back to the turbine. When a turbine trip signal occurs, the nonreturn valves lose air assist to open, thereby allowing them to close and prevent reverse flow. They also prevent water induction if high feedwater heater shell side water levels occur.

If the turbine speed increases to approximately 110%, a primary overspeed trip (turbine controller) will occur, closing the main stop valves as well as the control and intercept valves. Backup protection for the primary trip is provided by an independent emergency trip (protection module) at 110.3%.

The turbine-generator trip system monitors critical turbine-generator parameters and automatically closes the four main steam stop valves, turbine control valves, and CIVs to rapidly shutdown the turbine on any one of the following signals:

A. High reactor vessel water level,

B. Low lube oil or bearing oil pressure,

C. Overspeed Primary or Emergency Trip

D. High exhaust-hood temperature, below 30% main turbine intermediate pressure

E. Excessive thrust bearing wear,

F. Generator electrical faults,

G. Remote or local manual trips,

H. Low condenser vacuum,

I. Intentionally Deleted

J. Low EHC fluid pressure,

K. Loss of speed feedback signal,

L. High water level in any moisture separator, or

M. Loss of stator cooling without runback.

N. High vibration when enabled

10.2.3 Turbine Disk Integrity

Analyses of turbine failures which might cause a missile to be projected are addressed in Section 3.5.3.

10.2.3.1 Design and Materials

All original low-pressure turbine rotors were replaced with a design that was less susceptible to stress corrosion cracking. The original rotor design had “shrunk-on” rotors, which were replaced with rotor discs that used a “welded-on” design to minimize stress corrosion cracking. However, the replacement rotors continued to be susceptible to stress corrosion cracking in the area of the blade to wheel attachment, requiring greater inspection frequency. The susceptibility to stress corrosion cracking is due to the impact of high moisture content steam in a high stress area of a high strength material. Between 2011 and 2012, the low pressure rotors were replaced with rotors designed to address the problems at the wheel attachment to reduce the required inspection frequency. The design for the replacement rotors have lower stresses and used alloys that are not susceptible to stress corrosion cracking.[1]

10.2.3.2 Inservice Inspection and Testing

Tests and inspections are conducted to ensure adequate functional performance as required for continued safe operation and to provide maximum protection for operating personnel. One of these tests is periodic exercising of the main steam stop valves and the bypass valves. Each main steam stop valve is tested individually to full closure. The valves will close only 10% when multiple valves are tested simultaneously. The test procedure requires individual valve testing using individual test buttons to minimize the possibility of a transient. Other control valves not normally in motion are also periodically exercised. Primary and Emergency overspeed trips are tested periodically.

The turbine, including rotors, is inspected periodically at intervals recommended by the vendor to preclude the probability of turbine missiles due to stress corrosion cracking of the turbine disk.[1]

Acceptance testing and operability verification of the new rotors have been performed using manufacturer's procedures, station start-up procedures, and engineering department procedures.

10.2.4 Evaluation

The effects of component failures in this system have been evaluated in detail. The turbine system component failure events having the most significant effects on the plant are as follows:

A. Generator load rejection without bypass;

B. Turbine trip, coincident with failure of the turbine bypass system;

C. Inadvertent closure of main steam isolation valves;

D. Turbine trip (main steam stop valve closure);

E. Loss of EHC system oil pressure (turbine control valve fast closure);

F. Loss of condenser, and

G. Steam pressure regulator malfunction or failure.

Descriptions of these failures is contained in Chapter 15 and Section 5.2.2.

EGC's experience with turbines in its nuclear power plants has not shown significant radioactive contaminants during maintenance. A radiological evaluation of the turbine system is provided in Chapters 11 and 12.

10.2.5 References

1. DRE10-0033 “Dresden LP Retrofit – Missile Analysis Alstom Report # STD0010156,” August 2, 2011.

10.3 MAIN STEAM SYSTEM

The Unit 2 main steam system (MSS) is shown on Drawing M-12, and Unit 3 MSS is shown on Drawing M-345. The main steam isolation valves (MSIVs) are further discussed in Section 6.2. The safety relief valves (SRVs) are discussed in Section 5.2.

10.3.1 Design Bases

The performance objective of the main steam piping is to supply steam to the turbine-generator from the reactor vessel. To achieve this objective, the main steam piping was originally designed using the following bases:

Design pressure and temperature	1250 psig at 575°F
Piping design code	USAS B-31.1

Since then the piping has been re-evaluated at uprated power conditions and found to be satisfactory.

10.3.2 Description

The main steam piping consists of four lines which carry the reactor generated steam to the main turbine. Each steam line is equipped with two isolation valves, one on each side of the primary containment wall, and a combination flow restrictor and flow measuring venturi located between the reactor and the first isolation valve. The rated steam flow that the main steam line piping was originally designed to handle is 9.8×10^6 lb/hr at 965 psia. Unit operation would be permitted above rated steam flow rate and up to 9.90×10^6 lb/hr. Since then the piping has been re-evaluated at uprated power conditions and found to be satisfactory.

The MSS piping from the reactor vessel to the turbine is dynamically designed. The internal and external design load combinations and criteria are addressed in Chapter 3.

Design, fabrication, and installation of the main steam piping are summarized in Table 10.3-1.

In addition to providing steam to drive the main turbine, the MSS also provides steam to the following:

A. Turbine gland seal system,

B. Steam jet air-ejectors, and

C. Off-gas recombiner system.

Downstream of the outboard isolation valves, the four main steam lines are connected by a 30-inch diameter main steam equalizing header. Two 18-inch diameter lines connect the equalizing header to either end of the turbine bypass manifold. From the turbine bypass manifold, nine 8-inch lines connect to the turbine bypass valves, which discharge to the main condenser through horizontal perforated pipes located immediately below the tube bundles. The perforations are directed downward onto the condensate in the collecting trays. A maximum of 33.5% of rated steam flow can be bypassed to the main condenser.

From the main steam equalizing header, each of the four main steam lines passes through main steam stop valves and turbine control valves, then discharges to the high-pressure turbine.

Drains are provided at several locations along the main steam system to drain condensate from the line and return it to the condenser.

The main steam stop valves are described in Section 10.2. Steam pressure and flow measuring devices are described in Chapter 7.

10.3.3 Evaluation

Leakage from the MSS into the steam tunnel is evaluated in Section 15.6.

Evaluations of the MSS response to seismic and pipe break events is contained in Chapter 3.

