10.2 AUXILIARY FEEDWATER SYSTEM (AF)

One turbine (per unit) and two electric-driven (shared by the two units) auxiliary feedwater pumps are provided to ensure that adequate feedwater is supplied to the steam generators for heat removal under all circumstances, including loss of power and normal heat sink. Feedwater flow can be maintained until power is restored or reactor decay heat removal can be accomplished by other systems. The auxiliary feedwater system is designed as a Class I system. A backup supply of auxiliary feedwater can be provided from the Class I portion of the service water system by positioning remotely-operated valves from the control room. See Figure 10.2-1.

10.2.1 DESIGN BASIS

The auxiliary feedwater system is designed to supply high-pressure feedwater to the steam generators in order to maintain a water inventory for removal of heat energy from the reactor coolant system by secondary side steam release in the event of inoperability or unavailability of the main feedwater system. In order to meet the design basis required in the Loss of Normal Feedwater/Loss of All AC analysis, one motor driven auxiliary feedwater pump provides 200 gpm of flow either to one steam generator or split between two steam generators within 5 minutes following receipt of a low-low steam generator water level setpoint signal. Redundant supplies are provided by two pumping systems using different sources of power for the pumps. The design capacity of each system is set so that the steam generators will not boil dry nor will the primary side relieve fluid through the pressurizer relief valves, following a loss of main feedwater flow with a reactor trip.

The AF system performs the following safety-related functions:

The AF system shall automatically start and deliver adequate AF system flow to maintain adequate steam generator levels during accidents which may result in main steam safety valve opening. Such accidents include; LOSS OF NORMAL FEEDWATER (LONF), FSAR Chapter 14.1.10, and LOSS OF ALL AC POWER TO THE STATION AUXILIARIES (LOAC), FSAR Chapter 14.1.11, events. LONF and LOAC are time-sensitive to AF system start-up.

The AF system shall automatically start and deliver sufficient AF system flow to maintain adequate steam generator levels during accidents which require rapid reactor coolant system cooldown to achieve the cold shutdown condition within the limits of the analysis. Such accidents include; STEAM GENERATOR TUBE RUPTURE (SGTR), FSAR Chapter 14.2.4, and MAIN STEAM LINE BREAK (MSLB), FSAR Chapter 14.2.5.

The AF system shall be capable of isolating the AF steam and feedwater supply lines from the ruptured steam generator following a SGTR event.

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The AF system also performs the following functions related to regulatory commitments:

In the event of a station blackout (prolonged loss of offsite and onsite AC power) affecting both units, the AF system shall be capable of automatically supplying sufficient feedwater to remove decay heat from both units without any reliance on AC power for one hour (Reference 1).

In the event of plant fires, including those requiring evacuation of the control room, the AF system shall be capable of manual initiation to provide feedwater to a minimum of one steam generator per unit at sufficient flow and pressure to remove decay and sensible heat from the reactor coolant system over the range from hot shutdown to cold shutdown conditions. The AF system shall support achieving cold shutdown within 72 hours (Reference 2).

10.2.2 SYSTEM DESIGN AND OPERATION

The auxiliary feedwater system consists of two electric motor-driven pumps, two steam turbine-driven pumps, pump suction and discharge piping, and the controls and instrumentation necessary for operation of the system. Redundancy is provided by utilizing two pumping systems, two different sources of power for the pumps, and two sources of water supply to the pumps. The system is categorized as seismic Class I and is designed to ensure that a single fault will not obstruct the system function.

One system utilizes a steam turbine-driven pump for each unit (1/2P-29) with the steam capable of being supplied from either or both steam generators. This system is capable of supplying 400 gpm of feedwater to a unit, or 200 gpm to each steam generator through normally throttled MOVs AF-4000 and AF-4001. The feedwater flowrate from the turbine-driven auxiliary feedwater pump depends on the throttle position of these MOVs. Check valves are provided to help prevent backflow when the pumps are not in service. Each pump has an AOV (AF-4002) controlled recirculation line back to the condensate storage tanks to ensure minimum flow to dissipate pump heat. The pump drive is a single-stage turbine, capable of quick starts from cold standby and is directly connected to the pump. The turbine is started by opening either one or both of the isolation valves (MS-2019 and MS-2020) between the turbine supply steam header and the main steam lines upstream of the main steam isolation valves. The turbine and pump are normally cooled by service water with an alternate source of cooling water from the firewater system.

