10.0 STEAM AND POWER CONVERSION SYSTEM
TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

10.0 STEAM AND POWER CONVERSION SYSTEM
LIST OF TABLES

Table

TABLE OF CONTENTS (Continued)

10.0 STEAM AND POWER CONVERSION SYSTEM
LIST OF FIGURES

TABLE OF CONTENTS (Continued)

10.0 STEAM AND POWER CONVERSION SYSTEM
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.

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. [10.1-1]

Steam from the reactor flows directly to the high-pressure turbine. The high-pressure turbine exhaust steam flows through the moisture separators before entering the regenerative low-pressure turbines. The exhaust steam from the low-pressure turbines is condensed by the main condenser where it is de-aerated and collected in the condenser hotwell along with miscellaneous drains from the turbine cycle. Heat removed by the condenser is rejected to the Mississippi River via the circulating water system. The condensate pumps take a suction from the hotwell and pump the condensate through the steam jet air ejector condensers, turbine gland seal exhaust condensers, off-gas condensers, and filter/demineralizers to the suction of the condensate booster pumps. The condensate booster pumps increase the condensate pressure, and discharge the purified condensate through the low-pressure feedwater heaters to the suction of the reactor feedwater pumps. The reactor feedwater pumps discharge through the high-pressure feedwater heaters to the reactor.

Extraction steam from the low-pressure turbine is used for feedwater heating. The drains from the moisture separator and condensed extraction steam are 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 Sections 10.2, 10.3, 10.4, Table 10.1-1 and Table 10.4-4. [10.1-2]

Normally, the turbine will utilize all the steam being generated by the reactor. Automatic pressure-controlled bypass valves are supplied which will discharge excess steam directly to the condenser. The capacity of the bypass valves is sufficient to allow load rejections of up to 33.3% 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 interfaces between the turbine and condenser instrumentation, and the reactor protection system are described in Section 7.2, Reactor Protection System. Features of the steam and power conversion system that enhance the overall safety of the plant are described in detail in Section 10.2, 10.3, and 10.4. [10.1-3]

Table 10.1-1

MAJOR COMPONENT DESIGN AND PERFORMANCE
CHARACTERISTICS OF THE POWER CONVERSION SYSTEM

A.	Turbine data	
	1. Manufacturer	
	HP rotor manufacturer	General Electric Company
	LP rotor manufacturer	ALSTOM Power
	2. Type	Tandem compound, six flow exhaust
	3. Number of HP sections	1
	4. Number of LP sections	3
B.	Gross generator nameplate output (kVA)	1,068,000 at 0.945 PF
C.	Final feedwater temperature (°F)	350
D.	Throttled steam condition	
	1. Flow (x 10^6 lb/hr)	11.8
	2. Pressure (psig)	910
	3. Temperature (°F)	535.2
	4. Enthalpy (Btu/lb)	1191
	5. 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 (%)	33.3

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: [10.2-1]

Turbine Rating	1,003,277 kW
Steam Conditions:	
Throttle Pressure	910 psig
Quality	Saturated with 0.6% moisture
Exhaust Pressure	1.5 in. Hg absolute.

The inlet pressure of the turbine is dictated by the choice of the optimum reactor pressure. The quality of the saturated steam and the exhaust pressure are selected for the least amount of turbine blade erosion and the maximum turbine efficiency, respectively.

The turbine-generator load and reactor pressure are integrally controlled by the turbine control and the reactor recirculation flow control systems to maintain the turbine and reactor below design limitations for all anticipated maneuvering rates. [10.2-2]

There are no industry codes related to the design, manufacture, or installation of the turbine rotor. The turbine and turbine rotor were designed in accordance with the manufacturer's standards. [2]

10.2.2 Description

The turbine-generator system consists of the turbine, generator, exciter, controls, and required subsystems. [10.2-3]

Both turbines are a 1,003,277 kW, 1800-rpm, tandem-compound steam turbine, with six-flow, nonreheat low-pressure turbines, each with 38-inch last stage buckets. The turbines are designed for saturated steam conditions of 910 psig with 0.6% moisture, 1.5 in. mercury absolute exhaust pressure, and 0% makeup while extracting steam for four stages of feedwater heating as shown in P&IDs M-13, M-60, M-14, and M-61. The turbine units consist of one double-flow, high pressure element and three double-flow, low-pressure elements. Exhaust steam from the high-pressure turbine passes through moisture separators before entering the three low-pressure elements in which operation at a maximum backpressure of 7.5 in. mercury is permitted. The separators reduce the moisture content of the steam to less than 1% by weight.

The generator is directly driven from the turbine shaft and rated at 1,068,000 kVA at 0.945 power factor and a 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 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 3910 A and 500 Vdc.

Turbine steam flow is controlled by a set of four hydraulically operated control valves on the high pressure turbine main steam supply as shown in P&IDs M-13 and M-60. Four hydraulically operated main steam stop valves provide isolation of the main steam supply

to the turbine. High pressure turbine exhaust steam is routed to four moisture separators prior to entering the low pressure turbines. Steam flow from the moisture separators to the low pressure turbines is controlled by the combined intermediate valves (CIVs). Each CIV includes an intercept valve and an intermediate stop valve. The purpose of these valves is similar to the stop valves and control valves on the main steam supply in that the intercept valves can 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 turbines. [10.2-4]

The 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 electro-hydraulic control system (EHC) integrates the turbine-generator electrical control circuit with the hydraulic system. Electro-hydraulic control positions the turbine steam admission valves to control reactor pressure, generator load, and turbine speed. Refer to Section 7.7 for a description of the turbine control system.

The unit is designed to follow system load while maintaining reactor pressure within predefined limits. Turbine speed governor can override the initial pressure regulator, 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, up to 33.3% of rated steam flow can be routed directly to the main condenser via a set of nine bypass valves. The maximum rate of load change without opening steam bypass valves or tripping the reactor is 20 MWe gross per second. [10.2-5]

If a generator trip or load rejection occurs, the turbine control valves throttle to limit turbine overspeed. Due to the large quantity of energy in the turbine and moisture separator fluid, steam flow to the low pressure turbine could continue after the control valves are fully closed. The intercept valves provide overspeed protection by throttling to control this steam flow as follows. At 105% of rated speed, intercept valves 1, 3, and 5 begin to throttle close. [10.2-6]

When intercept valves 1, 3 and 5 are 50% closed, intercept valves 2, 4, and 6 fully close. Intercept valves 1, 3, and 5 are fully closed at approximately 107% of rated speed. Intercept valves 1, 3, and 5 begin to re-open as the turbine speed decreases below 107% of rated speed. When valves 1, 3, and 5 are 50% open, intercept valves 2, 4, and 6 fully open.