Dynamic loading of the main steam piping following turbine stop valve fast closure under extended power uprate conditions is discussed in Section 3.9.3.1.3.5.

10.3.4 Inspection and Testing Requirements

Inspection and testing for the main steam piping are essentially the same as those described in Section 5.2 for the primary process piping in general.

Portions of the main steam system within the primary containment are provided with removable thermal insulation to enable periodic inspection in accordance with the Technical Specifications.

Components and piping for the MSS were originally hydrostatically tested in accordance with ASA B-31.1. Inspection and acceptance standards were in accordance with ASME Code, Section VIII. All circumferential butt welds for 2½-inch diameter piping and larger were specified to be 100% radiographed in compliance with paragraph UW51 of ASME Code, Section VIII.

Inservice inspection (ISI) of the MSS is outlined in Section 6.6. Testing of the main steam stop valves is addressed in Section 10.2. Testing of the MSIVs is addressed in Section 6.2.

The opening times of the main turbine bypass valves are measured after any maintenance is performed that may affect the operation of the bypass system but at least once per refuel outage prior to unit startup. The results are used to confirm that the appropriate bypass valve opening times were used to establish the OLMCPR, which is presented in the Core Operating Limits Report (COLR).

10.3.5 Water Chemistry Pressurized Water Reactor (PWR)

This section is not applicable to Dresden Station.

10.3.6 Steam and Feedwater System Materials

The condensate/feedwater and main steam system piping, fittings, and valves connected to the reactor pressure vessel from and including the first weld at the vessel to and including the first isolation or shut off valve conform to ASME Section I. This piping is constructed of A 106 Grade B. The feedwater piping maximum wall thickness is 1.375 in. The main steam piping has a maximum wall thickness of 1.031 in.

The condensate and feedwater systems are described in Section 10.4.7.

10.3.6.1 Fracture Toughness

The 1965 edition of the code does not require impact testing nor does the original specification or ASTM specification. Current ASME Section III for class I components require impact testing. The Dresden Systematic Evaluation Program (SEP) compared the original testing requirements of the feedwater and main steam piping from the reactor vessel to the outermost isolation valve with the later code which requires impact testing if certain exemptions are not met. An exemption for a material is permitted if the lowest service temperature (LST) exceeds 150°F. The LST is defined as the calculated minimum metal temperature whenever the pressure within the component exceeds 20% of the preoperational system hydrostatic test pressure. Due to the high service temperature, well above 150°F, feedwater and main steam piping brittle fracture is not a problem and fracture toughness testing is not required.

10.3.6.2 Materials Selection and Fabrication

The materials selected for the main steam and feedwater piping, within the scope of the design specifications (including pipes, fittings, flanges, bolts, and valves), were originally in accordance with ASA B-31.1, which specified approved ASTM Specifications. The welding procedures are in accordance with ASME Code, Section IX. Austenitic stainless steel is not used in the main steam or feedwater piping.

Table 10.3-1

DESIGN, FABRICATION, AND INSTALLATION OF THE MAIN STEAM PIPING

<u>Pipe</u>	
Size	20 in. and 24 in.
Type	Seamless
ASTM Specification	A 106 Grade B
Schedule	80
<u>Weld Joint</u>	
Root pass	Gas tungsten arc (TiG)
Second pass	Gas tungsten arc (TiG)
Remainder	Shielded metal arc (SMA)
<u>Fittings</u>	
Type	Butt weld
ASTM Specification	B 16.9
ASTM Specification	A 234 grade WPB
Schedule	80

Notes

1. For piping 2" and under, ASTM A335 Grade P11 or P22 may be substituted for ASTM A106 Grade B material for the same schedule. For fittings and valves 2" and under, ASTM A182 Grade F11 or F22 may be substituted for ASTM A105 for the same rating. Substitutions are allowed up to a maximum temperature of 450°F (operating or design) and apply to non-safety related piping and fittings only. No generic substitution of safety related piping/fittings is allowed.

10.4 OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEM

10.4.1 Main Condenser

The functions of the main condenser are as follows:

A. To provide a heat sink for the turbine exhaust steam;

B. To condense the bypass steam after a turbine trip;

C. To accommodate feedwater heater drains, extraction steam, and steam line condensate routed to the condenser during operation with feedwater heaters out of service;

D. To retain the condensate for 1-1/2 minutes to allow for the decay of short-lived isotopes;

E. To deaerate the condensate and remove fission product gases, hydrogen, and oxygen; and

F. To provide adequate net positive suction head for condensate pumps.

10.4.1.1 Design Basis

The main condenser is not credited to support safe shutdown or to perform any reactor safety function.

10.4.1.2 System Description

The main condenser is a divided water flow, single-pass, multipressure type condenser with backwashing capability for each half of the condenser.

The condenser is designed for 3 exhaust pressures which results in performance comparable to an average exhaust pressure of 1.5 in.Hg abs with 60°F cooling water. The condenser is designed to accept bypass steam up to 33.5% of throttle steam flow. The condenser water boxes are of fabricated steel construction.

The condenser hotwell is designed to provide sufficient retention time (1-1/2 minutes) to permit decay of N-16 and O-19 to levels which eliminate the need for shielding of the condensate pumps.

The main condenser is designed for internal hydrostatic pressure (when filled) and external atmospheric pressure.

One-half of the Main Condenser water box may be isolated at reduced reactor power to facilitate maintenance activities.

During plant operation, steam, after expanding through the low-pressure turbine elements, exhausts through the bottom of the turbine casing to the condenser. The circulating water system, discussed in Section 10.4.5, provides the cooling medium to condense turbine exhaust steam. The condenser shell is supported on the turbine foundation mat. An expansion joint is fitted between each low-pressure element exhaust hood and condenser inlet connection. The condenser is divided into three separate compartments by two division plates, as shown in Drawing M-15. Cold circulating water enters the cold compartment which has 100% condensing capacity. The intermediate compartment has 99% condensing capacity because of the warmer temperature of the circulating water. The warm compartment has 97 - 98% condensing capacity. The excess steam is called reheat steam and is used for deaerating purposes.

Reheat steam heats the condensate streams at the weir plate to a boiling temperature that liberates the dissolved noncondensible gases. Vent pipes passing through the lower deaerating weir plate and collecting tray vent the noncondensible gases to the tube bundle in the intermediate compartment. Air leaking into the condenser and noncondensible gases are transported via vent pipes to the air cooler trays which extend the entire condenser length. These gases are removed by the main condenser evacuation system described in Section 10.4.2.