The other system is common to both units and utilizes two similar motor-driven pumps (P-38A and P-38B), each capable of obtaining its electrical power from the plant emergency diesel generators. Each pump has a capacity of 200 gpm with pump P-38A capable of supplying the A steam generator in either or both units through an AOV back-pressure control valve AF-4012 and normally closed MOVs, AF-4022 and AF-4023, and with pump P-38B capable of supplying the B steam generator in either or both units through an AOV back-pressure control valve AF-4019 and normally closed MOVs AF-4020 and AF-4021. Both back-pressure control valves fail open when instrument air to the valves is lost. The valves are provided with a backup nitrogen supply to provide pneumatic pressure in the event of a loss of instrument air. This backup supply assures that the valves do not move to the full open position which combined with low steam generator pressures may cause the pump motor to trip on time overcurrent due to high flow conditions. Each pump has an AOV, AF-4007 for P-38A and AF-4014 for P-38B, controlled recirculation line back to the condensate storage tanks to ensure minimum flow to prevent hydraulic instabilities and dissipate pump heat. The discharge headers also provide piping, valves, and tanks for chemical additions to any steam generator. The pump bearings are ring lubricated and bearing oil is cooled by service water. Chemicals may be added using the tanks installed in the discharge headers or via a cart built to carry the chemicals and inject them into the suction headers. The use of the cart is preferred for reasons of personnel safety and ease of addition.

The water supply source for the auxiliary feedwater system is redundant. The normal source is by gravity feed from two nominal capacity 45,000 gallon condensate storage tanks while the safety-related supply is taken from the plant service water system whose pumps are powered from the diesel generators if station power is lost.

It is possible that a loss of normal feedwater initiated by a seismic event could also result in the interruption of the normal source of auxiliary feedwater from the condensate storage tanks because the condensate storage tanks are not classified as seismic Class I. The plant operators would be alerted to this problem by receipt of low suction pressure alarms on the auxiliary feedwater pumps. Pump protection is ensured by providing a low suction pressure trip. This trips the motor-driven pump breakers and the turbine-driven pump trip/throttle valves 1MS-2082 and 2MS-2082, to ensure that the pumps are available, after a loss of condensate suction, to be switched to the safety-related water supply. Switchover to the alternate source of seismically qualified auxiliary feedwater, the service water system, can be accomplished by the operators in five minutes or less (Reference 3).

The auxiliary feedwater system has no functional requirements during normal, at power, plant operation. It is used during plant startup and shutdown and during hot shutdown or hot standby conditions when chemical additions or small feedwater flow requirements do not warrant the operation of the main feedwater and condensate systems.

During normal plant operations, the auxiliary feedwater system is maintained in a standby condition ready to be placed in operation automatically when conditions require. The auxiliary feedwater pumps are automatically started on receipt of any of the following signals:

Turbine-driven feedwater pumps

1. Low-low water level in both steam generators in one unit starts the corresponding pump.

2. Loss of both 4.16 kv buses supplying the main feedwater pump motors in one unit starts the corresponding auxiliary feedwater pump.

3. Trip or shutdown of both main feedwater pumps or closure of both feedwater regulating valves in one unit starts the corresponding pump. These signals are processed through AMSAC at power levels above 40%.

Motor-driven feedwater pumps

1. Low-low water level in either associated steam generator.

2. Trip or shutdown of both main feedwater pumps or closure of both feedwater regulating valves in one unit. These signals are processed through AMSAC at power levels above 40%.

3. Safeguards sequence signal.

The Anticipated Transients Without Scram Mitigating System Actuation Circuit (AMSAC) is further discussed in FSAR Section 7.4.

The motor-driven auxiliary feedwater pump discharge motor operated valves are configured to open automatically, based upon the same signals that start the motor-driven pumps. This ensures automatic delivery of auxiliary feedwater flow to an affected unit's steam generators without operator action. Auxiliary feedwater pump flow and direct flow indication for each steam generator is provided in the control room. Flow indication is also available locally at the discharge of each pump.

10.2.3 SYSTEM EVALUATION

In the event of complete loss of offsite electrical power to the station, decay heat removal would continue to be assured for each unit by the availability of either the turbine-driven auxiliary feedwater pump or one of the two motor-driven auxiliary feedwater pumps, and discharge to the atmosphere via the main steam safety valves or atmospheric relief valves. One motor-driven pump is capable of supplying sufficient feedwater for removal of decay heat from a unit operating at a power of 1518.5 MWt. In this case, feedwater is available from the condensate storage tanks by gravity feed to the auxiliary feedwater pumps. When the water in the condensate storage tanks is depleted, suction for the pumps can be shifted to the service water system via remotely operated MOVs from the control room to provide makeup water from the lake for an indefinite time period.

