APPENDIX 10.4.9A

EMERGENCY FEEDWATER SYSTEM

REQUIREMENTS EVALUATION

This Evaluation is documented in Tables

10.4.9A-1, 10.4.9A-2, and 10.4.9A-3.

TABLE 10.4.9A-1 (Sheet 1 of 7) Revision 15 (03/07)

EVALUATION OF THE WATERFORD SES UNIT NO.3 EMERGENCY FEEDWATER SYSTEM VERSUS THE REQUIREMENTS OF STANDARD REVIEW PLAN (SRP) 10.4.9 AND BRANCH TECHNICAL POSITION (BTP) ASB 10-1

A. SRP 10-4.9 Rev. 1

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
Acceptability of the design of the Auxiliary Feedwater System, as described in the applicant's Safety Analysis Report (SAR), is based on specific general design criteria and regulatory guides. Listed below are the specific criteria as they relate to the AFS.		
1. General Design Criterion 2, as related to structures housing the system and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods.	The EFS is designated seismic Category I. EFS pumps their controls, and the Condensate Storage Pool are located inside the RAB and are thus protected from site related phenomena such as tornadoes, hurricanes and floods. The EFS isolation valves and the Turbine Steam Supply Valves are located in the open area on top of the RAB and are protected by the RAB walls from flooding and direct tornado and hurricane winds. Additional makeup water for the EFS may be obtained from the Wet Cooling Tower (WCT) basins, which are designated seismic Category I and designed to withstand the effects of tornadoes, hurricanes and floods.	10.4.9.3.2, 9.2.5.3.3, Table 3.2-1 NRC Q.371-11
→(DRN 06-907, R15) 2. General Design Criterion 4, with respect to structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks. ←(DRN 06-907, R15)	The EFS pumps, their controls, and the Condensate Storage Pool are located inside the RAB and are are thus protected from external missiles; the EFS isolation and impingement forces associated with pipe breaks. Turbine Steam Supply Valves located in the open area on top of the RAB and are protected from tornado missiles by grating installed above the valves.	10.4.9.3.2, 3.5, Table 3.5-3
	The EFS is designed to withstand the effects of internally generated missles. This subject is discussed in Section 3.5 and summarized for the EFS in Table 3.5-3.	10.4.9.3 3.5

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
	The EFS is protected from the effects of pipe rupture. Each motor driven pump is located in its own room; the turbine driven pump is located away from high from high energy systems. The EFS isolation valves and the Turbine Steam Supply Valves are located adjacent to the break exclusion area portion of the main steam and feedwater piping. Otherwise, design features, such as separation, pipe whip restraints and barriers ensure that pipe break, will not impair the functional capability of the EFS.	3.6, 10.4.9
3. General Design Criterion 5, as related to the capability of shared systems and components important to safety to perform required safety functions.	Not Applicable	
➔(EC-41355, R307) 4. General Design Criterion 19, as related to the design capability of system instrumentation and controls for prompt hot shutdown of the reactor and potential capability for subsequent cold shutdown. ←(EC-41355, R307)	The EFS is automatically initiated by an Emergency Feedwater Actuation Signal (EFAS) as described in Section 7.3. The EFS can also be started manually from the Main Control Room and the auxiliary control panel. Safety related display information located in the main control room provides the operator with sufficient information to perform the required safety functions. See Section 7.5. Procedures are established for operating manual handwheel overrides or lining up backup air supplies for continued safety function after 10 hour mission time of the safety related motive gas accumulator.	10.4.9, 7.3.1.1.6, 7.5
5. General Design Criterion 44, to assure: ➔(DRN 00-786, R11-A) a. The capability to transfer heat loads from the reactor system to a heat sink under both normal operating and accident conditions. ←(DRN 00-786, R11-A)	The EFS supplies sufficient cooling water to the steam generators following loss of normal feedwater or main steam or main feedwater line break to provide cooldown of the Reactor Coolant System to the temperature and pressure at which the Shutdown Cooling System can be placed in operation.	10.4.9

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	ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
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	b. Redundancy of components so that under accident conditions the safety function can be performed assuming a single active component failure. (This may be coincident with the loss of offsite power for certain events.)	The EFS is designed to perform its safety functions assuming a single active component failure coincident with a loss of offsite power. The turbine driven EFS pump or both motor driven pumps together have been designed to provide 100% of the flow necessary for residual heat removal over the entire range of reactor operation including all postulated design basis accidents. However, it has been determined that under realistic conditions, any one EFS pump can supply adequate flow for decay heat removal to one (400 gpm required) or both (450 gpm total required) steam generators.	10.4.9
←			
	c. The capability to isolate components, subsystems, or piping if required so that the system safety function will be maintained.	The EFS isolation valves are powered from Redundant Class 1E dc buses to ensure that the emergency feedwater flow to the affected steam generator would be shut off, and at least one path would remain open to admit emergency feedwater to the intact steam generator when required, assuming a single active failure.	10.4.9
6.	General Design Criterion 45, as related to design provisions made to permit periodic inservice inspection of system components and equipment.	Provisions have been made in the design and layout of the EFS to allow for compliance with the inservice inspection requirements of ASME Code Section XI. The inservice inspection program will be submitted to the NRC at least six months prior to first refueling.	6.6

	ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
7.	General Design Criterion 46, as related to design provisions made to permit appropriate functional testing of the system and components to assure structural integrity and, leak-tightness, operability and performance of active components, and capability of the integrated system to function as intended during normal, shutdown and accident conditions.	The EFS shall undergo preopoperational tests to ensure its ability to function as intended. A description of this test is contained in Section 14.2.12.2.68.	14.2.12.2.68
		The EFS shall also undergo periodic functional testing of the system and its components to ensure the system functions as intended. These tests shall be conducted in accordance with the surveillance requirements of the plant technical specifications.	Technical Specification 4.7.1.2.
8.	Regulatory Guide 1.26, as related to the quality group classification of system components.	The design and fabrication of the EFS meet the requirements of Regulatory Guide 1.26. The safety class 2 and 3 portions of the EFS meet the Regulatory Guide 1.26 Quality Group B and C standards respectively.	3.2.2 Table 3.2-1
9.	Regulatory Guide 1.29, as related to the seismic design classification of system components.	The EFS meets the requirements of Regulatory Guide 1.29. It is designated as Seismic Category I and will thus perform its design functions following the SSE. The pertinent quality assurance requirements of Appendix B to 10CFR50 are applied.	10.4.9, 3.2.1, Table 3.2-1
10.	Regulatory Guide 1.62, as related to design provisions made for manual initiation of each protective action.	The EFS meets the requirements of Regulatory Guide 1.62. The operator may manually initiate the Emergency Feedwater Actuation Signal (EFAS) from an easily accessible location in the control room (RTG Board). Manual initiation will ensure that protective action goes to completion.	7.3.1.1.6, 7.3.2.1.2
→(DRN 00-786, R11-A; EC-42115, R307) 11.	Regulatory Guide 1.102, as related to the protection of structures, systems, and components important to safety from the effects of flooding.	The Waterford 3 Nuclear Plant Island Structure (NPIS) is a reinforced box structure with solid exterior walls and is flood protected up to elevation +30 ft. MSL. This is sufficient to accommodate at the Design Basis Flood identified in Regulatory Guide 1.59. The technical specification requirements of Regulatory Guide 1.02 position C.2 are therefore optional.	2.4.10 Technical Requirements Manual 3/4.7.5

←(DRN 00-786, R11-A; EC-42115, R307)

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
→(EC-42115, R307)		
	However, due to the nature of potential flooding, Technical Requirements Manual 3/4.7.5 which meets the intent of that Regulatory Guide position has been established. In regard to position C.3 of the guide it has been determined that all roofs housing safety related structures can safety store the maximum possible ponding reresulting from the PMP. See also item I above.	
←(EC-42115, R307)		
12. Regulatory Guide 1.117, as related to the protection of structures, systems, and components important to safety from the effects of tornado missiles	The EFS is protected from the effects of tornado as described in item 2 above.	
13. Branch Technical Position ASB 3-1 and MEB 3-1, as related to breaks in high and moderate energy piping systems outside containment.	The EFS is protected from the effects of pipe rupture as described in item 2 above.	
	The EFS itself is used only for emergency shutdown of the reactor when the Main Feedwater System is inoperative. Therefore in accordance with the APCSB 3-1, it is not analyzed as a high energy system. However, the EFS has been analyzed as a moderate energy system in accordance with the Branch Technical Position MEB 3-1.	3.6 3.6A
14. Branch Technical Position ASB 10-1, as related to auxiliary feedwater pump drive and power supply diversity.	See part B	

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B. BTP ASB 10-1 (DESIGN GUIDELINES FOR AUXILIARY FEEDWATER SYSTEM PUMP DRIVE AND POWER SUPPLY DIVERSITY FOR PRESSURIZED WATER REACTOR PLANTS)