The condenser hotwells retain the condensate for 1-1/2 minutes to allow short-lived radionuclides to decay. This condensate retention is accomplished by a series of baffles and tunnel arrangements at the condensate outlet. The condensate is pumped from outlet pipes by the condensate pumps described in Section 10.4.7.

The circulating water system, which provides the condenser tube single-pass cooling, is described in Section 10.4.5. Design data and operating performance requirements are shown in Table 10.4-1.

If core flooding or containment flooding is needed following a postulated loss-of-coolant accident, the standby coolant supply system provides an inexhaustible supply of water to the condenser hotwell so that feedwater flow to the reactor can be maintained. The standby coolant supply system is described further in Section 9.2.

10.4.1.3 Safety Evaluation

The condenser shell is protected by relief diaphragms on the turbine exhaust casing in the event of a failure of the turbine bypass valves to close on loss of condenser vacuum.

Double tube sheets prevent river water leakage through the tube joints to the condenser hotwell. Tube leakage is monitored by condensate demineralizer inlet conductivity. Plant operation in the event of high conductivity is discussed in Section 10.4.6

Tube leakage may be repaired during reactor operation by isolating one-half of the Main Condenser water box or by draining the condenser waterboxes after reactor shutdown.

If the Dresden Island Lock and Dam were to fail, the water level would recede within the condenser water box. Both units would be shutdown due to loss of condenser vacuum, as discussed in Section 9.2.5.3.1.

10.4.1.4 Tests and Inspections

The condenser is monitored for vacuum, circulating water pressure drop, and temperature rise. The condensate conductivity is measured at the condensate demineralizer inlet. All tests and inspections of the condenser are in accordance with station inspection and maintenance procedures.

10.4.1.5 Instrumentation Applications

Indication of condenser level and pressure is provided in the control room. The condensate level in the condenser hotwell is maintained within proper limits by automatic controls that provide makeup or transfer of condensate to or from the condensate storage tanks. Turbine exhaust hood temperature is monitored and controlled with water sprays which provide protection from exhaust hood overheating.

Loss of condenser vacuum is an indication of loss of normal heat sink. Therefore, loss of condenser vacuum initiates a closure of the main steam stop valves and turbine bypass valves which eliminates heat input to the condenser. Per Technical Specification reactor scram occurs in the RUN mode at ≥20.5 in.Hg vacuum, stop valve closure occurs at 20 in.Hg vacuum, and bypass valve closure occurs at 7 in.Hg vacuum. The reactor protection system, which initiates the scram, is addressed in Section 7.2.

The condenser pit underneath the hotwell is monitored for flooding due to circulating water system leakage. The condenser pit level alarms are set at the 1-foot level and the 3-foot level. The circulating water pump trip is set at 5 feet from the condenser pit floor. For flood protection, the condenser pit has a watertight submarine-type door as described in Section 3.4.

10.4.2 Main Condenser Evacuation System

The purpose of the main condenser evacuation system is to evacuate air leaking into the condenser and noncondensible gases (such as fission gases, activation gases, and hydrogen and oxygen from water dissociation) and to discharge them to the off-gas system.

10.4.2.1 Design Bases

The main condenser evacuation system is not credited to support safe shutdown of the reactor or to perform any reactor safety function.

The main condenser evacuation system is designed to evacuate the main condenser during startup and normal operation. The off-gas piping is designed in accordance with ASA B-31.1 Code for the original system; the recombiner and charcoal adsorber system is designed to ASME Section III, Subsection ND, Class 3.

10.4.2.2 System Description

The main condenser evacuation system is shown in Drawings M-43, Sheet 1 and M-371, Sheet 1.

The main condenser evacuation system for each unit consists of steam jet air ejectors (SJAEs) for normal plant operation and a mechanical vacuum pump for startup.

The SJAEs discharge through the off gas system. In the off gas system, hydrogen and oxygen are recombined to reduce volume and eliminate the explosive hazard. Off gas is filtered and passed through a charcoal adsorber. See Section 11.3 for details.

The air ejector and off gas condensers are cooled by the condensate system. Moisture extracted from off-gas flow is drained back to the main condenser.

The steam jet driving flow is from the main steam supply through pressure regulating valves set at approximately 125 psig.

The mechanical vacuum pump system provides the initial vacuum in the condenser during unit startup. The gases from the turbine and condenser system are discharged from the pump to the stack via the gland seal exhaust piping system. The mechanical vacuum pump detail is discussed in Section 11.3.2.

10.4.2.3 Safety Evaluation

The off-gas flow from the main condenser is one source of radioactive gas in the station. An inventory of radioactive contaminants in the effluent from the SJAEs is evaluated in Section 11.3. The main steam flow to the ejectors dilutes the off-gas to less than 4% hydrogen by volume to minimize the possibility of hydrogen detonation. The entire system is designed to maintain its integrity in the event of hydrogen detonation.

The SJAE suction valves close when the supply steam pressure is low and decreasing. Main steam line radiation monitors isolate the mechanical pump on high fission product radioactivity. The hydrogen water chemistry system is addressed in Section 5.4.3.

10.4.2.4 Tests and Inspections

The off-gas systems are used on a routine basis and do not require specific testing to assure operability. Monitoring equipment is calibrated and maintained on a specific schedule and on indication of malfunction. Tests and inspections of the main condenser evacuation system equipment are performed in accordance with normal station practices and procedures.

10.4.2.5 Instrumentation Applications

The off-gas system is continuously monitored for radiation within the 36-inch holdup pipe by dual radiation monitors. A high-radiation alarm is provided in the control room. If the radioactivity exceeds the limits of the off-site dose calculation manual, the holdup line of the off-gas system is automatically isolated after a 15-minute delay. The holdup of the off-gas provides sufficient time between detection and isolation to prevent release. Off-gas instrumentation is discussed in Section 11.3.2.1.

10.4.3 Turbine Gland Sealing System

The purpose of the turbine gland sealing system is to prevent air leakage into, or radioactive steam leakage out of, the turbine shaft packings and turbine admission valve stem packings. See Section 11.3.2.2 for a description of the turbine gland seal exhaust system.

10.4.3.1 Design Bases

The turbine gland sealing system is not credited to support safe shutdown of the reactor or required to perform any reactor safety function. The turbine gland sealing system is designed in accordance with ASA B-31.1 Code.