Non-return check 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 which would cause the turbine to overspeed. The non-return check valves close to prevent this reverse flow when a turbine trip signal occurs, and also to prevent water induction if high feedwater heater 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%. [10.2-7]

The turbine-generator trip system monitors critical turbine-generator parameters and automatically closes the four main stop valves, control valves and combined intermediate valves to rapidly shutdown the turbine on the following signals: [10.2-8]

A. High reactor vessel water level,

B. Low lube oil or bearing oil pressure,

C. Overspeed (primary or emergency trip),

D. Excessive thrust bearing wear,

E. Generator electrical faults,

F. Remote or local manual trips,

G. Low condenser vacuum,

H. Low electro-hydraulic control fluid pressure,

I. Loss of speed feedback signal,

J. High water level in any moisture separator,

K. Loss of stator cooling without runback, and

L. High vibration when enabled.

A turbine Supervisory Panel provides monitoring of Turbine eccentricity, expansion, and vibrations.

10.2.3 Turbine Disk Integrity

10.2.3.1 Design and Materials

All original low-pressure turbine rotors have been replaced with a design which is significantly less susceptible to stress corrosion cracking. Analyses of turbine failures which might cause a missile to be projected are addressed in Section 3.5.3. [10.2-9]

The original "shrunk-on" rotors were replaced with rotor discs that used a "welded-on" design to minimize stress corrosion cracking. However, these rotors continued to be susceptible to stress corrosion cracking in the area of the blade-to-wheel attachment since this is a high stress area. The impact of high moisture content steam on the high strength material in the area where the blades attach to the rotors has created an environment susceptible to stress corrosion cracking. These low-pressure rotors have once again been replaced with a design that results in lower stresses and that allows for lower yield strength alloys that are not susceptible to stress corrosion cracking.

A second design enhancement was made by changing the material of the turbine discs. The considerably lower yield strength of the material now used minimizes the probability of stress corrosion cracking. The stress-rupture effect at the high pressure rotor is negligible because the operating temperature is well below the temperature-dependent creep regime.

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. Among these tests are periodic exercising of the turbine stop valves and the steam bypass valves. Other control valves not normally in motion are also periodically exercised. Primary and emergency overspeed trips are tested periodically. [10.2-10]

Prior to entering economic generation control of the load control scheme and during operation, the EGC operating parameters are reviewed for acceptability in accordance with the Technical Requirements Manual. The turbine, including rotors, is inspected within the permissible inspection interval to preclude the probability of turbine missiles due to stress corrosion cracking of the turbine disk.[2]

Manufacturer's procedures, station startup procedures, and engineering department procedures were used for acceptance testing and operability verification of the new rotor.

10.2.4 Evaluation

The effects of component failures have been evaluated in detail. A list of all supported turbine component failures supported can be found in a unit’s current COLR however, typical turbine system component failures having the most significant effect on the plant are as follows: [10.2-11]

A. Power/load unbalance,

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

C. Full closure of MSIVs,

D. Loss of generator load,

E. Turbine stop valve closure,

F. Loss of condenser vacuum, and

G. Turbine pressure regulator failure.

A description of these failures is contained in Chapter 15.

Commonwealth Edison Company's experience with turbines in its nuclear power plants has not shown significant radioactive contaminants during maintenance. A radiological evaluation for the turbine system is provided in Chapters 11 and 12. [10.2-12]

10.2.5 References

1. Deleted.

2. "Quad Cities and Dresden LP Retrofit – Missile Analysis" by ALSTOM Power, Doc. STD0010156, June 6, 2009.

10.3 MAIN STEAM SYSTEM

The main steam system (MSS) discussed in this section consists of the main steam lines downstream of the outboard main steam isolation valves (MSIVs) to the turbine-generator main stop valves and includes the main steam supply lines to plant auxiliary equipment. The MSS from the reactor vessel to the outboard MSIVs is discussed in Section 5.4. The MSIVs are discussed in Section 6.2. The main steam radiation monitoring system is discussed in Section 11.5.

10.3.1 Design Bases

The MSS as defined above is not required to support safe shutdown of the reactor or to perform any reactor safety functions; however, the MSS is designed in accordance with ASA B31.1 Code and ASME Boiler and Pressure Vessel Code Section I. [10.3-1]

10.3.2 Description

The purpose of the MSS is to deliver steam from the reactor to: [10.3-2]

1. The turbine-generator over the entire operating range from initial warmup to rated flow and pressure conditions;

2. The balance of plant auxiliary steam loads; and

3. The bypass valve manifold to route up to 33.3% of rated steam flow around the turbine to the condenser.

The MSS is shown in FSAR Figure 10.3-1 and P&IDs M-13 for Unit 1, and M-60 for Unit 2. The main steam piping consists of four 24-inch diameter lines extending from the outermost MSIVs to the main stop valves of the turbine. All four main steam lines are connected by a 30-inch diameter main steam equalizing header. The equalizing header connects the four main steam lines to permit testing of the main stop valves and MSIVs during station operation with no load reduction from full power. Closing any one of these valves terminates flow in its associated line; however, total system flow remains unchanged because the remaining three lines allow increased flow to make up the difference, and each of the four main steam lines is designed to carry 33% of the rated steam flow (1/3 x 11.7 million lbm/hr).

Two 18-inch diameter lines extending from the main steam equalizing header provide steam to the turbine bypass valve manifold. There are nine turbine bypass valves which are connected to the condenser by nine 8-inch diameter lines. Referring to P&IDs M-13 and M-60 three auxiliary steam lines tap off the two 18-inch diameter lines to supply steam to the auxiliary equipment listed below:

A. Turbine gland seal system;

B. Steam jet air-ejector system;

C. Off-gas preheater, and

D. The condenser low load reheat coil supply (abandoned in place).

Low points of each of the main steam lines are provided with drains through a valved line to the main condenser. An orificed bypass is provided around the last valve to the main condenser to permit continuous draining of the steam line low points. The steam line drains upstream of the MSIVs are connected to the steam line drains downstream of the MSIVs to provide a means of equalizing pressure across the MSIVs prior to opening during startup or following a steam line isolation. [10.3-3]

