## CHAPTER 10 – STEAM AND POWER CONVERSION SYSTEM

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## 10.0 STEAM AND POWER CONVERSION SYSTEM

## 10.1 SUMMARY DESCRIPTION

The Steam and Power Conversion System is designed to convert heat energy from the reactor coolant to electrical energy. Two steam generators are utilized with steam being condensed and deaerated in a three stage multipressure steam surface condenser and the condensate-feedwater being heated in two parallel strings of both low and high pressure heaters. The condenser circulating water is cooled in two natural draft cooling towers, which are not vital for safe shutdown of the plant. Design of the entire system has been based on the maximum expected energy from the nuclear steam supply; optimizations of efficiency vs. cost have been incorporated where applicable, e.g., condenser and cooling tower surface.

The system is designed to maintain heat removal from the Reactor Coolant System in the event of either a failure in both feedwatertrains, or a loss of offsite power, or both, by supplying emergency feedwater to the steam generators through the Emergency Feedwater System.

Upon loss of full load, the system will dissipate all the energy existent or produced in the Reactor Coolant System through steam relief to the condenser and the atmosphere. The steam bypass to the condenser, atmospheric safety valves, and controlled atmospheric relief valves are utilized as necessary to achieve this load reduction.

## 10.2 TURBINE GENERATOR

### 10.2.1 DESIGN BASIS

a. Function

The turbine receives steam from two steam generators (thermal energy) and converts the thermal energy to mechanical energy through rotation of the turbine shaft. The turbine, in turn, is directly connected to an electric generator which produces electrical energy upon rotation of an excited field.

The turbine generator includes an electrohydraulic control system which is described in Subsection 10.2.2.

b. Process Data

Typical process data for the turbine and generator are shown in Tables 10.2-1 and 10.2-2, respectively.

c. Service Conditions

There are no components in the turbine generator system that are required for the safe shutdown of the plant. System piping is designed in accordance with the Power Piping Code USAS B31.1, 1967.

### 10.2.2 SYSTEM DESCRIPTION AND OPERATION

The turbine is a direct condensing, 1800 RPM, non-reheat, tandem compound, six-flow nuclear steam turbine. The turbine consists of four sections: a double-flow, high pressure section, and three double-flow, low pressure sections.

The steam space of each turbine section is sealed against steam leakage to the atmosphere and against internal leakage from one section to another by means of shaft packings which provide a series of throttlings that limit steam leakage along the rotating shaft to a minimum as it is throttled from the higher pressure space to the lower pressure space.

Dry and slightly superheated steam from the steam generators flows through four sets of separately mounted main stop valves and control valves and through four nozzle boxes into the 1800-rpm high pressure section. Exhaust steam from the high pressure section passes through the 6 moisture separators where excess moisture is removed. It then travels through the combined intermediate valves and enters the low pressure sections. Exhaust steam from the low pressure sections is discharged into the main condenser through the exhaust hood.

The four main stop valves are located one each in the four main steam supply leads upstream from the control valves to which they are welded. The four main stop valves are also welded together through the below seat equalizers. The main stop valves quickly shut off steam to the turbine under emergency conditions. One of the main stop valves is provided with an internal bypass valve capable of passing approximately twice the no-load flow for slow warming of the stop valves, control valves, high pressure shell, and for decreasing the pressure differential across the main stop valves so the hydraulic cylinders can open the valves. The remaining three stop valves have no bypass and are either fully open or fully closed.

The four control valves are of angle body type and are welded to the stop valves to make a single assembly which is separated from the turbine. Individual steam lines from each control valve are provided to the inlet bowl of the high pressure turbine. The valves are operated by individual hydraulic cylinders.

There are six combined intermediate stop/intercept valves, two per each low pressure turbine. One of these valves is located in each of the six lines supplying steam to the low pressure turbines to protect the turbine against overspeed from stored steam in the crossaround system.

The intercept valves are closed upon loss of generator load to shut off steam flow from the crossaround system to control overspeeding of the turbine. The intermediate stop valves quickly shut off steam to the LP turbines under emergency conditions if normal control devices fail to prevent excessive overspeed.

The turbine has an electrohydraulic control (EHC) system which controls acceleration, load, speed and overspeed by positioning of the steam valves (stop valves, control valves, combined intermediate valves). Once the turbine EHC system is reset, emergency trip system (ETS) oil pressure is supplied to the disc dump valves of the hydraulic actuators on each steam valve. This ETS pressure allows the steam valves to open on signals from the EHC system. Under emergency or test conditions as can occur during load rejection and overspeed testing, sudden relieving of the ETS oil pressure will result in rapid closure of all steam valves to prevent overspeed. When this occurs the turbine is said to be in a tripped condition.

The EHC system contains electronic protection circuits called the power/load unbalance and intercept valve trigger circuits. If a load rejection occurs, these circuits will anticipate an overspeed condition and will close the control valves and intercept valves to prevent an actual overspeed trip. For power load unbalance, the intercept valves close then return to speed control after a one second delay while the main control valves close and remain closed until the power/load mismatch condition clears. For intercept valve trigger, upon detection of an IV-1/3/5 position error, the intercept valves close then immediately reopen for speed control.

In the event the EHC system electronic speed control circuits cannot maintain speed within the safe overspeed range, a mechanical overspeed trip device mounted directly on the turbine shaft will operate through mechanical linkages to relieve ETS oil pressure and all steam valves will trip closed. This mechanical trip device is backed up by an independent electronic overspeed protection circuit (emergency overspeed trip) which can also trip the ETS pressure on excessive overspeeds.

A closed loop cooling system using hydrogen gas as the coolant is used to cool all of the generator components (except the stator winding internals).

The stator winding is also cooled by cooling water circulating through each of the hollow insulated copper conductors arranged in the form of rectangular bars that form the armature winding.

Carbon dioxide is used for purging out air or hydrogen, as required, to avoid having an explosive hydrogen-air mixture in the generator at any time, either when the generator is being filled with hydrogen prior to being placed in service, or when hydrogen is being removed from the generator prior to opening the generator for inspection or repairs.

Radioactive contamination of the turbine can occur only through leaks in the steam generator tubes. Because the maximum expected dose rate within the turbine is very low, no shielding is required for the turbine and associated equipment.

### 10.2.3 HISTORICAL INFORMATION

The turbine nameplate rating was increased from 837,478 KW to 872,000 KW because of an increase in reactor power and improvements to turbine thermal performance. Approximately 11,000 $KW_e$ resulted from the reactor power increase to 2568 $MW_{TH}$ with the remainder, 23,522 $KW_e$, a consequence of turbine improvements.

An extensive design review of the turbine generator was done by GPUN and General Electric to ensure that sufficient margins exist and that the turbine generator can operate satisfactorily at the increased electrical output of 872,000 KW. The design review concluded that all turbine generator systems, including the iso-phase bus and transformer, are capable of an additional 34,522 $KW_e$ with sufficient margin.

In 1R14, the original turbine was replaced with a GE Advanced Design Steam Path (ADSP) turbine. The only steam path components retained were the first stage nozzle block and associated brush seal. This more efficient design resulted in another increase in the turbine nameplate rating to 904,588 kW. General Electric and AmerGen again concluded upon extensive review that the generator, iso-phase bus, and main transformers were all capable of supporting the additional output with sufficient margin. As part of this upgrade, the original rotors, which utilized shrunk-on wheels and axial keyways, were replaced with ones manufactured from monoblock forgings.

TABLE 10.2-1
(Sheet 1 of 1)

TURBINE DATA

The following conditions are typical process data. Actual conditions may vary considerably depending on plant performance.

(TG-U-1HP, TG-U-1 LP A/B/C)

| | |
|---|---|
| Steam flow, lb/hr | 10,910,000 |
| Inlet pressure, psia | 900 |
| Inlet temperature, ºF | 588 |
| Inlet enthalpy, Btu/lb | 1250.6 |
| Back Pressure, in. Hg abs | 1.65/2.19/2.55 |
| Speed, rpm | 1800 |

The above conditions are based on 100 percent power, zero percent makeup, six stages of Feedwater heating in service, and with two 60 percent capacity condensing turbine-driven steam generator feed pumps in service.

Extraction Steam Pressure, psia

| | Valves Wide Open | 100% Operation |
|---|---|---|
| Twelfth stage | 3.40 | 3.37 |
| Tenth stage | 13.8 | 13.7 |
| Eighth stage | 53.8 | 53.3 |
| Sixth stage | 180.4 | 178.8 |
| Fourth stage | 310.5 | 307.6 |
| Second stage | 524.0 | 519.1 |

TABLE 10.2-2
(Sheet 1 of 1)

GENERATOR DATA

(TG-GN-0001)

Operation: Continuous

Rating: 1,037,900 kVA at 1800 rpm; 19,000 volts; 0.945 PF; 60-psig $H_2$ pressure, 31,539 amperes, 60 cycle

Actual generator electrical output may vary considerably depending on plant performance.

## 10.3 STEAM SUPPLY SYSTEMS

Steam systems include the main steam, turbine bypass, extraction steam and drains, and auxiliary steam including auxiliary boiler system.

### 10.3.1 MAIN STEAM SYSTEM SUPPLY TO MAIN TURBINE AND MAIN FEEDWATER PUMP TURBINES

#### 10.3.1.1 Design Basis

a. Function

The main steam system delivers steam from the steam generators to the high pressure turbine and the main feedwater pump turbines during startup, power operation, and when shutting down the unit. Under blackout or loss of main feedwater or loss of four reactor coolant pumps, receipt of a high containment pressure signal or low OTSG level, the Main Steam System delivers steam to the emergency feedwater pump turbine as described in 10.3.2 . The main steam system delivers steam to the gland seal steam system during startup.

The main steam system also provides overpressure protection of the Once Through Steam Generators (OTSG) via the main steam safety valves (discussed in section 10.7.4). The Main Steam Isolation Valves (MSIV) have a long-term closure function for containment integrity for the following design basis accidents: Large Break LOCA, Small Break LOCA, Main Steam Line Break and, steam generator tube rupture. The most limiting MSIV stroke time is based on the need to isolate an OTSG after a Steam Generator Tube Rupture (Reference 14.1.2.10). The stop check feature of the MSIV will prevent blowdown of the opposite OTSG in the event of a main steam line break upstream of a MSIV. The main steam system is shown in Drawing 302-011.

b. Process Data

The main steam system is designed to supply steam at a rate required by the main turbine. Typical process steam flow data is shown in Table 10.2-1. Refer to Table 10.3-1 for nominal design data on the main steam system major components.

c. Service Conditions

The portion of the main steam system up to and including the main isolation valves will maintain its structural integrity during a seismic event. The portion of the main steam system, downstream of the main isolation valves, which supplies steam to the main turbine and feedwater pump turbines is not required for safe plant shutdown or for maintaining the plant in a safe shutdown condition.