10.4.3.2 System Description

The turbine gland sealing system is designed to provide turbine shaft sealing, prevent steam leakage to the atmosphere, prevent air inleakage, and prevent leakage between turbine sections. The system also provides sealing to the valve stem packing of the main steam stop valves, turbine control valves, combined intermediate valves, and bypass valves. The steam-air mixture from the gland seal system is removed by the turbine gland seal exhaust system.

The turbine gland seal exhaust system is shown in Figure 10.4-2, Drawings M-43, Sheets 1 through 3 and M-371, Sheet 1. The turbine gland sealing system consists of a steam-seal feed valve with bypass, a steam unloading valve with bypass, a steam-seal header, exhaust headers, valves, piping, and instrumentation. The turbine steam is sealed against leakage along the shaft to the atmosphere by the labyrinth pressure packing. Air inleakage to the turbine is controlled by the labyrinth vacuum packing. These packings limit the leakage by a series of throttling seals from the high-pressure space to the low-pressure space. Sealing steam is supplied to the pressure packing at low load and to the vacuum packing at all loads.

At low load, sealing steam is supplied from main steam via an air-operated control valve, which reduces the pressure to 2.5-4.5 psig. The steam seal feed MOV has throttling capacity to also perform this function. The sealing steam is supplied to the high-pressure element shaft seals, low-pressure element shaft seals, valve stem packings of the main steam stop valves, turbine control valves, combined intermediate valves, and bypass valves. A mixture of steam, moisture, and air is routed to the exhaust header. At full load, the steam from the high-pressure element packing provides enough pressure for the low-pressure element vacuum packing. The feed control valve completely closes and the unloading valve opens to maintain pressure. The steam seal feed MOV may also be used to close off the sealing steam supply. The steam unloading valve discharges to the extraction lines of low-pressure heater A. The exhaust header need only be maintained at sufficient vacuum to prevent steam from coming out of the seals.

10.4.3.3 Safety Evaluation

The system is designed to provide low-pressure sealing steam to the turbine shaft glands.

The relief valve will maintain the system at a safe pressure if the control valves fail. Manual pressure control is possible using bypass valves. Section 11.3 discusses radiation issues.

10.4.3.4 Tests and Inspections

Tests and inspections of the turbine gland sealing system equipment are performed in accordance with station practices and procedures.

10.4.3.5 Instrumentation Applications

The steam seal header pressure and the exhaust header vacuum are indicated by instruments in the control room. The steam seal header is provided with a low-pressure alarm, as well as a thermocouple.

10.4.4 Turbine Bypass System

The purpose of the turbine bypass system is to bypass up to 33.5% of the turbine-generator throttle steam flow to the condenser.

Although the bypass valves are not credited for safe shutdown, evaluation of the accidents and transients for which the plant is designed considered the bypass valves. The main accidents and transients that the bypass valves affect are turbine trip, load reject, and feedwater controller failure. The description of the bypass valve function during accidents and transients can be found in Sections 15.1, 15.2 and 15.8.

10.4.4.1 Design Basis

The turbine bypass system is not credited to support safe shutdown of the reactor or to perform any reactor safety function.

The turbine bypass system is designed in accordance with ASA B-31.1 Code.

10.4.4.2 System Description

The turbine bypass valves discharge reactor steam directly to the main condenser. They are used during unit startup and shutdown to regulate the steam pressure in the reactor vessel and are designed to pass up to 33.5% of the turbine-generator throttle steam flow. The capacities of the bypass valves and relief valves are sufficient to keep the reactor safety valves from opening in the event of a sudden loss of full load on the turbine-generator; thus, the turbine bypass system provides protection against reactor vessel overpressure. The relief valves alone would be sufficient if a reactor scram were assumed to occur simultaneously with turbine trip and bypass system failure (see Section 5.2.2.2.2).

The turbine bypass system is shown in Drawing M-12, Sheet 2. Two 18-inch diameter pipes extend from the 30-inch main steam equalizing header to the turbine bypass manifold. Nine turbine bypass valves are situated on the bypass manifold and are sequentially operated by hydraulic pressure of the turbine electrohydraulic control (EHC) system. Nine 8-inch diameter bypass lines are piped directly to the main condenser via pressure reducing orifices. The turbine bypass system is used during normal startup and shutdown to pass partial main steam flow to the condenser.

The bypass valves are automatically controlled by reactor pressure. A triple modular redundant digital pressure controller utilizing a median select logic is provided. The setpoint of the pressure controllers is adjusted manually from the control room. The bypass valves may be manually controlled from the control room by the bypass valve jack.

10.4.4.3 Safety Evaluation

The bypass valves close automatically on low-condenser vacuum of 7 in.Hg. In the event of the loss of EHC hydraulic pressure, the check valve in the hydraulic system allows the accumulator to keep the turbine bypass valves open for approximately 1 minute to discharge steam to the condenser. The turbine bypass valves then fail closed on loss of EHC hydraulic pressure. On turbine trip or generator load reject, the turbine bypass valves open. The evaluation of all Anticipated Operational Occurrences (AOOs), including turbine trip coincident with the failure of the bypass system, may be found in Chapter 15.

10.4.4.4 Tests and Inspections

The opening and closing of the turbine bypass valves are performed during startup and shutdown in accordance with station practices and procedures.

The tests and inspection requirements of the turbine bypass system are addressed with the main steam system in Section 10.3.4.

10.4.4.5 Instrumentation Applications

The turbine bypass system is controlled by the EHC system as addressed in Section 7.7.4.

10.4.5 Circulating Water System

The purpose of the circulating water system is to remove the heat rejected from the main condenser.

10.4.5.1 Design Bases

The circulating water system is not credited to support safe shutdown or to perform any reactor safety function.

10.4.5.2 System Description

The circulating water system takes supply from the Dresden cooling lake (with makeup from the Kankakee River) or directly from the Kankakee River, directs the flow through the condenser, and discharges it back to the Dresden cooling lake and/or the Illinois River system.

The circulating water system has three vertical, drypit, centrifugal, removable element, mixed flow volute, circulating water pumps which deliver water from the crib house intake to the condenser water boxes. See Drawing M-36. Each pump suction pit is sectionalized to permit dewatering of one pit for maintenance while the remaining two pumps are in operation. In addition, each pump is provided with a shutoff valve at its discharge.

