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10.0 Steam and Power Conversion System

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10.1 Summary Description

The Steam and Power Conversion System (SPCS) is designed to convert the heat produced in the reactor to electrical energy.

The superheated steam produced by the steam generators is expanded through the high pressure turbine and then exhausted to the moisture separator reheaters. The moisture separator section removes the moisture from the steam and the two stage reheaters superheat the steam before it enters the low pressure turbines. The steam then expands through the low pressure turbines and exhausts into the main condenser where it is condensed and returned to the cycle as condensate. The heat rejected in the main condenser is removed by the Condenser Circulating Water System.

The first stage reheaters are supplied with steam from the A bleed steam line and the condensed steam is cascaded to the B feedwater heaters. The second stage reheaters are supplied with main steam and the condensed steam cascades to the A feedwater heaters for Units 2 and 3, and to the B feedwater heaters for Unit 1. Heat for the feedwater heating cycle is supplied by the moisture separator reheater drains and by steam from the turbine extraction points.

The hotwell pumps take suction from the condenser hotwell and discharge to the condensate polishing demineralizers. Downstream of the polishers, the condensate flows through the condensate coolers, generator water coolers, hydrogen coolers, condenser steam air ejectors and the steam packing exhaust steam seal condenser before discharging to the suction of the condensate booster pumps. After the condensate booster pumps, the condensate passes through three stages of low and intermediate pressure feedwater heaters (F, E, and D). The flow passes through the C feedwater heater, then it divides to the suction of the steam generator feedwater pumps. The steam turbine driven main feedwater pumps deliver feedwater through two stages of high pressure feedwater heaters (B and A), to a single feedwater distribution header where the feedwater flow is divided into two lines to the steam generators.

The 1A2 feedwater heater was removed from service by bypassing its feedwater flow, isolating the extraction steam servicing the 1A2 feedwater heater, and routing the second stage reheater drains to the B feedwater heaters.

The safety-related features of the SPCS include the main steam piping from the steam generators up to and including the main turbine stop valves. The steam lines supplying the emergency feedwater pump turbine are also safety-related. The feedwater piping from the feedwater control valves to the steam generator and the Emergency Feedwater System (EFWS) is also safety-related.

SPCS safety-related instrumentation includes the steam generator level instruments which input to the EFWS steam generator level control and steam generator dryout protection circuits. Another QA control circuit monitors Upper Surge Tank (UST) level and closes the UST to Hotwell isolation valves and the UST to Polishing Demineralizer Backwash Pump (PDBP) isolation valves regardless of hotwell level or PDBP status in order to maintain a minimum 6 foot level in the UST for an EFWS suction source. Other UST level indication is used for post-accident monitoring. The only additional safety-related instrumentation associated with the SPCS is the steam generator outlet pressure used for post-accident monitoring and as input to the Automatic Feedwater Isolation System circuitry.

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10.2 Turbine-Generator

10.2.1 Design Bases

The turbine-generator converts the thermal energy of steam produced in the steam generators into mechanical shaft power and then into electrical energy. Each unit is operated primarily as a base loaded unit, but may be used for load following when required.

A maximum rate of turbine load change of 10 percent full load per minute is permitted by the Turbine Electro-Hydraulic Control (EHC) System without restriction if the minimum load involved in the change is 46 percent full load or greater. Below 46 percent full load, the maximum rate of change is still 10 percent full load per minute, but the total load change may be restricted by turbine metal temperature considerations.

The rate of change of reactor power is limited to values consistent with the characteristics of the Reactor Coolant System and its control systems. These limitations are imposed by the Integrated Control System on the Steam and Power Conversion System. See Section 7.6.1.2 and Table 7-6.

Turbine-generator functions under normal, upset, emergency, and faulted conditions are monitored and controlled automatically by the Turbine Control System (TCS). The TCS includes redundant mechanical and electrical trip devices to prevent excessive overspeed of the turbine-generator. Additional external trips are provided to ensure operation within conditions that preclude damage to the turbine-generator. A standby manual control system is also provided in the event that the automatic control system is not available.

10.2.2 Description

Each unit's turbine-generator consists of a tandem (single shaft) arrangement of a double-flow high-pressure turbine, and three identical double-flow low pressure turbines driving a direct-coupled generator at 1800 rpm. The turbine is operated in a closed feedwater cycle which condenses the steam, and the heated feedwater is returned to the steam generators. The system is designed to utilize the entire output from the Nuclear Steam Supply System. The turbine generator is manufactured by the General Electric Company of Schenectady, New York.

The flow of main steam is from the steam generators to the high-pressure turbine through four stop valves and four control valves. After expanding through the high-pressure turbine, exhaust steam passes through external moisture separators and two stage steam-to-steam, shell and tube type reheaters. 'A' bleed extraction steam from the high-pressure turbine is supplied to the first reheater stage tube bundle in each reheater. Main steam is supplied to the second reheater stage tube bundle in each reheater. Reheated steam is admitted to the three low pressure turbines and expands through the low-pressure turbines to the main condensers.

Bleed steam for the six stages of feedwater heating is provided from the following sources:

Heater	Extraction Source
A	H-P turbine
B	H-P turbine
C	H-P turbine exhaust
D	L-P turbines

Heater	Extraction Source
E	L-P turbines
F	L-P turbines

Each main generator is a 1038 MVA, 1800 rpm, direct connected, 3 phase, 60 cycle, 19,000 volt conductor cooled synchronous generator rated at 0.90 P.F., and 0.50 SCR at hydrogen pressure of 60 psig. Generator rating, temperature rise, and class of insulation are in accordance with IEEE standards. Excitation is provided by a shaft driven alternator with its output rectified.

10.2.3 Turbine Disk Integrity

10.2.3.1 Materials Selection

Turbine wheels and rotors are made from vacuum melted or vacuum degassed Ni-Cr-Mo-V alloy steel by processes which minimize flaw occurrence and provide adequate fracture toughness. Tramp elements are controlled to the lowest practical concentrations consistent with good scrap selection and melting practices, and consistent with obtaining adequate initial and long life fracture toughness for the environment in which the parts operate. The turbine wheel and rotor materials have the lowest Fracture Appearance Transition Temperatures (FATT) and highest Charpy V-notch energies obtainable, on a consistent basis from water quenched Ni-Cr-Mo-V material at the sizes and strength levels used. Since actual levels of FATT and Charpy V-notch energy vary depending upon the size of the part and the location within the part, etc., these variations are taken into account in accepting specific forgings for use in turbines for nuclear application. Charpy tests essentially in accordance with Specification ASTM A-370 are included.

10.2.3.2 Fracture Toughness

Suitable material toughness is obtained through the use of materials described in Section 10.2 to produce a balance of adequate material strength and toughness to ensure safety while simultaneously providing high reliability, availability, and efficiency during operation. Bore stress calculations include components due to centrifugal loads, interference fit, and thermal gradients where applicable. The ratio of material fracture toughness, K_{IC} (as derived from material tests on each wheel or rotor) to the maximum tangential stress for wheels and rotors at speeds from normal to 115 percent of rated speed (the highest anticipated speed resulting from a loss of load is 110 percent) is at least $2\sqrt{in}$.

Turbine operating procedures are employed to preclude brittle fracture at start-up by ensuring that the metal temperature of wheels and rotors is adequately above the FATT and is sufficient to maintain the fracture toughness to tangential stress ratio at or above $2\sqrt{in}$.

10.2.3.3 Turbine Design

The turbine assembly is designed to withstand normal conditions and anticipated transients including those resulting in turbine trip without loss of structural integrity. The design of the turbine assembly meets the following criteria:

1. Turbine shaft bearings are designed to retain their structural integrity under normal operating loads and anticipated transients, including those leading to turbine trips.

2. The multitude of natural critical frequencies of the turbine shaft assemblies existing between zero speed and 20 percent overspeed is controlled in the design and operation so as to cause no distress to the unit during operation.
3. The maximum tangential stress in wheels and rotors resulting from centrifugal forces, interference fit and thermal gradients does not exceed 0.75 of the yield strength of the materials at 115 percent of rated speed.

10.2.3.4 Pre-service Inspection

The pre-service inspection program is as follows:

1. Wheel and rotor forgings are rough machined with minimum stock allowance prior to heat treatment.
2. Each finish machined wheel and rotor is subjected to 100 percent volumetric (ultrasonic), surface, and visual examinations using General Electric acceptance criteria. These criteria are more restrictive than those specified for Class 1 components in the ASME Boiler and Pressure Code, Sections III and V, and include the requirement that subsurface sonic indications are either removed or evaluated to assure that they will not grow to a size which compromises the integrity of the unit during the service life.
3. All finish machined surfaces are subjected to a magnetic particle test with no flaw indications permissible.
4. Each fully bucketed turbine rotor assembly is spin tested at or above the maximum speed anticipated following a turbine trip from full load.

10.2.4 Safety Evaluation

The turbine-generator and all related steam handling equipment are of conventional proven design. This unit automatically follows the core thermal power demand (CTPD) requirements in order to meet the unit power demand, See Section 7.6.1.2. There is also a tie-in with Keowee Hydro Station which can carry auxiliary load upon turbine trip.

Under normal operating conditions, it is possible for this system to become contaminated only through steam generator tube leaks. In this event, radioactivity in the Main Steam System is detected and measured by monitoring condenser air ejector off-gas which is released through the unit vent and by monitoring the steam generator water samples.

No radiation shielding is required for the components of the turbine-generator and related steam handling equipment. Continuous access to the components of this system is possible during normal conditions.

The condensate polisher demineralizers are available to remove radioactive particulates from the condenser hotwell in the event of primary to secondary leakage.

The turbine-generator is designed and manufactured in accordance with General Electric Company design criteria and manufacturing practices, procedures, and processes, as well as its Quality Assurance Program. The turbine-generator equipment conforms to the applicable ASA, ASME, and IEEE standards.

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10.3 Main Steam System

10.3.1 Design Bases

The Main Steam System is designed to achieve the following:

1. Provide steam flow requirements at main turbine inlet design conditions.
2. Dissipate heat from the Reactor Coolant System following a turbine and/or reactor trip by dumping steam to the condenser and atmosphere.
3. Provide steam as required for:
   a. Main and emergency feedwater pump turbines
   b. Condenser air ejectors
   c. Main feedwater pump turbine seals
   d. Steam reheaters
   e. Miscellaneous auxiliary equipment
4. Conform to applicable design codes.
5. Allow visual in-service inspection.
6. Protect adjacent equipment against heat damage.