Note that drain lines from the last valve before a main steam drainline steam trap, in the Intermediate Building up to and including the shutoff valve just downstream of the trap, while Seismic Class III have been judged by inspection to have significant Seismic resistance.

The main steam lines from the steam generator, out through containment up to and including the main steam isolation valves, are designed fabricated erected and inspected in accordance with the Power Piping Code USAS B31.1.0, seismic Category I. This includes piping to the emergency feedwater pump turbine. Safety valves on the main steam lines and branches to the emergency feedwater turbine are designed in accordance with ASME Code Section III, Class A requirements. This piping is seismic Class I.

The balance of piping is in accordance with Code USAS B31.1.0., and seismic Class III. Seismic classification for the main steam system is shown on Drawing 302011.

10.3.1.2 System Description and Operation

As shown on Drawing 302011, the main steam system consists of two main steam lines from each OTSG to the high-pressure turbine for a total of four lines. The only cross-connection between the lines is in the turbine steam chest between the turbine stop valves and control valves. Each of the main lines is furnished with a main steam isolation stop check valve and branch lines that supply steam to the main feedwater pump turbines and to the emergency feedwater pump turbine. The emergency feed pump turbine supply is upstream of the main steam isolation valves and also serves the turbine bypass system and the atmospheric steam relief.

The motor-operated main steam isolation stop check valves are located in the concrete portions of the Intermediate Building where they are protected from the effects of seismic, tornado, missile, or aircraft design events. These tight closing isolation valves are remotely operated from the Control Room to close in less than two minutes. Design data for these valves are shown in Table 10.3-1.

The main steam safety valves (settings are covered in Section 10.7) are located upstream of the main steam isolation stop check valves. Design data for these valves are shown in Table 10.3-1. Downstream of the main steam isolation stop check valves are the Main Turbine stop/control valve assemblies, which are covered in Section 10.2.

The main steam piping is so arranged and equipped with motor operated isolation check valves (MSIV) such that rupture of a line from one steam generator upstream of an MSIV will not blow the other steam generator dry. In the event of any MS line rupture, closure of the turbine stop valves prevents rupture of one line from affecting both OTSGs, and ensures a steam supply is available to the emergency feed pump turbine for all non-seismic events.

The following electrical components in the main steam system are not seismically qualified: a) cable routing of motor operators for main steam supply isolation valves to the turbine driven EFW pump (MS-V2A, MS-V2B); b) solenoid valves and limit switches which control the valves for providing main steam to the turbine driven EFW pump (MS-V13A, MS-V13D); c) cable routing of motor operators for main steam isolation valves (MS-V1A, MS-V1B, MS-V1C, and MS-V1D); d) cable routing of motor operators of main steam to turbine driven EFW pump (MS-V10A, MS-V10B); e) local starter for MS-V10A and MS-V10B motor operators; and f) limit switches on turbine driven EFW pump steam supply regulating valves. However, these components and the turbine driven EFW pump are judged non-essential to safe shutdown following a seismic event. The motor driven EFW pumps are seismically qualified and are capable of meeting the minimum flow requirement for postulated accident conditions following a seismic event.

The main steam safety valves discharge piping is designed with thermally compensating (heated) support posts. These heated posts minimize the vertical movement of the discharge piping caused by the force exerted by escaping steam when a relief valve lifts, and thereby limits the resulting stress on the relief valve header connections. The support posts maintain a close clearance by expanding along with the relief valve piping as the system heats up and expands. The clearance is based on the maximum allowable local stress at the main steam header-safety valve inlet pipe intersection, considering the combined effects of internal pressure, deadload, earthquakes, and safety valve reaction. This maximum local stress is not permitted to exceed the allowable stress.

The main steam system can only be radioactively contaminated when there is an OTSG tube leak. As described in Chapter 11, radiation level is very low and no shielding is required. Contamination of the main steam is detected by the main condenser air removal system radiation monitoring instruments.

## 10.3.2 TURBINE BYPASS AND EFW TURBINE STEAM SUPPLY SYSTEM

### 10.3.2.1 Design Basis – Turbine Bypass System

a. Function

The turbine bypass system is designed to serve the following functions:

1) Provide pressure control at low loads before the turbine is capable of accepting pressure control, i.e., startup.

2) Provide an independent high pressure relief from the safety valves that will operate proportionally to steam generator pressure.

3) Provide pressure control after a turbine trip to provide controlled cooling of the reactor coolant fluid.

4) Provide a means of dumping steam, during a load rejection from partial load, without opening the main steam code safety valves.

b. Process

The turbine bypass system can dump a total of approximately 33% of steam flow at 100% reactor power to the main condenser and an additional approximate 8.8% of steam flow at 100% reactor power to the atmosphere for a total design capacity of approximately 41.8% of steam flow at 100% reactor power.

c. Service Conditions

The portion of the turbine bypass system utilized for atmospheric dump is within the seismic boundary and will maintain its structural integrity during a seismic event, operation of the atmospheric dump valves is not essential for safe hot shutdown. The condenser dump portion is not required for reactor safety. Refer to Subsection 10.3.1 for description of the isolation valves in the steam supply headers.

The emergency feedwater pump turbine steam safety relief valves MS-V22 A/B and the atmospheric dump valves MS-V-4 A/B vent stacks meet Seismic Class 1 requirements. The vent stacks are designed to withstand a seismic event to prevent the release of main steam to the Intermediate Building, to reduce the possibility of overpressurization of the Intermediate Building and to protect Emergency Feedwater System components from exposure to a harsh steam environment and gravity missiles.

10.3.2.2 Design Description And Operation

As shown on Drawing 302011, Main Steam System, the turbine bypass valves which discharge to the condenser and the atmospheric dump valves which discharge to the environment, are located on branch lines off the main steam lines.

Each steam generator incorporates one atmospheric steam dump valve which exhausts to the environment and three turbine bypass valves which exhaust to the condenser.

Upon loss of full load, the main steam safety valves can dissipate all of the energy existent or produced in the reactor coolant to the environment. At low loads the turbine bypass and atmospheric dump valve can be modulated to prevent excessive cooling of the reactor coolant fluid.

10.3.2.3 Design Basis – EFW Turbine Steam Supply

The portion of the main steam system supplying the emergency feedwater pump turbine up to and including the main isolation valves will maintain its structural integrity during a seismic event. The turbine driven pump and associated steam supply valves are not required for loss of feedwater or small break LOCA in conjunction with a seismic event.

10.3.3 EXTRACTION STEAM AND DRAINS SYSTEM

10.3.3.1 Design Basis

a. Function

The extraction steam system provides steam to the high and low pressure stage heaters for feedwater heating, radioactive waste evaporators, auxiliary boilers for hot standby condition, and caustic solution heater for mixed bed demineralizer regeneration. The drain system collects and returns the drains to the feedwater system.

b. Process

The extraction steam and stage heater drains are designed and sized to provide six stages of extraction steam for the services mentioned in Subsection 10.3.3.1.a. Process design data of the system major components are shown in Table 10.3-2.

c. Service Conditions

Neither the extraction steam system nor the drain system is required for the safety of the plant. Piping is designed in accordance with Power Piping Code USAS B31.1.0.

10.3.3.2 System Description And Operation

The system provides two stages of high pressure and four stages of low pressure extraction steam for feedwater heating. The closed cycle feedwater heaters are half size units with two parallel strings. The second and fourth stages of the high pressure turbine provides steam for the second and fourth stage high pressure heaters. The sixth or last stage of the high pressure turbine provide steam to the sixth stage low pressure heater. Exhaust steam from the high pressure turbine is routed through parallel banks of moisture separators. Each bank consists of three moisture separators, three moisture separator drain tanks, and pumps. After passing through the moisture separators, the steam is exhausted into the three low pressure turbines. Each low pressure turbine provides extraction lines from the eighth, tenth, and twelfth stages to their respective eighth, tenth, and twelfth low pressure stage heaters. Additional steam supplies include sixth stage extraction for main feedwater pump turbines, caustic solution heater, eighth stage extraction for radioactive waste evaporators, and maintaining auxiliary boilers in a hot standby condition. Condensate from the second and fourth stage heaters, combined with the condensate from the moisture separator drain tanks, enters the sixth stage heaters and drains from the sixth stage heater to the sixth stage drain collection tank. Heater drain pumps deliver the water from the drain collection tank to the main feedwater pump suction header.

To protect the turbine against water induction, the second and eighth stage heaters have nonreturn valves. The fourth and tenth stage heaters have motor operated admission valves which will close on extreme high level. Sixth stage steam is extracted upstream of the moisture separators; therefore, a flooded heater will overfill and enter the moisture separator.

The system can become radioactively contaminated only through steam generator tube leaks. Radioactive contaminants are detected by the main condenser air removal system radiation monitoring instruments. Due to low expected radioactivity levels, no shielding is required.

10.3.4 AUXILIARY STEAM SYSTEM

10.3.4.1 <u>Design Basis</u>

a. Function

1) During startup, to supply steam for the following:

a) Main feedwater pump turbines

b) Gland sealing steam for the main turbine and main feedwater pump turbines

c) Eighth stage feedwater heating

2) During shutdown, to supply steam to the emergency feedwater pump turbine (EF-P1) if required.

3) To provide steam to the following during all plant conditions and as required: (Normally the below are supplied from the 8th stage extraction steam when the turbine unit is running)

   a) Radwaste evaporators

   b) Radwaste tank heaters

   c) Fuel Handling Decontamination pit

   d) Demineralized water treatment caustic dilution water heating

b. Process

The auxiliary steam supply header pressure is maintained at 200 psig. Auxiliary steam is supplied from auxiliary boilers which burn No. 2 fuel oil. Each of the two boilers is rated at a full steam capacity of 125,000 lb/hr. Process data are tabulated in Table 10.3-3.

c. Service Conditions

The auxiliary steam system is not required for the safe shutdown of the plant. The pressurized portions of the boiler are designed in accordance with Power Piping Code USAS B31.1.0 and the applicable ASME Code.