During a Station Blackout (SBO) event, only the turbine-driven pumps would be available for decay heat removal. The turbine-driven pumps are capable of supplying feedwater to the steam generators without an AC power source. The steam supply and auxiliary feedwater discharge valves are powered from diverse sources of vital 125V DC. Cooling water for the pump and turbine bearings can be supplied from the diesel driven firewater pump. The Technical Specification minimum amount of water in the condensate storage tanks, 13,000 gallons per operating unit, provides adequate makeup to the steam generators to maintain each unit in a hot shutdown condition for at least one hour concurrent with a loss of all AC power. Further information on the SBO event is provided in Appendix A.1. (Reference 1)

In order to meet the design basis, the limiting accident analysis of LOSS OF NORMAL FEEDWATER and LOSS OF ALL AC POWER TO THE STATION AUXILIARIES assumes either that one motor driven auxiliary feedwater pump provides 200 gpm of flow to one steam generator or split between two steam generators within 5 minutes following receipt of a low-low steam generator water level setpoint signal.

These minimum parameters are met or exceeded by system design and verified by required testing. The three other accident analyses which assume auxiliary feedwater initiation for mitigation are LOSS OF EXTERNAL ELECTRICAL LOAD, RUPTURE OF A STEAM PIPE, and STEAM GENERATOR TUBE RUPTURE. For these accidents, minimum auxiliary feedwater assumptions are not specified and in the latter two, auxiliary feedwater isolation to the affected steam generator is assumed. Although the auxiliary feedwater system may be initiated during a SMALL BREAK LOCA, the event has been analyzed with no credit for auxiliary feedwater.

Based on the operating characteristics of the minimum recirculation flow control scheme, a portion of each motor-driven auxiliary feedwater pump's discharge flow will be automatically recirculated to the condensate storage tank for approximately forty-five seconds after the pump starts. The forty-five second time delay in closing the mini-flow recirculation control valves is incorporated in the design to provide for pump stability and cooling during coastdown.

A postulated control failure causing a single motor-driven AFW pump recirculation valve (AF-4007 or AF-4014) to fail open will divert approximately 89 gpm pump flow back to the associated steam generator. However, the AFW flow to the steam generators from the other motor-driven pump and the unit turbine-driven pump are not affected by this failure. Similarly, if the control failure causes a single turbine-driven pump recirculation valve (AF-4002) to fail open, the failure will divert approximately 126 gpm of turbine-driven pump flow to the condensate storage tank, but will not affect flow to the steam generators from either motor-driven pump. For either of these control failures, the AFW system will be capable of supplying greater than the required 200 gpm per unit.

A failure analysis has been made and the results for the auxiliary feedwater pumps show that the failure or malfunction of any single active component will not prevent the system from performing its emergency function. Results are presented below.

Malfunction	Comments and Consequences
One AFW pump fails to start (following loss of main feedwater)	Four AFW pumps provided; each steam-driven pump is dedicated to one unit and each motor-driven pump is shared between units. Any three of the four AFW pumps provide the required feedwater flow to remove sufficient decay heat from both units.
Two AFW pumps fail to stop (trip) when required and subsequently run to failure (following a seismic- induced loss of main feedwater event)	Each AFW pump is provided with low suction pressure protection following a seismic event. Evaluations for a seismic-induced LONF event show that any two AFW pumps provide the required feedwater flow to remove sufficient decay heat from both units operating at 1518.5 MWt.

10.2.4 REQUIRED PROCEDURES AND TESTS

The AF system components are tested and inspected in accordance with Technical Specification surveillance criteria and frequencies. Testing verifies motor-driven pump operability, turbine-driven pump operability including a cold start, and operability of all required MOVs. Control circuits, starting logic, and indicators are verified operable by their respective functional test.

10.2.5 REFERENCES

1. FSAR Appendix A.1, Station Blackout

2. PBNP Fire Protection Evaluation Report (FPER)

3. NRC SER "Safety Evaluation on the Resolution of Unresolved Safety Issue A-46 at Point Beach Nuclear Plant Units 1 and 2 (TAC Nos. M69472 and M69473)", Enclosure page 3 of 10, dated July 7, 1998.