The following portions of the system are designed to withstand seismic loading (criteria for seismic loading defined in Section 3.2.2);

1. Main steam lines from steam generator through the turbine stop valves
2. Main steam line relief valves
3. The steam supply from the main steam lines to the emergency feedwater pump turbine including valve AS-38 and that portion of the auxiliary steam supply downstream from the valve
4. Through the first valve of all other lines leaving the main steam lines upstream of the turbine stop valves

10.3.2 Description

Main steam is generated in the two steam generators by feedwater absorbing heat from the Reactor Coolant System. Main steam is conveyed by two lines, one per steam generator, to the turbine inlet valves. A pressure equalization and steam distribution header is connected to each main steam line upstream of the turbine inlet valves. The Main Steam System from the steam generators through the turbine stop valves (including connected piping through the first isolating valve of connecting lines upstream of the turbine stop valves) is Duke Piping Class F, except for Unit 2, Trains A and B, which has some additional Class F piping associated with the Atmospheric Dump Valves. All other piping is Class G. Main Steam piping inside the Reactor Building is considered Reg. Guide 1.26 Quality Group B for purposes of Inservice Inspection. See Figure 10-1, Figure 10-2, and Figure 10-3.

Eight self-actuated safety valves are located on each main steam line (a total of sixteen) to prevent overpressurization of the Main Steam System under all conditions. The relief valve total capacity is such that the energy generated at the reactor high power level trip setting can be dissipated through this system at a pressure not exceeding 1155 psig (110 percent of system design pressure, 1050 psig). See Table 3-1 for applicable codes.

The main steam lines and the main and emergency feedwater lines are the only lines of the Steam and Power Conversion System which penetrate the Reactor Building. These lines can be isolated by the turbine stop valves and the main and emergency feedwater line valving. Each of the lines utilized for normal operation leaving the main steam lines before the turbine stop valves has motor operated valves to complete the isolation of a steam generator. These lines are:

1. Steam bypass to condenser and steam supply for auxiliary steam header (See Figure 10-1 for line to auxiliary steam header)
2. Supply to feedwater pump turbines and condenser air ejectors
3. Supply to steam reheaters
4. Supply to emergency feedwater pump turbine.

The arrangement of the valving and parallel piping shown schematically in Figure 10-1 minimizes blowdown of both steam generators from a single leak in the system with the assumption that the turbine stop valves close. For a majority of the Main Steam system, a postulated piping break would only depressurize one steam generator. However, if the break were to occur in either the steam supply to the auxiliary steam header or the emergency feedwater pump turbine cross-connect, blowdown of both steam generators could result. The motor operated valves that are used to isolate the leak require operator action to close and may not get closed until the steam generators are considerably depressurized. This situation has been analyzed and shown to have consequences that are bounded by the consequences of the accidents in Section 15.13 and Section 15.17.

Normally only one Unit is aligned to supply the Auxiliary Steam System. However, during periods of high steam usage, or when switching from one Unit to the other, multiple Units may be aligned to the Auxiliary Steam System. This situation has been analyzed, and determined that no unreviewed safety question exists (Reference 3).

The steam supply for the emergency feedwater pump turbine (Figure 10-1) will come from either of two sources (the main steam line or the auxiliary steam header) and exhausts to the atmosphere. The solenoid operated valve which controls the steam shutoff valve MS-93 is de-energized on loss of both main feedwater pumps, thus opening the steam shutoff valve. As the steam shutoff valve leaves the closed position, a limit switch starts the emergency feedwater pump turbine bearing oil pump. If a Main Steam Line Break is sensed by the Automatic Feedwater Isolation System, the solenoid valve (MS-SV-0074) will energize thus closing MS-93. MS-95 is designed to fail closed on loss of hydraulic oil pressure. An AFIS actuation will energize and close solenoid valve (TO-145) to isolate the hydraulic oil supply to close MS-95.

The ADV flow path for each steam generator is credited as a compensatory measure in Technical Specification (TS) 3.5.2, "High Pressure Injection (HPI)." In certain HPI configurations, the ADV flow path for one steam generator is credited to depressurize the steam generator and enhance primary-to-secondary heat transfer during certain small break loss of coolant accidents (LOCAs). This is done in conjunction with the EFW System providing cooling water to the steam generator.

10.3.3 Safety Evaluation

The Main Steam System delivers the generated steam from the outlet of the steam generators to the various system components throughout the Turbine Building without incurring excessive pressure losses. When replacement steam generators were initially put in service, steam was generated at approximately 60°F superheat conditions. Functional requirements of the system are as follows:

1. Achieve optimum pressure drop between the steam generators and the turbine steam stop valves.
2. Assure similar steam conditions between each steam stop valve and between each steam generator.
3. Achieve adequate piping flexibility for acceptable forces and moments at equipment interfaces.
4. Assure adequate draining provisions for startup and for operation with saturated steam.

The once-through nature of this recirculating steam condensate cycle is utilized in the removal of contaminants resulting from steam generator leaks, since it allows the flow through the steam generator to be subjected to purification. Radioactive contaminants will be removed by the Powdex polishing demineralizers and moisture separator reheaters (MSR) drain demineralizer as described for the control of impurities (Section 10.3.5.1). Provision is made for transferring the backwashed resins, when they contain radioactive material, as radwaste.

Trips, automatic corrective actions, and alarms will be initiated by deviations of system variables within the Steam and Power Conversion System. In the case of automatic corrective action in the Steam and Power Conversion System, appropriate automatic 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 listed in Section 10.4.6.5.

The analysis of the effect of loss of full load on the Reactor Coolant System is discussed in Section 15.8. Analysis of the effects of partial loss of load on the Reactor Coolant System is discussed in Section 7.6.1.2.3.2.

The effects of inadvertent steam relief or steam bypass are covered by the analysis of the steam line break given in Section 15.13, and in Section 15.17. The effects of an inadvertent rapid throttle valve closure are covered by the turbine trip discussion in Section 15.8.

Following a turbine trip, a reactor trip will occur if reactor power is above the anticipatory reactor trip system (ARTS) setpoint. 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. Steam may also be released to the atmosphere through a manually operated angle-body control valve on each main steam line.

Pressure relief is required at the system design pressure of 1050 psig, and the first safety valve bank will be set to relieve at this pressure. The design pressure is based on the operating pressure of 925 psia plus a 10 percent allowance for transients and a 4 percent allowance for blowdown. Additional safety valve banks will be set at pressures up to 1104 psig, as allowed by the ASME Code. Pressure relief is provided by eight safety valves on each main steam line, and the valve relief pressures are:

Number of Valves	**Relief Pressure (psig)**	**Allowable Relief Pressures (psig)**
1	1050	1019 – 1060
1	1065	1033 - 1096

Number of Valves	Relief Pressure (psig)	Allowable Relief Pressures (psig)
1	1070	1038 - 1102
1	1075	1043 - 1107
2	1080	1048 - 1112
1	1090	1058 - 1122
1	1104	1071 - 1137

The relief valve total capacity is such that the energy generated at the reactor high power level trip setting can be dissipated through this system at a pressure not exceeding 1155 psig (110 percent of system design pressure, 1050 psig).

10.3.4 Inspection and Testing Requirements

Steam from the steam generators is admitted to the turbine through four cast 24 inch main steam stop valves, arranged in parallel and located in the main steam lines upstream from the turbine control valves (See Figure 10-1). In the event of a steam line rupture accident, the stop valves serve to isolate the unaffected steam generator. See Section 10.3.2.

The main steam stop valve is designed for tight seating throughout its life. The valve stem extends through a guide bushing which centers the disc on the stem with some degree of freedom, permitting self alignment of the disc on its seat. The valve seat and disc have spherical seating surfaces so that perfect contact is made even if they are not in precise alignment. The use of stem sealing permits relatively large stem to bushing clearance, minimizing the possibility of stem sticking. The seating surfaces of the valve and the stem seal are hardened inlay contact areas which resist erosion and mechanical damage and assure tightness. A coarse-mesh internal screen strainer with removable fine mesh startup strainer is provided for each stop valve.

The main steam stop valves are fail-safe, requiring hydraulic pressure to open and closure is spring-assisted. The number two stop valve, MS-104, on each unit is a continuously positioned valve while the other stop valves have only two positions: fully opened and fully closed. Each stop valve will be tested periodically (while the turbine is in operation) and any tendency of the valve to remain open in opposition to a control signal will be detected. A stop valve will be disassembled, inspected, and required corrective action taken when a valve test warrants such action. The stop valves will be disassembled and inspected in accordance with OEM/NEIL recommended intervals.

The main steam stop valves are designed and tested to assure proper functioning. In the event of a steam line rupture accident, the two stop valves serving the unaffected steam generator will close in the presence of steam flow in the normal direction, thus precluding the possibility of reverse flow through the other two stop valves.

The motor operated valve on each of the lines connected to the main steam lines can be tested for operability when the unit is shutdown. These valves, the main steam stop valves, and the check valves that are provided in the two branch lines that cross-connect the main steam lines prevent uncontrolled blowdown of the unaffected steam generator in the unlikely event of a main steam line break. Their ability to close will be verified at periodic intervals.

Proper operation of the emergency feedwater pump and turbine, the steam shutoff valve (Figure 10-1), and the valves in the emergency feedwater supply to the steam generators (Figure 10-8) can be demonstrated when the unit is shutdown. The emergency feedwater pump and turbine, and the steam shutoff valve can be tested anytime by utilizing the recirculation test line. Proper functioning of the emergency feedwater supply will be verified at periodic intervals.

10.3.5 Water Chemistry

10.3.5.1 Secondary Side Water Chemistry

Hydrazine and/or carbohydrazide is added to the feedwater downstream of the condensate polishing demineralizers for oxygen control. An alternate addition point is directly to the condensor hotwell.

Ethanolamine or an alternate approved amine is used to increase pH to minimize formation of corrosion products.

A Titanium solution may be injected into the feedwater system downstream of the main feedwater pumps to mitigate intergranular attack (IGA) and intergranular stress corrosion cracking (IGSCC) of steam generator tubing.

The condensate polishing demineralizer utilizes the Powdex process, developed by Graver Water Conditioning Company as a unique, high quality water purification system. The Powdex units will function as a combination demineralizer and high purity filter, treating 100 percent of the feedwater flow to the steam generator under conditions of startup, reduced load, and normal full-load operation.