10.3.4.2 System Description And Operation

As shown on Drawing 302051, the auxiliary steam system consists of major distributor headers that supply auxiliary steam during plant startup to lines servicing the main feedwater pump turbines, the gland sealing system for the main turbine and main feedwater pump turbines, and the eighth stage feedwater heaters. The system also supplies steam to the emergency feedwater pump turbine, the radwaste evaporators, radwaste tank heaters, fuel handling decontamination pit, and the caustic dilution water heating in the demineralizer water treatment system during all plant conditions as required.

The auxiliary boilers are utilized when the main steam supply system is not available.

The boilers are of the forced-draft type with common stack and two-element pneumatic control and are equipped with a steam heating coil in the lower drum, which obtains steam from the turbine eighth-stage extraction header. When the boilers are shut down, steam from eighth-stage extraction maintains boiler temperature in a hot standby condition. Auxiliary boiler pressure will roughly track eighth-stage extraction pressure, which will vary with station load.

Two full capacity feed pumps are provided for the auxiliary boiler taking suction directly from the condensate storage tanks. Check valves allow pumps to take suction from a source with higher pressure. Boiler control is from the local control panel, and Control Room indication is provided for boiler drum level, steam flow, and steam pressure.

A low pressure supply header, nominally operated at between 5-8 PSI, may be supplied from either eighth stage extraction steam (normal), or the auxiliary steam system from the boilers.

This header provides steam for the radwaste evaporators as well as the radwaste tank heaters in the reclaimed boric acid tanks. In addition, the normal auxiliary steam header may supply either eighth stage extraction steam or boiler generated steam for the caustic water heater depending on plant mode.

The auxiliary steam major supply header pressure is maintained by a pressure control valve that discharges excess steam to the atmosphere through a silencer when the auxiliary boilers are operating and by pressure control valves in the extraction steam supply headers.

The auxiliary steam system may be supplied steam from any of the below sources:

a) Auxiliary Boilers located in the Unit 1 Turbine Building

b) Unit 1 6th stage extraction steam

c) Unit 1 8th stage extraction steam

TABLE 10.3-1
(Sheet 1 of 3)

MAIN STEAM MAIN COMPONENTS

Main Steam Isolation Valves
(MS-V-1A/B/C/D)

| | |
|---|---|
| Quantity | 4 |
| Type | Stop check |
| Manufacturer | Rockwell |
| Size, inches | 24 |
| Operator | Motor |
| Ends | Butt weld |
| Design pressure, psig | 1050 |
| Design temperature, ºF | 560 |
| Body materials | Carbon steel |
| Closing time, seconds | <120[1] |
| Seismic requirements | Class I[2] |
| Motor, hp | 45 |

[1] Against 55 psig
[2] See Section 10.3.1.2

TABLE 10.3-1
(Sheet 2 of 3)

MAIN STEAM MAIN COMPONENTS

Main Steam Safety Valves
(MS-V-17A/B/C/D, MS-V-18A/B/C/D),
MS-V-19A/B/C/D, MS-V-20A/B/C/D),
MS-V-21A/B)

| | |
|---|---|
| Quantity | 18 |
| Type | Safety |
| Manufacturer | Dresser |
| Size, inches | 16 - 6 x 10<br>2 - 3 x 6 |
| Ends | Raised face flange |
| Set pressure | See FSAR Subsection 10.7.4 |
| Body materials | Cast Carbon steel |

Main Steam Dump to Condenser Valves MSV-8A, MSV-8B and Steam Dump Isolation Valves MSV-2A, MSV-2B

| | |
|---|---|
| Type | Gate |
| Manufacturer | Walworth |
| Size, inches | 12 |
| Operator | Motor |
| Ends | Butt Weld |
| Schedule | 60 |
| Manufacturer pressure rating | 600 |
| Body Materials | Carbon Steel |
| Approx. closing time, minutes | 1[1] |
| Seismic requirements | Class I[2] |

[1] Against 55 psig
[2] See Section 10.3.1.2

TABLE 10.3-1
(Sheet 3 of 3)

MAIN STEAM MAIN COMPONENTS

Main Steam Dump to Condenser Valves MSV-3A through MSV-3F

| | |
|---|---|
| Quantity | 6 |
| Type | Control valve |
| Manufacturer | Fisher |
| Size, inches | 6 |
| Operator | Piston |
| Ends | Butt weld |
| Body materials | Carbon steel |
| Minimum Capacity per valve (at 600ºF and 940 psia) | $0.418 \times 10^6$ lb/hr |

Atmospheric Steam Dump Valves MS-V4A and 4B

| | |
|---|---|
| Quantity | 2 |
| Type | Control Valve |
| Manufacturer | SPX/Copes-Vulcan |
| Size, inches | 6 |
| Operator | Diaphragm, Reverse-Acting |
| Ends | Butt weld |
| Body Material | Carbon steel |
| Capacity per valve lb/hr at 925 psig | $0.481 \times 10^6$ |

TABLE 10.3-2
(Sheet 1 of 3)

EXTRACTION STEAM SYSTEM
MAIN COMPONENTS
NOMINAL DATA

A. Second Stage Heater Shell (FW-J-1A/B)

| | |
|---|---|
| Pressure, psig | 600 |
| Vacuum, inches | 30 |
| Temperature, ºF | 510 |
| Construction | Carbon steel |

B. Fourth Stage Heater Shell (FW-J-2A/B)

| | |
|---|---|
| Pressure, psig | 375 |
| Vacuum, inches | 30 |
| Temperature, ºF | 460 |
| Construction | Carbon steel |

C. Sixth Stage Heater Shell (FW-J-3A/B)

| | |
|---|---|
| Pressure, psig | 225 |
| Vacuum, inches | 30 |
| Temperature, ºF | 420 |
| Construction | Carbon steel |

D. Eighth Stage Heater Shell (FW-J-4A/B)

| | |
|---|---|
| Pressure, psig | 75 |
| Vacuum, inches | 30 |
| Temperature, ºF | 330 |
| Construction | Carbon steel |

E. Tenth Stage Heater Shell (FW-J-5A/B)

| | |
|---|---|
| Pressure, psig | 50 |
| Vacuum, inches | 30 |
| Temperature, ºF | 300 |
| Construction | SA-387-11 CL.2 |

TABLE 10.3-2
(Sheet 2 of 3)

EXTRACTION STEAM SYSTEM
MAIN COMPONENTS
NOMINAL DATA

F. Twelfth Stage Heater Shell
(FW-J-6A/B)

| | |
|---|---|
| Pressure, psig | 50 |
| Vacuum, inches | 30 |
| Temperature, ºF | 300 |
| Construction | Carbon steel |

G. Moisture Separators (MO-T-2A thru F)

| | |
|---|---|
| Pressure, psig | 300 |
| Temperature, ºF | 417 |
| Construction | Carbon steel |

H. Separators Drain Tank (MO-T-1A thru F)

| | |
|---|---|
| Pressure, psig | 300 |
| Temperature, ºF | 417 |
| Construction | Carbon steel |

I. Moisture Separators Drain Tank Pumps
(MO-P-1A thru F)

| | |
|---|---|
| Capacity, gpm | 340 |
| Temperature, ºF | 383 |
| TDH, feet | 140 |
| Speed, rpm | 1750 |
| Minimum NPSH, feet | 4 |
| Minimum flow, gpm | 100 |
| Horsepower | 25 |

J. Sixth Stage Drain Collection Tank (HD-T-1)

| | |
|---|---|
| Pressure, psig | 225 |
| Temperature, ºF | 420 |
| Construction | Carbon Steel |
| Diameter | 8 ft 10 inches |
| Length | 20 ft |

TABLE 10.3-2
(Sheet 3 of 3)

EXTRACTION STEAM SYSTEM
MAIN COMPONENTS
NOMINAL DATA

K. Heater Drain Pumps (HD-P-1A/B/C)

| | |
|---|---|
| Temperature, ºF | 420 |
| Capacity, gpm | 3600 |
| Total head, feet | 950 |
| Speed, rpm | 3600 |
| Minimum NPSH, feet | 36 |
| Minimum flow, gpm | 250 |
| Horsepower | 1000 |

L. L.P. Moisture Collection Tank (EX-T-1)

| | |
|---|---|
| Pressure, psig | 5 and full vacuum |
| Temperature, ºF | 300 |
| Construction | Carbon steel |

TABLE 10.3-3
(Sheet 1 of 1)

AUXILIARY BOILER SYSTEM

A. Auxiliary Boiler (AS-B-1A/B)

| Performance Of Each Boiler | Maximum Continuous |
|---|---|
| Rating, lb/hr | 125,000 |
| Maximum blowdown, lb/hr | 2000 |
| Boiler outlet pressure, psig | 200 |
| Boiler outlet temperature | Sat |
| Maximum output, MBTU/hr | 134 |
| Feedwater temperature, ºF | 160 |
| Maximum allowable blr. concentration, ppm | 2000 (total solids in drum) |
| Steam purity, ppm* | 1 |
| Heating surface, boiler and furnace, $ft^2$ | 8087 |
| Furnace volume, $ft^3$ | 1708 |

B. Auxiliary Boiler Feedwater Pumps (AS-P-1A/B)

Type:

Ingersoll-Rand model 3 x 12 AN, single stage, vertically split, single suction, overhung impeller, centerline supported centrifugal pumps with coupling guards.

Design conditions (each pump):

| | |
|---|---|
| Temperature, ºF | 160 |
| Capacity, gpm | 525 |
| Total head, feet | 600 |
| Speed, rpm | 3550 |

* An effort should be made to keep steam quality the same as that for a steam generator to prevent chemical contamination of the steam cycle.

# 10.4 CONDENSATE SYSTEM

## 10.4.1 MAIN CONDENSATE SYSTEM

### 10.4.1.1 Design Basis

a. Function

The main condensate system is designed to:

1) Deliver deaerated water from the condenser hotwell to the suction header of the feedwater pumps at conditions to meet the net positive suction head (NPSH) requirements of the feedwater pumps and the water purity requirements of the OTSG.

2) Provide a direct suction to the emergency feedwater pumps from the condensate storage tanks or directly from the hotwell.

3) Provide water to the following:

   a) Emergency makeup to nuclear services closed cooling water (NSCCW) and secondary services closed cooling water (SSCCW) Systems.

   b) Backup makeup of demineralized water to the reactor coolant bleed tanks (RCBTs)

   c) Turbine exhaust hood spray supply

   d) Seal water to vacuum pumps and main feedwater pumps

   e) Water to the condensate head tank, which provides water to the condenser expansion joints, main vacuum breaker seal, auxiliary vacuum breaker seal, condensate pump seals, chemical addition pump seals, and various valve seals.