At the condenser pit, the circulating water pipe becomes a supply header with two 10-foot diameter inlets to the condenser water boxes. Circulating water flows from the inlet water boxes through the condenser low-pressure section, intermediate-pressure section, and high-pressure section sequentially to the two outlet water boxes. From the outlet water boxes the circulating water is discharged to the discharge canal. Appropriate piping and valving is provided to permit reversing flow through the condenser thereby cleaning the tubes. An 8-foot ice melting line drains by gravity from upstream of the discharge flume weir back to the intake bays for ice melting during cold weather operation. The water reservoir in the discharge flume, the intake canal, and discharge canal also provides the ultimate heat sink for decay heat removal. The ultimate heat sink is addressed in Section 9.2.5.

Each circulating water pump has a capacity of 157,000 gal/min, with a total head of 36 feet. Each pump is driven by a 1750-hp, 3-phase, 60-Hz, 4000-V induction motor. A Unit 2 LOCA signal trips the CW 2C pump. A Unit 3 LOCA signal trips the CW 3C pump.

Equipment is provided to inject biocide and chemicals into the circulating water upstream of the condenser: sodium hypochlorite solution to minimize marine growth and bacteria, and aminomethlyene phosphonate and/or polyacrylate for scale inhibition and for solids dispersal to prevent settling on the condenser tubes.

Upstream of each circulating water pump there are traveling screens for removal of debris. Upstream of the traveling screens is a bar-grille trash rack with a rake for periodic removal of river debris.

The water from the discharge flume can be routed to the Illinois River or to the Dresden cooling lake. The circulating water discharge provides the necessary dilution for low level liquid radwaste discharges as discussed in Section 11.2. Station procedure provides guidance to operate within the limits of the National Pollutant Discharge Elimination System permit for circulating water discharge.

10.4.5.3 Safety Evaluation

Flooding due to the circulating water system leakage is prevented from entering the condensate pump room as addressed in Section 3.4.

The circulating water pumps trip at 5 feet above the condenser pit floor. Alarms are provided at 1 foot and 3 feet as addressed in Section 10.4.1.5.

10.4.5.4 Tests and Inspections

Performance tests are conducted on the circulating water system in accordance with station procedures and practices.

10.4.5.5 Instrumentation Applications

The circulating water discharge valve is interlocked to start opening as the pump motor starts and closes when the pump trips. The pump discharge has a pressure indicator. Differential pressures across the condenser and the valve line-up are indicated in the control room. Temperature elements at the inlet and outlet of the condenser are connected to the plant process computer.

10.4.6 Condensate Demineralizer System

The full-flow condensate demineralizer system supplies water of required purity to the reactor. The demineralizer system removes corrosion products originating from the turbine, condenser, and the feedwater heaters; protects the reactor against impurities from tube leaks; and removes condensate impurities which might enter the system in the makeup water.

10.4.6.1 Design Bases

The condensate demineralizer system is not credited to support safe shutdown or to perform any reactor safety function.

The condensate demineralizer system is designed in accordance with ASA B-31.1 Code.

10.4.6.2 System Description

The condensate demineralizer system can treat the entire condensate flow at any flow rate from 0 -100% of the maximum rated flow of 23,008 gal/min .

The system can maintain effluent impurity levels at or below the following concentration limits:

Total dissolved solids	-	25 ppb
Total iron as Fe	-	2.1/5* ppb
Total copper as Cu	-	8 ppb
Total nickel as Ni	-	5 ppb
Total silica as SiO_2	-	10 ppb
Total chloride as Cl	-	1/5* ppb
Specific conductivity at 77°F	-	0.1 µmho/cm
pH at 77°F	-	7

* The INPO chemistry performance index limits and the EPRI chemistry guideline for action level 1 limits, respectively.

The condensate pumps take suction from the condensers and discharge to the 100% condensate filtration system (CFS), the SJAE condensers, gland steam condensers, and off-gas condenser to a full-flow condensate demineralizer system to ensure the supply of high-purity water to the reactor. The 100% CFS is located downstream of the off-gas condenser. The condensate enters the mix-bed demineralizer vessel at the top and passes through the cation and anion resins. The resins remove dissolved cations and anions. The treated condensate exits the bottom of the vessel to the condensate booster pumps.

The system and auxiliaries, as shown in Drawing M-17, include resin transfer, ultrasonic resin cleaner (Note: the ultrasonic resin cleaner on Unit 3 was replaced with an advanced resin cleaner.), backwash, recycle pump, resin trap, and instrumentation and control for proper operation. The condensate demineralizer system can be used during refueling operation to treat suppression pool water.

The condensate demineralizer system is composed of seven mixed-bed demineralizer units. The demineralizer tanks are of the rubber-lined, carbon-steel-type and are rated by the manufacturer for a design flow rate of 3280 gal/min per tank to achieve proper performance within design parameters as related to ion exchange performance. Demineralizer flow rates that exceed 3280 gpm are acceptable with no anticipated mechanical damage to the demineralizer; however, higher flow rates will result in poorer effluent quality and shorter ion service times. Station water chemistry quality will determine the need to reduce demineralizer flow rates.

Exhausted resins are sluiced from a demineralizer unit to the resin separation tank. The resins are separately backwashed to remove insoluble material. After rinsing, the regenerated resins are sluiced to the resin storage tank for remixing of the resins and eventual reuse.

Any radioactive material removed from the exhausted resins by the rinse solutions is transferred to the radioactive waste system for analysis and treatment as required. Low-conductivity water is diverted to the waste collector tank, and high-conductivity water is routed to the waste neutralizer tank.

The condensate demineralizer and associated systems are manually controlled from a local panel. Integrated flow and conductivity monitors are provided for each demineralizer to indicate when backwash is required. Alarms and pressure drop recorders are provided in the control room.

The main flow valves are manually operated. Resin transfer from the demineralizing tanks to the resin separation tank and from the resin storage tank to the empty demineralizing tank is manually initiated and manually stopped. Backwash and rinsing of the resins, the transportation of resins to the resin storage tank, and resin mixing are automatically controlled.

The demineralizer vessels and associated tanks are located in a shielded area. Valves, pumps, and instrumentation are excluded from this area but are located nearby. Pipes carrying condensate or demineralized condensate do not require shielding.

The condensate conductivity is monitored in accordance with NOD-CY.2, "BWR Water Chemistry Control Limits." The goal of condensate conductivity at power operation is less than 0.1 μmho/cm. If condensate conductivity reaches 10 μmho/cm, the program requires either an orderly shutdown or approval from the corporate office to continue operation.

10.4.6.3 Safety Evaluation

Since the condensate demineralizer system also removes corrosion products which can be activated, adequate shielding is provided. All liquid wastes are treated in the station radwaste system. Solid wastes are treated, drummed, and handled in the radwaste facility as described in Section 11.4.