The Powdex process uses extremely fine particle-size (60-400 mesh) ion exchange resins which are applied to the external surface of specially design filter elements. The rapid ion exchange rates of these fine resins allows the use of a thin coating (1/16 inch to 1/2 inch) on the elements and permits a greater utilization of the ultimate capacities of the resins than is the case of bead type resins.

The Powdex resins are not chemically regenerated for repeated use but are replaced with fresh resins upon exhaustion. This continued resin replacement allows complete flexibility in the selection of the most advantageous type of resin or combination of resins for the removal of specific impurities.

The resins are selected for the effective removal of dissolved metallic cations and also anions such as halides, silicates, and sulfates. In addition, the resin will also remove by filtration the suspended and colloidal trace impurities such as corrosion products.

Exhaustion of each batch of resins is monitored and is indicated by an increase in pressure drop or by a decrease in treated water quality. Exhausted resins are backwashed from the units and pumped to a disposal facility.

A portion of the moisture separator drain liquid can be sent through a deep-bed demineralizer in order to remove selected chemical species that precipitate out in the moisture separator drain liquid. The demineralizer effluent is normally returned to the condenser. This allows for an overall condensate quality improvement.

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10.4 Other Features of Steam and Power Conversion System

10.4.1 Main Condenser

10.4.1.1 Design Bases

The main condenser is designed to condense turbine exhaust steam for reuse in the steam cycle. The main condenser also serves as a collecting point for various steam cycle vents and drains to conserve condensate which is stored in the condenser hotwell. The condenser also serves as a heat sink for the Turbine Bypass System which is capable of handling approximately 25 percent of rated main steam flow. Rejected heat is removed from the main condenser by the Condenser Circulating Water System.

10.4.1.2 System Description

The main condenser consists of three surface type deaerating condenser shells with each shell condensing the exhaust steam from one of the three low pressure turbines. The condenser shells are of conventional shell and tube design with steam on the shell side and circulating water in the tubes. One low pressure feedwater heater is mounted in the neck of each of the condenser shells. The combined hotwells of the three condenser shells have a water storage capability equivalent to approximately 10 minutes of full load operation (nominally 142,000 gallons). The internal condenser design provides for the effective condensing of steam, scavenging and removal of noncondensable gases, and the deaeration of the condensate. Impingement baffles are provided to protect the tubes from incoming drains and steam dumps.

The main condenser can accept a bypass steam flow of approximately 18 percent of rated main steam flow without exceeding the turbine high backpressure trip point with design inlet circulating water temperature. This bypass steam dump to the condenser function is in addition to the normal condenser functions expected.

10.4.1.3 Safety Evaluation

The main condenser is not assigned a safety class as it is not required for a safe reactor shutdown. The inventory of radioactive contaminants in the main condenser is a function of primary to secondary system leakage.

10.4.1.4 Tests and Inspections

Cleaning and Inspection of the Main Condensers is performed each Refueling Outage or every 24 months. Condenser performance is monitored and trended per the Site Thermal Performance Program. The conductivity, sodium content, and oxygen content of the condensate leaving the hotwell is continuously monitored. The condensate system's polishing demineralizer will remove many of the contaminants and thus reduce the impact of any leakage from the Condenser Circulating Water upon final feedwater chemistry.

10.4.1.5 Instrumentation Application

The main condenser hotwell is equipped with level control devices for automatic control of condensate makeup and rejection. On low water level in the hotwell, control valves supply condensate from the upper surge tanks to the hotwell by gravity. A QA-1 control circuit monitors UST level and closes the UST Riser Automatic Isolation valves regardless of Hotwell level in order to maintain a minimum 6 foot water level in the UST for an EFW suction source. A low hotwell level alarm is provided in the control room. Loss of condenser vacuum will trip the respective unit turbine. All instrumentation for this system is operating instrumentation, and none is required for safe shutdown of the reactor.

10.4.2 Main Condenser Evacuation System

10.4.2.1 Design Bases

The Main Condenser Evacuation System is designed to remove noncondensable gases and air inleakage from the steam space of the three shells of the main condenser. The Main Condenser Evacuation System consists of the Condenser Steam Air Ejector System and the Main Vacuum System which are shown on Figure 10-5 for Oconee 1, 2 and 3.

10.4.2.2 System Description

The Condenser Steam Air Ejector System consists of three condenser steam air ejectors (CSAE) per unit. Normally each CSAE draws the noncondensable gases and water vapor mixture from one of the three main condenser shells to the first air ejector stage. The mixture then flows to the intercondenser where it is cooled to condense the water vapor and motive steam. The second air ejector stage draws the uncondensed portion of the cooled mixture from the intercondenser and compresses it further. The compressed mixture then passes through the aftercondenser where it is cooled and more water vapor and motive steam are condensed. The intercondenser drains back to the main condenser and the aftercondenser drains to the condensate storage tank.

The Main Vacuum System consists of three main vacuum pumps connected to the condenser crossties on the Condenser Steam Air Ejector System to allow the main vacuum pumps to evacuate the main condenser, the main turbine casing, and the upper surge tanks during startup. These pumps are only used during startup since normal operation requires the use of the CSAE only.

10.4.2.3 Safety Evaluation

The Main Condenser Evacuation System is not assigned a safety class as it is not required for a safe reactor shutdown. Control functions of the Main Condenser Evacuation System indirectly influence Reactor Coolant System operation in that upon loss of vacuum the main condenser no longer provides a heat sink.

The noncondensable gases and water vapor mixture discharged to the atmosphere from the Main Condenser Evacuation System are not normally radioactive; however, in the event of primary to secondary system leakage due to a steam generator tube leak, it is possible for the mixture discharged to become radioactive. A full discussion of the radiological aspects of a primary to secondary leakage including radioactive discharge rates under postulated design conditions is discussed in Chapter 11 and Chapter 15.

10.4.2.4 Tests and Inspections

Proper operation of the Main Condenser Evacuation System is verified during unit startup, and is subject to periodic inspections by plant operating personnel. A flowmeter is provided in the discharge piping of each CSAE. Periodic readings of these flowmeters will indicate whether or not the air inleakage to the condenser is within acceptable limits. These readings will also indicate the operating effectiveness of the CSAE.

10.4.2.5 Instrumentation Applications

A radiation monitor is provided in the exhaust line from the CSAE's with remote indicator, recorder, and alarm located in the Control Room. Local indicating devices for pressure, temperature, and flow are provided as required for monitoring system operation. All instrumentation for this system is operating instrumentation and none is required for safe shutdown of the reactor.

10.4.3 Turbine Gland Sealing System

10.4.3.1 Design Bases

The Turbine Gland Sealing System (TGS) is designed to seal the annular openings around the rotor shafts of the high pressure (HP) and low pressure (LP) main turbines and the feedwater pump (FDWP) turbines where the shafts emerge from the shell casings. All seals for the LP main turbines and the exhaust end seals for the FDWP turbines are designed to prevent the leakage of atmospheric air into the turbines since the turbine shell pressures at these seal locations are subatmospheric at all unit loads. All seals for the HP main turbine and the steam inlet end seals for the FDWP turbines are designed to prevent atmospheric air leakage into the turbines since the turbine shell pressures at these seal locations vary from subatmospheric to above atmospheric as these turbines progress from startup to normal operation.

10.4.4 Turbine Bypass System

10.4.4.1 Design Bases

The Turbine Bypass System (TBS) is designed to reduce the magnitude of nuclear system transients following large turbine load reductions by dumping main steam directly to the main condenser and/or to the atmosphere, thereby creating an artificial load on the reactor.

10.4.5 Secondary Cleanup System

10.4.5.1 Condensate Cleanup System

10.4.5.1.1 Design Bases

(See Section 10.3.5.1)

10.4.5.1.2 System Description

The Condensate Cleanup System (CCS) for each unit consists of five powdered resin condensate polishing demineralizer vessels. Normally, all five vessels will be in service. There is also a separate regeneration skid for each unit consisting of a recirculation/resin feed tank and a precoat pump.

The current revision of the SGOG PWR Secondary Water Chemistry Guidelines (Chapter 3) and vendor recommendations are used to derive the operating specifications which are addressed in the Chemistry Section Manual.

The condensate polishing demineralizers are designed for automatic operation following mode initiation. This means that the operator is required to initiate each Phase of operation but, having once done so the polishers will operate automatically through that mode (i.e., backwash, precoat, filter, and hold). A polisher cycle continues until the effluent water quality deteriorates or until a predetermined differential pressure drop is reached across the polisher. When either of these conditions occur, the polisher will be backwashed.

Each polisher vessel normally is backwashed as required to meet secondary-side chemistry specifications. The vessels are backwashed to the Powdex sump. Each backwash takes about 15,000 gallons of water and contains roughly 17 cubic feet of spent resin. The resin water mixture is pumped to the Radwaste Facility Powdex Backwash Tank. Water is supplied to the Powdex Backwash Pumps form the UST. This source of water is automatically isolated on a low UST level.

The handling of polisher backwash during and after a steam generator primary to secondary leak is discussed in Chapter 11.

10.4.5.1.3 Safety Evaluation

The Condensate Cleanup System is not assigned a safety class as it is not required for a safe reactor shutdown. The condensate polishing demineralizer vessels and all regeneration equipment are located in the Turbine Building. The spent resin and water mixture discharged to the backwash sump from the polisher vessels is not normally radioactive; however, disposal of the mixture in the event of a primary to secondary leakage is discussed in Chapter 11.

10.4.5.1.4 Tests and Inspections

Proper operation of the Condensate Cleanup System is verified during unit startup, and is subject to periodic inspections by plant operating personnel.

10.4.5.2 Moisture Separator Drain Demineralizer

A portion of the moisture separator drain liquid can be sent through a heat exchanger and a deep-bed demineralizer in order to remove selected chemical species that precipitate out in the moisture separator drain liquid. The demineralizer effluent is normally returned to the condenser. The flow rate through this portion of the system is adjustable. The heat exchanger is cooled by Low Pressure Service Water (LPSW).

10.4.6 Condensate and Main Feedwater Systems

10.4.6.1 Design Bases

The Steam and Power Conversion System for each unit is designed to remove heat energy from the reactor coolant in the two steam generators and convert it to electrical energy. The closed feedwater cycle condenses the steam and the heated feedwater is returned to the steam generators. The system is designed to utilize the entire output from the Nuclear Steam Supply System.

The Condensate and Main Feedwater Systems operate within the power rate of change constraints discussed in the "Turbine-Generator, Design Bases" section.

The Condensate and Main Feedwater Systems are shown in Figure 10-6 and Figure 10-7.