4) Provide suction for auxiliary boiler feed pumps and Powdex backwash pumps.

5) Provide a gas-to-liquid partition factor of $10^{-2}$ for the radioactive iodine entering the condenser. This partition factor is specific for the Rod Ejection Accident event (see 14.2.2.2) and the OTSG Tube Failure event (14.1.2.10).

b. Process

The condensate system design is based on the maximum steam flow expected from the OTSGs and the valves wide open (VWO) condition of the turbine. Refer to Table 10.4-1 for design data of the major condensate system components.

c. Service Conditions

The tanks and all piping and components between condensate storage tank and the emergency feedwater pump suction header are designed to seismic Class I. The remaining components of the condensate system are designed to seismic Class III. Seismic classifications are shown in Drawing 302101. Pressure vessels are in accordance with ASME Section VIII and piping is designed to Power Piping Code USAS B31.1.0. The radioactive contamination that may result from an OTSG tube leak will not require shielding of the system components. Refer to Section 11.4 for radiation monitoring.

10.4.1.2 System Description And Operation

The condensate system is shown schematically on Drawing 302101.

Two of three 50 percent capacity motor-driven condensate pumps take suction from the condenser hotwell via a common suction header. The pumps discharge to a common header through a polishing unit and gland steam condenser to the suction header of the three 50 percent capacity condensate booster pumps. The booster pumps are provided with a recirculation line to the condenser to protect both the booster and condensate pumps and turbine gland steam condenser. Two of three motor-driven condensate booster pumps discharge to a header which splits into two parallel trains of low pressure feedwater heaters. Each low pressure heater train consists of a 12th stage external drain cooler, a 12th stage heater, a 10th stage heater, an 8th stage heater, and a 6th stage heater. Each heater train can be isolated from service by closing a motor-operated valve located upstream from the external 12th stage drain cooler and downstream of the sixth stage heater.

Either heater train can be bypassed for maintenance while plant operation continues. A line from the discharge of the condensate pumps supplies condensate to the low pressure turbine exhaust hood sprays for cooling purposes. Sample points are located at various points in the condensate system, allowing analysis of the fluids. Hydrazine, one or a combination of the approved advanced amines (ammonium hydroxide, morpholine, ethanolamine, and methoxypropylamine), and a steam generator corrosion inhibitor (boric acid) are added to the condensate system. Hydrazine is used as an agent to remove dissolved oxygen and is maintained at a small marginal excess which is detectable by analysis. The approved advanced amine(s) maintains the pH at system temperature ($pH_T$) of the condensate and feedwater. It has been determined that operation at $pH_T$ higher than the neutral pH at system temperature ($pH_N$) would minimize/reduce corrosion. The corrosion inhibitor is added to reduce the potential for corrosive degradation of steam generator materials.

The main condenser is an Ingersoll Rand Co. Model Ret-45 consisting of three separate stages on the steam side and two stages on the circulating water side, and is discussed in Section 9.6.2.1. Refer to Table 9.6-1 for the condenser circulating water system main components.

The condenser shells are mounted parallel to the turbine axis with the three turbine exhausts discharging downward into the top of the condenser. In addition to main turbine exhaust steam, the condenser is designed to receive steam and drains from the secondary startup system which uses a 15 percent capacity turbine bypass.

The two condensate storage tanks are the surge chambers for the hotwell with makeup water to the system from the demineralized water system. In each condensate storage tank there is installed a nitrogen header which is designed to deliver nitrogen gas to the forty-eight (48) 0.5-micron spargers located in the bottom of the tank. Nitrogen sparging can be used to control the dissolved oxygen concentration in the water. The flow to and from the condensate storage tanks is controlled by hotwell level. The storage tanks provide a direct suction for the emergency feedwater pumps and a supply of water for backwashing and precoating the Powdex filters. The feed pumps for the auxiliary boilers can also take suction from the condensate storage tanks. Overall system makeup is from the station demineralizers.

## 10.4.2 CONDENSATE POLISHING

### 10.4.2.1 Design Basis

a. Function

The condensate polishing system ensures that: the quality of the feedwater delivered to the steam generators is within the limits specified by the steam generator supplier; cleans up the secondary cycle prior to startup by removing all crud remaining after chemical cleaning and produced during hot functional testing; removes radioactivity from the secondary system when a steam generator tube leak exists; and removes contaminants entering the condensate via a leaking condenser tube permitting continued operation or orderly shutdown of a section of the condenser, depending on the size of the leak.

b. Process

The condensate polishing system (Powdex system) is designed to process the full flow of two condensate pumps. A separate deep bed demineralizer, MO-T-3, is designed to treat up to a maximum of 50 gpm from the discharge of moisture separator drain pump MO-P-1B using selected resins. Normal drains from the HP heaters and the other moisture separators are not typically treated. The capability is provided to route any or all of the drains from the moisture separators back to the condenser for cleanup via the Powdex system. The Powdex system removes ionic and particulate matter from the condensate stream to keep the total solids in the steam generator feedwater at a minimum.

c. Service Conditions

The condensate polishing system is not required for shutting the reactor down or maintaining the plant in a safe shutdown condition. Radiation levels due to contamination through leaks in the OTSG tubes is expected to be very low, therefore, no shielding is required.

### 10.4.2.2 Description And Operation

The system consists of a set of six element-type Powdex filter units, five of which will normally be in operation, each taking 20 percent of the total condensate flow. The sixth unit is normally on standby with a new precoat and available for operation immediately on removal of one of the other units from service.

A single precoating system is provided which is used for precoating any of the filter units with Powdex resin as required. This precoating operation is fully automatic with the exception of preparation of the Powdex resin slurry, which must be carried out manually by the operator at the commencement of the automatic sequence.

A 20 cu. ft. deep bed demineralizer vessel is installed to take up to 50 gpm from the discharge of moisture separator drain pump MO-P-1B. The water is cooled in a heat exchanger prior to the resin bed and returned directly to the main condenser. The demineralizer vessel is designed to accommodate lead shielding from a integral support ring.

The spent Powdex resin is normally processed for disposal via the Powdex Backwash Recovery System. Spent Powdex resins may be transferred or processed to other processing systems (e.g., Industrial Waste Filter System – IWFS) based on the radiological characteristics. Release of water separated from the Powdex resin may be released to the environment using routine effluent pathways in accordance with normal station requirements.

### 10.4.3 Condensate Chemical Treatment System

#### 10.4.3.1 Design Basis

The chemical treatment system provides control of:

a. Feedwater pH, by injection of one or a combination of the approved advanced amines (such as ethanolamine, methoxypropylamine morpholine, ammonium hydroxide, etc.) under control of feedwater pH measurement.

b. Feedwater oxygen, by injection of dilute hydrazine under control of hydrazine analysis.

c. Second stage high-pressure heater pH, by injection of the approved amines as required under control of drain pH measurement.

#### 10.4.3.2 System Description And Operation

The condensate chemical treatment system consists of concentrated chemical bulk containers, transfer pumps, mix tanks, injection pumps, controls and associated piping. The system is used to add chemicals approved for use (such as hydrazine, ethanolamine, methoxypropylamine morpholine, ammonia, boric acid, etc.) as required to the condensate/feedwater system to maintain water chemistry in accordance with approved specifications.

Chemical concentrations in the condensate/feedwater system are determined by laboratory analysis of grab samples or through use of on-line analyzers. Addition rates and concentrations of treatment chemicals are adjusted accordingly to control condensate/feedwater concentrations. The condensate chemical treatment system operates on a continuous but variable basis as required to achieve this.

The system is designed to minimize the effects of potential spills of chemicals through use of diked areas with capacity to accept full container volumes. It is also designed to limit atmospheric concentrations of these somewhat volatile chemicals by providing nitrogen blanketing capability for the bulk storage containers.

## 10.4.4 CONDENSER AIR REMOVAL SYSTEM

### 10.4.4.1 Design Basis

a. Function

The condenser air removal system removes air and non-condensables from the main and auxiliary condensers and maintains condenser vacuum during operation of the main turbine and main feed water pump turbines.

b. Process

The condenser air removal system is designed to pump a steam-air mixture without flashing in the vacuum pumps. The main vacuum pumps for the main condenser maintain the condenser at pressures listed in Table 10.4-1. The failure of any one vacuum pump will not affect normal operation.

Refer to Table 10.4-3 for the condenser air removal system main components design data.

c. Service Conditions

The system is not required for safe plant shutdown. Piping is designed in accordance with power piping Code USAS B31.1.0.

### 10.4.4.2 Design Description And Operation

The condenser air removal system (shown on Drawing 302131) consists of two separate subsystems. One subsystem serves the main condenser and the other the auxiliary condensers. Each subsystem consists of three identical positive displacement pumps and associated piping, controls, and radiation monitoring instrumentation. During normal plant conditions, one main and two auxiliary pumps are in operation. Both subsystems discharge to the atmosphere via the condenser air removal stack located within the Turbine Building.

The condenser air removal off-gas is continuously monitored by a radiation detector with an alarm in the Control Room to indicate high radiation levels. This monitor will detect leakage between the primary and secondary systems.

The alarm set point for this monitor will be calculated in accordance with NRC approved method in the Offsite Dose Calculation Manual (ODCM) to ensure that the alarm will occur prior to exceeding the limits of 10CFR20.

In addition, the Condenser Off-Gas Sampling System provides the capability to continuously sample the condenser vacuum pump exhaust (off-gas) for potential radioactive effluent. The sample is obtained from the vacuum pump discharge header where it is directed to a sample chamber that collects both particulates and iodines from the sample flow stream via a particulate filter and charcoal canister. The sample flow stream is returned to the main condenser vacuum pump suction line. At prescribed intervals, the sample chamber is removed for laboratory analysis.

## 10.4.5 CONDENSATE HOLDUP FOR RELEASE/RECYCLE

### 10.4.5.1 Design Basis

a. Function

The condensate holdup equipment retains condensate or other waters which would normally be released directly to the Susquehanna River during outages. This retention will enable analysis of the condensate water in parallel to other outage tasks to determine if it should be released as is, recycled to the condenser after the outage, or cleaned before either of the above options is undertaken.

b. Process

For condenser water, once the condenser has cooled sufficiently after shutdown, the option would be available to utilize a condensate pump to transfer condensate to a Processed Water Storage Tanks (PWST) via the TMI 1/2 condensate cross-connect line. This line has been reconfigured to interconnect the TMI-1 condenser with the PWSTs. As level drops in the condenser, alternate pump(s) may be used in place of the condensate pump. Water from one PWST can be pumped, via the PWST pumps, to the Chemical Cleaning Building for processing and return to the other PWST, back to the condenser, or to the condensate overboard line for discharge.