10.3.3 Evaluation

The MSS as defined in the introduction paragraph 10.3 is not safety-related. All components and piping for the MSS are designed in accordance with ASA B31.1. The piping and components are designed in accordance with these requirements to ensure that the MSS can accommodate both sustained and occasional loads, such as dead weight, internal pressure, thermal expansion and earthquake. Pipe whip outside the containment is discussed in Section 3.6. The effect of a main steam line break outside the containment is discussed in Section 15.6. Seismic analysis of the piping system is discussed in Section 3.7. Dynamic loading of the main steam piping following turbine stop valve fast closure under extended power uprate conditions is discussed in Section 3.9.3.1.3.4. [10.3-4]

10.3.4 Inspection and Testing Requirements

After installation, components and piping for the MSS were hydrostatically tested in accordance with ASA B31.1. Inspection and acceptance standards were in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. All circumferential butt welds for 2 1/2-inch diameter piping and larger were specified to be 100% radiographed in compliance with paragraph UW51 of ASME Boiler and Pressure Vessel Code, Section VIII. [10.3-4]

Inservice inspection of the MSS is performed in accordance with the ASME Boiler and Pressure Vessel Code, Section XI, IWA-2212, visual inspection for Class 1 components. The MSIV surveillance requirements are discussed in Section 6.2. [10.3-5]

10.3.5 Water Chemistry — Pressurized Water Reactor

This section is not applicable to Quad Cities Station.

10.3.6 Steam and Feedwater System Materials

10.3.6.1 Fracture Toughness

The main steam line and feedwater piping materials are specified as ASTM A106 Grade B. Since it is a seamless, fine grain steel which exhibits good fracture toughness, ASA B31.1 Code allows a minimum design temperature of -20°F without impact testing. Similarly, ASME Boiler and Pressure Vessel Code, Sections I and VIII exempt this material from impact testing for a minimum design temperature of -25°F. Because the operating temperatures of the main steam lines and feedwater systems are well above these minimum design temperatures, brittle fractures are not a problem. [10.3-6]

The fracture toughness characteristics have been measured for the same type of material, ASTM A106 Grade B, on a Tennessee Valley Authority plant and were found to be adequate. [10.3-7]

The main steam and feedwater piping were designed for fracture toughness to preclude brittle fracture by virtue of the codes and material specification.

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, are in accordance with ASA B31.1, which uses approved ASTM Specifications. The welding procedures are in accordance with ASME Boiler and Pressure Vessel Code, Section IX. Austenitic stainless steel is not used in the main steam or feedwater piping. [10.3-8]

10.4 OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEM

10.4.1 Main Condenser

The functions of the main condenser are: [10.4-1]

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

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

C. To accommodate large volumes of feedwater heater drains, extraction steam and moisture, which is bypassed to the condenser during reactor operation with the heaters out-of-service;

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

E. To de-aerate the condensate and remove fission gas, hydrogen, and oxygen; and

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

10.4.1.1 Design Bases

The main condenser is not credited to support safe shutdown or to perform any reactor safety function. [10.4-2]

10.4.1.2 System Description

The turbine condenser is of the divided water flow, single-pass, multipressure, de-aerating type with capacity for reverse flow for each half of the condenser. [10.4-3]

The condenser is designed for three exhaust pressures which result in performance comparable to an average exhaust pressure of 1.5 in.Hg absolute with 60^{o}F cooling water. The condenser is designed to accept bypass steam up to 33.3% 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. [10.4-4]

The main condenser is designed for internal hydrostatic pressure when filled and external atmospheric pressure. [10.4-5]

During plant operation, steam, after expanding through the low-pressure turbine, exhausts through the bottom of the turbine casing to the condenser. The divided water flow permits circulating water to be reversed periodically through each bank of tubes in each half of the condenser for cleaning purposes. The condenser shell is supported on the turbine foundation mat. An expansion joint is fitted between each low pressure turbine

exhaust hood and condenser inlet connection. The condenser is divided into three separate compartments by two division plates, as shown in P&IDs M-16 and M-63. 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 de-aerating purposes. [10.4-6]

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 de-aerating weir plate and collecting tray vent the noncondensible gases to the tube bundle in the intermediate compartment. The air in-leakage 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 radioactivity 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 Subsection 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 the Table 10.4-1.

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. [10.4-7]

Double tube sheets are used to prevent river water leakage through the tube joints into the hotwell. Tube leakage is monitored by condensate pump discharge or condensate demineralizer inlet conductivity. Plant operation in the event of high conductivity is discussed in 10.4.6. Tube leakage is normally identified by draining the condenser water boxes after shutdown, flooding the condenser shell, checking for leaks and plugging the defective tube. [10.4-8]

If the downstream dam on the river fails, the water level would recede in the condenser water box. Both units would be shutdown due to loss of condenser vacuum, as discussed in Section 9.2.5. [10.4-9]

10.4.1.4 Tests and Inspections

The condenser is monitored for the vacuum, and circulating water pressure drop and temperature rise. The condensate conductivity is measured at the condensate pump discharge. All tests and inspections of the condenser are in accordance with CECo's normal inspection and maintenance procedures. [10.4-10]

10.4.1.5 Instrumentation Applications

The condenser is provided with level and pressure indicators 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, as discussed in Section 9.2.6. Turbine exhaust hood temperature is monitored and controlled with water sprays available to provide protection from exhaust hood overheating. [10.4-11]

Loss of condenser vacuum is an indication of loss of normal heat sink. Therefore, loss of condenser vacuum initiates a closure of the turbine stop valves and turbine bypass valves which eliminates heat input to the condenser. Reactor scram occurs in the run mode at greater than or equal to 21.6 in. Hg vacuum per Technical Specifications, stop valve closure occurs at 20 in. Hg vacuum, and bypass valve closure occurs at 7 in. Hg vacuum. [10.4-12]

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. [10.4-13]

10.4.2 Main Condenser Evacuation System

The purpose of the main condenser evacuation system is to evacuate air in-leakage and noncondensible gases, such as fission gases, activation gases, and hydrogen and oxygen from water dissociation, and discharge them to the off-gas system. [10.4-14]

10.4.2.1 Design Bases

The main condenser evacuation system is not credited for safe shutdown of the reactor or to perform any reactor safety function. [10.4-15]

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 B31.1 Code for the original system; the recombiner and charcoal adsorber system is designed to ASME Section III, Subsection ND, Class 3. The recombiner and charcoal adsorber system pressure vessels shall be maintained to ASME Section III and the piping shall be maintained to ANSI B31.1-1971 edition. [10.4-16]

10.4.2.2 System Description

The main condenser evacuation system is shown on P&IDs M-42 and M-84.

The main condenser evacuation system for each unit consists of two trains of SJAE and a mechanical vacuum pump.