10.4.6.4 Tests and Inspections

Motor-operated shutoff valves are provided in the system to isolate each demineralizer for testing and maintenance during normal plant operation in accordance with station practices and procedures.

10.4.6.5 Instrumentation Applications

Local conductivity elements are provided for the influent header and effluent of each demineralizer. Conductivity at the demineralizer inlet is monitored in the control room. The condensate demineralizer outlet conductivity is indicated in the control room, and high conductivity is annunciated by an alarm. Each demineralizer vessel is provided with a local differential pressure indicator and alarm. Each resin trap is provided with a local differential pressure alarm.

Sample valves are provided to permit water quality testing. Flow transmitters and integrators are provided to indicate individual and total flow from the demineralizers.

10.4.7 Condensate and Feedwater Systems

The purpose of the condensate and feedwater systems is to deliver condensate from the condenser to the reactor. The portion of condensate and feedwater systems addressed in this section is from the outlet of the condenser up to the outboard feedwater check valve. The feedwater system from the outboard feedwater check valve to the reactor is addressed in Section 5.2. The condenser is addressed in Section 10.4.1. Feedwater system controls are addressed in Section 7.7.

10.4.7.1 Design Basis

The condensate and feedwater systems are not credited to support safe shutdown or to perform any reactor safety function. The feedwater system performance is, however, modeled in some of the Chapter 15.0 transients.

The objective of the condensate and feedwater systems is to supply the reactor vessel with demineralized water equivalent to the rate of water which is being generated into steam by boiloff. To achieve this objective, the condensate / feedwater system is designed to supply 11,426,000 lb/hr of water at 1100 psia.

The condensate and feedwater systems are designed in accordance with ASA B-31.1 Codes.

10.4.7.2 System Description

The condensate and feedwater systems consist of condensate pumps, condensate booster pumps, a 100% full-flow condensate filtration system, a demineralizer system, feedwater heaters (high- and low-pressure), feed pumps, feedwater regulating valves, piping, controls and instrumentation, and subsystems that supply the reactor with regenerative feedwater heating in a closed steam cycle.

The condensate system is shown in Drawing M-15. The condensate booster system is shown in Drawing M-16. The feedwater system is shown in Drawing M-14 and M-347.

The Zinc injection process system is addressed in Section 5.4.

The extraction steam system is shown in Drawing M-13. The heater drain system is shown in Drawing M-18. The heater vent and drain piping is shown in Drawing M-19.

The hydrogen water chemistry system is addressed in Section 5.4.

Four condensate pumping units are located next to the condenser pit. Each unit consists of one condensate pump and one condensate booster pump driven by one common motor. The pumps are horizontal, single-stage, centrifugal-type with a capacity of 6825 gal/min, sized so that four pumping units are required for normal full-load operation. In a 3 unit operation, the fourth unit auto starts on an operating unit trip or on low discharge pressure sensed at the reactor feed pump (RFP) suction header. If a LOCA is detected when all four pumping units are running, then the D unit will trip to limit loading on the 4kV buses. This trip cam then be reset to permit any of the four condensate pumping units to run during a LOCA. The drive motors are 1750-hp induction motors.

The four condensate pumps take their suction from both sides of the main condenser hotwell through a common 48-inch header that reduces to 24-inch piping. The condensate pumps then discharge to the cooling side of the SJAEs, gland steam condensers, off-gas condenser, the 100% condensate filtration system (CFS) and to the condensate demineralizers. The condensate booster pumps take their suction from the condensate demineralizers and are used to raise pressure immediately before the condensate passes through the low-pressure heaters and on to the feed pump suction. Minimum flow is maintained by circulation to the condenser.

The 100% condensate filtration system (CFS) is capable of filtering 100% of the rated EPU condensate flow. The CFS is capable of this performance with three filters in operation and the fourth filter in backwash. The filters are designed to remove non-soluble iron and other particulates upstream of the condensate demineralizers to reduce demineralizer resin cleaning and replacement frequency. The filters have an automatic backwash system that routes backwash to the Floor Drain Collector Tank for processing.

The condensate demineralizer system is addressed in Section 10.4.6.

The feedwater heaters are divided into three parallel strings. There are three low-pressure feedwater heaters, A, B, and C, and one high-pressure feedwater heater D in each string. Separate drain coolers are provided for each A heater, while the other heaters have integral drain coolers.

Separation of water in the extraction steam is accomplished in the heaters. All drains flow by pressure differential from the heater through the drain cooler to the next lower pressure heater. All heaters have stainless steel tubes welded to the tube sheets. Stainless steel baffles are provided at entering steam and drain connections.

The feedwater heater characteristics for inlet flow quantities of steam and/or water are listed in Table 10.4-4. The listed quantities are for one heater string only.

Valving and a bypass line permit bypassing each string of low-pressure heaters in the event of failure of any component in the string. Any of the three high-pressure heaters can be similarly bypassed.

The reactor feed pumps take suction from the low-pressure feedwater heater C and discharge through the feedwater regulating valves to high-pressure feedwater heater D. Three 2-stage horizontal feed pumps are provided, each with a capacity of 5,105,000 lb/hr. They are sized so that three are needed to be in service during normal full load operation. Each pump is driven by a 9000-hp, 4160-V, 3-phase, 60-Hz induction motor through a speed increasing gear unit with a rating of 10,350 hp. At an input speed of 1800 rpm, this unit drives the pump at a speed of 4521 rpm. Each pump has the design characteristics shown in Table 10.4-5.

A minimum flow of 900 gal/min is required from each reactor feed pump. When reactor feed requirements fall below this minimum, an air-operated flow control valve opens and allows feedwater recirculation back into the condenser hotwell. Loss of a running reactor feed pump in a two pump operation starts the pump on standby. The feed pump trips on reduced suction pressure.

For Unit 2 only, each reactor feed pump is equipped with a strainer on its suction line. The strainer imposes a suction pressure loss of 3 psid or less while clean and up to 12 psid when cleaning is required. The strainer has a negligible effect on reactor feed pump performance under these conditions. Strainer differential pressure is indicated locally.

Feedwater to the reactor is controlled by throttling the feedwater regulating valves (FWRVs). Two 18-inch full-flow FWRVs are provided for power operation and are normally set to automatically maintain reactor water level. One low-flow regulating valve is used for lower power operation. The feedwater control valves provide stable reactor water level control.