Water in the Turbine Building sump may be transferred to the PWSTs via jumper from the Turbine Building sump pump(s) to the interconnecting piping.

Refer to Table 10.4.4 for the condensate holdup system main components design data.

c. Service Conditions

The condensate holdup equipment is not required for shutting the reactor down or maintaining the plant in a safe shutdown condition. Radiation levels due to contamination of the condensate through leaks in the OTSG tubes is expected to be very low. Therefore, no shielding is required.

### 10.4.5.2 System Description and Operation

The equipment is shown schematically on Drawing 302-698

The system consists of two 500,000-gallon tanks and two support pumps. The tanks are atmospheric and are non-Seismic. They are heat traced to prevent freezing.

Normal operation of the system is on a batch mode basis. After one storage tank has received a batch, it is isolated and the contents are recirculated and sampled. Based on the results of the sample and the needs of the plant for returned water, the contents are released or recycled, with or without further treatment.

TABLE 10.4-1
(Sheet 1 of 5)

CONDENSATE SYSTEM MAIN COMPONENTS
NOMINAL DATA

A. Main Condenser (CO-C-1)

Design Data

| | 1st Stage | 2nd Stage | 3rd Stage |
|---|---|---|---|
| Exhaust steam flow, lb/hr | 2,094,163 | 2,094,163 | 2,094,163 |
| Exhaust pressure, inch Hg (abs) | 1.60 | 2.10 | 2.73 |
| LP heater drains, flow, lb/hr | 2,129,000 | | |
| LP heater drains, temperature, °F | 122.4 | | |
| Auxiliary condenser condensate total flow lb/hr | 172,800 | | |
| Auxiliary condenser condensate temperature, °F | 101.14 | | |
| Gland steam condenser drain flow, lb/hr | 9000 | | |
| Turbine seal leakage into condenser, lb/hr | 6000 | | |
| Makeup water flow, gpm | 50 to 100 | | |
| Makeup temperature, °F | 70 | | |
| Free $O_2$ at condensate pump discharge | 0.005 cc/liter at all load ranges of 100 to 60 percent with condenser cooling $H_20$ inlet temperature in range from 50 to 95F | | |

TABLE 10.4-1
(Sheet 2 of 5)
CONDENSATE SYSTEM MAIN COMPONENTS
NOMINAL DATA

B. Hotwell

| | |
|---|---|
| Nominal Storage capacity, gallons | 154,000 (Normal Operation)* |
| Type | Reheating deaerating |
| Dimensions, feet | |
| Length | 90 |
| Width | 31.5 |
| Height | 7.5 |

C. Condensate Storage Tanks (CO-T-1A/B)

| | |
|---|---|
| Quantity | 2 |
| Seismic Category | Class I |
| Capacity (each), gallons | 265,000 |
| Materials | Carbon Steel ASTM A283C |

D. Condensate Pumps (CO-P-1A/B/C)

Pump Data

| | |
|---|---|
| Quantity | 3 |
| Type | 4-stage vertical can |
| Capacity, gpm | 8300 |
| Water temperature, °F | 111 |
| Total dynamic head, feet | 395 |
| Minimum required NPSH, feet | 1.5 |
| Pump speed, rpm | 1180 |

* The hotwell capacity based on physical configuration is approximately 171,000 gallons. Based on the configuration of the condensate outlet pipe, the usable or "nominal" capacity is approximately 154,000 gallons.

TABLE 10.4-1
(Sheet 3 of 5)

CONDENSATE SYSTEM MAIN COMPONENTS
NOMINAL DATA

| | |
|---|---|
| Suction can and discharge head | Carbon steel |
| Impeller, bowls, shaft | 11 to 13% chrome steel |
| Motor, hp | 1250 |

E. Condensate Booster Pumps (CO-P-2A/B/C)

Pump Data

| | |
|---|---|
| Quantity | 3 |
| Type | Horizontal split case double suction |
| Capacity, gpm | 8300 |
| Water temperature, °F | 111 |
| Total dynamic head, feet | 825 |
| Required NPSH, feet | 62 |
| Pump speed, rpm | 3560 |
| Pump case | 4 to 6% chrome steel |
| Impeller shaft and shaft sleeve | 11 to 13% chrome steel |
| Impeller wear rings | 12% chrome steel |
| Motor Horsepower | 2000 |

TABLE 10.4-1
(Sheet 4 of 5)

CONDENSATE SYSTEM MAIN COMPONENTS
NOMINAL DATA

F. Low Pressure Heaters (FW-J-6A/B)

Design Data

| | |
|---|---|
| 12th stage | two-pass shell and U-tube: |
| Effective surface per heater, $ft^2$ | 14,420 |
| Feedwater inlet, ºF | 116 |
| Feedwater outlet, ºF | 131.2 |
| Tube design, ºF/psig | 300 - 725 |
| Tube material | Stainless steel |
| Shell material | Carbon steel |
| 10th stage (FW-J-5A/B) | two-pass shell and U-tube: |
| Effective surface per heater, $ft^2$ | 24,060 |
| Feedwater inlet, ºF | 131.2 |
| Feedwater outlet, ºF | 203.6 |
| Tube design, ºF/psig | 300/725 |
| Tube material | Stainless steel |
| Shell material | SA 387-11 CL.2 |

TABLE 10.4-1
(Sheet 5 of 5)

CONDENSATE SYSTEM MAIN COMPONENTS
NOMINAL DATA

| | |
|---|---|
| 8th stage (FW-J-4A/B) | two-pass shell and U-tube |
| Effective surface per heater, $ft^2$ | 17,814 |
| Feedwater inlet, ºF | 203.6 |
| Feedwater outlet, ºF | 277.5 |
| Tube design, ºF/psig | 330/725 |
| Tube material | Stainless steel |
| Shell material | Carbon steel |
| 6th stage (FW-J-3A/B) | two-pass shell and U-tube: |
| Effective surface per heater, $ft^2$ | 14,900 |
| Feedwater inlet, ºF | 277.5 |
| Feedwater outlet, ºF | 367.7 |
| Tube design, ºF/psig | 400/725 |
| Tube material | Carbon steel |
| Shell material | Carbon steel |

TABLE 10.4-2
(Sheet 1 of 1)

DELETED

TABLE 10.4-3
(Sheet 1 of 2)

CONDENSER AIR REMOVAL SYSTEM
MAIN COMPONENTS

A. Main Condenser Vacuum Pumps (VA-P-1A/B/C)

| | |
|---|---|
| Quantity | 3 |
| Type | Two-stage positive displacement |
| Inlet pressure, inch Hg abs | 1.0 |
| Inlet temperature, °F | 71.5 |
| Capacity free dry air, scfm | 15 |
| Capacity free dry air, lb/hr | 67.5 |
| Capacity associated vapor, lb/hr | 147.5 |
| Pump speed, rpm | 3550 |
| Design horsepower, hp | 72 |
| Peak horsepower (at 15 in Hg abs) hp | 128 |
| Seal Water Cooler Data | |
| Type | Water to water |
| Fixed tube bundle design | Straight through |
| Number passes | 2 |
| Materials | |
| Shell | Carbon steel |
| Bonnet | Cast iron |
| Tubes | 304 stainless steel |
| Cooling water supply, gpm | 168 |
| Cooling water pressure drop, psi | 2 |

TABLE 10.4-3
(Sheet 2 of 2)

CONDENSER AIR REMOVAL SYSTEM
MAIN COMPONENTS

B. Auxiliary Condenser Vacuum Pumps (VA-P-2A/B/C)

| | |
|---|---|
| Quantity | 3 |
| Type | Two-stage positive displacement |
| Inlet pressure, inch Hg, abs | 1.0 |
| Inlet temperature, °F | 71.5 |
| Capacity free dry air, scfm | 7.5 |
| Capacity free dry air, lb/hr | 33.75 |
| Capacity associated vapor, lb/hr | 74 |
| Speed, rpm | 3550 |
| Design horsepower, hp | 33 |
| Peak horsepower (at 15-inch Hg abs) hp | 60 |
| Seal Water Cooler Data | |
| Type | Water to water |
| Fixed tube bundle design | Straight through |
| Number passes | 4 |
| Materials | |
| Shell | Carbon steel |
| Bonnet | Cast iron |
| Tubes | 304 Stainless Steel |
| Cooling water supply, gpm | 75 |
| Cooling water pressure drop, psi | 4 |

TABLE 10.4-4
(Sheet 1 of 1)

CONDENSATE HOLDUP SYSTEM

A. Processed Water Storage Tanks (PW-T-1 and PW-T-2)

| | |
|---|---|
| Quantity | 2 |
| Seismic Category | Non-Seismic |
| Capacity (each), gallons | 500,000 |
| Materials | Carbon Steel, ASME SA285, Grade C |
| Interior Lining | Epoxy-phenolic type |

B. Processed Water Transfer Pump (PW-P-1)

Pump Data

| | |
|---|---|
| Quantity | 1 |
| Type | Single-stage horizontal centrifugal |
| Capacity, gpm | 160 |
| Nominal water temperature, °F | 37-120 |
| Total dynamic head, feet | 255 |
| Pump speed, rpm | 3500 |

C. Processed Water Transfer Pump (PW-P-2)

Pump Data

| | |
|---|---|
| Quantity | 1 |
| Type | Single-stage horizontal centrifugal |
| Capacity, gpm | 250 |
| Nominal water temperature, °F | 37-120 |
| Total dynamic head, feet | 270 |
| Pump speed, rpm | 3550 |

## 10.5 MAIN FEEDWATER SYSTEM

### 10.5.1 DESIGN BASIS

a. Function

The main feedwater system maintains level in the OTSG throughout all modes of normal plant operation. The lines feeding the OTSG are designed to preclude the occurrence of water hammer under the various conditions of OTSG levels, feedwater temperatures, and flow rates that exist throughout the range of the main feedwater system operation.

b. Process Data

The main feedwater system, in conjunction with the condensate and heater drains, is designed to supply water at a rate required by the steam generators. Refer to Table 10.5-1 for design data of the system major components.

c. Service Conditions

The main feedwater system is not required for safe plant shutdown and for maintaining the plant in the shutdown condition. The piping is designed in accordance with the Code for Power Piping, USAS B31.1.0. The system from the steam generator to and including the containment isolation check valves is seismic Class I. The balance of the system is seismic Class III. Seismic classification can be found on Drawing 302081.