A pair of two-stage SJAEs are provided for the turbine condenser to evacuate noncondensible gases while the turbine unit is in operation. Each SJAE is capable of removing the total volume of gas which is produced in the reactor plus air in-leakage into the condensing system. The first stage (primary) air ejectors take a suction from the turbine main condenser and discharge into the inter-condenser of the SJAE. [10.4-17]

The secondary air ejectors take a suction from the inter-condenser and discharge directly to the off-gas preheater. This modification was completed as a result of reoccurring recombination prior to the recombiner.

In all off-gas trains, the exhaust air from the preheater discharges to a catalytic recombiner train which empties into a 36-inch pipe which provides a hold up time of approximately 4 hours. After leaving the holdup pipe, the gases pass through particulate filters, charcoal adsorbers and another set of particulate filters before being discharged through the 310-foot chimney. See Section 11.3 for a more detailed coverage of the off-gas system.

The condensers of the air ejectors are cooled by the condensate system. Moisture extracted from off-gas flow is drained back to the main condenser. The second stage of the 1B air ejector is noncondensing and provides the motive force to the off-gas stream. [10.4-18]

The steam jet driving flow is from the main steam supply through a pressure regulating valve set at a minimum of 125 psig.

The mechanical vacuum pump system is provided to produce and maintain vacuum in the condenser when no steam is available to operate the SJAEs. The gases from the turbine and condenser system are discharged from the pump to the chimney via the gland seal exhaust piping system. This system provides a holdup time to allow for radioactive decay of short-lived products before release. The mechanical vacuum pump detail is discussed in Section 11.3.2.3.

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 Table 11.3-6.

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. [10.4-19]

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 (HWC) system injects air/oxygen upstream of the first stage air ejectors to control excess hydrogen, as discussed in Section 5.4.3.

10.4.2.4 Tests and Inspections

Tests and inspections of the main condenser evacuation system equipment are performed in accordance with normal CECo station practices and procedures. [10.4-20]

10.4.2.5 Instrumentation Applications

The off-gas radiation is continuously monitored for radiation upstream of the 36-inch holdup pipe by dual radiation monitors. A high radiation alarm is provided in the control room. If the radioactivity exceeds the limit established in accordance with the offsite dose calculation manual (ODCM), 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 11.3.2.1.5. [10.4-21]

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. [10.4-22]

10.4.3.1 Design Bases

The turbine gland sealing system is not credited for safe shutdown of the reactor or required to perform any reactor safety function. The turbine gland sealing system is designed in accordance with ASA B31.1 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 in-leakage, and prevent leakage between turbine sections. The system also provides sealing to the valve stem packing of the turbine stop valves, control valves, combined intermediate valves, and bypass valves. The steam-air mixture from the gland seal system is condensed by gland seal condensers, and its condensate is returned to the main condenser. The in-leakage air and noncondensibles are vented by the gland seal exhauster to the station chimney.

The turbine gland sealing system is shown in FSAR Figure 10.4-1, and P&IDs M-13 and M-60. The turbine gland sealing system consists of a steam-seal feed valve with bypass, a steam unloading valve with bypass, a steam-seal header, two full-capacity gland steam condensers, two full-capacity exhausters, valves, piping, and instrumentation. One condenser is used at a time during normal operation. The turbine steam is sealed against leakage along the shaft to the atmosphere by the labyrinth pressure packing. Air in-leakage 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 between 2.5 and 4.5 psig. The sealing steam is supplied to the high pressure turbine shaft seals; low pressure turbine shaft seals; valve stem packings of the turbine stop valves, control valves, combined intermediate valves, and by-pass valves. A mixture of steam, moisture, and air is routed to a double-pass gland seal condenser, which condenses the mixture and drains this condensate to the main condenser. A gland seal exhauster maintains vacuum at 10-20 inches of water gage to the gland seal condenser. The gland seal condenser, with a hotwell for level control, is cooled by the main condensate system. At full load, the steam from the high pressure turbine packing provides enough pressure for the low pressure turbine vacuum packing. The feed control valve completely closes and the unloading valve opens to maintain pressure. The steam unloading valve discharges to the extraction lines of low pressure heater A. The noncondensible gases from the gland seal exhauster are vented to the 310-foot chimney after passing through a 1.75-minute holdup. [10.4-23]

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 CECo station practices and procedures.

10.4.3.5 Instrumentation Applications

The condensate level in the hotwell of the gland seal condenser is maintained by a loop seal and level alarm. The steam seal header pressure and the gland exhauster pressure 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 33.3% of the turbine-generator design throttle steam flow to the condenser. [10.4-24]

10.4.4.1 Design Bases

The turbine bypass system is not credited for safe shutdown of the reactor, or to perform any reactor safety function. [10.4-25]

The turbine bypass system is designed in accordance with ASA B31.1 Code. [10.4-26]

10.4.4.2 System Description

The turbine bypass valves discharge reactor steam directly to the main condenser. The bypass valves are used during unit startup and shutdown to regulate the steam pressure in the reactor vessel, and are designed to pass up to 33.3% of the turbine-generator design throttle steam flow. The capacity of the bypass valves and relief valves is sufficient to keep the reactor safety valves from opening in the event of a sudden loss of full load on the turbine-generator. Thus, they provide protection against reactor vessel overpressure. [10.4-27]

The turbine bypass system is shown in P&IDs M-13 and M-60. 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 electro-hydraulic 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 bypass partial main steam flow from bypass valves to the condenser. [10.4-28]

The bypass valves are automatically controlled by reactor pressure. A triple modular redundant (TMR) digital pressure controller utilizing a median select logic is provided. The set point of the pressure regulators is adjusted manually from the control room. The bypass valves can also be manually controlled from the control room using the bypass valve jack. [10.4-29]

10.4.4.3 Safety Evaluation

The bypass valves will close automatically on low condenser vacuum of 7 in. Hg vacuum to prevent over-pressurizing the condenser. 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 close on loss of EHC hydraulic pressure. On turbine trip or generator load reject, the turbine bypass valves open in approximately 0.15 seconds. The event of turbine trip coincident with the failure of the bypass system is discussed in Section 15.2. [10.4-30]

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 CECo practices and procedures. The turbine bypass valves are also tested in accordance with the Technical Specifications. [10.4-30a]

The tests and inspection requirements are discussed in 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 discussed in Section 7.7.4. [10.4-31]

10.4.5 Circulating Water System

The purpose of the circulating water system is to remove the heat rejected from the main condenser. [10.4-32]

10.4.5.1 Design Bases

The circulating water system is not credited for safe shutdown or to perform any reactor safety function. [10.4-33]

The circulating water system takes suction directly from the Mississippi River, discharges the flow through the condenser, and directs it back to the river.