Piping supports and restraints were installed to mitigate flow-induced transient loads. A description of the feedwater system materials, particularly fracture toughness characteristics, is provided in Section 10.3.6.

Condensate storage and transfer systems, as described in Section 9.2.7, are provided for both units to fill the system during startup and to serve as a reservoir. Two 250,000-gallon contaminated condensate tanks are provided. The condensate hotwell level is the controlled variable for setting the rejection or addition rate of the condensate storage system.

10.4.7.2.1 Feedwater Regulating Valves and Low-Flow Feedwater Regulating Valve

The normal feedwater flow path from the reactor feed pumps is through the FWRVs. Each unit has two FWRVs, whose positions are determined by the feedwater level control system. The positions of these valves may be manipulated manually or automatically from the control room through the feedwater control system. Restrictions when operating with a FWRV in manual are listed in the cycle specific COLR.

The FWRVs each have drag type trim and an air cyclinder actuator.

The stroke time for the FWRVs ≥ 5 seconds, from full closed to full open.

100% flow through the 2B FRV is not recommended since flow-induced vibrations increase to unacceptable levels above 8.3 mlbs/hr feedwater flow. The vibrations are believed to be caused by the irregular piping configurations that cause feedwater velocity changes at elbows and other piping bends.

There is one air operated low-flow feedwater regulating valve dedicated to each unit. The capacity of the Unit 2 and 3 low-flow valves differ. The Unit 2 valve is approximately a 15% capacity drag valve. The Unit 3 valve is approximately a 25% capacity drag valve. The difference in capacity is due to the line sizes. The Unit 2 line is a 6-inch line and the Unit 3 line is a 10-inch line.

10.4.7.3 Safety Evaluation

During operation, radioactive steam and condensate are present in the feedwater heating portion of the system, which includes the extraction steam piping, feedwater heater shells, feedwater heater drains, and vent piping. Radioactivity may also be present in the condensate and feedwater. Shielding and controlled access are provided, as addressed in Section 12.3. The condensate is retained in the hotwell for approximately 1-1/2 minutes to allow for N-16 and O-19 radioactivity decay.

A multistring arrangement provides the ability to isolate and bypass condensate and feedwater systems' equipment and remove it from service. Impact of feedwater heater(s) out of service on reload analysis is addressed in Section 10.4.8, References 2 and 3 and the cycle-specific reload analysis document(s).

Loss of feedwater heating resulting from a loss of a feedwater heater can occur through either the malfunction of its level controller or inadvertent valve closure. The probability of simultaneous loss of more than one heater is very remote. Loss of feedwater heating will result in a gradual increase in subcooling and consequently a gradual rise in reactor power. The operator first will be warned by control room annunciation that indicates loss of feedwater heating and will take prompt action to reduce reactor power in accordance with station procedures. The average power range monitor high-flux alarm will warn the operator of the reactor power increase. Thus, there is sufficient time to take corrective action. Even if operator actions were assumed not to occur, the reactor would scram from high flux.

Failure of the feedwater control system is analyzed in Chapter 15. A description of the feedwater control system is contained in Section 7.7.

10.4.7.4 Tests and Inspections

Tests and inspections are conducted to assure functional performance as required for continued safe operation and to provide maximum protection for operating personnel. During normal operating periods, operational readiness of duplicate equipment is verified whenever equipment operation is rotated.

After installation, components and piping of the condensate and feedwater systems were hydrostatically tested in accordance with ASA B-31.1 Code. Inspection and acceptance standards were in accordance with ASME Code, Section VIII. All circumferential butt welds for 2½-inch diameter and larger piping were specified to be 100% radiographed as indicated in paragraph UW51 of ASME Code, Section VIII.

Inservice inspection of the feedwater system is performed in accordance with the Dresden Inservice Inspection Plan.

An erosion/corrosion inspection program is in place to monitor carbon steel piping systems for wall thinning in response to the NRC Generic Letter 89-08, "Erosion/Corrosion - Induced Pipe Wall Thinning." This program is conducted per NSAC 202L. Additional discussions of the erosion/corrosion program can be found in Section 5.2.3.5.2.

10.4.7.5 Instrumentation Applications

Feedwater flow control instrumentation measures the feedwater flowrate from the condensate and feedwater systems. This measurement is used by the feedwater control system which regulates the feedwater flow to the reactor to meet system demands. The feedwater control system is described in Section 7.7.

Instrumentation and controls regulate pump recirculation flowrates for the condensate pumps, condensate booster pumps, and reactor feedwater pumps. Measurements of pump suction and discharge pressures are provided where appropriate. Sampling means are provided for monitoring the quality of the final feedwater. Temperature measurements are provided for each stage of feedwater heating; these include measurements at the inlet and outlet on both the steam and water sides of the heaters. Steam pressure measurements are provided at each feedwater heater. Instrumentation and controls are provided for regulating the heater drain flowrate to maintain the proper condensate level in each feedwater heater. A high-level alarm and an automatic dump-to-condenser action on high level are provided as well.

10.4.8 References

1. Letter from J.M. Ross to D.F. Kelter, Acceptability of Increasing the FWRV Stroke Time, March 23, 1988.

2. "Dresden and Quad Cities Evaluation of Extended Final Feedwater Temperature Reduction," GE-NE-A13-00487-00-01P, Revision 1, August 2002.

3. "Dresden Unit 3 Cycle 17 FH00S Analyses With 120°F Reduction in Feedwater Temperature", DEG: 02101, June 6, 2002.

Table 10.4-1

CONDENSER DESIGN AND PERFORMANCE DATA

Design Data:

Size of condenser	30 ft. wide, 91 ft. long, and 63 ft. 4 in. high
Condenser plate	ASTM 7/8-in rolled steel
Number of passes	1
Tube surface	650,000 ft.^{2}
Number of tubes	61,464
Size of tubes	1 in OD
Effective tube length	40 ft. 4¾ in.
Tube material	AISI Type 304 stainless steel
Number of tube support sheets	20
Number of division plates	2
Number of tube sheets	4 doubles, 1-in thick tube sheet
Tube plate and sheet material	AISI Type 304 stainless steel
Number of water boxes	4 external, 2 internal
Size of hotwell	30 ft. wide, 90 ft. long, and 6 ft. high

Normal Operating Data:

Steam load (total)	7,520,907 lb/hr
Percent cleanliness	80%
Circulating water operating pressure	25 psig
Water velocity	7.00 ft/s
Circulating water	470,000 gal/min
Hotwell normal condensate	76,000 gal
Oxygen content	0.005 cc/l