### 10.5.2 SYSTEM DESCRIPTION AND OPERATION

The feedwater system, as shown on Drawing 302081, consists of two 60 percent capacity (nominal) turbine-driven feedwater pumps that take suction from the low pressure heaters outlet headers (see Drawing 302101) and discharge into a common header that supplies two trains of two high pressure heaters each. Each pump is provided with a recirculation line to the main condenser.

Feedwater from the high pressure heater flows through a temperature mixing header and then enters the steam generator via separate feed lines each provided with main feedwater regulating valves.

The feedwater regulating valves are positioned by the Integrated Control System (ICS) described in Section 7.2.3; differential pressure across the valve sets feed pump turbine governor speed. For start-up or low-load operation, a smaller regulating valve is provided in parallel with the main regulating valve. Also, for startup and hot standby operations, a small bypass line and valve are installed around each of the main feedwater valves to supply a continuous low flow rate to the steam generator feedwater nozzles. The main feedwater pumps are utilized both during start-up and cooldown. On start-up they are operated after the combined condensate/condensate booster pumps have reached their limit, and on cooldown they continue to pump until the condensate/condensate booster pumps alone suffice prior to the start of the Decay Heat Removal System at 250°F primary system temperature. The turbines driving these main feedwater pumps, which can be supplied steam from the main steam system, auxiliary steam, or extraction steam, are of the condensing type and are dependent upon the continued operation of the Circulating Water System, which is not operable during a blackout.

HSPS will isolate the main feedwater supply to the affected OTSG in the event of a failure of the main feedwater controls resulting in high level in either of the OTSG's. HSPS will also isolate the main feedwater to the affected OTSG in the event of low pressure in the depressurized OTSG line unless this interlock has been bypassed during normal shutdown.

Refer to Table 10.5-1 for main components data. Radioactive contamination that may result from OTSG tube leak will not require shielding of the system components. Refer to Chapter 11 for details.

TABLE 10.5-1
(Sheet 1 of 3)

FEEDWATER SYSTEM MAIN COMPONENTS
NOMINAL DATA

A. Main Feedwater Pumps (FW-P-1A/B)

| | |
|---|---|
| Quantity | 2 |
| Type | Single stage, vertically split case |
| Discharge capacity, lb/hr | 7,050,000 |
| Discharge capacity, gpm | 16,100 |
| Minimum flow rating, gpm | 1000 |
| Total dynamic head, ft | 2480 |
| Feedwater temperature, °F | 375 |
| Available NPSH, psi | 100 |
| Pump speed, rpm | 5500 |
| Brake horsepower | 10,160 |
| Efficiency, percent | 87 |
| Casing | Chrome steel |
| Other main parts | Stainless steel |

B. Main Feedwater Pump Turbines (FW-U-1A/B)

| | |
|---|---|
| Quantity | 2 |
| Type | Multistage condensing |
| Horsepower (normal/startup) | 8130/10,360 |
| Speed, rpm (normal/startup) | 5180/5500 |
| Inlet conditions psia (normal/startup) | 192.1/900 |
| Outlet conditions (normal/ startup), inches Hg abs | 2.0/2.0 |

TABLE 10.5-1
(Sheet 2 of 3)

FEEDWATER SYSTEM MAIN COMPONENTS
NOMINAL DATA

C. High Pressure Feedwater Heaters

| | |
|---|---|
| 2nd Stage (FW-J-1A/B) | Two-pass horizontal U-tube |
| Effective surface per heater, $ft^2$ | 17,695 |
| Feedwater inlet, °F | 411.1 |
| Feedwater outlet, °F | 461.5 |
| Tube design, °F/psig | 490/1700 |
| Tube material | Carbon steel |
| Shell material | Carbon steel |
| 4th Stage (FW-J-2A/B) | Two-pass horizontal U-tube |
| Effective surface per heater, $ft^2$ | 16,130 |
| Feedwater inlet, °F | 371.7 |
| Feedwater outlet, °F | 411.1 |
| Tube design, °F/psig | 450/1700 |
| Tube material | Carbon steel |
| Shell material | Carbon steel |

D. Feedwater Control Valves Startup (FW-V-16A/B)

| | |
|---|---|
| Quantity | 2 |
| Size, inches | 6 |
| Type | Fisher 476-1-5-CC |
| Actuator | Pneumatic |
| Capacity at 90 psi | $1.33 \times 10^6$ differential pressure, lb/hr |

TABLE 10.5-1
(Sheet 3 of 3)

FEEDWATER SYSTEM MAIN COMPONENTS
NOMINAL DATA

Main (FW-V-17A/B)

| | |
|---|---|
| Quantity | 2 |
| Size, inches | 16x20 |
| Type | Angle |
| Actuator | Pneumatic |
| Capacity at 35 psi differential pressure, lb/hr | $5.6 \times 10^6$ |

E. Feedwater Isolation Valve (FW-V-12A/B)

| | |
|---|---|
| Quantity | 2 |
| Size, inches | 20 |
| Type | Check |
| Material | Carbon Steel |
| Seismic class | I |
| Design pressure, psig | 1150 |
| Design temperature, °F | 475 |

## 10.6 EMERGENCY FEEDWATER SYSTEM

### 10.6.1 DESIGN BASIS

a. Function

The Emergency Feedwater (EFW) system supplies feedwater to the Steam Generators, removing heat (including reactor coolant pump energy, decay and sensible heat) from the Reactor Coolant System to allow safe shutdown of the reactor. The system is not required for plant start-up, normal plant operations or normal shutdown. The system is used only during emergency conditions and periodic testing.

The EFW system can withstand a design basis event and a single active failure, while performing its function to allow safe shutdown of the reactor. A single active failure will not inadvertently initiate EFW, nor isolate the Main Feedwater systems. An exception to the single failure criteria is the loss of all A/C power (Section 14.1.2.8) event. In this event, the turbine driven pump alone will deliver the necessary EFW flow. Consideration of a single active failure within the EFW system or HSPS is not required due to the low probability of the event. The EFW system actuates on loss of both Main Feedwater pumps, low Steam Generator water level, loss of all four Reactor Coolant Pumps, or high Reactor Building pressure. The Heat Sink Protection System (HSPS), providing the actuation and OTSG water level control signals, is described in Section 7.1.4.

The EFW system will control feedwater flow to maintain water level in the Steam Generators. The water level setpoint is based on the status of the Reactor Coolant pumps. Steam Generator water levels are maintained higher when all Reactor Coolant pumps are off to promote natural circulation in the Reactor Coolant system. Level control for the EFW system is independent of the Integrated Control system (ICS).

b. Process Data

The EFW system delivers water to the Once Through Steam Generators (OTSG) from various water sources, pumps, valves and piping. Chapter 14 describes the design basis events for which EFW must function. The most demanding design basis event requiring EFW is a loss of normal feedwater (LOFW) with off-site power available (See Section 14.2.2.7). The LOFW event requires any two (2) of the three (3) EFW pumps to provide feedwater at 550 gallons per minute total to the OTSGs at 1050 psig for heat removal from the RCS. The minimum pump performance for the design basis LOFW event satisfies the flow rate requirements for all other events requiring EFW function.

The turbine driven pump must operate alone in a loss of all A/C power (or Station Blackout) event until alternate A/C power sources become available (See Section 14.1.2.8). The minimum turbine driven pump performance required for the design basis LOFW event will assure adequate EFW system function for heat removal capability in the loss of all A/C power event.

Table 10.6-2 summarizes EFW system requirements for various events including the necessary feedwater flow rates and associated steam generator pressures.

The system consists of three (3) pumps, independently powered from diverse sources. Two (2) motor driven pumps are powered from separate Class 1E 4160V electrical trains, and are automatically loaded on the Emergency Diesel Generators following a loss of offsite power supply coincident with an EFW system actuation. The turbine driven pump is powered by steam supplied from the Steam Generators and redundant steam supply paths. The turbine exhaust is vented to the atmosphere. Table 10.6-1 contains additional pump and steam turbine details.

Vital power supplies the actuation and control circuitry for EFW, including valve control and motor driven pump emergency diesel loading.

The normal water supply for the EFW system consists of two (2) condensate storage tanks, each with a minimum storage capacity of 150,000 gallons. Additionally, operators can align the main condenser hotwell, accessing approximately 147,000 gallons, and a one-million gallon capacity demineralized water storage tank. An unlimited emergency supply of water from the Susquehanna River is available via the Reactor Building Emergency Cooling (RBEC) system as an additional source. The condensate storage tanks and the RBEC system (See Section 9.6.2.4) are safety grade sources of water. Alternate sources of water (demineralized water storage and condenser hotwell) are not safety grade, but have higher quality water and are preferred sources to river water for use in the OTSGs.

Each Steam Generator has one supply line from the common discharge header of the EFW system. Each OTSG supply line has two (2) redundant flow control paths, a flow-limiting (cavitating) venturi, and a check valve. Each redundant flow path consists of an automatic control valve and a manual isolation valve. The system control valves on the OTSG supply lines are positioned based on OTSG water level demand from the HSPS system. The cavitating venturis are installed to limit the flow of EFW to a depressurized OTSG, minimizing RCS overcooling potential. Also, in the event of a main steam line break inside the Reactor Building, the venturis limit the rate of mass and energy release within the building.

The control valves and the steam supply regulator to the turbine-driven pump are air operated. In addition to the normal air supply, the valves have a back-up bottled air supply system (See Section 9.10.3), providing at least two (2) hours of valve operation before operator action may be necessary.

c. Service Conditions

The EFW system is designed to meet seismic Class I conditions and is required for safe shutdown of the plant. Seismic classifications are shown on Drawing 302082. All equipment is located in the seismic Class I, aircraft impact and tornado missile protected portion of the Intermediate Building, with the exception of the condensate storage tanks (CST) and associated piping. These tanks are seismic Class I, redundant and located on opposite sides of the Turbine Building.

The motor driven pumps are seismically qualified and are capable of meeting minimum flow requirements for safe shutdown during loss of feedwater or small break LOCA following a seismic event (Generic Letter 81-14). The turbine driven pump control circuitry and associated main steam supply are not seismically qualified (See Section 10.3.1).

The EFW system has been evaluated to meet the environmental conditions in which it is required to operate. This includes the motor driven and turbine driven pumps in the Intermediate Building, along with the steam supply and supporting equipment in the Turbine and Control Buildings.