10.4.6.2 System Description

The closed cycle feedwater heaters are half-size units (two parallel strings), with the exception of “F” heater. There are three “F” heaters, one in each condenser neck. Deaeration is accomplished in the condenser.

All three hotwell pumps, two of the three one-half capacity condensate booster pumps and both of the main feedwater pumps are in normal use. Each of two main feedwater pumps is more than one-half capacity.

The main steam lines and the main and emergency feedwater lines are the only lines of the Steam and Power Conversion System which penetrate the Reactor Building. These lines can be isolated by the turbine stop valves and the normal and emergency feedwater line valving.

Feedwater supply to the steam generators following a reactor shutdown is assured by one of the following methods:

1. Either of the two main feedwater pumps is capable of supplying both steam generators at full secondary system pressure.
2. The hotwell and condensate booster pump combination has discharge shutoff head of approximately 620 psia. Three sets of half-size pumps are provided. If required, the Turbine Bypass System can be used to reduce secondary system pressure to the point where one of the hotwell and condensate booster pump combinations can supply feedwater to both steam generators.
3. A separate Emergency Feedwater System for each unit will supply feedwater at full system pressure (see Section 10.4.7).
4. Alternate auxiliary feedwater supplies are available from the Emergency Feedwater System of each of the other units.
5. The Protected Service Water System is capable of supplying both SGs of all three units at full secondary system pressure.
6. The SSF Auxiliary Service Water System is capable of supplying both steam generators of all three units at full secondary system pressure.

10.4.6.3 Safety Evaluation

The design, material, and details of construction of the feedwater heaters are in accordance with the ASME Code, Section VIII, Unfired Pressure Vessels.

The Feedwater System has been reviewed to determine the potential for “water hammer” during anticipated operational occurrences. It has been concluded that the existing Oconee Feedwater System is adequate to prevent flow instabilities. Because design features of the feedwater system preclude the probability of destructive “water hammer” forcing functions resulting from uncovering feedwater lines, no analyses have been performed nor test program conducted regarding this occurrence. The following considerations support this conclusion:

1. Neither the Main nor Emergency Feedwater Systems has horizontal or downward-sloping pipe runs adjacent to the steam generator. The auxiliary piping remains below the level of its junction with the steam generator. The main feedwater line rises above its steam generator connection only after downward and horizontal runs which effectively form a loop seal. Only in the unlikely event of steam generator shell pressure near the vapor pressure of the water in this pipe could a steam void occur.
2. The main and emergency feedwater distribution heads on the steam generator are designed to remain flooded regardless of steam generator water level, and would in any event be self-venting if steam were introduced. The main ring header is fed from the bottom, external to the steam generator, and empties upward through the vertical inlet lines. The auxiliary ring headers are similar in design to the main header. None of the feedwater headers can spontaneously drain into the steam generator.

3. Each steam generator has its auxiliary header separate from the main header. Therefore, there is no need to deliver the relatively cool auxiliary feedwater through the normal path for main feedwater. In addition, the QA-1 portions of Main FDW have been analyzed for pressure transient forces due to control valve closure and pump trip resulting from actuation of the Automatic Feedwater Isolation System circuitry.

10.4.6.4 Tests and Inspections

The operating characteristics of the hotwell, condensate booster, and main feedwater pumps are established throughout the operating range by factory tests. The main condensers, the hotwell pumps, the condensate polishing demineralizer vessels, the condenser steam air ejectors, the gland steam condenser, the condensate booster pumps, the feedwater heaters, and the main feedwater pumps are hydrostatically tested to the applicable code or standard.

Manways or removable heads are provided on all heat exchangers to provide access to the tube sheets for inspection and maintenance. A general routine visual surveillance of the system components and piping during operation and maintenance periods for signs of leakage or distress will be performed to verify system integrity.

10.4.6.5 Instrumentation Application

Sufficient instrumentation is provided to monitor system performance and to control the system automatically or manually under all operating conditions.

Trips, automatic corrective actions, and alarms will be initiated by deviations of system variables within the Steam and Power Conversion System. In the case of automatic corrective action in the Steam and Power Conversion System, appropriate automatic 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:

10.4.6.5.1 Turbine Trips

Following any turbine trip, a reactor trip will occur if reactor power is above the anticipatory reactor trip system (ARTS) setpoint.

1. Loss of 24V D-C supply to trip circuits
2. Low condenser vacuum
3. Loss of generator stator coolant (if runback fails)
4. Loss of both main feedwater pumps
5. Turbine overspeed
6. Reactor trip
7. Bearing oil low pressure
8. EHC Hydraulic Fluid low pressure
9. Moisture separator high level
10. Manual trip
11. Loss of speed feedback
12. OTSG Steam Generator high level
13. Turbine oil fire trip

14. Generator lockout relay 86GA

10.4.6.5.2 Automatic Actions

(Also see Integrated Control System Description.)

1. Low Water level in Upper Surge Tank

10.4.6.5.3 Principal Alarms

1. Low pressure at condensate booster pump suction
2. Low pressure at feedwater pump suction
3. Low vacuum in condenser
4. Low water level in condenser hotwell
5. High water level in condenser hotwell
6. High water level in steam generator
7. Low water level in steam generator
8. High pressure in steam generator
9. Low pressure in steam generator
10. Low feedwater temperature
11. Electrical malfunctions in the EHC
12. Low water level in Upper Surge Tank

10.4.6.6 Interactions with Reactor Coolant System

Following a turbine trip, the reactor will trip automatically if reactor power is above the anticipatory reactor trip system (ARTS) setpoint. 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.

In the event of failure of a main feedwater pump, there will be an automatic runback of the power demand. The one main feedwater pump remaining in service will carry approximately 60 percent of full load feedwater flow. If both main feedwater pumps fail, the turbine and reactor will be tripped, and the emergency feedwater pumps started.

On a low feedwater pump suction header pressure condition, the spare condensate booster pump starts automatically, provided pump start permissives are satisfied.

10.4.7 Emergency Feedwater System

10.4.7.1 Design Bases

The Emergency Feedwater (EFW) System provides sufficient feedwater supply to the steam generators (SGs) of each unit, during events that result in a loss of the Condensate/Main Feedwater, to remove energy stored in the core and primary coolant.

Following a reactor trip, the EFW System is capable of providing sufficient inventory to maintain hot standby for at least 4 hours with or without offsite power available. The EFW System is also capable of providing sufficient feedwater to the steam generators to cool down the RCS to decay heat removal entry conditions following events that result in a loss of main feedwater with and without offsite power available and during a steam generator tube rupture accident with offsite power available. The minimum required capacity of the EFW System is sufficient to reduce primary coolant temperature at a rate of 100°F per hour, assuming the largest capacity EFW pump is inoperable. Cooldown is a manually performed function. EFW inventory requirements are based on maintaining hot standby conditions for one hour, followed by a 50°F per hour cooldown to decay heat removal entry conditions. Although the EFW system capacity is sufficient to support a 50°F per hour cooldown rate, this rate is not achievable during certain events, such as a natural circulation cooldown. The EFW System design basis includes the ability to perform its function in the event of a single active failure. However, in some instances, as addressed in Section 10.4.7.3, alternate capability and operator actions are credited for performing the EFW function to compensate for specific single failures and system vulnerabilities that have been identified. The EFW System is not considered to be an Engineered Safeguard System and therefore was not designed to meet all of the design criteria applicable to Engineered Safeguard Systems. The EFW System is shown in Figure 10-8.

For diversity, the EFW System includes two AC motor-driven pumps and one turbine-drive pump that is independent of AC power. Sources of steam for driving the turbine-driven EFW pump (TDEFWP) are available from both steam generators. Following a loss of all AC power, the turbine-driven EFW pump will automatically actuate and is capable of operating for at least two hours completely independent of AC power. The water inventory that is immediately available to the turbine-driven EFW pump is sufficient to supply feedwater to the steam generators for at least 40 minutes assuming automatic steam generator level control and no reliance on operator action.

The EFW System is designed to start automatically in the event of loss of both main feedwater pumps. The automatic start on loss of both main feedwater pumps meets the single failure criterion. All automatic initiation logic and control functions associated with the EFW pumps and control valves FDW-315 and FDW-316 are independent from the Integrated Control System (ICS). Each OTSG is provided with a level control system (see UFSAR Section 7.4.3.2) that, on demand, enables the EFW System to supply sufficient initial and subsequent flow to the necessary SG to assure adequate decay heat removal.

The seismic qualification of the EFW System and Quality Group Classification is described in UFSAR Section 3.2.2. Only those components listed in UFSAR Section 3.2.2 are seismically qualified. The TDEFWP supporting equipment is not fully seismically qualified and therefore is not credited for Maximum Hypothetical Earthquakes (MHEs). However, it has been evaluated against Seismic Qualification Utility Group (SQUG) criteria and is expected to be available following a seismic event. Although redundancy is provided by two full-capacity seismically qualified Motor Driven Emergency Feedwater Pumps (MDEFWPs), they are also susceptible to failure in a seismic event due to flooding induced by the event. However, alternative seismically qualified means of decay heat removal are provided by the Standby Shutdown Facility (SSF) Auxiliary Service Water (ASW) System and the High Pressure Injection (HPI) System.

The EFW System is seismically qualified to the MHE level out through the first isolation valves, consistent with the design criteria given in Section 3.7.3.9. Piping beyond these boundary points is not seismically qualified. The primary suction to the EFW pumps is from the UST. The Upper Surge Tank (UST) is seismically qualified. Operator action is relied upon to shift the suction of the EFW pumps from the UST to the non-safety condenser hotwell before the UST is completely depleted. The condenser hotwell is seismically qualified with a nominal capacity of 120,000 gallons (References 12, 13, and 14). However, not all piping from the condenser hotwell, such as the suction supply to the TDEFWP and to the hotwell pumps, is seismically qualified. The piping from the hotwell to the TDEFWP; however, is designed and supported such that it would be expected to withstand the design basis earthquake. The piping from the hotwell to the MDEFWPs is seismically qualified.

Portions of the EFW System are vulnerable to tornado missiles. Thus, the plant relies upon diverse means to provide feedwater to the SGs in the event of a tornado. These diverse means include the SSF ASW System and the PSW System.

The Emergency Feedwater System was not designed to withstand the effects of internally generated missiles. If such an event were to occur and if main feedwater were unavailable, the single train SSF ASW System would provide an assured means of providing heat removal from the SGs. A detailed evaluation of the capability of the existing EFW System to withstand missiles was not considered necessary (Reference 2).

The effects of High Energy Line Breaks have been analyzed as addressed in UFSAR Section 3.6.1.3.