	BRANCH TECHNICAL POSITION	COMPLIANCE	FSAR REFERENCE
1.	The auxiliary feedwater system should consist of at least two full-capacity, independent systems that include diverse power sources.	The EFS consists of two motor driven pumps, each with a design flow capacity of 395 gpm (45 gpm recirculation included and powered from separate, redundant Class 1E 4.16 KV buses, and one 780 gpm (80 gpm recirculation included) turbine driven pump. The turbine driven pump or both motor driven pumps together have been designed to provide 100% of the flow necessary for residual heat removal over the entire range of postulated design basis accidents. However it has been determined that under realistic conditions, any one EFS pump can supply adequate flow for decay heat removal to one (400 gpm required) or both (450 gpm total required) steam generators.	10.4.9
2.	Other powered components of the auxiliary feedwater system should also use the concept of separate and multiple sources of motive energy. An example of the required diversity would be two separate auxiliary feedwater trains, each capable of removing the afterheat load of the reactor system, having one train powered from either of two ac sources and the other train wholly powered by steam and dc electric power.	The turbine driven pump, system safety controls, and turbine steam supply valves are powered from the SA/B Class 1E 125V dc bus. The EFS isolation valves are also fail-open and powered from Class 1E 125 dv buses. This ensures that flow to the depressurized steam generator can be terminated and at least one path to the intact steam generator will be available assuming any single active failure.	
→(DRN 00-786)			
3.	The piping arrangement, both intake and discharge, for each train should be designed to permit the pumps to supply feedwater to any combination of steam generators. This arrangement should take into account pipe failure, active component failure, power supply failure, or control system failure that could prevent system function. One arrangement that would be acceptable is crossover piping containing valves that can be operated by remote manual control from the control room, using the power diversity principle for the valve operators and actuation systems.	The piping arrangement is designed to permit the pumps to supply feedwater to any combination of steam generators. Waterford 3 uses the crossover piping scheme. This is described in FSAR Section 10.4.9 and shown in the schematic of Figure 10.4-6. The EFS exceeds this BTP criteria in that the pipelines to each steam generator are isolated by four pneumatically operated fail open isolation valves. The power diversity designed into the system is summarized above. The design of the EFS thus ensures that in the event of a single failure it can supply water to one or both steam generators, and that water could be prevented from entering the ruptured line during the postulated main steam feedwater line break.	10.4.9
←(DRN 00-786)			

	BRANCH TECHNICAL POSITION	COMPLIANCE	FSAR REFERENCE
4.	The auxiliary feedwater system should be designed with suitable redundancy to offset the consequences of any single active component failure; however, each train need not contain redundant active components.		
→ 5.	When considering a high energy line break, the system should be so arranged as to assure the capability to supply necessary emergency feedwater to the steam generators, despite the postulated rupture of any high energy section of the system, assuming a concurrent single active failure. ←	The Waterford 3 EFS is not used during normal reactor startup, hot standby or shutdown. It is only used for emergency shutdown when main feedwater is inoperative. In accordance with the definition and criteria of APCSB 3-1, the EFS is not a high energy system. However, the EFS has been analysed as a moderate energy system in accordance with Branch Technical Position MEB 3-1.	3.6, 3.6A

TABLE 10.4.9A-2 (Sheet 1 of 11)

EVALUATION OF THE WATERFORD SES UNIT NO.3 EMERGENCY FEEDWATER SYSTEM
VERSUS THE NRC EFW SHORT AND LONG TERM RECOMMENDATIONS

A. Short Term Recommendations

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
1) 5.2.1 Technical Specification Time Limit on AFW System Train Outage		
Concern - Several of the plants reviewed have Technical Specifications that permit one of the AFW system trains to be out of service for an indefinite time period. Indefinite outage of one train reduces the defense-in-depth provided by multiple AFW system trains.		
Recommendation GS-1 - The licensee should propose modifications to the Technical Specifications to limit the time that one AFW system pump and its associated flow train and essential instrumentation can be inoperable. The outage time limit and subsequent action time should be as required in current Standard Technical Specifications; i.e., 72 hours, respectively.	Waterford Emergency Feedwater System limiting conditions for operation and surveillance requirements state that an inoperable EFS train restored to operable status in 72 hours or be in hot shutdown within the next 12 hours. This is in accordance with current standard Technical Specifications.	Technical Specifications 3/4.7.1.2
2) 5.2.2 Technical Specification Administrative Controls on Manual Valves - Lock and Verify Position		
Concern - Several of the plants reviewed use a single manual valve or multiple valves in series in the common suction piping between the primary water source and the AFW system pump suction. At some plants the valves are locked open, while at others, they are not locked in position. If the valves are inadvertently left closed, the AFW system would be inoperable, because the water supply to the pumps would be isolated. Since there is no remote valve position indication for these valves, the operator has no immediate means of determining valve position.		
Further, the Technical Specifications for plants with locked-open manual valves do not require periodic inspection to verify that the valves are locked in the correct position. For most plants where the valves are not locked open, valve position is verified on some periodic basis.		