10.4.5.2 System Description

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 bay to the condenser water boxes. See P&ID M-28. 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. [10.4-34]

At the condenser pit, the circulating water pipe becomes a supply header with four 10-foot diameter inlets and four outlets for the condenser water boxes. Two inlets and two outlets are used at one time. This arrangement allows for circulating water flow reversal line-up. The circulating water leaves the condenser to the discharge flume outfall structure. 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 operation. The water reservoir in the discharge flume also provides for the ultimate heat sink. The ultimate heat sink is discussed in Section 9.2.5. [10.4-35]

Each circulating water pump has capacity of 157,000 gal/min, with a total head of 36 feet and a speed of 236 rpm. The pump is driven by 1750-hp, 236-rpm, 3-phase, 60-Hz, 4000-V induction motor. If a LOCA is detected, selected circulating water pump will trip to aid in system voltage recovery when utilizing the Reserve Auxiliary Transformer automatic load tap changer (LTC).

Equipment is provided to inject biocide and silt disperant and/or scale inhibitor at the crib house to protect the circulating water system. A dechlorination chemical is injected at the circulating water discharge to neutralize any residual chlorine from the biocide that is present in the water before it is released to the river. [10.4-36]

A floating boom, bar grill, trash rack, rake, and traveling screens are provided ahead of the circulating water pumps to remove river debris.

The water from the discharge flume can be routed to the two 16-foot diameter discharge lines to the Mississippi River. The river discharge provides the necessary dilution for low level liquid radwaste discharges as discussed in Section 11.2. Station procedures provide guidance on station electrical output to be within the limits of the National Pollutant Discharge Elimination System (NPDES) permit for circulating water discharge. [10.4-37]

10.4.5.3 Safety Evaluation

Flooding due to the circulating water system leakage is prevented from entering the condensate pump room as discussed in Section 3.4. [10.4-38]

Circulating water pump trip is at 5 feet above the condenser pit floor. Alarms are provided at 1 foot and 3 feet as discussed 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 CECo station procedures and practices. Periodic inspections are performed.

10.4.5.5 Instrumentation Applications

The circulating water pump 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 each condenser are indicated in the control room. Temperature elements at the inlet and outlet of the condenser and circulating water pump discharge pressure transmitters provide an input to the plant process computer.

10.4.6 Condensate Demineralizer System

A full-flow condensate Powdex filter/demineralizer system is provided to supply water of required purity to the reactor. The 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. [10.4-39]

10.4.6.1 Design Bases

The condensate demineralizer system is not credited for safe shutdown or to perform any reactor safety function. [10.4-40]

The condensate demineralizer piping is designed in accordance with USAS/ASME B31.1 Code. [10.4-41]

10.4.6.2 System Description

The objectives of the condensate demineralizer system are: [10.4-42]

A. To remove ionic and particulate materials from feedwater so as to maintain high reactor feedwater quality (this minimizes corrosion product input to the reactor which could affect fuel performance and accessibility of primary system components and reduce the capacity required of the reactor clean-up system.);

B. To protect the primary system from entry of foreign materials which may occur due to condenser leaks;

C. To provide final polishing of makeup water entering the power loop; and

D. To protect the purity of water rejected to condensate storage.

The condensate demineralizer system contains a bypass valve, which can divert flow around the condensate demineralizer vessels. The purpose of this bypass valve is to mitigate a demineralizer system failure by automatically opening to maintain flow to the reactor feed pumps upon a high differential pressure across the demineralizer system. [10.4-43]

The demineralizer vessels are designed for a normal, full power condensate flowrate of 23,008 gpm. Each demineralizer vessel contains 302 elements that are approximately 60 inches long. Filter elements of various diameter sizes, filter media, surface area, micron filtration rating, and maximum flow capability may be used. The filter elements are selected to optimize feedwater quality, condensate demineralizer system capacity, system reliability (e.g., element life, ability to avoid resin bleedthrough, etc.), and radwaste generation.

The maximum design temperature of the condensate demineralizer system is 140°F with the resin being the most limiting factor.

During normal operation, the condensate demineralizer system is capable of producing an effluent that does not exceed the Action Level I requirements of system chemistry procedures. The condensate and reactor water cleanup demineralizer systems function together to maintain reactor coolant water chemistry within the limits of the BWR Water Chemistry Program, which uses EPRI, nuclear fuel warranty, and other guidelines for monitoring BWR water chemistry. The goals of enhanced water chemistry are nuclear fuel reliability, reduction in Intergranular Stress Corrosion Cracking (IGSCC) of susceptible piping and structures, and reduced plant radiation exposure due to activation of impurities in the reactor coolant.

The condensate pumps take a suction from the condensers and discharge the flow through the SJAE condensers, gland steam condensers, and off-gas condenser to a full-flow condensate demineralizer system to insure the supply of high purity water to the reactor. Normally, the condensate enters the demineralizer vessel at the bottom and passes through the precoat deposited to the outside of the filter elements. The precoat consists of fine particles of cation and anion resins. The resins remove dissolved cations and anions and filter out suspended solids. The treated condensate from the filter elements exits the

bottom of the demineralizer vessel to the condensate booster pumps. In limited circumstances, it may be desirable to place a condensate demineralizer in service without resin on the filter element. Water chemistry will limit the length of time in this configuration. [10.4-44]

The condensate demineralizer system is composed of eight Powdex filter-demineralizer units and the required tanks, piping, and valving for recharging the demineralizers. Although only seven units are required for rated flow, eight filter-demineralizers are normally in service. They operate in parallel and are sized for condensate flow at turbine rated conditions. The demineralizer vessels are carbon steel. [10.4-45]

The system and auxiliaries, (P&IDs M-18 and M-65), include precoat systems, backwash systems, holding pumps, vessels, effluent strainers, instrumentation and controls for proper operation and protection against malfunction. [10.4-46]

The condensate demineralizer system can be used during refueling operation to treat suppression pool water. [10.4-47]

The condensate conductivity is monitored in accordance with the system chemistry procedures. [10.4-48]

10.4.6.3 Safety Evaluation

Since condensate demineralizer system also removes corrosion products which can be activated, adequate shielding is provided. All vented gases and liquid wastes are treated in the station radwaste system. Solid wastes are processed, packaged, and handled in the radwaste facility as described in Section 11.4. [10.4-49]

10.4.6.4 Tests and Inspections

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

10.4.6.5 Instrumentation Applications

The inlet to the condensate demineralizers (i.e., the condensate pump discharge header) and the individual demineralizer effluents can be monitored for conductivity locally at the Turbine Building Sample Panel (reference Section 9.3.2.2.1). High conductivity at condensate pump discharge due to condenser tube leaks are 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 indicator and alarm. [10.4-50]

Sample valves are provided to permit water quality testing. Each individual demineralizer is equipped with flow, pressure, and differential pressure indication. The post strainer is equipped with differential pressure indication.