Provisions for water hammer events are considered unnecessary due to the use of Once Through Steam Generators (OTSG) (Reference 9).

Portions of the Emergency Feedwater system are credited to meet the Extensive Damage Mitigation Strategies (B.5.b) commitments, which have been incorporated into the Oconee Nuclear Station operating license Section H - Mitigation Strategy License Condition.

10.4.7.1.1 Deleted Per 2002 Update

10.4.7.1.2 Deleted Per 2002 Update

10.4.7.1.3 Deleted Per 2002 Update

10.4.7.1.4 Deleted Per 2002 Update

10.4.7.1.5 Deleted Per 2002 Update

10.4.7.1.6 Deleted per 1996 Revision

10.4.7.1.7 Deleted Per 2002 Update

10.4.7.1.8 Deleted Per 2002 Update

10.4.7.1.9 Deleted Per 2002 Update

10.4.7.1.10 Deleted Per 2002 Update

10.4.7.2 System Description

There are three EFW pumps provided for each unit. There are two motor-driven pumps with a design flow rate of 450 gpm/pump. There is one turbine driven pump with a design flow rate of 1080 gpm. The motor-driven pumps are provided with automatic recirculation control valves that close when sufficient demand to the SGs occurs. The turbine driven pump is provided with a minimum recirculation path that is normally open and limited by fixed orifices. The flow rate through the fixed orifices is not available for feeding the SGs. The fixed orifices are sized to pass < 200 gpm. The total combined SG feed capacity of all three EFW pumps is therefore approximately 1780 gpm.

Each motor-driven pump normally serves a separate SG; while the turbine-driven pump normally serves both SGs. EFW is supplied to each SG through its auxiliary feedwater header. The three units are provided with separate EFW Systems. The discharge header of each EFW System can be cross-connected making each system capable of supplying any unit.

The EFW System can accommodate a plant cooldown at the maximum allowable cooldown rate. The EFW flow demand requirements for plant cooldown (from full power operation to RCS temperatures where switchover to Decay Heat Removal System is achievable) have been analyzed for two different cooldown rates. The analysis assumes the cooldown is initiated one hour after plant shutdown and that two reactor coolant pumps are secured prior to cooldown. An EFW suction temperature of 130°F is assumed. All heat sources (decay heat, pump heat, fuel, structural steel, and coolant sensible heat) have been included. The average EFW flow rate to support a cooldown rate of 100°F/hr from hot standby conditions to DHR entry conditions is 430 gpm. If a 100F°/hr cooldown rate is established 15 minutes following reactor trip, the average EFW flow rate during the first hour of the cooldown is 480 gpm. The average EFW flow rate to support a cooldown rate of 50°F/hr from hot standby conditions to DHR entry conditions is 340 gpm.

Cooldown of the Reactor Coolant System (RCS) is a manual function controlled by the operator to obtain the cooldown rate desired and within Technical Specification limits. Without crediting recirculation via the Turbine Bypass System, the condensate inventory consumed for a 100°F/hr cooldown to decay heat removal switchover is approximately 115,000 gallons. The condensate inventory consumed for a 50°F/hr cooldown to decay heat removal switchover is approximately 155,000 gallons. This inventory is well within the capacity available within the UST and hotwell (refer to Table 10-1).

10.4.7.2.1 Motor Driven EFW Pumps (MDEFWPs)

There are two MDEFWPs per unit. The pumps are physically located in the basement of the Turbine Building. Each of the MDEFWPs is normally aligned to a separate SG. Each of the MDEFWPs is supplied with its own independent starting circuit, as described in UFSAR Section 7.4.3.1, that allows the operator manual or automatic control of the pump. During periods of shutdown and cooldown the circuit selector switch is normally positioned to automatically start the MDEFWPs on a LOW STEAM GENERATOR WATER LEVEL signal in either steam generator after a time delay to prevent spurious actuation. The LOW STEAM GENERATOR

WATER LEVEL initiation function, which was added for SG dryout protection (Reference 11), is not designed to meet the single failure criterion as it is not relied upon for the mitigation of any accident. During normal plant operation, the selector switch is positioned to automatically start the MDEFWPs on a LOSS OF BOTH MAIN FEEDWATER PUMPS, LOW STEAM GENERATOR WATER LEVEL or AMSAC signal. Loss of both main feedwater pumps is sensed by pressure switches that monitor main feedwater pump turbine hydraulic oil pressure. The AMSAC start signal is described in Section 7.8.2.1. Once automatically started the MDEFW pumps will continue to operate until manually secured by the operator. Automatic starts of the MDEFWPs are disabled if a main steam line break is sensed by the Automatic Feedwater Isolation System (AFIS) circuitry. Upon AFIS actuation, the MDEFWP aligned to the affected steam generator will automatically stop and be inhibited from any automatic starts. The operator can manually start the motor driven pump by placing its selector switch to RUN. The MDEFWPs require cooling water for continuous operation. Sufficient cooling water is initiated automatically from the Low Pressure Service Water System, upon manual or automatic start of MDEFWPs.

The MDEFW pumps are powered from the 4160VAC Switchgear TD and TE. The switchgear are located side by side on the ground floor of the Turbine Building and are not protected from high energy line breaks. The normal station auxiliary AC Power System normally provides power for the switchgear. During loss of offsite power operation, these switchgear are automatically aligned to the Emergency AC Power System.

10.4.7.2.2 Turbine Driven EFW Pump (TDEFWP)

There is one TDEFWP per unit. The pump is physically located in the basement of the Turbine Building. The TDEFWP is normally aligned to supply both SGs. The TDEFWP is supplied with its own independent starting circuit, as described in UFSAR Section 7.4.3.1, that allows the operator manual or automatic control of the pump. During normal plant operation the circuit selector switch is positioned to automatically start the TDEFWP upon a LOSS OF BOTH MAIN FEEDWATER PUMPS or an AMSAC signal. Loss of both main feedwater pumps is sensed by pressure switches that monitor feedwater pump turbine hydraulic oil pressure. The AMSAC start signal is described in Section 7.8.2.1. Automatic starts of the TDEFWP are disabled if a main steam line break is sensed on either steam generator by the AFIS circuitry. Upon AFIS actuation, the TDEFWP will automatically stop and be inhibited from any automatic starts. The operator can manually start the TDEFWP by placing the selector switch to RUN. The TDEFWP can also be started locally in the basement of the Turbine Building.

For all units cooling water is automatically supplied to the turbine oil cooler via an AC driven cooling water pump. Analysis has shown that the turbine pump may operate in excess of 4 hours without cooling water to the oil cooler. Both of these cooling water supplies may be lost following a loss of AC power. A backup source of cooling for the oil cooler is provided by the High Pressure Service Water (HPSW) System and is automatically aligned following a loss of AC power. The HPSW System is capable of providing cooling through gravity feed from the Elevated Water Storage Tank.

Motive steam for the TDEFWP is provided from either of the two SGs by main steam lines upstream of the main turbine stop valves or by the auxiliary steam header, and is exhausted to the atmosphere. Any of the three steam supplies will provide sufficient steam for turbine operation, and both steam sources are normally aligned and available to supply the TDEFWP. Any steam supply may be isolated if necessary. A check valve is provided in each main steam supply line to minimize uncontrolled blowdown of more than one SG following a MSLB (refer to UFSAR Section 10.3.2 for further details). A check valve is also provided in the auxiliary steam supply line to prevent a loss of the main steam source should auxiliary steam be lost. Valve MS-

93, the TDEFWP steam admission valve, in the common supply to the turbine, is equipped with instrument air, auxiliary instrument air, and bottle nitrogen backups. The three sources are passed through a common, normally energized solenoid valve to the valve operator to maintain the valve closed. Upon receipt of a manual or automatic start signal, the solenoid valve will de-energize and isolate the supply air to MS-93. MS-93 is designed to fail open upon loss of compressed air or power to the normally energized solenoid valve. An AFIS actuation will re-energize the solenoid valve to supply compressed air to MS-93 operator. The bottled nitrogen backup will provide at least 2 hours of closure for MS-93.

Automatic or manual starting of the TDEFWP from the Control Room relies on DC power from the station power batteries. Each TDEFWP is equipped with a DC auxiliary oil pump (AOP). The auxiliary oil pump is located near the TDEFWP in the basement of the Turbine Building. Power for the AOP is supplied by 250VDC load center DP. This load center is located on the ground floor of the Turbine Building adjacent to the 4160VAC Switchgear TC, TD, and TE. The AOP automatically starts when MS-93 opens. The AOP provides the initial oil pressure to open the turbine governor valve (MS-95) and supply lube oil for the turbine bearings. The EFW pump turbine speed is controlled by MS-95. The position of MS-95 is regulated by a hydraulic oil speed governing mechanism, with oil supplied from either the auxiliary oil pump or the shaft driven oil pump. MS-95 is designed to fail closed on loss of hydraulic oil pressure. An AFIS actuation will energize and close solenoid valve (TO-145) to isolate the hydraulic oil supply to close MS-95. When the turbine approaches operating speed, the shaft driven oil pump will supply adequate oil pressure for the governor valve and bearing lubrication.

10.4.7.2.3 EFW Pump Suction Source

The condensate/feedwater reserve, specifically the Upper Surge Tank for each unit, is normally aligned to the EFW pump suctions. A minimum of 30,000 gallons of water is maintained in the UST. The UST consists of two connected tanks. The condensate/feedwater reserve for each unit is maintained among the sources in Table 10-1. The UST provides makeup to a common header which divides into three separate pathways to the non-safety condenser hotwell. The common header is automatically isolated on a low UST level. The UST also provides a source of water to other non-safety equipment. These pathways are normally isolated by closed manual valves. If power is available, inventory in the UST can be replenished from a variety of sources. These sources include the plant Demineralized Water System through the makeup demineralizers, the Condensate Storage Tank (CST) via the CST pumps, and the condenser hotwell via a hotwell pump recirculation pathway. The makeup sources are non-safety. If the UST inventory cannot be maintained following an accident, the EFW pump suction may be aligned to the condenser hotwell directly, which has a nominal inventory of 120,000 gallons. Condenser vacuum must be broken to provide adequate net positive suction head to the EFW pumps when aligned to the hotwell. Condenser vacuum is broken by the opening of a single vacuum breaker valve (V-186). This vacuum breaker valve is normally operated from the Control Room and is physically located on the ground floor of the Turbine Building on the east side of the condenser hotwell. The vacuum breaker would be locally operated in the event of a loss of offsite power. To complete the transfer of suction for the MDEFWPs, a single manual valve in the common suction piping (located in the basement of the Turbine Building near the MDEFWPs) must be closed. TDEFWP suction is transferred by opening the hotwell supply valve (C-391) and closing the UST supply valve (C-156 or C-157). Assuming that offsite power is not available, EFW pump suction can be transferred to the condenser hotwell in approximately 20 minutes. This is well within the time that is available based on the minimum required UST inventory. Limitations associated with hotwell inventory are further addressed in Section 10.4.7.3. All necessary valves in the discharge flow path are maintained in normal standby alignment to assure an open flow path for each pump, and to assure piping separation and independence. All manually operated valves in the piping from the UST to the suction of the EFW pumps are locked open (Reference 2).