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ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
Recommendation GS-2 - The Licensee should lock open single valves or multiple valves in series in the AFW 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 are located 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.	All manually operated valves in EFS suction are locked open and are provided with limit switches for position monitoring by plant computer. In addition, the Waterford EFW system has redundant, parallel flow paths (piping and valves) so that there is no single valve which if left closed, could interrupt all flow.	10.4.9.2 Figure 10.4-6
3) 5.2.3 AFW System Flow Throttling-Water Hammer Concern - Several of the plants reviewed apparently throttle down the AFW system initial flow to eliminate or reduce the potential for water hammer. In such cases, the overall reliability of the AFW system can be adversely affected.		
Recommendation GS-3 - The licensee has stated that it throttles AFW system flow to avoid water hammer. The Licensee should re-examine the practice of throttling AFW system flow to avoid water hammer. The Licensee should verify that the AFW system will supply on demand sufficient initial flow to the necessary generators to assure adequate decay heat removal following loss of main feedwater flow and reactor trip from 100% power. In cases where this reevaluation results in an increase in initial AFW system flow, the licensee should provide sufficient information to demonstrate that the required initial AFW system flow will not result in plant damage due to water hammer.	The Waterford 3 EFS does not throttle flow to avoid water hammer. The EFS will supply on demand sufficient initial flow to assure adequate decay heat removal. Water hammer considerations have been taken into account in the final design.	10.4.9.3.4
4) 5.2.4 Emergency Procedures for Initiating Backup Water Supplies Concern - Most of the plants do not have written procedures for transferring to alternate sources of AFW supply if primary supply is unavailable or exhausted. Without specific criteria and procedures for an operator to follow to transfer to alternate water sources, the primary supply could be exhausted and result in pump damage or a long interruption of AFW flow.		

TABLE 10.4.9A-2 (Sheet 3 of 11)

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
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: (1) The case in which the primary water supply is initially available. The procedures for this case should include any operator action required to protect the AFW system pumps against self-damage before water flow is initiated. (2) 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.	Primary EFS water supply is provided by the Condensate Storage Pool (CSP). Alternate EFS water supply is provided by the Wet Cooling Tower (WCT) basins. Procedures will be provided on Waterford which will include criteria to inform the operator when, and in what order, the transfer to the alternate water supply should take place.	
5) 5.2.5 Emergency Procedures for Initiating AFW Flow Following a Complete Loss of Alternating Current Power		
Concern - Some operating plants depend on ac power for all sources of AFW system supply including turbine-driven pump train. In the event of loss of offsite and onsite ac power, ac-dependent lube oil supply or lube oil cooling for the pump will stop, and/or manual actions are required to initiate AFW flow from the turbine-driven pump by manually opening the turbine steam admission valve and/or AFW system flow control valves. There are no procedures available to the plant operators for AFW system initiation and control under these conditions. This could result in a considerable time delay for AFW system initiation, since the operators would not be guided by procedures dealing with this event.		
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 ac power source. If manual AFW system initiation or flow control is required following a complete loss of ac 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 ac power, design or procedural changes shall be made to eliminate this dependency as soon as practicable Until this is done, the emergency proceures should provide for an individual to be stationed at the turbine driven pump in- the event of the loss of all ac power to monitor pump	The EFS turbine-driven pump is independent of ac power. Lube oil supply is internal to the pump and therefore requires no oil pump. Cooling water for the turbine oil cooler is supplied from an extraction point on the first stage of the pump. The turbine steam supply valves (TSSV) are motor operated, fail as is valves, powered from the A/B dc bus.	10.4.9

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
→ bearing and/orlube oil temperatures. If necessary, this operator would operate the turbine-driven pump in an on-off mode until ac power is restored. Adequate lighting powered by direct current (dc) power sources and communications at local stations should also be provided if manual initiation and control of the AFW system is needed. (See Recommendation GL-3 for the longer term resolution of this concern.)	The EFS system pipeline to each steam generator consists of two parallel branches, each with an isolation valve and a flow control valve. The isolation valves are pneumatically operated, fail open, and are controlled by redundant, Class 1E 125V dc buses. The primary and backup control valves are pneumatically operated, fail open, and the E/P's receive their signal from redundant PAC cabinets.	
6) 5.2.6 AFW System Flow Path Verification Concern - Periodic testing of the AFW system is accomplished by testing of individual components of one flow train (periodic pump recirculation flow test or automatic valve actuation), thus altering the normal AFW system flow path(s). The flow capability of the entire AFW system, or at least one integral AFW system train, is only demonstrated on system demand following a transient, or if the AFW system is used for normal plant startup or shutdown. Recent Licensee Event Reports indicate a need to improve the quality of system testing and maintenance. Specifically, periodic testing and maintenance procedures inadvertently result in (1) more than one AFW system flow train being unavailable during the test, or (2) the AFW system flow train under test not being properly restored to its operable condition following the test or maintenance work. The Office of Inspection and Enforcement has taken action to correct Item (1): the recommendation below is made to correct Item (2).		
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: ← (1) 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.	Waterford 3 maintenance procedures will be implemented requiring operator to determine that the EFS valves are properly aligned and a second operator to independently verify that the valves are properly aligned.	Technical Specifications 3/4.7.1.2
(2) 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.	In addition, Technical Specifications have been provided to assure that, prior to plant startup following any cold shutdown 30 days or longer, or whenever feedwater line cleaning through the emergency feedwater line has been performed, a test will be performed to verify the normal flow path from the primary EFS water source to the steam generators. This flow test will be conducted during cold shutdown, with EFS valves in the normal alignment for EFS flow from the primary water source to the steam generators.	Technical Specifications 3/4.7.1.2