### 10.6.2 SYSTEM DESCRIPTION AND OPERATION

The EFW system consists of two (2) motor-driven pumps powered from separate Class 1E 4160-V buses and one (1) turbine-driven pump which receives steam from the main steam lines. The motor-driven and turbine driven emergency feedwater pumps automatically start on loss of both main feedwater pumps, loss of all four reactor coolant pumps, high containment pressure, or low OTSG water level. The motor driven emergency feedwater pumps are automatically loaded on the diesel generator during loss of offsite power coincident with an EFW system actuation with or without the simultaneous existence of ESAS actuation. The three EFW pumps are located in the Intermediate Building. The turbine-driven pump is physically separated from the motor-driven pumps.

Each emergency feedwater pump is protected by seismic Class I minimum flow recirculation lines back to the “B” condensate storage tank. The bearings of the emergency feed pumps and turbines are cooled by the fluid being pumped. Table 10.6-1 describes the nominal pump and turbine performance information.

Chapter 14 describes those design basis events that are mitigated using the EFW system function to remove RCS heat, supporting safe shutdown of the reactor. Further, the motor-driven EFW pumps are “seismically capable” consistent with NRC Staff requests made in Generic Letter 81-14. The seismic event is postulated to occur in conjunction with either a loss of feedwater accident or a small break LOCA. No other accidents were required to be mitigated along with a seismic event. The system can withstand a single active failure, resulting in one motor-driven pump (the turbine driven pump is not “seismically capable”), providing system function. The acceptance criteria and input assumptions for the Generic Letter events are delineated in References 2 and 3.

The emergency feedwater pumps take suction, through separate lines, from the two (2) condensate storage tanks, the primary source, and from the condenser hot well and demineralized water storage tank. As a final backup source, river water can be utilized via the redundant Reactor Building emergency cooling water pumps (refer to Section 9.6.2.4). Transferring water from the demineralized water and condensate systems to the condensate storage tanks is administratively controlled to limit the water temperature in the supply piping to the EFW pumps below the design basis evaluation assumption (135°F).

Each of the redundant condensate storage tanks have diverse level indications and two (2) low level alarms. One alarm is set to actuate at 11.5 feet to warn that tank level is approaching the Technical Specification limit (150,000 gallons). A safety grade, low-low level alarm is set at approximately 5 feet to alert the operator that there is no less than 20 minutes of available storage remaining at the emergency feedwater flow rate of 1250 gpm.

One CST (150,000 gallons) provides 12 hours of water for decay heat removal with steam discharge to the atmosphere. If additional cooling water is required, operators would use the hotwell and/or the demineralized water storage tank (if available). If these sources are not available, operators could align the River Water System (via EF-V-4 and 5) which is a seismically qualified safety grade suction source with an unlimited amount of cooling water for decay heat removal.

The spectacle flange is installed between normally closed isolation valves EF-V4 and EF-V5 on the river water supply line to the EFW pumps is maintained in the open position. This lineup permits the control room operator to remotely establish a river water supply to EFW if required.

The three (3) emergency feedwater pumps discharge into a common header from which separate 6-inch lines deliver water to each steam generator. Each of the 6-inch supply lines contains a check valve, flow-limiting venturi, and two (2) parallel flow control paths, each containing an air operated control valve and a manual block valve. The air operated control valves are throttled automatically by HSPS or manually by the operator. The HSPS controls OTSG water level using emergency feedwater flow from the pumps as discussed below.

The emergency feedwater control valves are air operated and are supplied from the main instrument air compressors (Section 9.10.1), or from the station service air compressors (Section 9.10.1). The main instrument air compressors can be manually loaded on the emergency bus from the engineered safeguards motor control center in case of a loss of offsite power. In the event that the two normal sources of instrument air are lost, the valve air supply is automatically transferred to the 2-hr. backup instrument air supply system (Section 9.10.3). No single failure can result in loss of air or control power to the control valves. The EFW flow control valves fail closed upon loss of all air. This failure mode reduces the potential for severe overcooling transients. Adequate time is available to the operator to take action to open a flow control valve and restore flow should the flow control valves fail closed. A failure of one (1) EFW flow control valve in the closed position will not prevent EFW flow control to each OTSG.

Local manual EFW block valves are provided to assure isolation of EFW flow from a failure of the EFW flow control valve in the open position. In the event of a main steam or main feedwater line break inside containment, the operator can take local manual action at the block valve itself to close it. In addition, the cavitating venturis in each EFW supply line to the steam generators will limit flow to an affected steam generator under line break and transient conditions. Limiting EFW flow provides the operator with additional time to take procedural actions that reduce the event consequences.

The emergency feedwater system actuation and control system (HSPS) is divided into train "A" and train "B". Both trains are simultaneously activated upon loss of all four reactor coolant pumps, loss of both main feedwater pumps, low OTSG water level, or high Reactor Building pressure. No single active failure will inadvertently isolate the main feedwater system. Four independent channels of sensing are combined in a two-out-of- four logic so that no single channel failure will prevent the system from operating when required or cause the system to operate when it is not required. The initiating logic is separated into two independent trains so that no single failure will prevent the system from performing its function. For heatup and cooldown operations, and to permit testing, defeat switches are provided to prevent automatic actuation of the emergency feedwater pumps. In addition, Control Room annunciation for all auto-start conditions has been provided.

Activation of HSPS train "A" starts the "A" motor-driven emergency feedwater pump and the turbine-driven pump. Activation of HSPS train "B" starts the "B" motor-driven emergency feedwater pump and the turbine-driven pump. The turbine-driven pump is thus activated by either HSPS train by immediately opening valve MS-V13A in the steam supply line and MS-V13B 40 to 60 seconds later. This arrangement provides redundant power (steam) supply to the turbine driven pump while minimizing challenges to the steam supply line safety relief valves MS-V22A/B.

The following table illustrates the event and the time of initiation of the emergency feedwater pumps:

| Event | Turbine Driven Pump Steam Supply Valve | Motor Driven Pumps Start Signal |
|---|---|---|
| a. EFW System actuation | Immediate | 5 sec |
| b. Event (a) above with LOOP | Immediate | 15 sec |
| c. Event (a) above with ESAS | Immediate | 20 sec |
| d. Event (a) above with ESAS and LOOP | Immediate | 30 sec |

The turbine driven pump requires approximately 43 seconds to reach full flow. The motor-driven pumps should be capable of accelerating to full speed in less than 10 seconds. Therefore, under worst case conditions emergency feedwater flow would be established within approximately 43 seconds.

The HSPS is set to maintain a 25-inch water level in the steam generators when any reactor coolant pump is operating, and 50 percent on the operating range level indicator for natural circulation when no reactor coolant pumps are operating. During normal plant power operation, the HSPS maintains the emergency feedwater control valves closed because the set point (zero) is lower than normal OTSG operating levels. Manual control of these valves from the Control Room is provided to permit the operator to maintain desired OTSG levels. Control of EFW flow to each steam generator is independent of the control of flow to the other OTSG.

Should the emergency feedwater system automatic or manual controls become unavailable, the operator may control emergency feedwater flow rate and OTSG level by starting and stopping the motor-driven pumps, and opening and closing the valves in the turbine-driven pump steam supply line or in the EFW pump discharge line. Also, an operator may be dispatched to the Intermediate Building to take local control of the emergency feedwater control valves. In the event the Control Room should have to be evacuated, manual control of the valves is also provided on remote shutdown panels.

Each of the emergency feedwater supply lines has also been provided with two (2) redundant Class 1E flow indication loops. For each emergency feedwater supply line, one (1) venturi serves as the source for two (2) redundant differential pressure transmitters. The differential pressure transmitters provide flow signals, through Class 1E instrument loops, to the main Control Rooms, where indicators are installed to read flow directly. These venturis are installed downstream of the control valves before the lines enter the containment building.

The following valves must be open to align the emergency feed pumps to the steam generators. All are normally open at all times except emergency feed pump turbine steam supply valves MS-V10A/B and MS-V13A/B and the EFW flow control valves EF-V30 A/B/C/D (H = hand valve, M = motor-operated, P = pneumatic):

| Valve Name | Valve No. |
|---|---|
| Condensate storage tank isolation (M) | CO-V10A or B |
| Emergency feedwater pumps recirculation return valve (H) | CO-V176 |
| Turbine-driven pump suction gate valve (H) | EF-V6 |
| Motor-driven pumps suction gate valve (H) | EF-V16A/B |
| Valve Name | Valve No. |
| Motor-driven pumps discharge gate valve (H) | EF-V10A/B |
| Suction header sectionalizing valves (M) | EF-V1A/B |
| Discharge header sectionalizing valves (M) | EF-V2A/B |
| Steam header isolation valves (M) | MS-V2A/B |
| Motor-driven pumps recirculation isolation valves (H) | EF-V20A/B |
| Motor-driven pumps recirculation control valves* | EF-V8A/C |
| Turbine-driven pumps recirculation isolation valve (H) | EF-V22 |
| Turbine-driven pump recirculation control valve* | EF-V8B |
| Motor-driven pumps bearing cooling water valves (H) ** | EF-V36A/B,<br>EF-V38A/B |
| EFW block valves (H) | EF-V52A/B/C/D |
| EFW flow control valves (P) | EF-V30A/B/C/D |
| Turbine-driven pump bearing cooling water valve (H) ** | EF-V31 |
| Turbine-driven pump bearing cooling water pressure control ** | EF-V45A/B |
| Pump packing cooling and seal water (H) ** | EF-V46A/B<br>EF-V48A/B |

EF-V50A/B

* Valves mechanically blocked open
** Valves may be throttled to control bearing cooling and packing cooling flow rate and pressure.

Thermal sleeves are provided for the emergency feedwater nozzles to mitigate the effects of thermal shock from the injection of condensate or river water.

TABLE 10.6-1
(Sheet 1 of 2)

EMERGENCY FEEDWATER SYSTEM
MAIN COMPONENTS

A. Turbine-Driven Emergency Feedwater Pump (EF-P-1)

| Pump Data | (A) | (B) |
|---|---|---|
| Quantity | 1 | |
| Type | Five-stage, horizontal split case | |
| Capacity, gpm | 920 | 370 |
| Minimum flow, gpm | 174 | |
| Total dynamic head, feet | 2700 | 190 |
| Speed, rpm | 3800 | 1120 |
| Temperature, °F | 40-110 (150) (C) | |
| Specific gravity | 1.0 | |
| NPSH required, feet | 16.5 | |
| Brake horsepower required | 835 | 25 |
| Efficiency, percent | 75 | |

| Turbine Drive Data (EF-U-1) | (A) | (B) |
|---|---|---|
| Type | Single-stage, horizontal split case | |
| Horsepower | 835 | 32 |
| Speed, rpm | 3800 | 1120 |

(A) Nominal operating value based on original procurement specifications.
(B) Lower operating value based on original procurement specifications.
(C) Higher temperature evaluated as acceptable per Ref. 4.