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 to the outboard feedwater check valve. The feedwater system, from the outboard feedwater check valve to the reactor vessel, is addressed in Section 5.4. [10.4-51]

10.4.7.1 Design Bases

The condensate and feedwater systems are not credited for safe shutdown or to perform any reactor safety function. [10.4-52]

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 and feedwater systems are designed to nominally supply 11,426,000 lbs/hr of water at 1085 psig. [10.4-53]

The condensate and feedwater systems are designed in accordance with ASA B31.1 Codes. [10.4-54]

10.4.7.2 System Description

The condensate and feedwater systems consist of condensate pumps, condensate booster pumps, a demineralizer system, feedwater heaters, feed pumps, piping, valves, control and instrumentation and subsystems that supply the reactor with regenerative feedwater heating in a closed steam cycle. [10.4-55]

The condensate system is shown in P&IDs M-16 and M-63. The condensate booster system is shown in P&IDs M-17 and M-64. The feedwater system is shown in P&IDs M-15 and M-62.

The extraction steam system is shown in P&IDs M-14 and M-61. The heater drain system is shown in P&IDs M-19 and M-66. The heater vent and drain piping is shown in P&IDs M-20 and M-67.

The hydrogen water chemistry system, which injects hydrogen into the discharge of each of the condensate pumps for control of intergranular stress corrosion cracking of the reactor stainless steel components, is addressed in Section 5.4.3.

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 6,825 gal/min, sized so that four pumping units are required for normal full-load operation. If a LOCA is detected when all four pumping units are running, then the D condensate pumping unit will trip to limit loading on the 4kV buses. This trip can then be reset to permit any three of the four condensate pumping units to run during a LOCA. The drive motors are 1750-hp, 3-phase, 60-Hz, 4000-V induction motors with a speed of 1800 rpm. [10.4-56]

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 through the cooling side of the SJAEs, gland steam condensers, and off-gas condenser to the condensate demineralizers. The condensate booster pumps take their suction from the full-flow condensate demineralizers, and are used to raise the pressure of the condensate immediately before passing through the low-pressure heaters, and on to the feed pumps suction. The pump characteristics are shown in Tables 10.4-2 and 10.4-3. The condensate demineralizer system is discussed 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 of the A heaters, 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.

Each feedwater heater shell receives quantities of steam and/or water under the conditions in the amounts listed in Table 10.4-4. The listed quantities are typical values for one heater string only.

Valving and bypass line permit bypass of 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. [10.4-57]

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 two-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, 4000-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 4500 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, a flow control valve opens and allows feedwater recirculation back into the condenser hotwell. During two pump operation (reduced power), loss of either running reactor feed pump starts the pump on standby. Staggered tripping of feed pumps is initiated on detection of low suction pressure and all feed pumps trip simultaneously on low-low suction pressure.

Feedwater to the reactor is controlled by throttling the feedwater regulating valves. Two 14-inch full-flow feedwater regulating valves are provided for power operation. One 4-inch low-flow regulating valve is used for lower power operation, and is normally set to automatically maintain reactor water level. Both 14-inch feedwater regulating valves are hydraulically operated. The feedwater control valves provide stable reactor water level control. [10.4-58]

Piping supports and restraints were installed to mitigate flow-induced transient loads. [10.4-59]

Condensate storage and transfer systems, as described in Section 9.2.6, are provided for both units to fill the system during startup and to serve as a reservoir. Two 350,000-gallon contaminated condensate tanks are provided. One 100,000-gallon demineralized water tank is available for normal makeup use. The condensate hotwell level is the controlled variable for setting the rejection or addition rate of the condensate storage system. The makeup demineralizer system provides makeup to the condensate storage system. The makeup demineralizer system is discussed in Section 9.2.4.

An injection system is provided to inject a zinc oxide solution into the feedwater system. It may be used as desired. The purpose of this system is to reduce radiation buildup on recirculation piping in the containment. Dose in the containment of a BWR is largely the result of the incorporation of Co-60 into the corrosion layer of the reactor recirculation pipes. Studies have shown that if zinc is maintained in the reactor coolant, the amount of Co-60 released from the fuel cladding is suppressed, and incorporation of Co-60 on pipe corrosion layers is reduced. A reduction in dose rates to personnel is thereby obtained. [10.4-60]

The zinc injection system is mounted on a skid, located near the reactor feedwater pumps. Two taps are provided, one each from the discharge of the A and B feedpumps to supply flow to the skid. The water flows through a vessel on the skid which contains zinc oxide pellets, and to the feedwater pump suction header. The driving force for the injection is the differential pressure between the discharge and suction of the feedpumps. The zinc oxide dissolution rate is controlled by varying the flow through the skid with a manually operated flow control valve. Normally, a sufficient amount of zinc is loaded into the vessel to last the length of the fuel cycle, but, if necessary, more zinc oxide pellets can be added at mid-cycle.

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 drain, and vent piping. Shielding and controlled access are provided as discussed in Section 12.1. The condensate from the hotwell of the condenser is retained for approximately 1 1/2 minutes to allow for N-16 and O-19 radioactivity decay. [10.4-61]

A multi-string arrangement provides the ability to isolate and bypass condensate and feedwater system equipment and remove it from service. [10.4-62]

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. The design basis for Feedwater Heaters out-of-service, and Final Feedwater Temperature Reduction is addressed in the cycle specific reload report. Loss of feedwater heating will result in a gradual increase in subcooling, and consequently a smooth rise in reactor power. The operator first will be warned by control room annunciation that indicates loss of feedwater heating. In several minutes, the APRM High alarm will warn the operator of the reactor power increase. Thus, there is sufficient time to take corrective action by inserting control rods. Finally, if the operator ignores all indications of increasing power, the reactor will scram from high flux.