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	ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
7)	5.2.7 Non-Safety Grade, Non-Redundant AFW System Automatic Initiation Signals		
	Concern - Some plants with an automatically initiated AFW system utilize some initiaiton signals that are not safety-grade do not meet the single failure criterion, and are not required by the Technical Specification to be tested periodically. This can result in reduced reliability of the AFW system.		
	Recommendation GS-7 - The licensee should verify that the automatic start AFW system signals and associated circuitry are safety-grade. If this cannot be verified, the AFW system automatic initiation system should be modified in the short-term to meet the functional requirements listed below. For the longer-term, the automatic initiation signals and circuits should be upgraded to meet safety-grade requirements, as indicated in Recommendation GL-5.	Waterford Emergency Feedwater System signals and circuits are all safety related Class 1E. The Waterford EFS is in accordance with Recommendation GS-7.	7.3
	(1) The design should provide for the automatic initiation of the AFW system flow.		
	(2) The automatic initiation signals and circuits should be designed so that a single failure will not result in the loss of AFW system function.		
	(3) Testability of the initiation signals and circuits shall be a feature of the design.		
	(4) The initiation signals and circuits should be powered from the emergency buses.		
	(5) Manual capability to initiate the AFW system from the control room should be retained and should be implemented so that a single failure in the manual circuits will not result in the loss of system function.		
	(6) The ac motor-driven pumps and valves in the AFW system should be included in the automatic actuation (simultaneous and/or sequential) of the loads to the emergency buses.		
	(7) The automatic initiation signals and circuits shall be designed so that their failure will not result in the loss of manual capability to initiate the AFW system from control room.		

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
8) 5.2.8 Automation Initiation of AFW Systems		
Concern - For plants with a manually initiated AFW system there is the potential for failure of the operator to manually actuate the system following a transient in time to reassure reactor decay heat removal via the steam generator(s). While IE Bulletin 79-06A requires a dedicated individual for W-design operating plants with a manually initiated AFW system, further action should be taken in the short-term. This concern is identical to Item 2.1.7a of NUREG-0578.		
Recommendation GS-8 - The licensee should install a system to automatically initiate AFW system flow. This system need not be safety-grade; however, in the short-term, it should meet the criteria listed below, which are similar to Item 2.1.7a of NUREG-0578. For the long-term, the automatic initiation signals and circuits should be upgraded to meet safety-grade requirements, as indicated in Recommendation GL-2.	Waterford Emergency Feedwater System is automatically initiated. The Waterford EFS is in accordance with Recommendation GS-8.	10.4.9
(1) The design should provide for the automatic initiation of the AFW system flow.		
(2) The automatic initiation signals and circuits should be designed so that a single failure will not result in the loss of AFW system function.		
(3) Testability of the initiation signals and circuits shall be a feature of the design.		
(4) The initiation signals and circuits should be powered from the emergency buses.		
(5) Manual capability to initiate the AFW system from the control room should be retained and should be implemented so that a single failure in the manual circuits will not result in the loss of system function.		
(6) The ac motor-driven pumps and valves in the AFW system should be included in the automatic actuation (simultaneous and/or sequential) of the loads to the emergency buses.		
(7) The automatic initiation signals and circuits shall be designed so that their failure will not result in the loss of manual capability to initiate the AFW system from control room.		

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
9) 5.3.1 Primary AFW Water Source Low Level Alarm Concern - Plants which do not have level indication and alarm for the primary water source may not provide the operator with sufficient information to properly operate the AFW system. → Recommendation - The licensee should provide redundant level indication 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 action, assuming that the largest capacity AFW pump is operating. ←	The Condensate Storage Pool (CSP), the primary EFS water source, has redundant, safety grade level indication and low level alarms in the control room. The low level alarm setpoint is at the Technical Specifications minimum useable volume of 170,000 gallons and includes uncertainty. A low-low level alarm is initiated in the control room when the water inventory in the CSP is depleted to not less than 30,000 gallons usable volume. This amount is sufficient to supply water to one 700 gpm capacity pump or two 450 gpm capacity pumps for at least 30 minutes (See A.5b).	10.4.9
10) 5.3.2 AFW Pump Endurance Test Concern - Since it may be necessary to rely on the AFW system to remove decay heat for extended periods of time, it should be demonstrated that the AFW pumps have the capability for continuous operation over an extended period without failure. → 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 and then restarted and run for one hour. Test acceptance criteria should include demonstrating that the pumps remain within design limits with respect 10 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. ←	In accordance with staff's position on endurance tests for EFS pumps set forth NUREG-0800 10.4.III.3, a 48 hour endurance test has been performed on the Waterford 3 EFS pumps.	
11) 5.3.3 Indication of AFW Flow to the Steam Generators Concern - Indication of AFW flow to the steam generators is considered important to the manual regulation of AFW flow to maintain the required steam generator water level. This concern is identical to Item 2.1.7.b of NUREG-0578.		

