ENCLOSURE 1

YANKEE ROWE

AUXILIARY FEEDWATER SYSTEM

X.17.1 System Description

X.17.1.1 Configuration and Overall Design

The auxiliary feedwater system (AFWS) is designed to supply water to the steam generators for reactor coolant system decay heat removal when the normal feedwater system is not available. The AFWS is not normally used for other plant operations such as startup or shutdown. The system can also be used for performing hydrostatic tests during plant shutdown. A dedicated operator for initiating flow for this system is available with direct communication with the control room operator. The auxiliary feedwater (emergency boiler feed pump-EBFP) must be started locally and four normally closed manual valves in parallel in the EBF pump discharge lines must locally opened. After starting the pump, the flow can be controlled from the control room. However, the dedicated operator remains on station even if flow is being controlled from the control room.

The AFWS is shown in simplified form on Figure 1 attached. The system consists of a steam turbine driven positive displacment pump, with steam being supplied from each steam generator into a common header to the pump turbine. Discharge from the pump feeds into a common header which supplies each of four steam generators via the main feedwater piping. Each of the AFWS lines containsa normally closed manual isolation valve. The pump capacity is $\geq$80 gpm at 1200 psi and takes suction from a 30,000 gallon Demineralized Water Tank (DWT).

A secondary source of water is available from a 135,000 gallon Primary Water Storage Tank (PWST). Water from the 135,000 gallon tank is gravity fed to the 30,000 gallon demineralized water tank by opening one manual valve or directly fed to pump suction by opening a different manual valve. Level indication from the 30,000 gallon and 135,000 gallon tanks are provided in the control room, with high and low level alarms in the control room for the 30,000 gallon tank.

A backup method of supplying feedwater to the steam generators in the event of failure in the AFWS is the plant's primary coolant system charging pumps with total capacity of $\sim$100 gpm (33 gpm/pump). Two of the pumps have variable speed motors. The system is connected permanently by a spool piece that connects to the main feedwater header. The operation of ten manual valves (two drains and eight isolation) is required to initiate flow from this source. The water supply to the charging pumps is the 135,000 gallon Primary Water Storage Tank.

The High Pressure Safety Injection and Low Pressure Safety Injection pumps provide another backup method of supplying feedwater to the steam generators. Flow from this source is obtained by the operation of the same manual valves used when the charging system is the source, plus the operation of one of two redundant motor operated valves (MOV). Flow is then directed to the steam generators through the same permanently connected spool piece used for the charging pump path as described above. The flow available from this source is 200 gpm per train (three trains available).

AFW flow is controlled by the normal feedwater control valves in the main feedwater (MFW) lines to the steam generators. The preferred system to be used upon demand is the steam driven turbine pump (AFW) system. The charging pumps or the S.I. pumps are backups to the AFW system. The minimum AFW flow required for decay heat removal is approximately 80 gpm.

The turbine driven pump steam admission valve is a manual valve, which is in the auxiliary steam header. The auxiliary steam header is isolated on receipt of a containment isolation signal by operation of an air operated trip valve. Capability is provided to override the containment isolation signal from the control room. The trip valve also closes on loss of air pressure. An alternate supply of nitrogen is provided (in tanks) in the event of loss of the normal air supply. A number of normally open isolation valves are also located in the header between the admission valve and the trip valve that feeds steam to various steam auxiliary systems.

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X.17.1.2 Component Design Classification

The steam piping and primary piping (charging, SI systems) are non-seismic systems, Safety Class 2, classified in accordance with ANSI 18.2, which requires either safety Class 2 or 3 piping. Control and Instrumentation Systems are non-Class IE.

X.17.1.3 Power Sources

Power for the charging pumps and MOVs is supplied from separate nonsafety 480V AC buses, which are capable of being fed by the emergency 480V AC buses by remote manual operation of circuit breakers. The injection pumps are connected to the 480V emergency buses. Offsite power normally feeds the emergency buses. Diesel generators are automatically connected to the emergency 480V AC buses on loss of offsite power.

The plant electrical bus arrangement consists of three independent divisions of 2400V AC buses, one bus fed by one offsite line, a second fed from an independent offsite line, and the third fed from the unit generator. Capability exists to manually transfer from one supply to the other. The three 2400V AC divisions then feed three independent 480V AC through transformers.

The instrumentation and control power is 120V AC from an inverter connected to the 125V DC battery supply.