Failures associated with feedwater are addressed in Chapter 15. A description of the reactor feedwater control system is contained in Section 7.7. [10.4-63]

10.4.7.4 Tests and Inspections

Tests and inspections will be conducted to assure functional performance as required for continued safe operation and to provide maximum protection for operating personnel. During normal operating periods duplicate equipment will be rotated on a regular basis to assure that backup equipment is in operational readiness at all times. [10.4-64]

After installation, components and piping of the condensate and feedwater systems were hydrostatically tested in accordance with ASA B31.1 Code. Inspection and acceptance standards were in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. All circumferential butt welds for 2 1/2-inch diameter piping and larger were specified to be 100% radiographed in compliance with paragraph UW51 of ASME Boiler and Pressure Vessel Code, Section VIII. [10.4-65]

Inservice inspection of the feedwater system is performed in accordance with the ASME Boiler and Pressure Vessel Code, Section XI, IWA-2212, visual inspection for Class 2 components. [10.4-66]

Inspection and Enforcement Bulletin 87-01 "Thinning of Pipe Walls in Nuclear Power Plants", and Generic Letter 89-08, "Erosion/Corrosion – Induced Pipe Wall Thinning", addressed the issue of pipe wall thinning in single-phase and two-phase high-energy carbon steel systems. Quad Cities Station has implemented a comprehensive long-term Erosion/Corrosion Inspection Program. [10.4-67]

10.4.7.5 Instrumentation Applications

Feedwater flow control instrumentation measures the feedwater flow rate 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. [10.4-68]

Instrumentation and controls regulate pump recirculation flow rates for the condensate pumps, condensate booster pumps, and reactor feedwater pumps. Measurements of pump suction and discharge pressures are provided for all pumps in the system. 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 flow rate to maintain the proper condensate level in each feedwater heater drain cooler. A high-level alarm and an automatic dump-to-condenser action on high level are provided as well. Pneumatic limiters were provided for the "B" low-pressure (LP) heaters automatic dump to the condenser controls, to allow procedural heater level control by manually opening the drains dump valves to the condenser. The "B" LP heater drains were selected because diverting the drains at that location has a minimal impact on feedwater heating.

10.4.8 References

1. Deleted.

2. General Electric Safety Evaluation NEDO-31400A "Safety Evaluation for Eliminating the Boiling Water Reactor Main Steam Isolation Valve Closure Function and Scram Function of the Main Steam Line Radiation Monitor," October 1992.

3. DCP 9900185, Unit 1 MSL Rad Monitor Scram and Group 1 Isolation Trip function removal.

4. EC 23949 (DCP 9900184) Unit 2 MSL Rad Monitor Scram and Group 1 Isolation Trip Functions Removal.

Table 10.4-1

CONDENSER DESIGN AND PERFORMANCE DATA

Design Data:	
Size of condenser	30 feet wide, 91 feet long, and 63 feet 4 inches high
Condenser plate	ASTM 7/8-inch rolled steel
Number of passes	1
Tube surface	650,000 ft^2
Number of tubes	61,464
Size of tubes	1 inch OD
Effective tube length	40 feet 4 3/4 inches
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-inch 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 feet wide, 90 feet long, and 6 feet high
Operating Performance Data:	
Normal steam load (total)	7,520,907 lb/hr
Percent cleanliness	80%
Circulating water opening pressure	25 psi
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

CONDENSER DESIGN AND PERFORMANCE DATA

	Cold Compartment	Intermediate Compartment	Warm Compartment
BTU rejected per hour (x 10^6)	2292	2292	2292
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)	zero lb/hr

Table 10.4-2

CONDENSATE PUMP CHARACTERISTICS

Water temperature	70 — 110°F
Capacity	6,825 gal/min
Required NPSH	17 ft
Total developed head	315 ft
Satisfactory capacity operating range	0 — max gal/min
Maximum rated speed	1800 rpm

Table 10.4-3

CONDENSATE BOOSTER PUMP CHARACTERISTICS

Water temperature	70 — 110°F
Capacity	6,825 gal/min
Required NPSH	40 ft
Total developed head	555 ft
Satisfactory capacity operating range	0 — max gal/min
Maximum rated speed	1800 rpm