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
Recommendation - The licensee should implement the following requirements as specified by Item 2.1.7.b on page A-32 of NUREG-0578: steam generator level indication is (1) Safety-grade indication of AFW flow to each steam generator should be provided in the control room. (2) The AFW flow instrument channels should be powered from the emergency buses consistent with satisfying the emergency power diversity requirements for the AFW system set forth in Auxiliary Systems Branch Technical Position 10-1 of the Standard Review Plan, Section 10.4.9.	Safety grade emergency feedwater flow indication and safety grade, redundant available to the operator in the control room. These instrument loops are powered by the uninterruptible 120V ac Class 1E power source.	7.3.1.1.6, Table 7.5-1
12) 5.3.4 AFW System Availability During Periodic Surveillance Testing		
Concern - Some plants require local manual realignment of valves to conduct periodic pump surveillance tests on one AFW system train. When such plants are in this test mode and there is only one remaining AFW system train available to respond to a demand for initiation of AFW system operation, the AFW system redundancy and ability to withstand a single failure are lost. ➔(DRN 00-786, R11-A; EC-41355, R307)		
Recommendation - Licensees with plants which require local manual realignment of valves to conduct periodic tests on one AFW system train and which have only one remaining AFW train available for operation should propose Technical Specifications to provide that a dedicated individual who is in communication 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 from the test mode to its operational alignment. ←(EC-41355, R307)	Procedures are established for testing manual handwheel overrides on the EFS Flow Control Valves. The procedure performs a single stroke and then restores the valve to the operational alignment. Other than this brief manual realignment, local manual realignment of valves to conduct surveillance tests on EFS trains is not required. Periodic pump surveillance tests can be conducted by merely starting the pump and water will be pumped from the CSP through the mini-flow recirculation lines back to the CSP. The manual handwheel override test will have specific instructions regarding the need to immediately restore the handwheel position to normal upon any interruption of the test.	10.4.9.2
B. 5.4 Long-Term Recommendations		
1) 5.4.1 Automatic Initiation of AFW Systems		
Concern - This concern is the same as short-term generic recommendation GS-8; namely, failure of an operator to actuate a manual start EFW in time to maintain steam generator water level high enough to assure decay heat removal via the steam generator(s).		
Recommendation GL-1 - For plants with a manual AFW system, the licensee should install a system to automatically initiate the AFW system flow. This system and associated automatic ←(DRN 00-786, R11-A)	Not applicable. Waterford 3 initiation is automatic, safety grade, and redundant.	10.4.9, 7.3.1.1.6, 7.3.1.1.1

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
initiation signals should be designed and installed to meet safety-grade requirements. Manual AFW system start and control capability should be retained with manual start serving as backup to automatic AFW system initiation.		
2) 5.4.2 Single Valves in the AFW System Flow Path		
Concern - This is the same short-term generic recommendation GS-2 - namely, AFW system inoperability due to an inadvertently closed manual valve that could interrupt all AFW system flow.		
Recommendation GL-2 - Licensees with plant design in which all (primary and alternate) water supplies to the AFW systems pass through valves in the single flow path should install redundant parallel flow paths (piping and valves). Licensees with plant designs in which the primary AFW system water supply passes through valves in a single flow path, but the alternate AFW system water supplies connect to the AFW system pump suction piping downstream of the above valve(s), should install redundant valves parallel to the above valve(s) or provide automatic opening of the valve(s) from the alternate water supply upon low pump suction pressure. The licensee should propose Technical Specifications to incorporate appropriate periodic inspections to verify the valve positions into the surveillance requirements.	All manually operated valves in EFS suction are locked open and are provided with limit switches for position indication in the control room. In addition, the Waterford EFS system has redundant, parallel flow paths (piping and valves) so that there is no single valve which if left closed, could interrupt all flow.	10.4.9, Figure 10.4-6
3) 5.4.3 Elimination of AFW System Dependency on Alternating Current Power Following A Complete Loss of Alternating Current Power		
Concern - This concern is the same as short-term generic recommendation GS-5 namely, delay in initiation of AFW system operation or maintaining AFW system operation following a postulated loss of onsite and offsite ac power; i.e., ac power blackout. ➜ Recommendation GL-3 - At least one AFW system pump and its associated flow path and essential instrumentation should automatically initiate AFW system flow and be capable of being operated independently of any ac power source for at least two hours. Conversion of dc power to ac power is acceptable. ←	Waterford's EFS turbine-driven pump is dc controlled and capable of being operated independently of ac power for at least four hours. The turbine steam supply valves are motor operated, fail as is valves, from A/B dc bus. The EFS system pipeline to each steam generator consists of two parallel branches, each with an isolation	10.4.9, 8.1A