Table 10.4-1 (continued)

	Cold Compartment	Intermediate Compartment	Warm Compartment
BTU rejected per hour (x 10^6)	2,292	2,292	2,292
Absolute pressure	1.2 in.Hg	1.5 in.Hg	1.9 in.Hg
Circulating water temperature	60.4°F	70.2°F	79.9°F

The other steam and water loads are as follows:

Discharge from moisture removal stage (total)	222,054 lb/hr
Steam from gland seal regulator (total)	6,000 lb/hr
Drains from low pressure heater (total)	4,031,420 lb/hr
Drains from gland seal exhausters (total)	9,000 lb/hr
Drains from steam jet air ejectors (total)	10,000 lb/hr
Water from makeup system (total)	0 lb/hr

Table 10.4-2

Intentionally Deleted

Table 10.4-3

Intentionally Deleted

Table 10.4-4

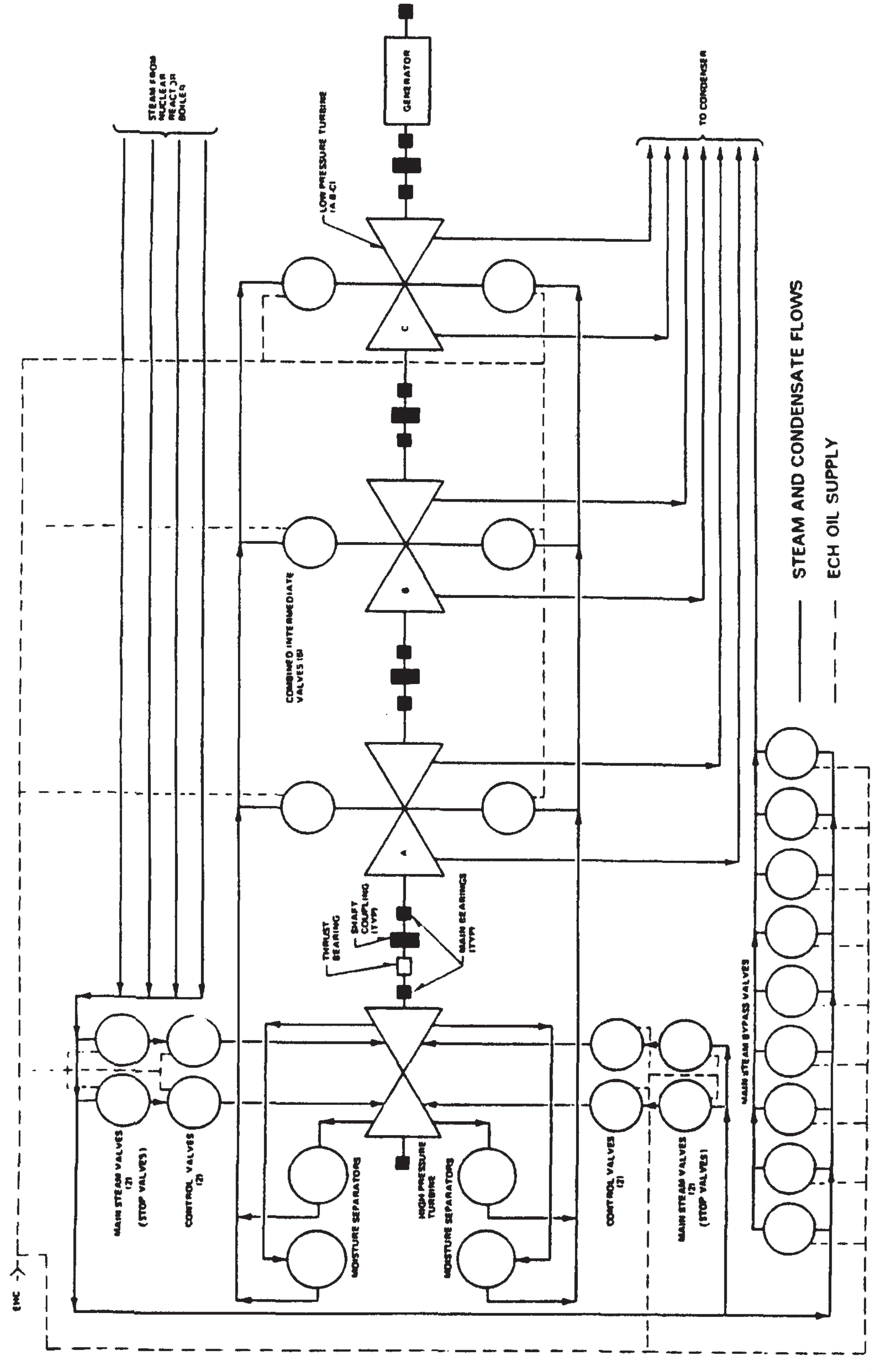
FEEDWATER HEATER CHARACTERISTICS

Heater Designation	Source	Fluid	Quantity lb/hr	Enthalpy Btu/lb
A1	Extraction	Steam	132,204	1011.7
	SSR	Steam	1,219	1126.5
	Moisture removal stage	Water	36,281	510.0
	Moisture removal stage	Water	39,449	154.0
A2	Heater drains	Water	1,181,600	149.9
B	Extraction	Steam	211,388	1056.1
	Extraction	Water	11,342	218.5
	Heater drains	Water	749,777	218.9
C	Extraction	Steam	274,219	1122.4
	Extraction	Water	3,603	295.7
	Heater drains	Water	471,955	297.8
D	Extraction	Steam	123,857	1156.7
	Moisture separator	Water	343,031	384.2
	Valve leak-off	Steam	3,301	1191.5
	Seal leak-off	Steam	1,767	1119.1

Table 10.4-5

FEED PUMP CHARACTERISTICS

Capacity	5,105,000 lb/hr
Pumping temperature	298°F
Suction head	285 ft
Discharge head	3021 ft
Total developed head	2736 ft
Pump speed at design load	4500 rpm
Motor speed (induction)	1800 rpm
Approximate NPSH available at design load	100 ft
Pump suction design pressure (based on maximum cold water shutoff head on condensate pumps of 965 feet)	450 psig
Range in feedwater temperature	60 - 310°F



DRESDEN STATION
UNITS 2 & 3

TURBINE-GENERATOR SET FLOW DIAGRAM
AND EHC OIL SUPPLY

FIGURE 10.2-1