Table 10.4-4

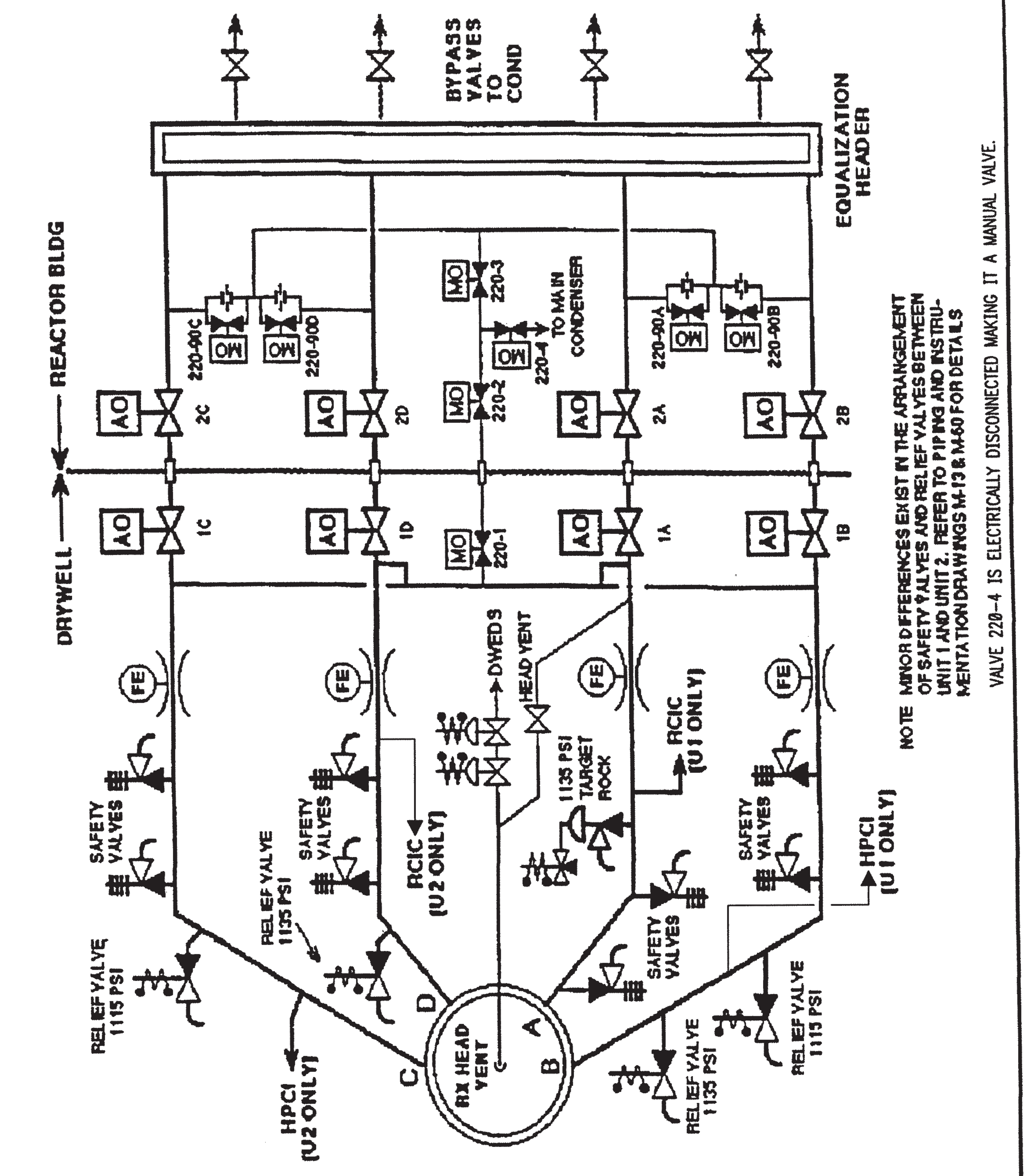
FEEDWATER HEATER CHARACTERISTICS

Heater Designation	Source	Fluid	Quantity lb/hr	Enthalpy Btu/lb
A1	Extraction	Steam	132,204	1,011.7
	Steam Seal Regulator (SSR)	Steam	1,219	1,126.5
	Moisture Removal Stage	Water	36,281	510.0
	Moisture Removal Stage	Water	39,449	154.0
A2	Heater Drains	Water	1,181,660	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	1,122.4
	Extraction	Water	3,603	295.7
	Heater Drains	Water	471,955	297.8
D	Extraction	Steam	123,857	1,156.7
	Moisture Separator	Water	343,031	384.2
	Valve Leak-Off	Steam	3,301	1,191.5
	Seal Leak-Off	Steam	1,767	1,119.1

Table 10.4-5

FEED PUMP CHARACTERISTICS

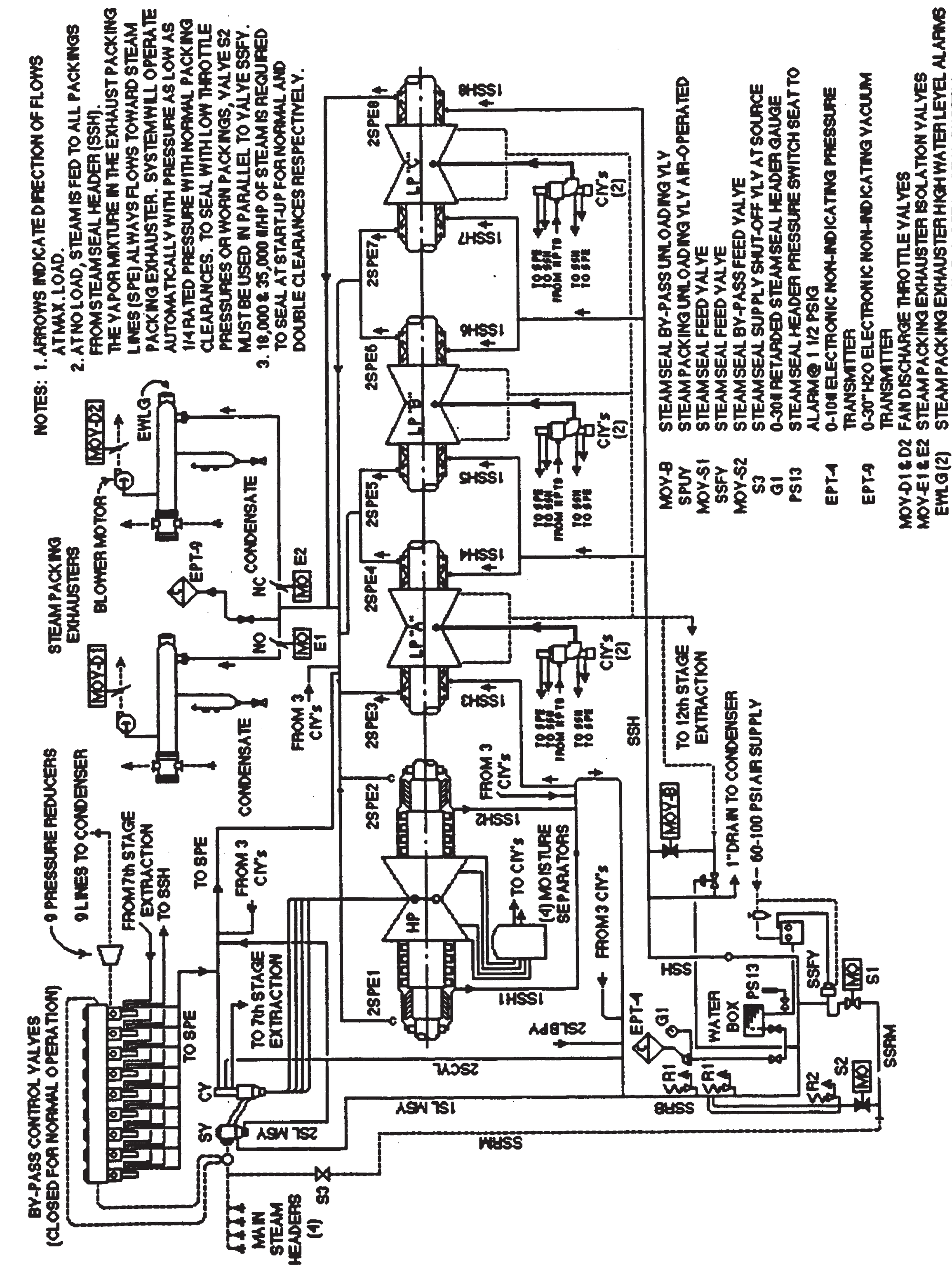
Capacity	5,105,000 lb/hr
Pumping temperature	298 °F
Suction head	285 ft
Discharge head	3021 ft
Total developed head	2736 ft
Pump speed at design load	4000 — 5000 rpm
Motor speed (synchronous)	1800 rpm
Approximate NPSH available at design load	100 ft
Pump suction design pressure (based on maximum cold water shutoff head on condensate pumps of 965 feet)	450 psig
Range in feedwater temperature	60 — 310°F



QUAD CITIES STATION
UNITS 1 & 2

DIAGRAM OF MAIN STEAM PIPING

FIGURE 10.3-1
REVISION 8, OCTOBER 2005



QUAD CITIES STATION UNITS 1 & 2

DIAGRAM OF STEAM SEAL PIPING

FIGURE 10.4-1

REVISION 7, JANUARY 2003