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
→	valve and a flow control valve. The isolation valves are pneumatically operated, fail open, and are controlled by redundant, Class 1E, 125V dc buses. The primary and backup control valves are pneumatically operated, fail open, and the E/P's receive their signal from redundant PAC cabinets.	
4) 5.4.4 Prevention of Multiple Pump Damage due to Loss of Suction Resulting From Natural Phenomena ←		
Concern - In many of the operating plants, the normal water supply to the AFW systems pumps (including the interconnected piping) is not protected from earthquakes or tornadoes. Any natural phenomenon severe enough to result in a loss of the water supply could also be severe enough to cause a loss of offsite power with loss of main feedwater, resulting in an automatic initiation signal to start the AFW system pumps. The pumps would start without any suction head, leading to cavitation and multiple pump damage in a short period of time, possibly too short for the operators to take action that would protect the pumps. This may lead to unacceptable consequences for some plants, due to a complete loss of feedwater (main and auxiliary).		
Recommendation GL-4 - Licensees having plants with unprotected normal AFW system water supplied should evaluate the design of their AFW systems to determine if automatic protection of the pumps is necessary following a seismic event of a tornado. The time available before pump damage, the alarms and indications available to the control room operator, and the time necessary for assessing the problem and taking action should be considered in determining whether operator action can be relied on to prevent pump damage. Consideration should be given to providing pump protection by means such as automatic switchover of the pump suctions to the alternate safety-grade source of water, automatic pump trips on low suction pressure, or upgrading the normal source of water to meet seismic Category I and tornado requirements.	Not applicable. The normal water supply to the EFS system is the Condensate Storage Pool (CSP). The CSP is located inside the Reactor Auxiliary Building and thus is protected from site related phenomena. The CSP is also designed as seismic Category I. The EFS isolation valves and TSSV are located atop the RAB and are protected from flooding and direct hurricane and tornado winds by the RAB walls. The valves are designed to withstand the pressure differential induced by a tornado and are protected by a grating against tornado missiles.	10.4.9
5) 5.4.5 Non-Safety Grade, Non-Redundant AFW System Automatic Initiation Signals		
Concern - This concern is the same as short-term generic recommendation GS-7 - namely, reduced AFW system reliability as a result of use of non-safety-grade, non-redundant signals, which are not periodically tested, to automatically initiate the AFW system.		

Table 10.4.9A-2 (Sheet 11 of 11) Revision 6 (12/92)

ACCEPTANCE CRITERIA	COMPLIANCE	FSAR REFERENCE
→ Recommendation GL-5 - The licensee should upgrade the AFW system automatic initiation signals and circuits to meet safety-grade requirements. ←	Waterford 3 EFS automatic initiation signals and circuits are safety-grade.	7.3.1.1.6

TABLE 10.4.9A-3 (Sheet 1 of 4)

COMPARISON OF WATERFORD EFW SYSTEM WITH NRC EFW 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 without 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.

1. a. The design bases for the Waterford 3 Emergency Feedwater System (EFS) are described in Subsections 10.4.9 and 10.4.9.1 of the FSAR. The adequacy of the EFS during transient and accident conditions is shown in Chapter 15 of the FSAR, for each event where EFS is required to function. The following references are provided to show where each of the events listed in the question have been considered.

   1. Loss of Main Feed - FSAR Subsection 15.2.2.5
   2. Loss of Main Feed w/loss of offsite power - FSAR Subsection 15.2.3.2
   3. Loss of Main Feed w/loss of onsite and offsite power - FSAR Subsection 10.4.9.1(f)
   4. Plant Cooldown, FSAR Subsection 10.4.9.1(a)(2)
   5. a. Turbine Trip with bypass. If the Trubine Bypass System functions, it follows that the main condenser is operable and emergency feedwater actuation is not required.

      b. Turbine trip without Bypass. FSAR Subsection 10.4.9.1(b)
   6. MSIV Closure. FSAR Subsection 10.4.9.1(b)
   7. Main Feed Line Break. FSAR Subsection 10.4.9, Introduction
   8. Main Steam Line Break. FSAR Subsection 10.4.9, Introduction
   9. Small Break LOCA. FSAR Subsections 6.3.3 and 6.3.3.4.2.c.2
   10. Other transients. FSAR Chapter 15