10.4.7.2.4 EFW Pump Minimum Recirculation

A flow path is also provided to the UST dome for minimum recirculation flow and testing purposes. A continuous recirculation flow is provided for the TDEFWP, limited by fixed orifices. The orifices in the minimum flow recirculation loop were resized in 1992 in response to NRC Bulletin 88-04, Potential Safety-Related Pump Loss, to ensure the recirculation flowrate satisfies the manufacturer's requirement which was also revised in response to the bulletin, (Reference 15). A self-contained automatic recirculation valve is provided for each MDEFWP to assure individual pump minimum flow when needed during operation. A flow path is provided from the discharge of each MDEFWP to the UST for full flow testing. During normal system alignment, the test loops are isolated and pump minimum recirculation would be routed back to the UST for reuse.

10.4.7.2.5 EFW Discharge Flow Control Valves

Each EFW discharge line to each SG is provided with a control valve and check valve. Discharge flow from the EFW pumps is normally aligned and controlled by control valves FDW-315 and FDW-316. FDW-315 (EFW flow control to ‘A’ SG) is physically located in the East Penetration Room. FDW-316 (EFW flow control to ‘B’ SG) is physically located in the West Penetration Room. Open/Closed valve position indication is provided for each control valve at the valve manual loader in each Control Room.

The valves are arranged to fail to the automatic control mode upon loss of DC control power to the manual/auto select solenoid. If the selected train of automatic control fails, then the valve would fail open. Also, upon loss of station air, the valves will maintain their position with N2 backup. If N2 backup fails then the valve would fail open. These modes of operation show that emergency feedwater isolation is not possible with valve control circuitry or motive force failure. Open/Closed valve position indication is provided for each control valve in the main control room at the valve.

These valves are controlled independently of the Integrated Control System and arranged to fail to the automatic control mode upon loss of Control power to the Hand/Auto relay. If the output of the selected train of automatic control fails, then the valve would fail open. Also, upon loss of all station air, the valves will maintain their position with a nitrogen supply. If the nitrogen supply fails, then the valve would fail open. In automatic, the control valve Auto/Manual relay is de-energized, thereby aligning the valve to automatic control and positioning the valve per the automatic setting. Control valves FDW-315 and FDW-316 are modulated by separate control signals from the electric current to pneumatic converter. These valves may be automatically controlled, or manually controlled by the operator to limit or increase feedwater as necessary to maintain feedwater inventory and cooldown rate. A pushbutton on the respective Auto/manual station is provided for each control valve to allow the individual valve to be placed in either an automatic level control mode or in a manual mode of operation. Power to the controller is battery backed DC converted to AC via the vital inverters.

Independent level transmitters are utilized in the automatic control system circuit. Upon loss of all four reactor coolant pumps, such as during LOOP events, the level control setpoint is automatically raised to promote natural circulation in the Reactor Coolant System. For events where core subcooling margin has been lost, operators must manually control SG levels at the loss of subcooling margin setpoint.

10.4.7.2.6 Instrumentation and Controls

Each of the EFW pumps is supplied with an independent starting circuit (described in UFSAR Section 7.4.3.1). The independent control circuits are powered by the 125 VDC safety-related station batteries.

Sufficient indication is provided in the Control Room to allow the operator to monitor unit parameters during a cooldown. Specific indication provided for the EFW System is listed in Table 10-2.

Refer to Section 7.4.3 for additional discussion of the EFW controls.

10.4.7.2.7 Alternate Flow Path

Although not normally aligned or utilized in the safety related function of the EFW System, a redundant, separate flow path to the SGs and means of controlling EFW pump discharge flow is provided by MFW startup control valves FDW-35 and FDW-44. This additional non safety-related flow path may be aligned manually during startup, shutdown or following EFW flow control valve failures.

The 'A' MDEFWP can be aligned to feed the 'A' SG via the MFW startup path by opening motor operated valves FDW-38 and FDW-374 and closing motor operated valves FDW-33, FDW-36, and FDW-372. The 'B' MDEFWP can be aligned to feed the 'B' SG via the MFW startup path by opening motor operated valves FDW-47 and FDW-384 and closing motor operated valves FDW-42, FDW-45, and FDW-382. These motor operated valves are operated from the Control Room and receive non-safety power. FDW-36, FDW-38, FDW-45, and FDW-47 are DC motor operated valves that receive power from the station power batteries. FDW-372, FDW-374, FDW-382, and FDW-384 are AC motor operated valves that receive power from non-safety, non-load shed sources. FDW-33 and FDW-42 are AC motor operated valves that receive power from a non-safety, load shed source. The MDEFWPs must be stopped to allow alignment of this flow path.

The TDEFWP can also be aligned to feed both SGs via the MFW startup path by opening two manually operated valves (FDW-94 and FDW-96) located in the Turbine Building basement and closing motor operated valves FDW-368 and FDW-369. The motor operated valves are operated from the Control Room. FDW-368 and FDW-369 are AC motor operated valves that receive power from non-safety, non-load shed power. Repositioning of FDW-33, FDW-36, FDW-38, FDW-42, FDW-45, and FDW-47 would also be required as described in the alignment of the MDEFWP's to the MFW startup path. The TDEFWP must be stopped to allow alignment of this flow path.

Once the EFW pump is aligned to the MFW startup path, FDW-35 and/or FDW-44 are used to control EFW flow to the SGs. Using air that is supplied by the plant Instrument Air System, air operated control valves FDW-35 and FDW-44 are modulated by the ICS based on SG water levels. The control valves may be operated manually from the Control Room. The ICS and the plant instrument air are non-safety. As in the case of control valves FDW-315 and FDW-316, the level control setpoint is automatically raised upon loss of all four reactor coolant pumps to promote natural circulation in the Reactor Coolant System.

The alignment of EFW through the MFW startup path is vulnerable to LOOP events. FDW-33 and FDW-42 receive power from a load shed source. These valves would have to be manually closed locally or power must be restored to the load shed source to allow the valves to be operated from the Control Room. The valves are located on the ground floor of the Turbine Building. Plant instrument air is also vulnerable. Upon a LOOP that deenergizes the Primary IA Compressor or low Instrument Air Header Pressure, the Service Air Diesel Air Compressor(s) should automatically start and supply Instrument Air. The diesel service air compressors are located outside at the south end of the Turbine Building. The startup and main feedwater control valves (FDW-32, FDW-35, FDW-41, and FDW-44) are supplied with backup compressed air from an accumulator tank. This source of compressed air is sufficient for their 2 hour mission time in the event they must be closed and stay closed in response to an AFIS signal for a steam line break, concurrent with a Loss of Offsite Power (LOOP). None of the feedwater control valves require operation of the Service Air Diesel Air Compressor(s).

10.4.7.2.8 Alarms

Sufficient alarms are provided to alert the operator of conditions exceeding normal limits. Essential plant parameters are annunciated or alarmed by the process computer in addition to the specific EFW System alarms as listed below:

1. MDEFWPs low suction pressure
2. SG low level alarms
3. Hotwell low level alarms
4. UST low level alarms
5. Low MDEFWP cooling water flow
6. MDEFWP stator winding high temperature
7. MDEFWP motor bearing high temperature
8. MDEFWP bearing high temperature
9. Motor cooler excessive leakage
10. MDEFWP A auto start blocked
11. MDEFWP B auto start blocked
12. TDEFWP EFW pump auto start blocked
13. MDEFWP A low level start
14. MDEFWP B low level start
15. TDEFWP turbine lube oil low pressure
16. TDEFWP turbine oil high temperature
17. TDEFWP turbine hydraulic oil low pressure
18. TDEFWP turbine auxiliary oil pump overload
19. TDEFWP tripped
20. FDW-315 controller Bypassed
21. FDW-316 controller Bypassed
22. Loss of Primary control power for FDW-315
23. Loss of Primary control power for FDW-316
24. FDW-315 Hand/Auto Station Failure
25. FDW-316 Hand/Auto Station Failure
26. FDW-315 Hand/Auto Station in Manual Mode

27. FDW-316 Hand/Auto Station in Manual Mode
28. FDW-315 Automatic Control on Primary Control
29. FDW-316 Automatic Control on Primary Control
30. FDW-315 Nitrogen Pressure A Low
31. FDW-316 Nitrogen Pressure A Low
32. FDW-315 Nitrogen Pressure B Low
33. FDW-316 Nitrogen Pressure B Low

10.4.7.3 Safety Evaluation

Feedwater inventory is maintained in the SGs following reactor shutdown by one of the following methods listed:

1. Either of the two main feedwater pumps in combination with a hotwell pump and a condensate booster pump are capable of supplying both SGs at full secondary system pressure.
2. The two MDEFWPs are capable of supplying their associated SG at full secondary system pressure.
3. The single TDEFWP is capable of supplying both SGs at full secondary system pressure.
4. An alternate EFW supply available from the EFW System of one of the other units, capable of supplying both SGs at full secondary system pressure.
5. The hotwell and condensate booster pump combination has a discharge shutoff head of approximately 620 psia. There are three hotwell pumps and three condensate booster pumps. If required, the Turbine Bypass System or the Atmospheric Dump Valves (ADVs) can be used to reduce secondary system pressure to the point where one hotwell and condensate booster pump combination can supply feedwater to both SGs.
6. The SSF Auxiliary Service Water System is capable of supplying both SGs of all three units at full secondary system pressure.
7. The Protected Service Water System is capable of supplying both SGs of all three units at full secondary system pressure.

A sufficient depth of backup measures is provided to allow SG water inventory to be maintained by any of the diverse methods listed above. Although redundancy and diversity is provided as listed above, the EFW System has been designed with special considerations to enable it to function when conventional means of feedwater makeup may be unavailable.