X.17.1.4 Instrumentation and Controls

X.17.1.4.1 Controls

The water level for each steam generator is controlled manually from the control room by the feedwater controllers that normally are used in the main feed system lines. Steam generator water level can also be controlled locally at the controllers. All MOVs can be remote manually operated from the control room. The charging pumps and SI pumps can be started from the control room.

X.17.1.4.2 Information Available to the Operator

The following indications are available in the control room:

1. Level Indication - 30,000 gallon demineralized water tank
2. Level Indication - 135,000 gallon PWST
3. Flow to steam generators when SI system used
4. Charging pump discharge pressure
5. Steam generator water level
6. Steam generator steam pressure

X.17.1.4.3 Initiating Signals for Automatic Operation

The AFWS initiation is manual. (See section 17.1.1 for manual operation)

X.17.1.5 Testing

Steam Turbine System

The steam turbine is tested every 15 days and operated for 15 minutes. The discharge pressure is monitored to verify rated output (950 psi).

In addition to the operational test, the valve lineup of the system is verified.

The SI system is tested weekly on a staggered basis. The flow is recirculated to the supply tank and pump current is monitored (vibration tests are performed monthly for both the AFWS and SI system). In addition, at the completion of the operational test, valve position of the system is verified.

X.17.1.6 Technical Specifications

The AFWS must be operable or the unit must be in hot standby in one hour and hot shutdown in next 12 hours.

X.17.1.7 Additional Information

The AFW system is manually actuated, however, approximately one hour of steam generator water inventory is available subsequent to loss of feedwater and reactor shutdown.

The offsite power is exceptionally reliable, having experienced only one outage in 19 years of operation.

No challenges to the AFW system have been made during the entire operational history.

X.17.2 Reliability Evaluation Results

X.17.2.1 Dominant Failure Modes

Failure modes of the AFWS were assessed for three types of initiating transients. The dominant failure modes for each transient type are discussed below.

Loss of MFW with Offsite Power Available

The dominant failure mode of the AFWS for this transient results from a set of human errors. The first human error, which causes the unavailability of the AFWS, is the inadvertent closure of one of six manual valves in the steam supply line to the AFWS pump turbine. Upon a demand for the AFWS, the operator has up to an hour to detect this fault and correct it (i.e., open the valve). An alternative for the operator is to manually open the valves from the charging pumps and supply water to the steam generators from these pumps. Thus, the dominant failure mode is the combination of a human error inadvertently closing one of the steam supply line valves and the error of failing to reopen the valve, or realigning the charging pumps, within about one hour after a demand on the AFWS.

Loss of MFW with Only Onsite AC Power Available

AC power dependencies were considered as potential faults for this analysis. It was concluded that the dependence on onsite power instead of offsite power does not significantly alter the results of the assessment. Thus the dominant failure mode of combinations of human errors before and after the transient event is considered to be dominant for this transient also.

Loss of MFW with Only DC Power Available

For this event, the probability of AFWS failure is reduced to the probability of failure of the steam driven pump train. The dominant failure mode within this train is failure to provide steam to the turbine, caused by the inadvertent closure of any 1 of 6 valves in the steam supply line, coupled with failure to reopen the closed valve(s) within approximately one hour after a demand on the AFWS.

X.17.2.2 Principal Dependencies

Within this plant, the principal dependency is the requirement for human actions, such as valve manipulations, to start the AFWS or the backup systems such as the charging pumps or the safety injection pumps. No other dependencies of significance were identified in this evaluation.

X.17.3 Recommendations for this Plant

The short-term recommendations (both generic, denoted by GS, and plant-specific) identified in this section represent actions to improve AFW system reliability that should be implemented by January 1, 1980, or as soon thereafter as is practicable. In general, they involve upgrading of Technical Specifications or establishing procedures to avoid or mitigate potential system or operator failures. The long-term (both generic, denoted by GL, and plant-specific) recommendations identified in this section involve system design evaluations and/or modifications to improve AFW system reliability and represent actions that should be implemented by January 1, 1981, or as soon thereafter as is practicable.

X.17.3.1 Short-Term

1. Recommendation GS-2 - The licensee should lock open single valves or multiple valves in series in the AFW system pump suction piping and lock open other single valves or multiple valves in series that could interrupt all AFW flow. Monthly inspections should be performed to verify that these valves are locked and in the open position. These inspections should be proposed for incorporation into the surveillance requirements of the plant Technical Specifications. See Recommendation GL-2 for the longer term resolution of this concern.