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: - 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.	b. The acceptance criteria for each of the events analyzed in Chapter 15 of the FSAR are determined by the event classifications set forth in Regulatory Guide 1.70, Revision 2. That is, the allowable transient RCS pressure, fuel design limit, or degree of fuel damage is determined by the estimated frequency of occurrence of the event being analyzed. To the extent that the EFS is activated, or must be activated, the response of the EFS is included in the analysis; in addition, single failures in the EFS are considered in the single failure analyses required for each event. The EFS control system is designed to avoid overfilling the steam generator and enable the operator to control the rate of RCS cooling.
→(DRN 05-544, R14) 2. Describe the analyses and assumptions and corresponding technical justification used with plant condition considered in 1.a. above including: a. Maximum reactor (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 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. ←(DRN 05-544, R14)	2. The analysis performed for each event is described in detail in Chapter 15 of FSAR, and is prescribed in Regulatory Guide 1.70, Revision 2, the assumptions (and technical justification for those assumptions) are included in the FSAR. Parameters and assumptions common to several accidents are described in Section 15.0 of the FSAR. a. Maximum reactor power is given in FSAR Table 15.0-4. b. Delay times associated with individual reactor trips are given in Table 15.0-3. c. The Emergency Feedwater Actuation Signal (EFAS) is described in Subsection 7.3.1.1.6 of the FSAR. Where there is any significance, the time delay between initiating event and introduction of the EFS flow into the steam generator(s) is shown in the "Sequence of Events" Tables in Chapter 15, e.g., Tables 15.2-1, 15.2-6, 15.2-8, and 15.2-10. d. The steam generator water level assumed for each event analyzed is chosen to maximize the severity of those events in which it may be significant. An example of this is provided in Subsection 15.2.2.5.3.2 of the FSAR. e. The reactor decay heat used in all safety analysis is the ANS Standard Decay Heat Curve, with the uncertainties defined in the ANS Standard. Refer to Subsection 6.3.1.2 of the FSAR. The steam generator fluid mass inventory is shown as a function of time in the FSAR for those events where it is a parameter of interest. Refer to FSAR Figures 15,1-11, 15.1-19, 15.1-30, 15.1-38d, 15.1-57, 15.1-70, 15.2-11, 15.2-35,,15.2-47, and 15.2-63.

→(DRN 03-2064, R14; 05-544, R14)

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.	f. The steam generator pressure as a function of time is shown in the FSAR for those events where it is a parameter of time interest, and the time at which the EFS is started is shown in the "Sequence of Events" Tables. Refer to Figure 15.2-7 and Table 15.2-1
k.	Volume and maximum temperature 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.	g. In the absence of normal feedwater, emergency feedwater must be supplied to at least one steam generator.
m.	Primary and secondary system water and metal sensible heat used for cooldown and AFW flow sizing.	h. There is no requirement for reactor coolant pump operation. There is sufficient natural circulation flow for plant cooldown and transfer to shutdown cooling.
n.	Time at hot standby and time to cooldown RCS to RHR system cut in temperature to size AFW water source inventory.	i. The maximum expected EFW inlet temperature is 100 °F.
		j. For the main steam line break, refer to FSAR Table 15.1-12. For the feedwater line break, refer to FSAR Table 15.2-8. The water inventory in the intact steam generator is shown on Figure 15.1-38d for the main steam line break and on Figure 15.2-47 for the feedwater line break case. For the analysis of the steam line break, it is assumed that the blowdown is saturated steam with no moisture carryover. This results in the maximum energy removal from the RCS (maximum cool down) with the greatest resultant moderator reactivity feedback potential for fuel damage (FSAR Subsection 15.3.1.3.2). For the feedwater line break, it is assumed that the blowdown is saturated liquid, with no steam content, and, at the same time, it is assumed that normal feedwater flow to the intact steam generator goes instantaneously to zero. These assumptions minimize the energy removal from the RCS, with the maximum resultant transient pressure.

←(DRN 03-2064, R14; 05-544, R14)

TABLE 10.4.9A-3 (Sheet 4 of 4) Revision 9 (12/97)

	k. The volume and maximum temperature of water in main feed lines between the steam generators and the EFS connection to the main feed line is as follows: 1. Volume for Steam Generator 1 line is 2043.3 gallons 2. Volume for Steam Generator 2 line is 2050.5 gallons The maximum expected feedwater temperature is 448 °F.
	l. The steam generator blowdown line is isolated either by the EFAS or CIAS. For all postulated faulted conditions (LOCA, steam or feed line break) the blowdown will be terminated automatically.
	m. The EFS flow requirements are established by the reactor decay heat immediately after reactor trip. Sensible heat removal during cooldown has a second-order effect on the calculations performed to verify that the bases defined in FSAR Subsections 10.4.9 and 10.4.9.1 are satisfied. The volume of water used in these calculations is given in Table 5.1-2 in the FSAR. The mCp for the RCS is approximately 0.64 x 10^6 BTU/F.
	n. The time requirements used in establishing the water inventory for the EFS are given in FSAR Subjection 10.4.9.1.e.
➜ 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. ←	3. The EFS is designed to perform its intended function in the event of a single failure in the system and a postulated pipe break, as required by Branch Technical Position APCSB3-1 (FSAR Subsection 10.4.9.1.c). In the event of loss of ac power (onsite and offsite) an additional single failure is not postulated (FSAR Subsection 10.4.9.1.f). The bounding event for the EFS is the FWLB which requires an EFW pump delivery to the intact steam generator of 575 gpm at 1102 psig. The minimum capability for the two electric driven pumps or the one turbine driven pump exceeds this requirement accounting for pump recirculation flow, seal leakage and pump wear.