Redundancy is provided with separate, full capacity, motor and turbine driven pump subsystems. Except as noted in the subsections that follow, failure of either the MDEFWPs or the TDEFWP will not reduce the EFW System below minimum required capacity. Pump controls, instrumentation, and motive power are separate in design.

The transients that require EFW have been evaluated assuming only one MDEFWP is available to deliver the necessary feedwater. Except as noted in the subsections that follow, no single failure in the three pump, two flowpath EFW System design will result in only one available MDEFWP (i.e., two EFW pumps will remain available). Therefore, the evaluation assuming only one MDEFWP available is conservative. These analyses verify the acceptability of the EFW System design.

The Safety Analyses acceptance criteria for each EFW transient are as follows:

Conditions of Transient	Acceptance Criteria
Loss of Main Feedwater Loss of Offsite Power Turbine Trip	Peak RCS Pressure ≤ 2750 psig
Main Feedwater Line Break Main Steam Line Break	10CFR 50.67 dose limits
Small Break LOCA	10CFR 50.46 PCT limits 10CFR 50.67 dose limits
Steam Generator Tube Rupture	10CFR 100 dose limits

10.4.7.3.1 EFW Reponse Following a Loss of Main Feedwater

The plant transient that requires the highest EFW System flow is the loss of feedwater transient with offsite power available. A loss of main feedwater is the result of both main feedwater pumps tripping. All three EFW pumps would be available with or without offsite power being available. Both EFW flowpaths should remain available. With offsite power being available, the reactor coolant pumps are assumed to remain running. If any reactor coolant pump is operating, the EFW flow control valves will modulate to control steam generator level at 30 inches.

For this transient, it is assumed that MFW flow entering the SGs decreases to zero flow 5 seconds after the MFW pumps trip off. A high initial 102 percent power level is assumed to maximize energy removal requirements. A low initial SG mass is assumed to minimize post-trip heat removal during SG boil down. The Turbine Bypass System is assumed to be unavailable such that steam relief is by the main steam safety valves. The analysis assumes a limiting single failure with respect to flowrate demand of an EFW control valve failed closed. In addition, no credit is taken for the TDEFWP. Thus, the EFW System is limited to one MDEFWP delivering flow to one SG. The maximum allowable Upper Surge Tank temperature of 130°F is assumed to minimize the heat removal capability of the EFW System. Reactor trip and the subsequent turbine trip are assumed to occur on the high RCS pressure trip function. Reactor coolant pumps are assumed to be left on to maximize the heat input. Decay heat power is based on end-of-cycle burnup. The flowrate demand on the EFW System for other transients is bounded by this loss of main feedwater transient (with offsite power available). The safety analyses model of EFW flow rate is a function of SG pressure. Based on the results of the accident analyses, one MDEFWP delivering 375 gpm at a SG pressure of 1064 psia and an EFW temperature of ≤ 130°F provides adequate heat removal capability for this transient.

If offsite power is not available, the reactor coolant pumps will not be operating and EFW flow control valves will modulate to control steam generator level at a higher setpoint to promote the natural circulation mode of heat removal. Since there is no reactor coolant pump heat, the initial EFW flow rate requirements for a loss of main feedwater transient are bounded by the loss of main feedwater transient with offsite power available.

The volumes maintained in the UST and the condenser hotwell satisfy the EFW inventory required to support a plant cooldown following a loss of main feedwater transient with or without offsite power available. Assuming automatic steam generator level control, the minimum

Technical Specification required 30,000 gallon inventory in the UST will provide at least 40 minutes of EFW flow with all three EFW pumps operating simultaneously (Reference 10). This inventory requirement also assures that the plant operators have at least 20 minutes to act, following the UST low level alarm, before the UST is emptied. The EFW pumps will remain aligned to the UST as long as adequate inventory can be maintained. If the UST inventory cannot be maintained, EFW pump suction will be aligned to the hotwell. A combined inventory in the UST and condenser hotwell of 155,000 gallons is sufficient to permit cooldown of the primary coolant at a rate of 50°F per hour following a reactor trip to decay heat removal entry conditions assuming a maximum allowable UST and hotwell temperature of 130°F (see Section 10.4.7.2).

The non-safety hotwell is not designed to withstand a single active failure. The limiting single active failure with respect to EFW inventory is the failure to break condenser vacuum. This renders the hotwell as unavailable. In the event of this single failure, sufficient depth of backup measures is provided to allow steam generator water inventory to be maintained by either the PSW or the SSF Auxiliary Service Water (see Section 10.4.7.3.8).

10.4.7.3.2 EFW Response Following a HELB

10.4.7.3.2.1 HELBs Resulting in Loss of TC, TD, TE Switchgear

HELBs in the vicinity of the TC, TD, TE switchgear could cause their failure. The consequence of the switchgear failure would cause a complete loss of the Condensate and Feedwater System (loss of pumps). This event is similar to a station blackout on the affected unit. This would also cause a loss of both MDEFWPs due to loss of power. In addition, the DC power supply to the auxiliary oil pump (AOP) for the TDEFWP could be lost due to its location being adjacent to the switchgear. Loss of the AOP results in an inability to start the TDEFWP from the Control Room. The TDEFWP could be locally started and has sufficient capacity to satisfy the flowrate requirements for this event. A single failure of the TDEFWP would lead to a complete loss of main and emergency feedwater. If the TDEFWP is the single failure, the SSF ASW System is credited to feed the SGs. In addition, alignment of an unaffected unit's EFW System could be performed to feed the SGs.

10.4.7.3.2.2 Feedwater/Main Steam Line Breaks Causing Loss of SG Pressure Boundary

Large line breaks in the Feedwater/Main Steam System that result in a depressurization of the steam generator will result in actuation of the Automatic Feedwater Isolation System (AFIS). Once actuated, all main feedwater will be automatically isolated to the faulted steam generator and the TDEFWP will be inhibited from automatically starting. The MDEFWPs will automatically start and feed both steam generators. If the AFIS rate of depressurization setpoint is exceeded coincident with low steam line pressure, the MDEFWP feeding the faulted steam generator will be tripped. For smaller break sizes that do not exceed the rate of depressurization setpoint, the operator is required to manually terminate EFW flow to the faulted steam generator by either closing the EFW flow control valve or by stopping the MDEFWP. These actions can be done from the Control Room. The operator has sufficient Control Room indication of SG level and pressure and would be aware of such a situation. Concurrently, the operator would monitor the intact SG to maintain adequate inventory and secondary heat removal via the EFW System.

In the event of a single active failure of the MDEFWP to the intact steam generator, manual operator action is required to start the TDEFWP to provide sufficient flow for adequate core cooling. AFIS would isolate main feedwater to the faulted steam generator, and inhibit the automatic start of the TDEFWP. The preferred method of mitigating this event, after having isolated flow to the affected SG, would be to restart the TDEFWP by manual operator action in the Control Room. However, if the TDEFWP is not available, the remaining MDEFWP could be aligned to the unaffected SG by manual operator action outside of the Control Room via the cross connect (FDW-313 and FDW-314).

In the event of a postulated failure of the EFW flow control valve to the intact steam generator, manual operator action would be required to align the MDEFWP through the main feedwater startup control valve. The AFIS circuitry must be disabled by the operator to allow EFW flow alignment through the non-safety MFW startup control valves. This alternate path through the main feedwater startup control valve relies on non-safety equipment and non-safety support systems (electrical power and instrument air). This alignment may not be available in LOOP events. The main feedwater startup block valves receive power from load shed power which may not be immediately available following a LOOP.

If the EFW control valve on the unaffected SG fails to open and the main feedwater startup path is unavailable, then the SSF ASW System would be required to feed the unaffected SG for heat removal. If the EFW flow control on the unaffected SG fails open (on a loss of compressed air and nitrogen), this could result in the SG overcooling and subsequent loss of EFW to the unaffected SG due to pump runout. The safety analyses assume both SGs are isolated within 10 minutes, with subsequent action outside the Control Room for local manual control of the EFW control valve if the valve failed open. The EFW flow control valves are located in the penetration rooms adjacent to the Control Room. Except in those cases where the break makes these valves inaccessible, an operator could manually adjust either valve. In the event this path were unavailable, the SSF ASW System provides an alternate means of establishing feedwater flow to the unaffected steam generator.

Certain breaks could deplete hotwell inventory. The impact of this loss of inventory is encompassed by the high energy line breaks described in Section 10.4.7.3.2.3.

10.4.7.3.2.3 Other Condensate/Feedwater Line Breaks that Result in a Loss of Condenser Hotwell Inventory

This class of condensate and feedwater line breaks could result in depletion of stored inventory in the hotwell due to continued operation of the hotwell and condensate booster pumps. These line breaks cause the hotwell makeup valves to open to control hotwell level. On a low UST level, automatic closure signals are sent to close the UST Riser Automatic Isolation valves to preserve the minimum required inventory of 30,000 gallons in the UST. The SSF ASW System would be available for feeding the SGs. HPI forced cooling also remains available. In addition, EFW could be aligned from an alternate unit using the unit cross connects.

10.4.7.3.3 EFW Response Following a SBLOCA

For certain size small break loss of coolant accidents, feedwater is required to remove the decay heat and reactor coolant pump heat which is not relieved through the break. The EFW flow rate demand requirements for a SBLOCA, with and without a loss of offsite power, are bounded by the LOMFW event in Section 10.4.7.3.1 in which a break in the primary system is not present to help remove system heat.

10.4.7.3.4 EFW Response Following a SGTR

This event does not assume a loss of offsite power has occurred. With offsite power available, main feedwater should continue to operate and provide inventory to the SGs. In addition, the condenser should remain available as a means of removing heat from the SGs via the Turbine

Bypass System to the Condenser Circulating Water (CCW) System. However, should the Main Feedwater System be unavailable, the EFW System would be required to provide secondary side cooling. All three EFW pumps would be available to provide inventory to the SGs. Prior to isolation of the ruptured SG, EFW inventory requirements are diminished to a certain degree due to primary system leakage boiloff in the ruptured SG. If the EFW flow control valve for the unaffected SG failed to open, the flow path can be realigned to bypass the failed valve and reach the SG through the main feedwater startup flow path. This alternate path through the main feedwater startup control valve relies on non-safety equipment and non-safety support systems (electrical power and instrument air). With offsite power being available, the main feedwater startup path should remain available. However, if this path were unavailable, the SSF ASW System provides an alternate means of establishing feedwater flow to the unaffected SG. Prior to cooling the unit down to DHR conditions, one RCP per loop is tripped, further reducing the demand for EFW. The flowrate and inventory demands for EFW following a SGTR event is bounded by the demand for EFW following a loss of main feedwater with offsite power available.