2. Recommendation GS-4 - Emergency procedures for transferring to alternate sources of AFW supply should be available to the plant operators. These procedures should include criteria to inform the operator when, and in what order, the transfer to alternate water sources should take place. The following cases should be covered by the procedures:

   - The case in which the primary water supply is not initially available. The procedures for this case should include any operator actions required to protect the AFW system pumps against self-damage before water flow is initiated; and,
   - The case in which the primary water supply is being depleted. The procedure for this case should provide for transfer to the alternate water sources prior to draining of the primary water supply.

3. Recommendation GS-5 - The as-built plant should be capable of providing the required AFW flow for at least two hours from one AFW pump train independent of any alternating current power source. If manual AFW system initiation of flow control is required following a complete loss of alternating current power, emergency procedures should be established for manually initiating and controlling the system under these conditions. Since the water for cooling of the lube oil for the turbine-driven pump bearings may be dependent on alternating current power, design or procedural changes shall be made to eliminate this dependency as soon as practicable. Until this is done, the emergency procedures should provide for an individual to be stationed at the turbine-driven pump in the event of the loss of all alternating current power to monitor pump bearing and/or lube oil temperatures. If necessary, this operator would operate the turbine-driven pump in an on-off mode until alternating current power is restored. Adequate lighting powered by direct current power sources and communications at local stations should also be provided if manual initiaton and control of the AFW system is needed. (See Recommendation GL-3 for the longer-term resolution of this concern.)

4. Recommendation GS-6 - The licensee should confirm flow path availability of an AFW system flow train that has been out of service to perform periodic testing or maintenance as follows:

- Procedures should be implemented to require an operator to determine that the AFW system valves are properly aligned and a second operator to independently verify that the valves are properly aligned.
- The licensee should propose Technical Specifications to assure that prior to plant startup following an extended cold shutdown, a flow test would be performed to verify the normal flow path from the primary AFW system water source to the steam generators. The flow test should be conducted with AFW system valves in their normal alignment.

5. Recommendation - The AFW surveillance tests should require that the normally closed manually operated valves in the connection between the charging pumps/safety injection pumps and the AFW system be cycled each quarter.

X.17.3.2 Additional Short-Term Recommendations

The following additional short-term recommendations resulted from the staff's Lessons Learned Task Force review and the Bulletins and Orders Task Force review of AFW systems at Babcock & Wilcox-designed operating plants subsequent to our review of the AFW system design at W- and C-E-designed operating plants. They have not been examined for specific applicability to this facility.

1. Recommendation - The licensee should provide redundant level indications and low level alarms in the control room for the AFW system primary water supply to allow the operator to anticipate the need to make up water or transfer to an alternate water supply and prevent a low pump suction pressure condition from occurring. The low level alarm setpoint should allow at least 20 minutes for operator actions, assuming that the largest capacity AFW pump is operating.

2. Recommendation - The licensee should perform a 72-hour endurance test on all AFW system pumps, if such a test or continuous period of operation has not been accomplished to date. Following the 72-hour pump run, the pumps should be shut down and cooled down then restarted and run for one hour. Test acceptance criteria should include demonstrating that the pumps remain within design limits with respect to bearing/bearing oil temperatures and vibration and that pump room ambient conditions (temperature, humidity) do not exceed environmental qualification limits for safety-related equipment in the room.

3. Recommendation - The licensee should implement the following requirements as specified by Item 2.1.7.b on page A-32 of NUREG-0578:

   "Safety-grade indication of auxiliary feedwater flow to each steam generator shall be provided in the control room.

The auxiliary feedwater flow instrument channels shall be powered from the emergency buses consistent with satisfying the emergency power diversity requirements for the auxiliary feedwater system set forth in Auxiliary Systems Branch Technical Postion 10-1 of the Standard Review Plan, Section 10.4.9."

4. <u>Recommendation</u> - Licensees with plants which require local manual realignment of valves to conduct periodic test on one AFW system train, <u>and</u> there is only one remaining AFW train available for operation should propose Technical Specifications to provide that a dedicated individual who is in communiciation with the control room be stationed at the manual valves. Upon instruction from the control room, this operator would realign the valves in the AFW system train from the test mode to its operational alignment.

X.17.3.3 <u>Long-Term</u>

Long-term recommendations for improving System are as follows:

1. Recommendation - At least one AFW system pump, its associated flow path and essential instrumentation should be capable of being initiated from the control room and being operated independently of any alternating current for at least two hours. Conversion of direct current to alternating current is acceptable.

2. Recommendation - Initiation of AFW flow (including flow from the backup systems-charging/SI) to the steam generators requires several local manual operator actions outside the control room. Even though there is a reasonable time period (up to one hour before the S/G's will boil dry) for operator action and a dedicated operator, the licensee should improve the reliability of initiating AFW flow by providing the capability to start the pumps and open the valves of the AFWS by operator action from the control room. Local manual operation capability should be retained as a backup to remote manual operation capability.