TABLE 10.6-1
(Sheet 2 of 2)

EMERGENCY FEEDWATER SYSTEM
MAIN COMPONENTS

| | (A) | (B) |
|---|---|---|
| Inlet conditions | | |
| Pressure, psig | 150-200 | 15 |
| Temperature, °F | Sat. | 260 |
| Outlet conditions, psig | 1 | |
| Steam consumption, lb/hr | 8,000-26,000 | 5120 |

B. Motor-Driven Emergency Feedwater Pump
(EF-P-2A/B)

Pump Data

| | |
|---|---|
| Quantity | 2 |
| Type | Eight-stage, horizontal split case |
| Capacity, gpm | 460 |
| Total dynamic head, feet | 2700 |
| Speed, rpm | 3570 |
| Temperature, °F | 40-110 (150) (C) |
| Specific gravity | 1.0 |
| NPSH required, feet | 16.0 |
| Efficiency, percent | 69.5 |
| BHP required | 450 |
| Minimum flow, gpm | 84 |
| Motor horsepower | 450 |

(A) Nominal operating value based on original procurement specifications.
(B) Lower operating value based on original procurement specifications.
(C) Higher temperature elevated as acceptable per Ref. 4.

TABLE 10.6-2

EMERGENCY FEEDWATER REQUIREMENTS

| Event | | Flow Rates (gpm) | OTSG Pressure (psig) | Notes |
|---|---|---|---|---|
| Loss of Feedwater, Chapter 14 | | | | |
| | Any 2 of 3 pumps | 550 | 1050 | Establishes bounding hydraulic demand, flow variance with pressure credited |
| | | 500 | 1075 | |
| Loss of all A/C Power, Chapter 14 and SBO, Section 8.5 | | | | |
| | TDP only | 350 | 1050 | No additional failures beyond loss of off-site and on-site A/C power, flow variance with pressure credited |
| | | 315 | 1075 | |
| Small Break Loss of Coolant Accident (SBLOCA), Chapter 14 | | | | |
| | Any 2 of 3 pumps | 400 | 1050 | |
| GL 81-14, Seismic Capability Evaluation | | | | |
| LOFW | MDP only | 314 | 1050 | flow variance with pressure credited in LOFW |
| | | 297 | 1075 | |
| SBLOCA | MDP only | 314 | 1050 | SBLOCA assumed constant flow rate |

## 10.7 SYSTEM ANALYSIS

### 10.7.1 TRIPS, AUTOMATIC CONTROL ACTIONS, AND ALARMS

Trips, automatic control actions, and alarms will be initiated by deviations of system variables within the Steam and Power Conversion System. Appropriate corrective action will be taken to protect the Reactor Coolant System. The more significant malfunctions or faults which cause trips, automatic actions, or alarms in the Steam and Power Conversion System are:

a. Turbine Trips

1) Generator electrical faults

2) Loss of condenser vacuum

3) Loss of bearing oil pressure

4) Loss of hydraulic oil pressure

5) Turbine overspeed

6) Manual electrical trip

7) Deleted

8) Loss of generator stator coolant

9) Loss of 2 of 3 control or protection turbine speed signals

10) Deleted

11) Manual mechanical trip

12) Reactor trip

13) Thrust bearing wear high

14) "High-High" level in any two moisture separators or high level in one moisture separator with any other LP line isolated

15) Both feed pumps tripped

b. Automatic Control Actions

1) Loss of generator stator coolant results in runback to ~25 percent rated load.

2) Loss of one feed pump results in a runback to the power corresponding to the remaining pump capability and at a rate that will maintain a continuous rod insertion demand.

3) Loss of one or more reactor coolant pumps results in a runback to the power corresponding to the remaining pumps capability and at a rate that will maintain a continuous rod insertion demand.

4) “High-High level in any moisture separator will close the associated intercept valve

5) Loss of all condensate pumps results in tripping of all booster and feedwater pumps.

6) Loss of two out of three condensate or booster pumps results in tripping one feed pump.

7) When an asymmetric rod withdrawal pattern exists, the ICS will runback thermal power to a level that will limit the increase in local linear heat rate in the fuel that is induced by the dropped rod.

c. Principal Alarms

1) Low main condenser vacuum

2) Low auxiliary condenser vacuum

3) Deleted

4) High and low hotwell level

5) High and low steam generator level

6) High and low steam pressure

7) High feed pump turbine speed

8) Main and feed pump turbine, eccentricity, differential expansion, or thrust bearing wear; and, feed pump turbine high vibration.

9) Major rotating equipment high bearing and motor stator temperatures

10) Emergency feedwater automatic initiation

11) High and low condensate storage tank level

10.7.2 TRANSIENT CONDITIONS

The analysis of the effects of loss of full load on the Reactor Coolant System is discussed in Chapter 14. Analysis of the effects of partial loss of load on the Reactor Coolant System is discussed in Section 7.2.3.3.

## 10.7.3 MALFUNCTIONS

The effects of inadvertent steam relief or steam bypass are covered by the analysis of the steam line failure given in Chapter 14. The effects of an inadvertent rapid throttle valve closure are covered by the loss of full load discussion in Chapter 14.

## 10.7.4 OVERPRESSURE PROTECTION

The pressure relief capacity of the MSSVs meets the overpressure protection requirements of ASME Section III 1968 edition [Reference 5 and 6] for the OTSGs. The pressure relief capacity of the MSSVs meets the overpressure protection requirements of USAS B31.1 1967 edition for the main steam line piping.

The maximum system design pressure is based on the original OTSG secondary side design pressure of 1050 psig. Although the replacement OTSG has a higher secondary design pressure of 1150 psig, the main steam piping design pressure of 1050 psig remains unchanged.

For the two steam generators there are:

a. Two 3 by 6 inch valves that pop at 1040 psig, MS-V21A and MS-V21B;

b. Six 6 by 10 inch valves that pop at 1050 psig, MS-V17A, MS-V17B, MS-V17C, and MS-V17D and MS-V20A, and MS-V20D;

c. Four 6 by 10 inch valves that pop at 1060 psig, MS-V18A, MS-V18B, MS-V18C, and MS-V18D;

d. Four 6 by 10 inch valves that pop at 1080 psig, MS-V19A, MS-V19B, MS-V19C, MS-V19D; and,

e. Two 6 by 10 inch valves that pop at 1092.5 psig, MS-V20B, and MS-V20C.

The MSSV pressure relief capacity is such that the energy generated at the reactor high power level trip setting can be dissipated through this system.

The main steam safety valves have additional capacity beyond that which is required to maintain OTSG and main steam piping below code allowable during a full power load rejection [Reference 7].

In addition, two (2) safety valves, MS-V22A and MS-V22B are provided in the steam supply to the emergency feedwater pump turbine to prevent overpressurization of the turbine. The set pressure of safety valves MS-V22A and MS-V22B are 260 psig and 280 psig, respectively. The vent stacks for these valves are designed to Seismic Class I requirements.

## 10.7.5 INTERACTIONS

Following a turbine trip at or below 45 percent power, the control system will reduce reactor power output immediately. The safety valves will relieve excess steam until the output is reduced to the point at which the steam bypass to the condenser can handle all the steam generated.  A turbine trip above 45 percent power will trip the reactor (see Chapter 7 for reactor trip descriptions).

In the event of failure of a single feedwater pump, there will be an automatic runback of the power demand.  The one feedwater pump remaining in service will carry approximately 60 percent of the full- load feedwater flow.  If both feedwater pumps fail, the reactor will be tripped and the emergency feedwater pumps started.  If Reactor Coolant System conditions reach trip limits, the reactor will trip, and this also results in a turbine trip.

On failure of a condensate pump or condensate booster pump, the spare condensate pump or condensate booster pump will be automatically started.

Upon a turbine trip coincident with loss of offsite power, the reactor will trip due to loss of reactor coolant pumps.  Decay heat removal is accomplished initially by the emergency feed pumps and finally by the Decay Heat Removal System on diesel power.  Condensate inventory maintained is discussed in Chapter 14.

## 10.8 TESTS AND INSPECTIONS

### 10.8.1 GENERAL

The valves and major components are subjected to manufacturer's shop tests including hydrostatic and performance tests.

Tests and inspection such as the radiographic inspection for the welds and the hydrostatic leak test prior to initial operation is made in accordance with the requirements of the codes and standards to which the system is designed. In addition, completed systems are subjected to pre-operational testing at the design conditions.

### 10.8.2 EMERGENCY FEEDWATER SYSTEM TESTS AND SURVEILLANCE

#### 10.8.2.1 Initial Restart Tests

A 48-hour endurance test on all Emergency Feedwater System pumps was performed. Following this test, the pumps were shut down, cooled down, and then restarted and run for 1 hour. Test acceptance criteria include demonstrating that the pumps remained within design limits with respect to bearing/bearing oil temperatures and vibration and that pump room ambient conditions (temperature and humidity) do not exceed environmental qualifications for safety related equipment in the room were met.

The testing was performed in the same manner as currently used to meet the surveillance test requirement of Section XI of the ASME Boiler & Pressure Vessel Code except that the duration of continuous operation was 48 hours. This testing method restricted pump flow to that which can be obtained through the pump minimum flow recirculation lines.

## 10.9 REFERENCES


1. Letter #5211-84-3137 from John F. Stolz, USNRC, to Henry D. Hukill, GPU Nuclear, dated April 27, 1984, “Emergency Feedwater System Minimum Flow Requirements.”

2. GPU Nuclear Calculation C-1101-220-5450-016, “Loss of Feedwater with one EFW Motor Driven Pump at 2568 Mw(t) with 20% SG Tube Plugging,” Rev. 1.

3. Framatome Technologies, Inc. Report No. 86-5002073-03, Appendix A, “TMI-Specific EFW Flow Sensitivity Studies,” dated October 1999.

4. Amergen EER 00185285 dated June 29, 2000, “Revise Design Temperature for Emergency Feedwater System Piping per CAP T 1999-0478.”

5. BAW-10043, "Overpressure Protection for Babcock and Wilcox Pressurized Water Reactors.”

6. 77-9007390 Rev. 1, "Overpressure Protection Report Addenda."

7. 86-9054640 Rev. 5, "TMI-1 MSSV Operability Phase 2 Results."