If the EFW flow control valve on the unaffected SG fails open (on a loss of compressed air and nitrogen), this could result in the SG overcooling. The safety analyses assume action outside the Control Room for local manual control of the EFW control valve if the valve failed open. The EFW flow control valves are located in the penetration room adjacent to the Control Room.

10.4.7.3.5 EFW Response Following a MHE

Original Licensing Basis (no pipe break postulated)

The original licensing of Oconee addressed earthquakes. UFSAR Section 3.2.1.2 states that all three units can be safely shut down in the event of a MHE. Section 3.2.2 lists the systems to which seismic design was originally applied (including portions of the EFW System). In addition, a series of letters between Duke Energy and NRC helped clarify the seismic licensing basis. This correspondence documented that a seismic event was used to provide the design criteria for piping, equipment, and structures used for mitigation and prevention of accidents for safe shutdown of the plant. The characteristics of those forces and loads were calculated and applied based on seismic analyses, but an actual earthquake, with all of its potential effects, is not postulated. More importantly, UFSAR Section 3.2.2 states, “pipe failures during a maximum hypothetical earthquake are not postulated as part of the accident analysis.” (Reference 18 and 19)

Generic Letter (GL) 81-14 Licensing (Earthquake induced pipe break floods EFW)

Post TMI, NRC issued GL 81-14 to specifically evaluate the seismic design of the licensees’ Auxiliary Feedwater Systems. Although a seismically induced pipe break was not within Oconee’s licensing basis, NRC postulated a break in the non-seismic CCW piping in the Turbine building as part of GL 81-14 that could cause flooding and failure of the EFW Pumps. In such an event, the SSF ASW System was credited for secondary side heat removal. The SSF ASW System is not single failure proof. Penetration seals and waterproof doors have been installed between the Turbine Building and Auxiliary Building in each unit to provide waterproofing up to a height of twenty feet above the Turbine Building basement floor. Thus the High Pressure Injection (HPI) System, located in the Auxiliary Building, would be available as an alternative to the EFW System and the SSF ASW System for shutdown decay heat removal (Reference 6).

As defined in Reference 6, Oconee was deemed to meet the criteria of Generic Letter 81-14 regarding adequate post-seismic event decay heat removal capability by:

1. requiring portions of the EFW System (defined in UFSAR Section 3.2.2) to be capable of withstanding a MHE, and
2. providing alternative seismically qualified means of decay heat removal with the SSF ASW System and the HPI System.

10.4.7.3.6 EFW Response Following Tornado Missiles

Reference 7 concludes that the Standard Review Plan probabilistic criterion is met based upon the probability of failure of the EFW and station ASW Systems combined with the protection against tornado missiles afforded the SSF ASW System. Subsequently, PSW replaced station ASW relative to this function.

10.4.7.3.7 EFW Response Following a SBO

This event is similar to the LMFW with LOOP analysis with the additional assumption that the onsite emergency AC power sources have been lost. This results in the loss of the MDEFWPs. The TDEFWP should be available for 2 hours during this event because of its AC power independence. The SSF ASW System; however, is credited to remove the decay heat in this event. The SBO event, which is not a design basis event, is described in UFSAR Section 8.3.2.2.4.

10.4.7.3.8 Initiation of SSF ASW, PSW, and HPI Forced Cooling

The SSF ASW System, PSW, and HPI forced cooling serve as alternate means of decay heat removal for some of the EFW design events described in Section 10.4.7.3.

Once the control room decides to use the SSF ASW system, the system can be aligned within 14 minutes, consistent with the assumptions in the safety analyses. The SSF ASW flow rate provided to each unit's steam generators is controlled using the motor operated valves on each unit's SSF ASW supply header. The SSF contains adequate instrumentation to maintain the plant in a safe shutdown condition. The SSF ASW System is described in Section 9.6 of the UFSAR.

The Protected Service Water (PSW) system is designed as a standby system for use under emergency conditions. The PSW System is powered from either the Central Tie Switchyard via a 100 kV transmission line to a 100/13.8 kV substation or the Keowee Hydroelectric Station. The PSW System is provided as an alternate means to achieve and maintain safe shutdown for one, two, or three units.

The PSW System is capable of cooling each unit's RCS to approximately 250°F and maintaining this condition for an extended period. Failures in the PSW System will not cause failures or inadvertent operations in existing plant systems. The PSW System is operated from the Main Control Rooms (MCRs) when existing diverse emergency systems are not available. The power to PSW controlled pressurizer heaters must be manually aligned outside the MCR.

Please note that information associated with powering the pressurizer heaters and vital I&C battery chargers will not be effective until completion of Milestone 5, but is being included in the UFSAR for completeness.

If feedwater is unavailable, operator action is taken on high RCS pressure or pressurizer level to initiate HPI forced cooling. These actions are from the control room and include starting HPI pumps, opening the PORV, and throttling HPI flow as necessary. HPI forced cooling is initiated within 5 minutes of exceeding the initiation criteria. The HPI System is described in Section 6.3 of the UFSAR.

10.4.7.4 Inspection and Testing Requirements

A comprehensive test program is followed for the EFW System. The program consists of periodic tests of the activation logic and mechanical components to assure reliable performance during the life of the unit.

During unit operation, the EFW System is tested by utilizing the recirculation test line to the upper surge tank dome. Pump head and flow is verified utilizing this method.

10.4.7.5 Instrumentation Requirements

Sufficient instrumentation and controls are provided to adequately monitor and control the EFW System. The safety related instrumentation and controls that monitor SG level and pressure, automatically start the EFW pumps, and automatically align the supply, meet the system requirements for redundancy, diversity and separation

10.4.7.5.1 Turbine Driven Emergency Feedwater Pump

Instrumentation used in the automatic initiation circuitry on loss of main feedwater pumps for the TDEFWP is safety grade, as listed in Section 3.1.1.1, but not all of the equipment required to provide auto start capability is safety grade. This non-safety grade equipment includes: the TDEFWP Auxiliary Oil Pump, the 250VDC Load Center DP (which supplies power to the TDEFWP Auxiliary Oil Pump), the limit switch for MS-93 and and the pressure switch (FDWPS0300) which senses hydraulic pressure for the TDEFWP. Instrumentation used in the automatic initiation of the pump following an ATWS event is not required to be safety grade. A failure in the automatic initiation circuitry will not prevent manual start capability from the Control Room.

10.4.7.5.2 Motor Driven Emergency Feedwater Pumps

Instrumentation used in the automatic initiation circuitry on loss of main feedwater pumps for the MDEFWPs is safety grade. Instrumentation used in the automatic initiation of the pumps following an ATWS event is not required to be safety grade. Instrumentation used to provide automatic initiation of the pumps on low steam generator level is QA-1, but is not single failure proof. A failure in the automatic initiation circuitry will not prevent manual start capability from the Control Room. All non-safety related instruments and controls are designed such that failure of this equipment will not cause degradation of any safety related equipment function.

10.4.7.5.3 EFW Flow Indication to the Steam Generators

Each MDEFWP has a (non safety) flow transmitter with remote indication in the Control Room. Each EFW flow path to the steam generators contains two safety grade flow transmitters with remote indication in the Control Room. Each steam generator contains two safety grade level transmitters that are used to provide steam generator level control for the EFW System. The operators are capable of manually selecting between the primary and backup level transmitter from the Control Room. Safety grade level indication is provided in the Control Room. All non-safety related instruments and controls are designed such that failure of this equipment will not cause degradation of any safety related equipment function.

10.4.7.5.4 UST Level Indication

The UST has two safety grade level instruments. These instruments are used by the operators to monitor UST inventory. The UST low level alarm allows the operators at least 20 minutes to swap suction of the EFW pumps to the hotwell prior to depleting the UST inventory.

10.4.8 OTSG Condenser Recirculation System

10.4.8.1 Design Bases

The basis of the OTSG recirculation system is to provide a means to control steam generator corrosion during non-operating periods by filling the steam generators, draining the steam generators, and recirculating the water in the steam generators.

10.4.8.2 System Description

Each unit has one OTSG recirculation pump for both steam generators, as seen in Figure 10-9. This pump is utilized to fill the steam generators, drain the steam generators, transfer water between steam generators, and recirculate the water in the steam generators. The OTSG recirculation pump can take its suction from several points on either steam generator. The recirculation pump is locally controlled in the reactor building. The recirculation pump is isolated during modes 1, 2, and 3 due to the pressure rating of the piping/components. A permanent connection near the OTSG recirculation pump inlet provides a means for chemical addition for wet lay-up of the OTSGs.

10.4.9 References

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2. W. O. Parker (Duke) letter to H. R. Denton (NRC), April 3, 1981, page 32.
3. ONOE-11376, changes to support multiple unit alignment to the Auxiliary Steam Header.
4. Deleted per 1999 Update
5. NSM ON-13076, NSM ON-23076 and NSM ON-33076, Separation of Air Systems to FDW-315 and FDW-316.
6. NRC Safety Evaluation Report for Oconee Nuclear Station, Units 1, 2, and 3, regarding Seismic Qualification of the EFW System, dated January 14, 1987.
7. NRC Safety Evaluation Report on the Effect of Tornado Missiles on Oconee EFW System, dated July 28, 1989.
8. D. E. LaBarge (NRC) letter to W. R. McCollum, Jr. (Duke), Amendments 234, 234, and 233 to DPR-38, DPR-47, and DPR-55 for Oconee Nuclear Station, Units 1, 2, and 3, respectively, dated December 7, 1998.
9. J. F. Stolz (NRC) letter to W. O. Parker, Jr. (Duke), Safety Evaluation Report for Oconee Nuclear Station, Units 1, 2, and 3, regarding NUREG-0737 Item II.E.1.1, “Auxiliary Feedwater System Evaluation,” dated August 25, 1981.
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16. License Amendment 386, 388 and 387 for DPR-38, DPR-47, DPR-55 for Oconee Nuclear Station Units 1, 2, and 3, respectively, dated August 13, 2014.
17. License Amendment 325, 325 and 326 for DPR-38, DPR-47, DPR-55 for Oconee Nuclear Station Units 1, 2, and 3, respectively, dated June 11, 2002
18. Duke Energy letter to NRC, "Seismic Licensing Basis," May 25, 1994.
19. Duke Energy letter to NRC, "Seismic Licensing Basis," August 18, 1994.

THIS IS THE LAST PAGE OF THE TEXT SECTION 10.4.