3. Recommendation - A pipe break in the Main Feedwater header upstream of the control valves could cause loss of all AFW flow to all steam generators since the AFW pump and the charging/SI pumps connect to this header. The licensee should evaluate the consequences of a pipe break in this section of the MFW header and 1) determine any system design changes or emergency procedures necessary to detect and isolate the break and direct the required AFW flow to the steam generators before they boil dry or 2) describe how the plant can be brought to a safe shutdown condition by use of other available systems following such a postulated event.

4. Recommendation - The air operated trip valve in the auxiliary steam header which supplies steam to the turbine driven AFW pump closes upon receipt of a containment isolation signal. The

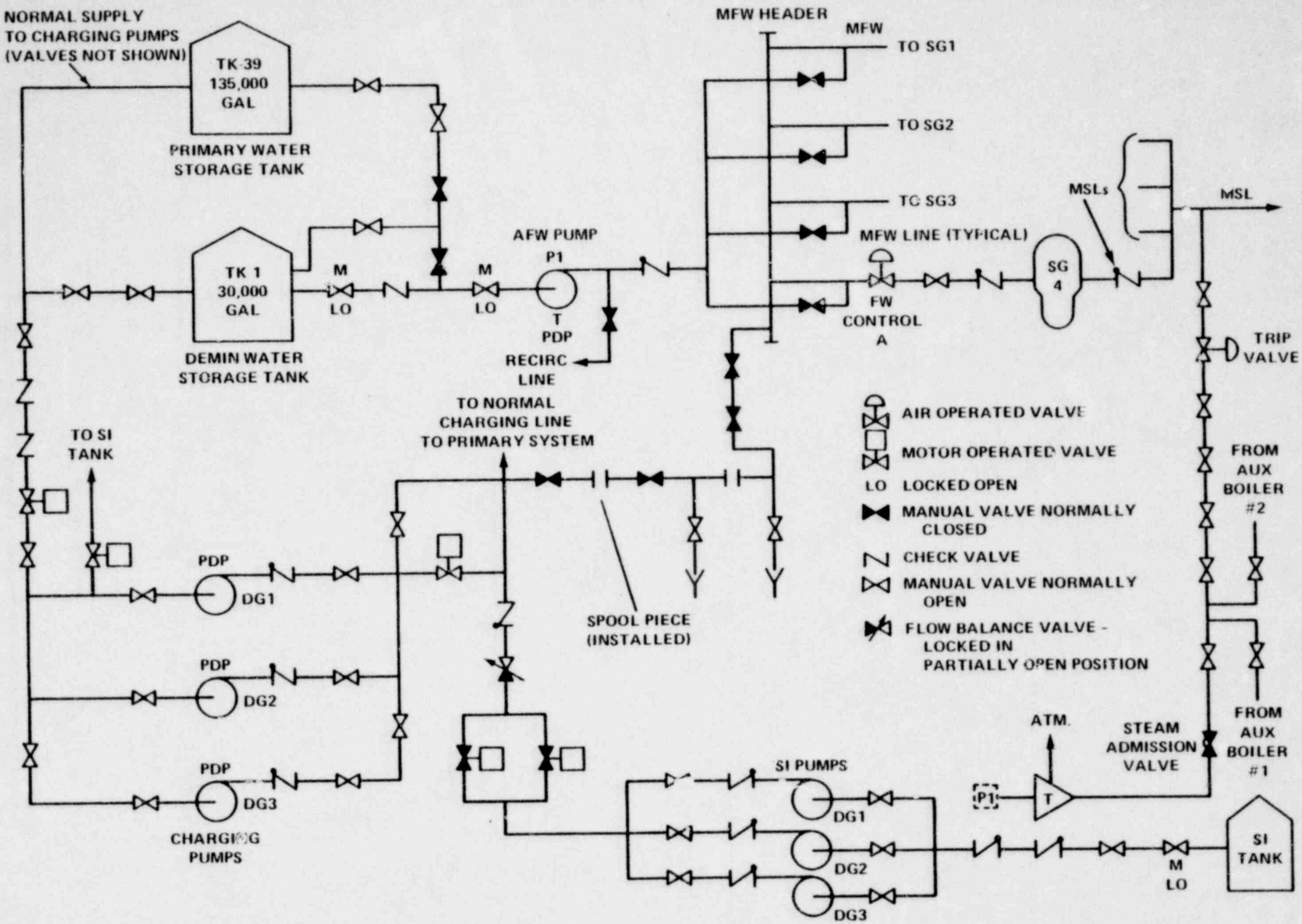
licensee should review the design basis for this circuit logic to determine whether all events that can generate a containment isolation signal should in fact, shutdown the AFWS. As a result of this review, describe any design changes of procedure changes that will be proposed to assure AFW system and containment isolation capability.

5. Recommendation - The licensee should evaluate the need for the charging pumps and associated instruments and control to be normally supplied by the emergency electrical buses since the charging pumps are backups to the one AFW pump.

6. Recommendation - The plant is within the scope of the Systematic Evaluation Program (SEP). The following additional long term concerns have been identified by SEP, and are applicable.

   a. The Yankee Rowe Nuclear Plant including the AFWS will be reevaluated during the SEP with regard to internally and externally generated missiles, pipe whip and jet impingement, quality and seismic design requirements, and earthquakes, tornadoes, and floods.

   b. The Yankee Rowe AFWS is not automatically initiated and the design does not have capability to automatically terminate feedwater flow to a depressurized steam generator and provide flow to the intact steam generator. This is accomplished by manual valve operation,either from the control or locally. The effect of this will be assessed in the main steam line break evaluation for the plant.



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Auxiliary Feedwater System
Yankee Rowe
Figure 1

ENCLOSURE 2

Basis for Auxiliary Feedwater System Flow Requirements

As a result of recent staff reviews of operating plant Auxiliary Feedwater Systems (AFWS), the staff concludes that the design bases and criteria provided by licensees for establishing AFWS requirements for flow to the steam generator(s) to assure adequate removal of reactor decay heat are not well defined or documented.

We require that you provide the following AFWS flow design basis information as applicable to the design basis transients and accident conditions for your plant.

1. a. Identify the plant transient and accident conditions considered in establishing AFWS flow requirements, including the following events:

   1) Loss of Main Feed (LMFW)
   2) LMFW w/loss of offsite AC power
   3) LMFW w/loss of onsite and offsite AC power
   4) Plant cooldown
   5) Turbine trip with and witnout bypass
   6) Main steam isolation valve closure
   7) Main feed line break
   8) Main steam line break
   9) Small break LOCA
   10) Other transient or accident conditions not listed above

   b. Describe the plant protection acceptance criteria and corresponding technical bases used for each initiating event identified above. The acceptance criteria should address plant limits such as:

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- Maximum RCS pressure (PORV or safety valve actuation)
- Fuel temperature or damage limits (DNB, PCT, maximum fuel central temperature)
- RCS cooling rate limit to avoid excessive coolant shrinkage
- Minimum steam generator level to assure sufficient steam generator heat transfer surface to remove decay heat and/or cool down the primary system.

2. Describe the analyses and assumptions and corresponding technical justification used with plant condition considered in 1.a. above including:

   a. Maximum reactor power (including instrument error allowance) at the time of the initiating transient or accident.

   b. Time delay from initiating event to reactor trip.

   c. Plant parameter(s) which initiates AFWS flow and time delay between initiating event and introduction of AFWS flow into steam generator(s).

   d. Minimum steam generator water level when initiating event occurs.

   e. Initial steam generator water inventory and depletion rate before and after AFWS flow commences - identify reactor decay heat rate used.

f. Maximum pressure at which steam is released from steam generator(s) and against which the AFW pump must develop sufficient head.

g. Minimum number of steam generators that must receive AFW flow; e.g. 1 out of 2?, 2 out of 4?

h. RC flow condition - continued operation of RC pumps or natural circulation.

i. Maximum AFW inlet temperature.

j. Following a postulated steam or feed line break, time delay assumed to isolate break and direct AFW flow to intact steam generator(s). AFW pump flow capacity allowance to accommodate the time delay and maintain minimum steam generator water level. Also identify credit taken for primary system heat removal due to blowdown.

k. Volume and maximum temperature of water in main feed lines between steam generator(s) and AFWS connection to main feed line.

l. Operating condition of steam generator normal blowdown following initiating event.

m. Primary and secondary system water and metal sensible heat used for cooldown and AFW flow sizing.

n. Time at hot standby and time to cooldown RCS to RHR system cut in temperature to size AFW water source inventory.

3. Verify that the AFW pumps in your plant will supply the necessary flow to the steam generator(s) as determined by items 1 and 2 above considering a single failure. Identify the margin in sizing the pump flow to allow for pump recirculation flow, seal leakage and pump wear.

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